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Volatility Spillovers Between Oil Prices, Exchange Rates, and Stock Markets in BRICS Countries: A Time-Varying Analysis Using DCC-GARCH Framework

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1. Introduction

This quickening pace of financial integration of international markets enhanced the cross-asset volatility transmission enormously, generating intricate interdependencies, which are especially high among the emerging markets. One of them, namely, The BRICS nations, which include Brazil, Russia, India, China, and South Africa, provides an excellent argument in favor of investigating cross-market volatility spillovers given the increasing economic importance, diversified nature, and stronger response to globally shocking factor commodity prices and exchange rates volatility. These economies that together constitute more than 40 percent of the world population and almost a quarter of the global GDP (Mensi et al., 2021; IMF, 2023) have seen a significant advance in terms of development of their financial market over the last decades in such a way that their stock markets are gaining prominence as a place of portfolio investment of foreign investors.

Dynamic nature of stock price, exchange rates and macroeconomic related operations is the primary intrinsic of financial market delivery, and the volatility spillover is a key risk transferring tool between markets (Yu & Liao, 2017). The ties between the two have only been complicated by the progress of information technology and the financial globalization that have improved information rates and capital mobility heightening interdependencies in the market (Jebran & Iqbal, 2016). The relationship existing among these markets may tend to serve as prognosticians; they may tend to know what the market is doing. Distress in some of these markets might also be noticed earlier as compared to other markets (Singh et al., 2025). It is possible to analyse the interdependence of these markets in terms of linkages that would assist in reducing the adverse effect of the market volatility on investments (Singh et al., 2019)

The empirical support proves the single channels through which volatility is transmitted across markets. Empirical evidences have indicated that stock market performance can substantially modify with a number of channels by exchange rate volatility. First, appreciate or depreciate their currency can enhance competitiveness of export-oriented firms but in fact it will raise the burden of debts on firms with foreign currency based debt (Agrawal et al., 2010). Second, foreign investors depend on the trends of the exchange rates as the currency risk is the significant constituent of overall investment risk in the emerging economies (Bekaert & Harvey, 2003). Third, the volatility of having to exchange the currency might represent instability in the macro economy, which influences the overall investor attitudes and risk taking ability (Bodart & Reding, 1999). The impacts are notably critical in BRICS nations because they are becoming deeply involved in the international financial market and foreign portfolio flows are becoming decisive (Koijen & Yogo, 2019).

Equally, commodity prices shocks have a disproportional impact on the BRICS countries, enriching those countries that export oil products such as Russia and at the same time impoverishing those who import oil products such as India in the inflationary pressures and trading equilibrium (Sadorsky, 1999; Arouri & Rault, 2012; Zhang & Chen, 2021). Correlation between oil price volatility and performance index of stock markets has also received significant analyses in the financial economics research with various researches recording disparity in volatility spill and swells depending on net importer or exporter state of any given country (Sadorsky, 1999; Arouri & Rault, 2012). Stock markets are positively correlated with oil prices in oil-exporting countries such as Russia and Brazil because they are mostly dominated by energy companies when it comes to market capitalization, negatively correlated with oil prices in oil-importing economies such as India and China, which experience inflationary and trade balance effects of oil price rise (Zhang & Chen, 2021).

Nonetheless, there are a number of key gaps in these interrelationships that have not been addressed so far, especially with regards to the BRICS economies. To begin with, majority of the literature focuses on an oil-stock or FX-stock relationship being independent of triangular relationships that do exist among the oil prices, exchange rates and the stock market that defines these open, commodity dependent economies. Second, standard ways of doing this presume constant fit between the markets, and fail to reflect how financial volatility spillovers could magnify in times when there is a financial crisis or uncertainty across the globe. Third, the heterogeneity of the BRICS group has not received enough attention and the

countries are quite different and their economic structure, oil dependency and exchange rate regime are probably very different and this is likely to moderate volatility transmission mechanisms.

This research paper fills these critical gaps by relying on the DCC-GARCH (Dynamic Conditional Correlation Generalized Autoregressive Conditional Heteroskedasticity) analysis to assess time-variant volatility spill over among oil prices, exchange rate and stock market across the BRICS nations. The DCC-GARCH framework, proposed by Engle (2002), in particular, would be ideally suited to this analysis as it has comes with a number of important advantages over the traditional techniques: (1) because correlations between various markets are treated as time-varying, this model can be used to detect the situations when volatility is most likely to spread across markets (such as a financial crisis period); (2) it takes into consideration heteroskedasticity observed in financial time series, thus drawing more efficient estimates of parameters; and (3) since it was proposed in a multiple-

Policymakers and market participants are specifically interested in the direction and the intensity of these spillovers since the latter hinder financial stability and the predictability of the market indicators to a substantial degree (Grobys, 2015; Ebrahim, 2000). The ability to comprehend the character and extent of volatility spillovers becomes essential to formulating macroprudential policies as well as designing policies that prevent the occurrence of crises.

The rest of this paper will be structured as follows: Section 2 will have a thorough coverage of the literature on volatility spillover in emerging markets both theoretical and empirical. In section 3 we explain our econometric technique, i.e. specification of DCC-GARCH model and data description. The empirical outcomes are introduced in 4, whereas time-varying correlations are estimated. In Section 5 we interpret our findings as they apply to policy and practice in the financial stability setting and investment practice, and provide a conclusion along with suggestions of how to take the research further in the future. We hope that the present analysis will not only support a better scholarly comprehension of volatility infection channels in BRICS markets but also can serve as lessons learned by market players and policymakers that work with these volatile emerging economies.

1. Review of literature

Academic research on the interconnectedness of financial markets has been placed at the center of interest especially on the propagation of volatility across asset classes. This segment will review the existing body of knowledge on nexus amongst exchange rates, oil prices and stock markets by putting a special emphasis on the economies of BRICS. In the review, I start by discussing the theoretical and empirical background on the links between exchange rates and stock markets, which are then followed by the analysis on the connections between the oil prices and stock markets. It subsequently examines the more complicated triangular nexus among all three variables and come up with the key gaps that have hitherto existed in the existing literature that this study in particular seeks to fill.

To answer the question of relationship between exchange rate and stock market, there are two prevailing theoretical frameworks that have been intensively examined. Flow-oriented approach In this approach that was developed by Dornbusch and Fischer (1980) it is assumed that trading of services and goods affects the competitiveness of the companies leading to an impact on the stock prices of the export-oriented firms. It is against this that the stock-oriented approach (Branson, 1981) focuses on the dynamics of the capital account and capital market as the force behind the demand effect on the currency in the portfolio rebalancing effect through equity market performance returns. The actual observations through empirical investigations show that there are subtle ways in which these relationships are taken place especially in prospective markets.

The case of bidirectionality of volatility spillover in BRICS countries is evidenced by recent studies, but bidirectional effects become evident on both the currency and stock market with the exchange rates to stocks having stronger effects compared to the vice versa (Singh et al., 2021). There is also asymmetric responses in the fact that negative stocking market shocks are likely to enhance volatility in the rate of exchange more highly as compared to positive shocks (Aloui, 2007). Such economic shocks as the 2008 financial crisis and the COVID-19 epidemic have added to such spillovers, especially in Russia and India (Kumar, 2023; Nyopa & Khumalo, 2022). The significance of the findings made is that exchange rate-equity market connection must be studied in the presence of international macroeconomic shocks.

Transmission of oil market volatility into the equity markets works in several ways, and the impacts on this are widely dissimilar among the oil exporter and the oil importing economies. To the net oil exporters such as Russia, an increase in oil prices is generally used to increase the fiscal revenue and with the corporations to make a profit hence becoming

positively correlated to the stock market index. On the other hand, oil-importing countries like India tend to suffer as a consequence of the pressure of inflation and worsening trade balances (Zhang & Chen, 2021).

Empirical analysis reveals significant contribution of oil market risk in articulating the volatility on BRICS economies stock market. As an example, in these markets, more than 50 percent of the risk in the stock market was due to the price dynamics of crude oil, with Russia being the most sensitive to these dynamics and China being least sensitive (Liu et al., 2019). 2008 was a revolutionising point in the said relationships, and since that year, spillovers are more observed, as is volatility spread by gold as a secondary source (Pandey & Vipul, 2018). Such results indicate that relative dynamics in the energy markets are becoming more and more important in determining the performance of equity markets in the emerging economies.

The bilateral models have attracted a lot of attention whereas there are not many models looking at the triangular dependence of oil prices, stock market and exchange rate. Chen et al. (2022) use a ternary asymmetric VAR-BEKK-DCC-GARCH to examine the existence of these linkages in the BRICS market and hopes to find gold as a volatility conduit in the Chinese and Brazilian market. Their results indicate that the transmission paths are complex, where Russia has a bilateral spill over, and South Africa lacks one.

Exchange rate channels also influence the stock market after having had an indirect effect on it due to oil price shock. This is because the currency movements that are caused by oil impulse may change the level of inflation expectation and the monetary policy reaction leading to secondary effects on equity valuations (Sadorsky, 1999). Such relationships are further complicated by the heterogeneity in the BRICS nations since various volatility transmission mechanisms occur because of the differences in oil dependence, exchange rate regimes, and the structure of the markets (Hussain et al., 2023).

Along with these developments, there still exist some large gaps in the literature. To begin with, majority of researchers concentrate on bilateral relationships leaving out the fact that oil prices, exchange rates, and the stock markets are intertwined in terms of how they relate in commodity-depended economies. Second, the traditional frameworks tend to assume that the correlations are fixed and overlook that the spillover levels increase in times of financial turmoil. Third, the peculiar nature of BRICS countries and their economies, however, is seldom tested and considered as a part of one framework, e.g. the fact that Russia is considered an oil-exporter country and that China maintains a managed exchange rate regime.

In this study, the authors deal with these shortcomings by using DCC-GARCH model to investigate changing volatility spillover of three asset classes in BRICS markets. Inclusion of the recent crises, such as the COVID-19 pandemic and the Russia-Ukraine conflict during the period of analysis adds value as it allows understanding how these pairings change during a stressful period. The results are relevant to both the academic knowledge and practicality of the policymakers and investors who find it difficult to address such complex emerging markets.

1. Data and Research Methodology

The 1/06/2012 to 30/05/2025 period of our empirical analysis includes several cycles of oil prices, the 2014-2016 oil price slump, and the 2020 COVID-19 oil demand shock, the currency crises (including the 2013 taper tantrum, and the 2022 Russia-Ukraine war volatility), and a divergence of monetary policy regimes within BRICS countries. This longer sample range can enable us to explore the history of the changes in volatility transmission mechanisms in inter varying market conditions in a variety of policy surroundings.

The daily spot price of the West Texas Intermediate (WTI) in US dollars is availed by the Energy Information Administration (EIA) and the data concerning the exchange rate is available under the official site of the Bank of International Settlement. Taking the daily data of stock market indices is done using the official websites of Ibovespa (Brazil), Russell 2000 (Russia), Nifty 50 (India), Shanghai Composite Index (China) and the FTSE/JSE (South Africa). The analysis performed in the study involved the use of the return series because the price series might have unit root. Returns are calculated as the natural logarithm of the ratio between the current price and the price from the previous day, expressed as r_{it}= log ($\frac{p_{it}}{p_{i,t-1}}$), where r_{it} is the return of the i^{th} security for t^{th} the day and p_{it} is the price of i^{th} security for the t^{th} day.

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GARCH, Dynamic Conditional correlation (DCC) and ARCH

Launched by Robert Engle in the early 1980s and generalized by Bollerslev in 1986-Introduction Active in the disciplines of econometrics and time series analysis, both the ARCH (Autoregressive Conditional Heteroskedasticity) and GARCH (Generalized Autoregressive Conditional Heteroskedasticity) have become popular in the prediction and forecasting volatility of time series data. It is applied to the model conditional variance of time series that is, it is applied to model variances of the series over a period of time conditional on the observations in the past.

An ARCH model is meant to model the conditional variance of the time series at any given period as dependent upon previous squared residuals (quicks) of the time series itself. It is a volatility autoregressive model. ARCH model postulates that the square of past errors is a linear effect of conditional variance.

Comparatively, GARCH models are more successful in reflecting the serial correlation in volatility, being more flexible then. A GARCH (p, q) model indicates that p lags of the conditional variance are used, as well as q lags of squared residuals in the model. In the application of ARCH /GARCH there are two preconditions, which are ARCH effect and volatility clustering. ARCH effect is a terminology benefiting the condition of time series data whereby the conditional variance of the data series varies with time and further this variation in variance is dependent on past values of the series, especially squared errors or residuals of the series. Volatility clustering Volatility clustering is the phenomenon that demonstrates the ARCH effects in series of data It can be explained by the fact that higher volatility climbing is usually followed by other volatility climbing, and vice versa. This type of ARCH effect is deployed using an autoregressive framework with the probability of variance at time t being conditional on the previous squared errors or residuals. It is normally depicted mathematically as a linear combination of the squared residuals of the past.

The GARCH model can be expressed as below:

$$Y_t = \theta + \gamma X_t + \varepsilon_t$$

$$h_t = \omega + \alpha \ \ \varepsilon_{t-1}^2 + \beta h_{t-1}$$

Where, Parameter's restrictions in the GARCH model are $\omega \geq 0, \alpha \geq 0, a\ \beta \geq 0$ $,(\alpha + \beta) \leq 1$

To investigate volatility spillover, the study employs the Dynamic Conditional Correlation Generalised Autoregressive Conditional Heteroskedasticity (DCC-GARCH) model. This econometric approach is particularly suited for capturing time-varying relationships, offering dynamic insights into how volatility is transmitted between oil price, exchange rates and stock markets across different periods. The DCC-GARCH model accounts for both fluctuating correlations and heteroskedasticity in return series, providing a robust framework for exploring the intricate dependencies between oil price, exchange rates and stock market indices. The model's time-varying nature aligns with the dynamic economic environment under study, as it captures subtle shifts in correlation structures across various periods.

The DCC-GARCH model is operated as follows: to begin, the univariate GARCH models are estimated using each of the financial time series included in the data.The univariate GARCH model is specified as:

$$\sigma_{i,t}^2 = \omega_i + \ \alpha_i \varepsilon_{i,t-1}^2 + \ \beta_i \sigma_{i,t-1}^2$$

Here, $\sigma_{i,t}^2$ is the conditional variance of series at i at time , ω_i, α_i and β_i are GARCH parameters, $\varepsilon_{i,t-1}^2$ is the squared residual at time $t-1$. These univariate GARCH models capture the volatility dynamics of each time series independently.

The dynamic conditional correlation matrix *Qt* is introduced to model the time-varying relationships between the residuals of different time series. The DCC model is expressed as:

$Rt = D_t Q_t D_t$

Rt is a diagonal matrix containing the conditional variances. *Qt* is the dynamic conditional correlation matrix. *Dt* is a diagonal matrix with elements $(\sigma_{i,t}, \sigma_{j,t})^{-1}$. The dynamic conditional correlation between series $i\ and\ j$ is given by:

$$\rho_{i,j,t} = \frac{Q_{i,j,t}}{\sqrt{Q_{i,i,t} Q_{j,j,t}}}$$

Here, $\rho_{i,j,t}$ is the dynamic conditional correlation between series $i\ and\ j$. *Qi,j,t* is the i,jth element of the *Qt* matrix. The parameters of the DCC-GARCH model include the GARCH parameters (ω_i, α_i, β_i) for each univariate GARCH model

and the parameters governing the dynamics of the conditional correlation matrix. . The DCC-GARCH model gives time varying conditional correlations and so it tells us how the associations between the financial time series vary at different times. It can be especially helpful to know how shock or external events affect the connectedness in markets.

The DCC-EGARCH model would be applicable in the examination of the volatility spillover, in the present study, since it is able to capture the dynamic and asymmetric patterns between exchange rates and stock markets (Oberholzer & Venter, 2015) (Sayed & Auret, 2019). In addition, the ability of the model to absorb structural breaks and regime shifts is also essential to the prevailing macroeconomic environment, which has been marred with high levels of geopolitical and economic turmoil (Jebari & Hakmaoui, 2020).

With the use of this methodological analysis, the project seeks to make subtle contributions to the performance of oil price, exchange rates and stock market interaction in BRICS countries, especially in times when the world might be experiencing events of great impacts. The integration of daily data with the complex DCC-GARCH model forms a robust approach to investigating the dynamics of volatility spillover in this distinct geopolitical context.

4. Empirical results

The dynamic conditional correlation (DCC) is used and its results to explore volatility spillover between oil market to stock market association and exchange rate to stock market are illustrated in table 9. First, the spillover of oil to stock market is introduced and then it is proceeded by the spillover of exchange rate to stock market. In terms of the table, the symbol of μ gives the general mean whereas a1 and a2 represent the arch terms of different markets respectively.

The individual presentations of the garch terms are beta 1 and B2. The arch shows that there is or is not influence on present squared residual by lagged squared residual whereas garch shows existence of volatility persistence. Additionally, there is spillover on the DCCa1 and DCCb1 which delve in the short and long run respectively, market to another market.

Based on spillover between oil market to stock market in Brazil, there is a spotting of positive means in both oil market and stock market as their 0.00069 and 0.86653 are both positive. The arch of oil market (a1) is insignificant and arch of stock market (a2) is significant. The implication is that new information is not reflected in oil market but it is reflected in the stock market. Moreover, both markets garch terms (B1 and B2) are thus positive and significant suggesting that volatility persistence exists in the oil and the stock markets. Regarding the summation of a1 and B1, they notice that the sum of oil market is 0.1151 whereas that of stock market is 0.0060. It is worth it to note that shock of stock market decays rapidly can be argued on the basis that its summation is lower. Second, the coefficient of DCCa1 and DCCb1 is significant that refers that there is spillover of oil market with stock market in both the short and the long run. It implies that the investors and portfolio managers in Brazilian stock market who consider the possibility of investing in oil market as well does not have the opportunity of diversifying the investment. The crude oil spills its effect on Brazilian market both in short and long run; to be precise.

Then, the spill over of the oil market with Russia stock market is recorded. As in Brazil, oil and Russian stock market are observed with positive mean gain. The alpha 1 of oil market is insignificant and the beta 1 is significant which indicates that oil market does not explain any new information and oil market has volatility persistence. Equally, the Russian stock market is identified with trivial arch term and large garch term. It refers to that fact that any new information within examining period is not recorded by Brazilian stock market yet volatility persistence does exist. As regards spillover of oil market to Russian market, we observe that no spillover does exist between oil market and Russian market in short run but as far as the long run is concerned we can say that it exists because the DCCa1 is insignificant whereas the DCCb1 is significant. It implies that any investor who would want to diversify his portfolio, it is possible to invest in both these two markets in the short run.

Going back to oil and Indian stock market, both markets deliver positive mean returns. Moreover, a curious finding in view of arch and garch effect of the oil market is noticed because both of them are significant. It implies that oil market absorbs newly available information and as well as persistence. On the basis of the arch and garch terms of Indian market, arch is found significant but garch is not. It implies the fact that Indian market can absorb new information and its effect, and there is no persistence of volatility. Also, DCCa1 is not significant and DCCb1 is significant and this guarantees that volatility spill over only in the long run not in short run. It is therefore possible to diversify the portfolio in order to reduce the risk presented by these two markets.

Moreover, the spill over of Chinese stock market to oil market is provided. The oil market natural scoops up their new tidings and the volatility persistence is seen because the oil market has the great arch and garch terms and when added together their values are less than one. Remarkably, Chinese market is observed to have insignificant arch as well as garch terms hence, they imply that there is no information capturing, and no volatility persistence in Chinese market. Going to the spillover, spillover is also observed to be experienced, but only in long run and not in short run as is experienced in other markets. Thus investors who are considering investing to reduce the risk might invest their hard earned money in China also. In relation to oil market and South African market, it is observed that arch and garch terms of oil market are significant that indicate that new information is picked by oil market and it is identified with volatility persistence. The arch term of South African market, on the other hand, is only meaningful representing that there is no volatililty persistence because the market is just capturing new information. Talking about spillover, the spillover does not exist in the short as well as the long run as the terms, DCCa1 and DCCb1 is not significant. Speaking to be more exact, one should say that there is a portfolio possibility to diversify in oil and South African market.

Diversification has been regarded as a rallying cry by every stakeholder in the whole world of investment such as the fund manager, financial planner and the investor. Meanwhile, the task of mixing another investment within a diversified portfolio is one of the challenging ones. Dynamic correlation/spillover of one market with another is investigated to create an investing strategy that dampens the possible losses in a volatile market. In this regard, the portfolio managers, investors, policy analysts and financial planners can look into the connectedness. Concerning the spillover of oil market to BRICS equity markets, it is recorded that there is none of the oil market spill over to equity market of Russia, India, China and south Africa but there is only spillover of oil market to Brazilian market. There is also long run spillover in every market besides South African stock market. Summarily, the average opportunity level is of diversification in short run as compared to long run below average in BRICS. The reason why there is spillover in the long run is mainly because the majority of the markets under examination do not absorb information in the short run that has been evident in their arch terms as a result of which they respond in the long run. It concludes that any occurrence that happens responds in the longer run. Therefore, the spillover is long term.

Table 9: Results of DCC GARCH model

		Oil to stock market		Exchange rate to stock market	
		Estimate	t value	Estimate	t value
Brazil	μ	0.000695	1.5474	0.000284	1.36534
	α_1	0.000017	2.2265	0.000002	0.75149
	β_1	0.115162	5.4154*	0.072261	2.33082
	μ	0.86653	53.2497*	0.910285	24.29383*
	α_2	0.000558	1.7894*	0.000558	1.79165
	β_2	0. 0.0055	11.0963*	0.000015	11.09699*
	$DCCa_1$	0.0080116	2.7067*	0.01309	1.30327
	$DCCb_1$	0.98653	236.9372*	**0.974716***	28.00796*
Russia		Estimate	t value	Estimate	t value
	μ	0.000695	1.5461	0.000029	0.16912
	α_1	0.000017	2.2449	0.000002	1.13202

	β_1	0.115162	5.4555*	0.124679	3.80196*
	μ	0.86653	53.3304*	0.871434	31.55373*
	α_2	0.000502	1.8635	0.000502	1.8629
	β_2	0.859523	23.969382*	0.844351	18.78781*
	$DCCa_1$	0.008775	1.7864	**0.011575***	3.86111*
	$DCCb_1$	**0.98393***	84.3557*	**0.976706***	178.25151*
India		Estimate	t value	Estimate	t value
	μ	0.000695	1.5483	0.000136	1.6676
	α_1	0.000017	2.2545*	0.000001	1.2019
	β_1	0.115162	5.4567*	0.076488	3.7225*
	μ	0.86653	53.5108*	0.891007	41.6923*
	α_2	0.000851	3.9229*	0.000851	3.9215*
	β_2	0.000003	1.9135	0.000003	1.9162
	$DCCa_1$	0.006977	2.0144	**0.00973***	3.2823*
	$DCCb_1$	**0.985866***	113.8406*	**0.98721***	134.5422*
China		Estimate	t value	Estimate	t value
	μ	0.000695	1.54816	-0.000275	-301.140135*
	α_1	0.000017	2.253247*	0	0.052
	β_1	0.115162	5.430272*	0.070881	307.800623*
	μ	0.86653	53.550413*	0.917554	9105.857752*
	α_2	0.000248	0.40028	0.000248	0.40025
	β_2	0.000001	0.05845	0.000001	0.05844
	$DCCa_1$	0.003158	0.87049	0.024575	0.00187
	$DCCb_1$	**0.981047***	80.483156*	0.639389	14.355890*
South Africa		Estimate	t value	Estimate	t value
	μ	0.000695	1.5471	0.000371	1.6626

	α_1	0.000017	2.26479*	0.000001	4.5335*
	β_1	0.115162	5.49076*	0.02763	8.8346*
	μ	0.86653	53.57078*	0.959339	392.6281*
	α_2	0.000602	2.64198*	0.000602	2.6418*
	β_2	0.000005	1.89653	0.000005	1.9131
	$DCCa_1$	0.069084	0.65365	0.028552	1.5887
	$DCCb_1$	0.132197	1.75383	**0.743554***	4.8747*

Source: Author

Regarding the spill-over of the exchange rate to the stock markets, in the first place, spillover of the exchange rate to the Brazilian market is depicted. As it is observed, the arch (a1) of exchange rate and arch of Brazilian stock market (a2) are not important. It concludes that it does not cover new information in both series. Additionally, garch parameters (B1 and B2) of both markets are of positive nature however, only Brazilian market is significant, which implies that the volatility persistence exists in the case of the Brazilian market. Both of the series have less than 1 summation of arch and garch terms, which is arguably because the shock decays, over the passage of time. Going to the coefficient of DCCa1 and DCCb1, the DCCa1 is non significant and DCCb1 is significant. It has implied that the investors and portfolio managers in Brazilian stock market who would like to venture in the forex market (exchange rate) in the long run cannot diversify. Nevertheless, it is possible to diversify at the short run by investing their assets in these markets.

Moreover, the spill over between exchange rate and Russian stock market is registered. Similar to Brazil, there is seen a positive mean in oil and Russian stock market. Alpha 1 and alpha 2 are not important to exchange rate and Russian stock market but beta 1 and beta 2 are important. It shows that there is no new information in the exchange rate and the Russian markets as there is volatility persistence as their beta is not zero. With reference to the spillover, it is observed that DCCa1 and DCCb1 are substantial which implies that spillover exists between exchange rate and Russian market both in the short and the long run. It means that the investor who is willing to diversify his or her portfolio is unable to divide his money between the exchange rate and the Russian stock market. Then the exchange rate and Indian stock market dynamics is reported. With Indian stock market, exchange rate is known to be realizing positive average return. In further record it has been drawn up that the arch of exchange rate is not significant whereas the garch is significant and just the vice versa yardstick has been observed in case of Indian stock market as well because it has a significant beta not arch. It indicates that exchange rate fails to reflect the influence of new information in its presence since there is persistence in volatility. However, the volatility does not exist in India market, as it can only capture new information and its effect. Regarding spillover of exchange rate to Indian stock market, it is obtained that the DCCa1 and DCCb1 turn out to be significant and it is ensured that volatility spillover occurs in both the long run and in the short run. It fails to provide diversification opportunity to the portfolio managers and the investors as there is even spill-over.

More, the relationship between the exchange rate and Chinese market is summarized. Based on Table, it can be identified that alpha 1 gives the value of 0.52 and was not significant indicating that the exchange rate failed to capture any new information. Nevertheless, it is marred with volatility persistence because it posses substantial terms of garch 1. In the case of the Chinese market, both the arch and garch lack significance and this is an indication that does not seem to capture the new information in the market and there is no volatility persistence. Going onto the spillover, the spillover is found to be present in long run and not short run because DCCa1 is not significant. On this note, China can assume that investors who were thinking of alleviating the risk will park their earned money in China within the short run. Lastly, the South African market phenomena are provided with connectedness of exchange rate. It is noted that the arches of both exchange rate and the South African market are serious. On this understanding, it could be stated that, the markets capture the information. Nonetheless, they lack volatility persistence as they are marked in insignificant garch. When it comes to the spill over, there will be no exchange rate spill to the South African market because it has insignificant DCCa1 in the short run. But,

it experiences bit high p-value implying that there is a spill-over in the long run. It is on this basis that portfolio diversification opportunity is said to be available in the short run only.

According to the spillover of exchange rate to BRICS stocks, it is identified that the spillover exits, in the case of Russian market and Indian market in the long run. It is notable that in the short run only Chinese market does not have spillover in its stock market. In this case to be precise some of the stock markets that investors and portfolio managers who plan to reduce the risk in their portfolio should not overlook are Brazil, China and South Africa in the long term. Moreover, there is Chinese market the only one which provides diversification opportunity in the short-run. The main causes of both short and long run relatedness of exchange rate to the Russian and Indian stock markets is because the US is the global economic power house, and these two economies trade in their exports and imports using the US currency. Moreover, BRICS is a favorite place where global investors strongly consider an investment in the place as a way of reducing their portfolio risk. The obtained findings do not coincide with Singh at el., (2021) and Naresh et al., (2018).

Table 10: Summary of DCC results for support and against support

S. No.	**Hypotheses**	**Countries**	**Oil to stock market**		**Results**	
			Short run	Long run	Short run	Long run
H07	There exists no significant volatility spillover between oil price and the stock indices	Brazil	Yes	Yes	**Not Supported**	**Not Supported**
		Russia	No	Yes	Supported	**Not Supported**
		India	No	Yes	Supported	**Not Supported**
		China	No	Yes	Supported	**Not Supported**
		South Africa	No	No	Supported	**Supported**
S. No.	**Hypotheses**	**Countries**	**Exchange rate to stock market**		**Results**	
			Short run	**Long run**	**Short run**	**Long run**
H08	There exists no significant volatility spillover between exchange rates and the stock indices	Brazil	No	Yes	Supported	**Not Supported**
		Russia	Yes	Yes	**Not Supported**	**Not Supported**
		India	Yes	Yes	**Not Supported**	**Not Supported**
		China	No	No	Supported	**Supported**
		South Africa	No	Yes	Supported	**Not Supported**

Source: Author

5. Finding and Conclusion

The paper has conducted a systematic study of volatility spillovers between oil markets, exchange rates, and stock markets in BRICS economies based upon a DCC-GARCH model. The empirical findings indicate that there are complex interacting dependencies which differ widely with reference to countries as well as time horizons, and they can be very useful both to financial market participants as well as to financial academicians.

The analysis proves that volatility transmission occurs in accordance with particular patterns across BRICS countries. The Brazilian economy is heavily related to commodity dependence, which is the reason why it reflects oil-to-stock market spillover. Russia, India and China are profound extended-term spill overs of oil markets to their equity market, whereas South Africa is a major spillover that has minimal effect, and this country has potential in terms of diversification. When analyzing changes that occur in exchange rates, conditioning is most vivid in both that Russia and India experience a two-way volatility transmittion to the stock market, and that the controlled exchange rate system of China seems to have dampened these developments.

The findings contribute significantly to the body of knowledge in some ways. First, they justify the need to investigate triangular interrelations in the commodity, currency and equity markets, instead of them being investigated individually. Second, the findings indicate a very high importance of calibrating time-varying correlations especially in times of market turmoil. Third, the amount of spillover effect across BRICS countries was shown to be significantly heterogeneous, which disproved the commonly accepted idea of uniform market behaviour in emerging economies.

These findings can be used by the market players as practical insights. South African equities and Chinese markets are of interest to investors who need diversification opportunities in the short term. The asymmetric spillover patterns are to be presented in the risk models of portfolio managers, paying particular attention to the exposures to the long-term oil prices in Brazil and Russia. The dynamism in these relations also implies that trading strategies with dynamic hedging could work better in comparison to those whose strategies are affirmed as static and of best effect after important economic occasions.

Although this study enhances knowledge on BRICS financial markets, it has also outlined various areas where studies should be done in the future. It might be insightful to further extend the analysis to cover other commodity markets in addition to oil so that a better picture of resource-based transmission of volatility can be obtained. The inclusion of the macroeconomic fundamentals could assist in the explanation of the cross-country differing intensity of spillover. Moreover, additional information about intraday volatility behaviour might be acquired using high-frequency data analysis.

To sum up, the given study is strong evidence of the dynamic, and intricate interactions among central financial markets of BRICS economies. The results indicate the increasing integration of these new markets as well as the structural variations that have continued to exist. The outcomes reiterate to policy makers that there should be country-specific financial stability frameworks involving subtlety. To investors, they provide good direction on how to undertake such dynamic markets. Given that BRICS countries are continually growing in terms of its global economic prominence, these cross-market connections are going to become ever more useful in making accurate choices in both the state policy and the corporate investment realms.