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FINANCIAL INTEGRATION OF INDIAN AND DEVELOPED MARKETS: A DCC GARCH ANALYSIS

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Abstract

The stock market is the main channel of financial integration for emerging economies like India. Globalization, deregulation of the market, capital account convertibility, and information and technology are the key factors contributing to the integration of the world markets. However, linkages of the financial markets are associated with risk and volatility. The ripple effects of volatility in one market can be seen in the stock markets of other countries. The ability of the country to absorb external shock depends upon the financial integration of the economy. The purpose of the paper is to analyze the degree of financial integration by estimating the volatility interdependence of stock indices of countries like India, China, USA, Germany, Japan, and UK. Time-varying correlation and volatilities among the stock market are studied using Dynamic Conditional Covariance (DCC)-Generalized Auto-Regressive Conditional Heteroscedasticity (GARCH) model and Baba , Engle, Kraft, Kroner BEKK model while the flow of information is determined through Granger Causality test. The study analyzes daily returns of SENSEX, Shanghai Stock Exchange, Dow Jones, NIKKEI, DAX and Financial Times Stock Exchange (FTSE) from 2008-2020. The study documents that the unconditional volatility is maximum in China, followed by Japan, Germany, India, USA, and UK. The financial integration of the Indian market is highest with China, followed by the USA. The policymakers can use the research findings in developing the lead-lag relation of the Indian stock market with the rest of the world. It will enable the investor to diversify their international portfolio by investing in the markets which are not correlated.

Key Variable: financial openness, free movement of capital, integration of financial services and relaxation of capital control

Introduction:

The stock market is a medium for integrating the world economy. Integration of financial markets is a process of unifying markets leading to convergence of risk-adjusted returns for assets across the markets Reddy (2003). Various factors like deregulations of the emerging countries, capital account convertibility and advancement in Information Technology have stimulated financial segment integration. Moreover, electronic payment and communication systems have reduced arbitrage opportunities, thereby aiding the cross-border mobility of funds. Even the basic framework of monetary policy promotes uniformity in the pricing of the financial product. All the above factors have accelerated financial integration. Recent developments in the global financial market have revived the interest in Financial Integration. Researchers and policymakers have revisited the benefits of integration, given the aftermath

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of the subprime crisis, devaluation of the Chinese currency, Asian crisis, and more recently, COVID19.

Unification of the financial market comes with many opportunities for economic growth for a country. Levine (2001) explained that the co-movement of the market induces market discipline and operational efficiency. It reduces the profits associated with cartelized markets and results in the reduction of the cost of investment. Mohan (2004a) emphasized that an efficient and integrated capital market provides a platform for channelizing saving into an investment, thereby accelerating economic growth. As a result, emerging companies depend upon international investment to supplement domestic savings. Capital market integration acts as a mechanism of the price signal. It enables the policymaker to develop policies that will reduce shock .Reddy (2003) with an emphasis on macroeconomic discipline, information disclosure, and fostering economic growth, policymakers are design policies that will aid financial integration. Though financial openness maximizes the longer-run gains, it also has a potential cost. Agenor (2003) documented that integration brings the benefits of inter-temporal consumption smoothening, reduces trading cost, and portfolio diversification opportunity. But it is accompanied by investment reversal at the time of crisis. The ripple effects of volatility in one market can be seen in the stock markets of other countries. According to Dadush, Dasgupta & Rath (2000) potential risks associated with financial openness include concentration of capital flow, misallocation of funds, capital flight, and stock market volatility.

Financial indicators reflect the international transmission of shock from one capital market to another. It not only affects financial entities but also affects the volatility in the capital market. Consequently, policymakers are interested in contriving an early warning mechanism. The research findings can be used to identify the lead-lag channel of transmission. Unification of the stock market across the world significantly affects the structure of global portfolio. The decision of the global investor is conditional to the outcome of the integration of the stock market. It provides an opportunity for the investor to achieve a higher risk-adjusted return. A highly integrated stock market indicates that the investor cannot benefit through diversification strategy as the stock market returns are correlated Ling &Dhesi (2010). Consequently, investors explore the volatility transmission among various stock markets to ensure an optimum portfolio.

This research contributes to the meager published literature by studying financial integration for an emerging country like India.The aftermath of the Economic reforms of 1991, has changed the nature of the, India's trade and capital market. Indian capital market is expanding and is increasingly attracting investment from foreign countries. The country is moving towards capital account convertibility. Progressively liberal policies to attract foreign capital have led to an increased inflow of foreign investment in India. Foreign direct investment has increased from US$4 million in 1991 to US$30,004 as of September 2020. Foreign portfolio investment has increased from US$1 million in 1992 to US$ 174.31 billion as of September 2020[1]. Consequently, volatility transmission from the developed capital market to the Indian stock exchange becomesa critical research area. The study investigates the integration of the

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Indian market with USA, Germany, Japan, and China. These five-stock markets lead the international capital market based on market capitalization, and India is a growing stock market.India is now the 5th economy based on PPP and the 8th largest stock market. It is one of the main countries of the emerging market. Cost & Widrick (2007) studied the emerging markets and documented that India is one of the important emerging markets which is important destination for foreign investment.

Recognizing the critical value of financial integration to economic agents, investors, and policymakers, numerous studies in the applied finance literature have concentrated on measuring the degree of integration among national stock markets. In the copious literature, most of the previous research focuses on developed economies. Limited literature is available for emerging countries and India is one of the major countries among the emerging economies. Consequently, the paper contributes to the existing body of literature by studying the co-movement of an India, with five major stock markets of the world. Most of the Indian researches have studied financial integration using the co-integration framework or GARCH model. The current research adopts new techniques like Dynamic Conditional Correlation – Generalized Autoregressive Conditional Heteroscedasticity model to study the time-varying volatilities and integration of the stock market. It also used the BEKK-GARCH.

The study uses daily closing prices of SENSEX (India), NIKKEI (Japan), Dow Jones (U.S.), SHANGHAI Stock Exchange (China), DAX (Germany), and Financial Times Stock Exchange (UK), from 2008 to 2020. Dynamic Conditional Correlation – Generalized Autoregressive Conditional Heteroscedasticity model (DCC-Garch) is used in the current research to study the time-varying volatilities and integration of the stock market. We have use the BEKK- GARCH for cross check the results of the DCC- GARCH.

The remainder of the paper has the following structures; section 2 reviews the relevant literature on volatility transmission among the stock market. Section 3 discusses the methodology used to study financial integration. Section 4 documents the result of the research, followed by the conclusion.

2. Literature Review

Integration of the stock market is a well-established fact in International Finance. There is a vast body of literature on financial co-integration, ranging from assessing the factors responsible for integration, international capital flow to studying the co-movement return and volatility spillover across boundaries.Brouwer (1999) attributed synchronization of the stock market to the free flow of goods and services and capital across geographical boundaries. Ruble (1968) documented that with no international barriers, country risk, and exchange rate premium, financial assets with same liquidity and risk will yield similar returns. According to Marashdeh & Shreshtha (2010), access to cheap finance and underpricing assets in foreigncountries encourages investment opportunities. It enables investors to reduce economy specific risk and reap profits. Cross border investment promotes integration but entails costs. Integration comes with capital flight, transmission of volatility, and crisis. Obadan (2006) in

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his study emphasized the need for sound macroeconomic policies, orderly liberalization of capital accounts, and adequate preparation of national financial systems to reap the benefits of financial integration. Sharma & Seth (2012) classified and presented a literature review on the integration of the stock market.

Global financial markets unification accelerates volatility transmission. To reap the benefit of product diversification, the investor should invest in the markets with little correlation. Markowitz (1952) documented that investors can maximize their returns by monitoring the volatility and inter-linkages among various stock markets.Coeurdacier, Rey &Winant (2020) proposed a unified framework to study the gains of financial integration. The model incorporated risk, potential asymmetry and capital accumulation. The study shows that risky country not only benefit from diversification, they reallocate saving towards safer countries, leading to capital accumulation.Chuluun (2017) studied the subprime crisis and explained how stock market synchronization of the stock market led to crisis from one sector of the US become a global crisis.

Volatility transmission is more pronounced when the flow of information is from developed countries to emerging countries. Wu &Xu (2015) explored volatility and information transmission from the USA, Japan, and Hong Kong to Asian countries using time-varying correlation and vector Auto-regression with an impulse response function. The study documented evidence of volatility spillover from the USA market to Asian countries. Researchers like Huyghebaert & Wang (2010) and Chevallier, Nguyen, Siverskog & Sala (2017) studied the Asian market within the co-integration framework using the VAR methodology. Both the studies documented a high level of financial integration in the Asian market, and it gets strong during the period of shocks. Wang, Zhu, Yang &Mul (2017) used the return spillover measure to study the financial co-integration of Pacific region. The study revealed that ASEAN countries were more affected by volatility in the US market as compared to East Asia.Loh (2013) used Wavelet coherence to study the co-movement of 13 Asia pacific stock markets with European and US stock markets. The study found dissimilarity in co-movement across the time scale for European and US stock markets during financial crises.

Most of the researches mentioned above focuses on the Co-integration framework. Recently financial openness across countries is being studied using the DCC GARCH methodology. Diebold &Yilmax (2009) proposed dynamic connectedness procedure based on the notion of forecast error variance decomposition from vector auto-regression. Various studies have used this methodology.Abid (2014) use the DCC- GARCH model to study the time-varying integration of South Asian Markets. The study also identified factors affecting financial integration. The research documented that regional factors determine 70 % of the risk premium. Boubakri (2015) used DCC- GARCH model to study the integration in the East Asian market. Baumöhl & Lyócsa (2014) studied 32 stock markets of developed and developing companies using weekly returns from 2000-2012. Using the DCC GARCH model, the study documented significant spillover integration between the markets and concluded that diversification benefits decrease over the period. Reasearcher like

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Antonakakis & Gabauer (2017), Antonakakis N.,Gabauer, Gupta, & Plakandaras, (2018) and Barunik, Kocenda, & Vacha (2016) used a two-step procedure is used to study the volatility transmission mechanism in all these studies. The multivariate GARCH model is used to calculate volatilities, and these volatilities are used in the second stage as fundamental in the rolling window of the VAR procedure.Vinh Vo & Ellis, (2018) studied financial integration for markets like Vietnam, USA, Hong Kong, and Japan during the global financial crisis. The researcher investigated the return linkage and volatility transmission using VAR and GARCH BEKK model. The study established a lead-lag relation from the developed countries to the Vietnamese stock market. Ahmed, Abdullahi ,& Huo, (2019) studied the impact of Chinese stock market fall (2015-16) on the Asian Pacific Stock market. The resaercher used BEKK GARCH model to study the asymmeteric volitality spill over. The study documented chinese market was significantly integerated with the regional markets and price spillover from China was stronger during bullish period. Hartmann, Borgioli, Alina , & Molitor (2021) studied the impact of COVID 19 on Euro Financial Integeration . The study explores the the asset prices of the European Union countries duing the crisis and documented high degree integeration among the member countries.

Despite the increasing interest in stock market integration, there is limited research in India. Literature review suggests that previous studies in India have studied market integration through the conventional methodology of correlation, cointegartion and granger causality test Narayan, Smith, & Nandha (2004) explored the inter-linkages of the stock market like Bangladesh, India, Pakistan, and Sri Lanka using a temporal Granger causality approach. Wong, Aggrawal, & Du, (2006) used granger causality and frictional co-integration to document that the Indian stock market is integrated with mature markets like the USA, UK, and Japan. Similar results were documented by Sanati (2010). Researchers like Abbas, Khan, Zulfiqar, & Shah, (2013) used the bi-variate GARCH model from 1997 to 2009 to study the volatility spillover of the stock market in the regional block for countries like India, China, Pakistan, and Sri Lanka, and developed CCccjkhdkwqjdhcountries in the regional block. The study documented one-way information flow from the USA, Japan, and Singapore, to the Asian regional block. Since there is a lack of studies in the domain for emerging countries like India, **t**he current study will add value to the existing body of literature in the current field.

Methodology

The current paper uses the DCC –GARCH and BEKK model to study the integration of the Indian stock market with developed countries like USA, UK, Japan, Germany, and China. The short tem direction of flow of direction of volatility is determined through Granger causality.The DCC GARCH model captures time varying correlation between the return of stock market indices. The DCC approach documents the time varying volatality over a period of time. Literature on financial integeration documents correlation among various stock indices. The DCC GARCH model proposed by Engle (2002) estimates time varying conditional correlation. It over comes limitation of alternative models like CCC Garch and cointegeration.Chiang, Jeon & Li (2007), Aawaar, and, Nsiah (2018). Since DCC GARCH

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estimates correlation coefficient of standardized residual, the model accounts for hetroskedasity. Direct deduction on cross index conditional correlation. Additional regressorscan be added in the model. The DCC model examins the asset return without using too many parameters. Acording to Chiang, Jeon & Li (2007) DCC Garch is eefective to study the co-movemnts among stock market within multiple setting. Consequently this model is effective in analysisng the global financial integeration across multiple regime shifts,shocks and crisis.

Constant Conditional Correlation GARCH model proposed by Bollerslev (1990) and BEKK-GARCH Engle & Kroner (1995) are alternative models. CCC model is based on an unrealistic assuption of constant correlation between thea time series .Thus the paper compares the result of BEKK GARCH with DCC GARCH. It will allow us to compare the outcome of two models for better analysis. The null hypothesis in this study is that there is no financial integeration of the Indian stock market with the capital markets of the developed countries like China, USA, Germany, Japan and UK. While the alternative hypothesis assumes the financial integeration. Through DCC Garch and diagnal BEKK GARCH model the study attempts to examine the hypothesis.

The structural framework of the DCC GARCH model is given by two steps. In the first step volatility of each stock- index is calculated using the uni-variate GARCH model. The standard residual in the GARCH model is used as inputs for estimating a time-varying correlation matrix**.**

$$H_t = D_t R_t D_t \quad (1)$$

where $H_t$is conditional variance matrix, D_t is a diagonal matrix of conditional time varying standardizedresidual that were obtained from the GARCH model -for diagonal elements. R_t is time varying correlation matrix for off diagonal.

The conditional variance (h_{it}) for the stock indexes assessed using GARCH model is given

$$h_{it} = \omega_i + \sum_{x=1}^{X_i} \lambda_{1x} r_{it-x}^2 + \sum_{Y=1}^{Y_i} \lambda_{2y} h_{it-y} \quad (2)$$

Whereω_i, λ_{ix}, λ_{iy} are non-negative and $\sum_{x=1}^{X_i} \lambda_{ix} + \sum_{y=1}^{Y_i} \lambda_{2y} < 1$.

The residual (ε_{it}) and conditional standard deviation $\sqrt{h_{it}}$ obtained from the first step is used to estimate the diagonal matrix D_t and correlation matrix R_t.. The Dt matrix is obtained by

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placing elements of conditional standard deviation on the diagonal side as depicted in equation 3

$$D_t = \begin{bmatrix} \sqrt{h_{11t}} \dots & 0 & 0 \\ 0 & \sqrt{h_{22t}} & 0 \\ 0 & 0 & \sqrt{h_{33t}} \end{bmatrix} \quad (3)$$

The time varying correlation matrix is obtained as

$$R_t = Q_t^{*-1} Q_T Q_t^{*-1} \quad (4)$$

$$Q_t^* = \begin{bmatrix} \sqrt{q_{11t}} \dots & 0 & 0 \\ 0 & \sqrt{q_{22t}} & 0 \\ 0 & 0 & \sqrt{q_{33t}} \end{bmatrix} \quad (5)$$

Equation 5 depicts Q_t^* is a diagonal matrix of its diagonal elements. Q_t is a symmetric conditional covariance matrix $Q_t = (q_{ij,t})$ and Q BAR = unconditional covariance of the standard residual of univariate GARCH model.

$$Qt = (1\text{-}a\text{-}b)\ \overline{Q} + a\varepsilon_{t-1}\ \text{-}1\varepsilon'_{t-1} + bQ_{t\text{-}1} \quad (6)$$

BEKK GARCH (1,1).

The paper also tries to capture the volatility spill over among the stock market through BEKK GARCH model.

$$Y_t = \mu_t(\theta) + \varepsilon_t \quad (7)$$

$$H_t = C`C + A_i`\varepsilon_{t-1}` \varepsilon_{t-1} A_i + B_i`H_{t-1}B \quad (8)$$

C representsupper triangle matrix and diagonal variance co-variance model is represented by A and B. Diagonal elements depict the volatility in the stock market while off diagonal

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document the impact of volatility transmission from one market toanother. A matrix documents the correlation of conditional variance with past squared errors while B matrix documents the effect of past conditional variance on the current level of consitional variance. Thus B matrix shows the degree of valatality persistence in conditional volatility among the stock market.

- Granger Causality: To explore the short term association between the share price market and the currency rate causality test suggested by C.J Granger in 1969 has been used.The following equation is used to check the casual association between ER_t and SP_t series.

$$SENSEX_t = \sum_{k=1}^{p} \alpha_k SX_{t-k} + \sum_{k=1}^{p} \beta_k DJ_{t-k} + \sum_{k=1}^{p} \beta_k FTSE + \sum_{k=1}^{p} \beta_k DAX_{t-k} + \sum_{k=1}^{p} \beta_k NIKKEI_{t-k} + \sum_{k=1}^{p} \beta_k SHANG\ S.E_{t-k} + \mu_t\, \mu_t\, \mu_t\, \mu_t$$

Where SX – daily stock return -Indian Stock Market, DJ – daily exchange rate return USA Stock Market, FTSE – daily stock return UK Stock Market -, DAX – weekly exchange rate return Germany Stock Market ,NIKKEI – daily stock return -Japan, Shanghai S.E – daily exchange rate return Chinese Stock Market , α_K and β_k ,$\square_k$,δ_k are constants; and μ_t and $\boldsymbol{\upsilon}_t$ are orthogonal disturbance terms with mean zero and variance finite NIID (0,1). The null hypothesis of the Granger Causalty test states that USA, China, Japan, Germany and UK's stock market do not Granger Cause the Indian Stock market and vice versa. The alternative hypothesis states that Stock market of developed countries (studied in the research) Granger Cause the Indian stock market . Consequently the research tries to study the direction of Volatality Spill over among the various stock market studied.

4. Result and Analysis

Daily returns of SENSEX (India), NIKKEI (Japan), Dow Jones (U.S.), SHANGHAI (China), DAX (Germany), and Financial Times Stock Exchange (FTSE-UK) were analyzed from 3rd March 2008 to 30 the March 2020. The study uses secondary data collected from reliable

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websites like Index Mundy, trading economies, and World Bank, Bombay Stock Exchange. Descriptive statistics are used to specify the distributional properties of the daily return series of stock market indices during the study period (table1). The table depicts that the stock index selected has diverse returns and volatility. The average returns of Dow Jones (USA) are the highest (2.48 %), followed by the BSE SENSEX –India (2.42%). The average return of and Shanghai Stock Exchange (China) and Financial Time stock Exchange (UK) is negative. The lowest return is of FTSE -UK at negative 2.06%. In terms of volatility, the variation is maximum for the Shanghai Stock exchange -China (1.74 %), followed by the Japanese Stock Exchange at 1.703 %. FTSE exchange-UK (1.37%) and Dow Jones-USA (1.39%) are stable. Indian Stock market is less volatile as compared to the Chinese, Germany, and Japanese Stock Exchange. Dow Jones (USA), Shanghai stock exchange (China), financial time stock exchange (UK), and NIKKEI Stock Exchange (Japan) are negatively skewed, while BSE shows positive skewness.

Table 1: Descriptive Analysis

	India	**USA**	**Germany**	**Japan**	**China**	**UK**
Mean	0.000242	0.000248	0.000161	0.000159	-0.00018	-0.000000206
Median	0.000527	0.000606	0.000895	0.000684	0.000546	0.000427
Maximum	0.1599	0.1313	0.134627	0.136669	0.119701	0.111112
Minimum	-0.11604	-0.13842	-0.13055	-0.12715	-0.10695	-0.11512
Std. Dev.	0.015398	0.013971	0.016195	0.01703	0.017484	0.013785
Skewness	0.187108	-0.446	-0.3286	-0.57964	-0.41396	-0.26341
Kurtosis	14.74253	18.96026	12.51853	12.7926	8.323321	15.34441
Jarque-Bera	13923.47	25776.13	9183.085	9808.979	2927.717	15399.77
Probability	0	0	0	0	0	0
Observations	2421	2421	2421	2421	2421	2421

Source: Authors calculation using Eviews

To visualize the price series of all six stock markets, figure 2-6 presents the graph of daily returns (2008 -2020) for SENSEX (India), NIKKEI (Japan), Dow Jones (U.S.), Shanghai Stock Exchange (China), Financial Times Stock Exchange (U.K.), and DAX (Germany). The graphs depict that stock market returns took a sharp plunge during the Sub Prime crisis in 2008-2009. The fall was acutest for the U.S., followed by China and India. The debt crisis of Greece led to the crash of Germany and the U.K. market during 2015. Lastly, the stock market crashed in March 2020 due to the COVID 19. However, the research does not capture the effect of the pandemic.

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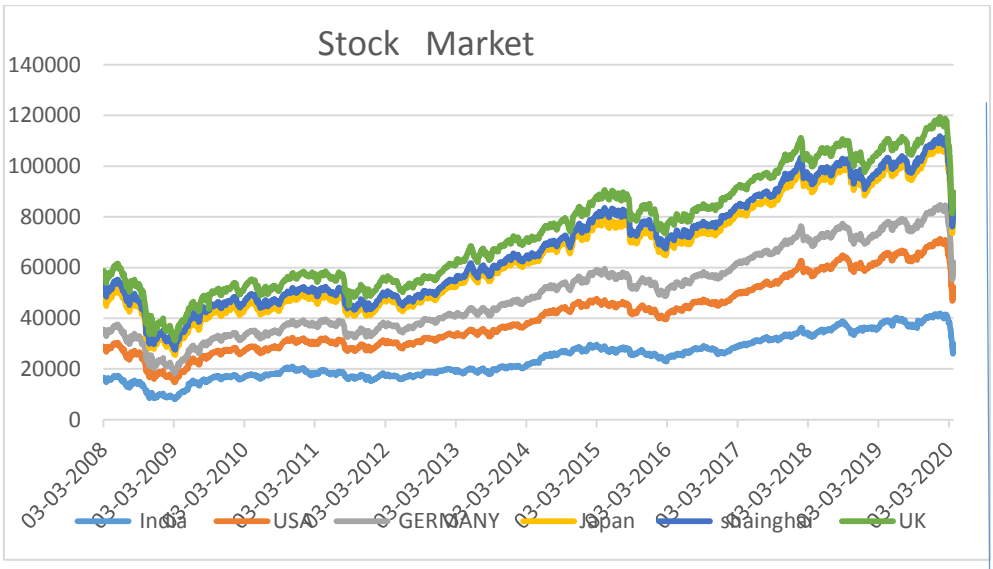

Figure 1: Stock market value, India (SENSEX), U.S.A (Dow Jones)

Germany (DAX) Japan (NIKKEI) , China (Shanghai Stock Exchnage) , and U.K. (Financial Times Stock Exchange)The figure no 1 represent the stock market prices of the selected countries and it also point out the different disruptions in international stock markets namely subprime crises,Greece crisis, Brexit,US-China trade war and Covid 19. It shows that during subprime crises, every stock market fall more or less but all the markets grown faster but Indian market was almost flat and took some time to grow. During the Greece Crises and Brexit , European and other developed market fell first than followedby the India.US-China trade war announced in 2018 led to stock market crash in both China and USA. As per Amiti, Kong, & Weinstein,(2020)the US firms lost$1.7 trillion dollars.Equity prices crashed by 6% out of which 3.4% was due to negative sentiments while 2.6% was due to poor performance of firms importing the product from China. Similar impact was ducmented by Bekkers & Schroeter, (2020).The trade war not only impacted the stock market and economic conditions of USA and China, and it also affected the world markets. Setiawan (2020) .The study documented that ASEAN stock market return fell by 7.4%. Howeve the biggest crash came in 2020 – COVID 19 crisis.The pandemic caused a fall in all the markets.

Unit root

Table 2 documents the outcome of the Augmented-Dickey Fuller test. ADF test, computed at the intercept, reveals that both the financial series are non-stationary at level but stationary at first difference. The t- statistic of the stock exchange is greater than the critical value (-1.091634 > -2.865256). Consequently, at level, the null hypothesis is accepted. However, at first difference, the stock market's critical value is greater than the calculated t statistics. Thus

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the series don not have a unit root in the first difference. Further analysis uses the log return series to study the co-movement of the stock exchange**.**

	Table 2: Test of Stationary – Augmented Dickey Fuller Test					
	ADF Level			ADF First Difference		
	T-statistics	Critical Value	Probability	T-statistics	Critical Value	Probability
India	-1.091634	-2.865256	0.7213	-30.9112	-3.415942	0
USA	-0.818644	-2.865256	0.8132	-34.19092	-3.415942	0
Germany	-1.309510	-2.865256	0.6273	-48.44145	-3.415942	0.0001
Japan	-1.060604	-2.865256	0.7331	-49.46265	-3.415942	0.0001
China	-3.204289	-2.865256	0.0199	-47.31507	-3.415942	0.0001
UK	-1.988621	-2.865256	0.2921	-49.68557	-3.415942	0.001

Source: Authors calculation using Eviews

Table 3 documents the result of the correlation matrix of the six stock index used in the study. The correlation matrix depicts that the value of the index move in the same direction. The range of correlation for various indexes is from 0.329 to 0.975. The range is lower than 0.8 documenting low co-movement and absence of collinearity. The finding corroborates with earlie researches Joyo &Lefen (2019) and Vo & Ellis (2018). The correlation between Dow Jones (USA) and Sensex (India) is the highest while the correlation between the Dow Jones (USA) and Shanghai Stock market (China) is the lowest.

Table 3 : Correlation Matrix						
	India	USA	Germany	Japan	China	UK
Sensex (India)	1	0.975	0.940093	0.928	0.408	0.880
Dow Jones (USA)		1	0.946	0.939	0.329	0.896
DAX (Germany)			1	0.958	0.450	0.938
NIKKEI (Japan)				1	0.5	0.866
Shanghai S.E (China)					1	0.342
FTSE Exchange (UK)						1

Source: Authors calculation using Eviews

The short term relationship among the the stock marmet is checked using Granger causality test is conducted on the first difference of the two variables. This test enables the researcher

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to identify the time-varying relationship between the various stock market indexes. The result is documented in table 4. The result shows uni directional flow of information from the USA, Chinese and UK stockmarket to Indian Stock market while bi—directional flow of information of Germany and Japanese Stock Market with Inida.

Table no 4: Granger Causality

Null Hypothesis	**F Statistic**	**Prob**
USA. Stock Market does not Grang cause INDIA Stock Market	77.1283	3.E-33
Indian stock Market does not Granger Cause USA Stock Market	0.51640	0.5967
Germany Stock Market does not Granger Cause India Stock Market	23.2379	1.E-10
INDIAN Stock Market does not Granger Cause Germany Stock Market	81.2850	7.E-35
Japanese Stock Market does not Granger Cause Indian Stock Market	33.8323	3.E-15
INDIAN Stock Market does not Granger Cause Japanese Stock Market	9.33676	9.E-05
Chinese Stock Market does not Granger Cause Indian Stock Market	45.5434	4.E-20
INDIAN Stock Market does not Granger Cause Chinese Stock Market	1.32281	0.2666
U.K Stock Market does not Granger Cause Indian Stock Market	22.3913	2.E-10
INDIAN Stock Market does not Granger Cause Germany Stock Market	0.02611	0.9742

Source: Authors calculation using Eviews

The integration of the Indian market with the developed countries is studied using DCC - GARCH model. The model uses both Gaussian and T distribution. It enables comparison based on maximum likelihood values. Table 5 documents the volatility decay parameter ($\lambda 1$, $\lambda 2$) while $\delta 1$ and $\delta 2$ represent the correlation decay parameters computed using Gaussian and T distribution. Both the model shows that the decay parameters are statistically significant. The sum of $\lambda 1+$, $\lambda 2$ is less than one for all indices except the Shanghai stock exchange. It indicates that the model is stationary and mean-reverting. The conditional volatilities for all the indexes die gradually. However, for the Shanghai stock exchange, the volatility tends to last over some time. The sum of the correlation matrix ($\delta 1$ and $\delta 2$) is less than one for the log returns. It shows that condition correlation is also mean-reverting and returns to normality. The result corroborates with researchers like Joyo &Lefen (2019) and Jaffar, Dewandaru, &MasihMa (2017). The decay factor for the DCC GARCH model is calculated by 1-($\delta 1$ + $\delta 2$

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). In the current analysis, decay factors are 0.11408 (Gaussian distribution) and 0.000386 (t – distribution).

Table 5: DCC Analysis

λ_1	Estimate	T- Ratio	Estimate	T- Ratio	Probability
	(Gaussian distribution)		(T distribution)		
Sensex (India)	.85208	45.1091	.90923	63.8213	0
Dow Jones (USA)	.78784	35.2441	.88533	58.0890	0
DAX (Germany)	.87488	66.8915	.91014	64.9521	0
NIKKEI (Japan)	.83688	43.9914	.91813	68.3188	0
Shanghai S.E (China)	.92135	98.6045	.93825	98.6151	0
FTSE Exchange (UK)	.81920	34.1815	.90887	64.4884	0
λ_2					
BSE (India)	.13175	8.2902	.080304	6.7417	0
Dow Jones (USA)	.18201	10.0507	.098739	8.0373	0
Dax (Germany)	.10527	10.2963	.072746	6.9700	0
NIKKEI (Japan)	.13036	9.4502	.066314	6.6570	0
Shanghai S.E(China)	.073151	8.7657	.056460	6.7945	0
FTSE Exchange (UK)	.14034	8.5100	.072595	7.2815	0
Delta1 (δ_1)	.98561	611.5942	.98477	619.31	0
Delta2 (δ_2)	.012847	10.3039	.014844	11.2836	0

Source: Authors calculation using Microfit

Comparison between Gaussian distribution and T distribution shows that the maximized Log Likely hood value is higher for T distribution (45764.9) than Gaussian distribution (45148.9). Also, the degree of freedom for the T distribution model is below 30. It indicated that the DCC – t distribution model is more superior as compared to Gaussian distribution. Backed by literature Najeeb, Bacha, &Maseh (2015) Jaffar, Dewandaru, &MasihMa (2017) documented that T distribution is appropriate for series with heavy tail or kurtosis. Thus, for further analysis, the result obtained through DCC t- distribution is used.

Table 6 documents the unconditional volatilities (diagonal elements) and unconditional correlation (off-diagonal elements) .The matrix is based on DCC – GARCH model (T distribution). Unconditional volatilities and correlation help the investor in reaping the benefit of portfolio diversification among various markets. The diagonal elements in the covariance matrix represent unconditional volatilities. The result documents that volatility is maximum in the Shanghai stock exchange while lowest in FTSE (UK). It indicates that the UK market

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is the most stable, followed by USA. Germany, Japan, and India are moderately stable markets as compared to other countries**.**

. **Table 6 : T-DCC Unconditional Volatilities and Unconditional correlation**						
	India	**USA**	**Germany**	**Japan**	**China**	**UK**
BSE (India)	.012837	-.29973	-.13230	-.092707	.33380	-.003740
D.JONES(USA)	-.29973	.012179	-.068796	-.04781	0.38626	-.001390
DAX(Germany)	-.13230	-.068796	.014646	-.092682	-.27825	0.0025081
NIKKEI (Japan)	-.092707	-.04781	-.092682	.014938	-.094536	-.0023785
Shanghai(China)	.33380	-.38626	-.27825	-.094536	.017119	.0024139
FTSE (UK)	-.00374	-.00139	-.0025081	-.023785	.0024139	.010280

Source: Authors calculation using Microfit

The conditional correlation describes co-movement between the various stock indexes of countries like India, USA, Germany, Japan, China, and the UK. The unconditional correlation among the stock market has been ranked from lowest to highest in table 7. The result documents that the Indian Sock market is highly correlated to the Shanghai Stock Exchange, followed by Dow Jones of United States. SENSEX (India) is least correlated with the United Kingdom Stock market (FTSE). A low level of correlation enables the investor to diversify its portfolio.

Table7 : T-DCC Ranking of Unconditional Volatilities			
Rank	**Country**	**Index**	**Unconditional Volatility**
1	China	Shanghai S.E	.017043
2	Japan	NIKKEI	.014938
3	Germany	DAX	.014646
4	India	SENSEX	.012837
5	USA	Dow Jones	.012179
6	UK	FTSE	.010280

Source: Authors compilation using Microfit

Table 8 depicts the integration of the stock market for various countries. The study documents that the Indian stock market is highly integrated with countries like China, followed by USA, but least with UK. Similarly, there is a strong co-movement of the Chinese Stock market with the Indian Market. UK stock market is least affected by the Indian capital market. The table also documents that all the stock market used for analysis in the study is highly related to the Chinese capital market. US market conditions are an important source

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of information for Indian markets. USA and China are the world biggest stock market. China being the biggest market has a major impact on the economies of the rest of the world.

	Table 8: Level of integration of Stock Market					
Level of integration	**India**	**USA**	**Germany**	**Japan**	**China**	**FTSE**
Lowest	UK	UK	UK	UK	UK	India
	Germany	Japan	India	USA	Japan	USA
	Japan	Germany	USA	Germany	Germany	China
	US	India	Japan	India	India	Japan
Highest	China	China	China	China	USA	Germany

Source: Authors compilation using Microfit

Figure 2 showsthe value of conditional volatility of the six Stock market used in the study-Sensex(India), Dow Jones (USA), NIKKEI (Japan), DAX (Germany), Shanghai Stock Exchange (China). The graph shows time varying volatilities of the six stock indices. The volatilities show upward trend during 2008 which reflects the subprime crisis, the second wave of volatility can be seen in 2011 which marks the Euro Zone crisis. Theworld financial market was volatile around 2016. Multiple factors led like Chinese Stock Market Crash, Oil prices and BREXIT led to the volatility in the capital market. The latest volatility can be seen due to COVID 19 which has caused one of the biggest slow down the world has seen after the great depression of 1933. Figure 3 depicts the conditional volatility graph shows a close correlation of the important stock exchange

Figure 2 Conditional volatilities: Stock market returns Germany, U.S.A, Japan, India, China, and U.K.

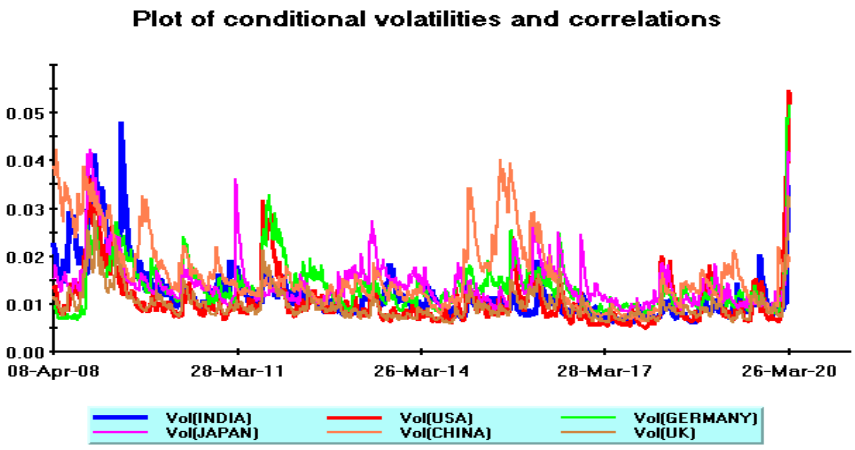

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Figure 3 Conditional Correlation: Stock market returns Germany, U.S.A, Japan, India, China, and U.K.

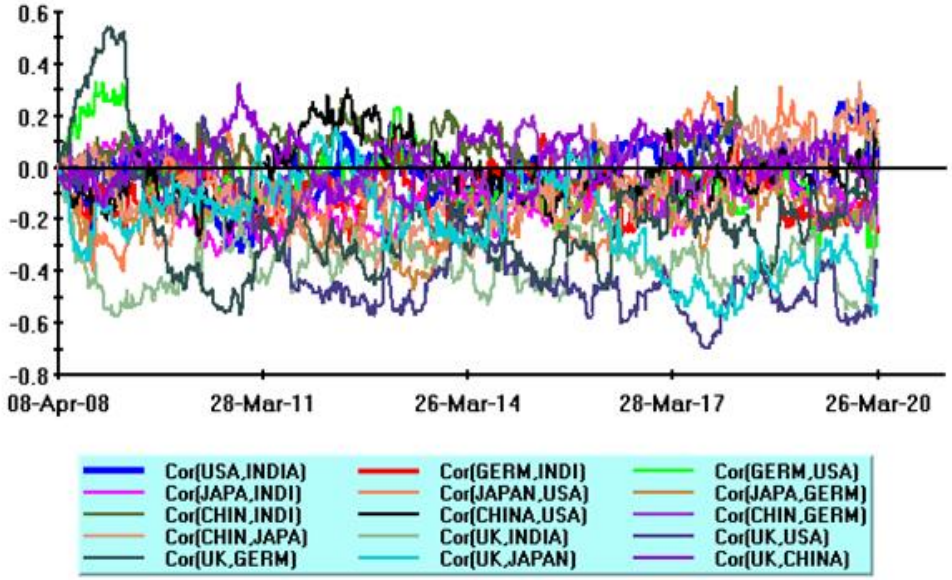

Figure 3 depicts the conditional correlation between the major six stock market indices of the world. The results are similar to the results of unconditional volatility. The figures depict high level of correlation of the Indian stock market with the world indices. The correlation of BSE Sensex market is the highest with Shanghai stock market followed by Dow Jones. FTSE of UK is least correlated to Indian Stock Market

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Table 9 BEKK Model						
Estimate	**India**	**USA**	**GERMANY**	**Japan**	**China**	**UK**
Conditional Mean Equation						
constant						
$\lambda_{i\,1}$	0.000466 (0.0253)	0.066401 (0)	0.066808 (0)	0.136654 (0)	0.038028 (0.0016)	0.0005 (0.1625)
$\lambda_{i\,2}$	0.000806 (0)	-0.002548 (0.8410)	0.059095 (0)	0.024510 (0)	0.015886 (0.0109)	0.01587 (0.3099)
$\lambda_{i\,3}$	0.000160 (0.4750)	0.199513 (0)	0.038704 (0.0029)	0.177778 (0)	0.197667 (0)	0.017886 (0.2109)
$\lambda_{i\,14}$	0.000316 (0.2134)	0.049988 (0.0001)	0.005310 (0.7732)	0.373865 (0)	0.053225 (0)	0.15886 (0.345)
$\lambda_{i\,5}$	0.00225 (0.9277)	0.020225 (0.3545)	0.111304 (0)	0.013960 (0.4846)	-0.011776 (0.5215)	0.0088676 (0.876)
$\lambda_{i\,6}$	0.00225 (0.6277)	0.03225 (0.1276)	0.06225 (0.0277)	0.06722 (0.0477)	0.876225 (0.0015)	0.015886 (0.012)
Conditional Variance Equation						
C_{1i}	0.00136 (0)	-0.00262 (0.0452)	-0.000366 (0.0048)	-0.000444 (0.0246)	0.0135 (0.0003)	-0.00004 (0.532)
C_{2i}		0.00359 (0)	0.000311 (0.0759)	0.00218 (0)	0.000071 (0)	0.00004 (0.98752)
C_{3i}			0.00056 (0)	0.0003.22 (0.2275)	0.000004.12 (0.8307)	0.15764 (0.532)
C_{4i}				0.00869 (0)	0.000081 (0.0001)	0.02344 (0.234)
C_{5i}					9.50E-06 (0)	0.01564 (0.632)
C_{6i}						0.00624 (0.0034)

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ARCH term	**Coefficient**	**Std. Error**	**z-Statistic**	**Prob.**
A_{11}	0.192139	0.006993	27.47444	0.0000
A_{22}	0.328572	0.008934	36.77753	0.0000
A_{33}	0.270456	0.009076	29.80010	0.0000
A_{44}	0.282339	0.008306	33.99281	0.0000
A_{55}	0.172597	0.005424	31.82116	0.0000
A66	0.2678	0.00524	32.8211	0.000
GARCH term	**Coefficient**	**Std. Error**	**z-Statistic**	**Prob.**
B_{11}	0.978290	0.001461	669.5005	0.0000
B_{22}	0.936245	0.003190	293.4733	0.0000
B_{33}	0.949812	0.003526	269.4054	0.0000
B_{44}	0.943618	0.003668	257.2381	0.0000
B_{55}	0.983617	0.001029	956.0833	0.0000
B_{66}	0.983617	0.001029	956.0833	0.0000

Source: Authors calculation using Microfit

Table 9 indicates that value of the diagonal elements $C_{11,}$ $C_{22,}$ $C_{33,}$ $C_{44,}$ $C_{55,}$ $C_{66.}$ These cofficient shows the effect of the stock market itself. $A_{11,}$ A_{22} $A_{33,}$ $A_{44,}$ $A_{55,}$ $A_{66,}$ represent the ARCH term while $B_{11,}$ $B_{22,}$ $B_{33,}$ $B_{44,}$ $B_{55,}$ B_{66} represents the GARCH term. The ARCH and the GARCH values are significant at 1% significance level indicating previous shocks in the own market significantly affect future volatility. Off diagonal elements $\lambda_{i\ 1,}$ $\lambda_{i\ 2,}$ $\lambda_{i\ 3,}$ $\lambda_{i\ 4,}$ $\lambda_{i\ 5,}$ $\lambda_{i\ 6,}$, represents the short run cross market spill over while $C_{1i,}$ $C_{2i,}$ $C_{3i,}$ $C_{4i,}$ $C_{5i,}$ C_{6i} documents the long run spill over. The probability value of all coefficients is significant showing the volatility spill over from all the stock market. This show a high level of financial integration. The table indicates that the Indian Stock market is most affected by the Chinese stock market. However the UK stock market does not affect the Indian Stock Market. The result is in confirmation with the DCC model. Table 10 and 11 represents a comparison of Unconditional Volatility and Conditional correlation of Indian stock market with other stock indexes used in the study. The comparison depicts Indian Stock Market is highly integrated with the world market. The volatility spill over is maximum from China followed by USA capital market.

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Table 10: Comparison of DCCG GARCH and Diagonal BEKK Garch

Country	Unconditional Volatility	
	DCC GARCH	Diagnal BEKK Model
China	.017043	0.000095
Japan	.014938	0.00869
Germany	.014646	0.00056
India	.012837	0.00136
USA	.012179	0.00359
UK	.010280	0.00624

Source: Authors calculation using Microfit

Table 11 Comparison : Unconditional correlation of India with other stock markets		
Countries	**DCC GARCH**	**Diagnal BEKK Model**
UK	-.003740	-0.00004
Germany	-0.13230	-0.000366
Japan	-.092707	-0.000444
US	-0.29973	-0.00262
China	0.33380	0.0135

Source: Authors calculation using Microfit

Conclusion

The research paper uses the conditional correlation of the generalized autoregressive conditional heteroscedasticity (DCC GARCH) technique to analyze the financial integration of the Indian stock market with the world capital market. The co-movement of SENSEX (India) was studied with the Dow Jones (USA), DAX (Germany), NIKKEI (Japan), FTSE (UK), and Shanghai Stock Exchange (China) by using the time-varying nature of correlation. The study documents that the Indian capital market is highly integrated with the Shanghai Stock Exchange, followed by Dow Jones. However, the Indian market is least affected by the U.K.stock exchange. The study documents unit directional flow of information from the

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USA, Chinese and UK stock market to Indian Stock market while bi—directional flow of information of Germany and Japanese Stock Market with India .The study limits itself in scope. Apart from studying the integration of the Indian market with the developed markets, regional countries like Pakistan, Sri Lanka, and Bangladesh can also be studied. Despite the limitations, the findings can be used by international investors to develop a diversification strategy. It will help investors in choosing an optimum portfolio and reap profits. From the policy perspective, a co-integrated market act like a signal to form a lead-lag policy. Efficient policies can aid stability by reducing the volatility transmission from the rest of the world.

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Appendix Figure 4: Conditional Covariance using BEKK model