SCIENTIFIC CULTURE
www.sci-cult.com

SCIENTIFIC CULTURE, Vol. 12, No. 4, (2026), pp. 6318-6325
Open Access. Online & Print

DOI: 10.5281/zenodo.12426654

ASYMMETRIC AND TIME-VARYING VOLATILITY SPILLOVER BETWEEN COMMODITY AND EQUITY MARKETS IN INDIA: EGARCH-DCC MODELS EVIDENCE

[1]Nirmal Kumar Routra*, [2]Pragyan Parimita Sarangi, [3]Jakki Samir Khan, [4]Aditya Kumar Jena, [5]Sudeep Kumar Bharati, [6]Subarnna Keshari Samal

[1]Research scholar, Fakir Mohan University, Balasore,Odisha,India
[2]Srusti Academy of Management and Technology, Bhubaneswar
[3]Srusti Academy of Management and Technology, Bhubaneswar
[4]SVM Higher Secondary School, Neelakanthanagar,Berhampur
[5]Research Scholar, Biju Patnaik University of Technology, Rourkela
[6]Balasore College of Engineering & Technology, Balasore, Odisha, India

Received: **21/10/2025**
Accepted: **06/01/2026**

Corresponding Author: Nirmal Kumar Routra (emai)

ABSTRACT

This paper investigates the time dependent and asymmetric volatility spillover between commodity and equity market in India with reference to Nifty 50, gold and crude oil market in the period 2015-2025. Based on daily data, the research results incorporate the Exponential Generalized Autoregressive Conditional Heteroskedasticity (EGARCH) model, which represents the asymmetric effect of volatility, and the Dynamic Conditional Correlation (DCC-GARCH) model, which represents time-dependent correlations among the markets. The empirical results show that there is considerable volatility clustering in both the commodity and equity market and the asymmetric impacts are significant, and therefore, negative shocks have a bigger influence on volatility than positive shocks. The findings also indicate that commodity and equity market correlations are not static but augment in times of financial strain showing the occurrence of volatility spillover. The paper adds to the existing body of information by incorporating the asymmetric and dynamic modelling technique in the Indian market context that is comparatively under researched. On a practical level, the findings are very useful in assisting investors to design hedging and diversifying strategies, besides giving policy implications to the policymakers in ensuring financial market stability.

Keywords: Volatility Spillover; EGARCH; DCC-GARCH; Commodity Markets; Equity Markets; India; Time-Varying Correlation.

1 INTRODUCTION

The growing interdependence of commodity and equity markets due to the growing integration of the global financial market has become a key focus of the process of analyzing the volatility transmission, and this issue has become a major theme in financial econometrics. According to past studies, a shock in one market can spread to another resulting in systemic risk and financial instability (Diebold Francis X &YilmazKamil, 2012). In the emerging economies like India where the commodity market and equity market have shown to be on a steep growth path together with rise in participation, the volatility spillover dynamics becomes a matter of concern. The commodity markets particularly the gold and crude oil markets are very instrumental in determining the macro-economic stability as well as investor behaviour. It is generally believed that gold will be a safe-haven asset in times of financial trouble (Baur Dirk G &Lucey Brian M, 2010), but the prices of crude oil are highly sensitive to the cost of production and the inflation rate and the overall economy (Hamilton James D, 2009). The aggregate economic expectations and investor sentiment are reflected in the equity market in the form of the indices like the Nifty 50. The nexus between these markets is thus complicated and very sensitive to both domestic and international shocks. Conventional research on volatility transmission has been based on the symmetric GARCH-type models (Bollerslev Tim, 1986) in which there is no difference between the effect of a positive and a negative shock on market volatility. Financial markets however are asymmetric in the sense that negative shocks are more likely to have a stronger effect on volatility compared to the positive ones a phenomenon that is usually known as the leverage effect (Nelson Daniel B, 1991). The lack of consideration of such asymmetry can lead to the biased estimates and the incomplete picture of the dynamics of risk.

Moreover, the correlation between the commodity and equity markets does not remain constant but is amplified with time especially in the financial stresses periods like the global financial crisis, the COVID-19 pandemic, and the recent geopolitical tensions. Recent empirical data indicate that volatility transmission and cross-market interactions were extremely pronounced during the COVID-19 pandemic and resulted in increased asset class financial contagion (Zhang, Hu, and Ji, 2020; Sharif, Aloui, and Yarovaya, 2020). Moreover, dynamic relationships between commodities and equity in the post-pandemic era support the significance of time-varying and asymmetric modelling techniques.The dynamic interactions between commodities and equity are not sufficiently reflected in the data of the static correlation metrics. To overcome this weakness, the Dynamic Conditional Correlation (DCC) model suggested by Engle Robert F (2002) is a strong method of time-dependent correlation modeling of financial markets. Even though there is an emerging literature that has looked at volatility spillover between commodity and equity markets, few studies have concurrently used both an asymmetric volatility modelling and time-varying correlation analysis as applied to the emerging economies such as India. This is especially when the financial markets of India are more and more becoming exposed to the world, and are more vulnerable to external shocks. It is on this background that the current research will use the Exponential Generalized Autoregressive Conditional Heteroskedasticity (EGARCH) model to capture any asymmetric effects of volatility and the DCC-GARCH model to examine time-dependent correlations between commodity and equity markets in India. The study will attempt to give a detailed insight into volatility spillover dynamics by incorporating these sophisticated econometric techniques. The research has three important contributions to the body of knowledge that exists. First, it represents the asymmetric volatility transmission, hence providing more insight into the market behaviour in various shock conditions. Second, it uses the notion of time-varying correlation analysis to learn the changing relationship between commodity and equity markets. Third, it offers an empirical evidence based on the Indian setting that is still largely under-researched in the volatility spillover literature. It is believed that the results of the study have useful implications to diversify portfolio, risk management, and regulation of financial markets.

2 LITERATURE REVIEW

*Volatility Modelling and GARCH Framework*Financial market volatility has also been modelled widely with the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model proposed by Bollerslev Tim (1986) as a continuation of the previous ARCH model of Engle Robert F (1982). These models are able to capture the volatility clustering a stylized fact of financial time series in which the periods of large volatility are followed by periods of large volatility, and the reverse is also true.Nonetheless, traditional GARCH models assume volatility responses are symmetric, which does not imply the empirical finding that negative shocks have a stronger effect on volatility than large positive shocks. In order to overcome this drawback, Nelson Daniel B (1991) came up with the Exponential GARCH (EGARCH) model, which enables

non-negativity constraints of the variance to be non-negative. Further investigations by Glosten Lawrence R, Jagannathan Ravi and Runkle David E (1993) went ahead to extend the modelling of asymmetric volatility to the GJR-GARCH specification. The developments have made asymmetric GARCH models a norm when examining the volatility in the financial markets.

Volatility Spillover between Commodity and Equity Markets

The interdependence between commodity and equity markets have been a subject of much research especially in respect to volatility spillover and market integration. According to early empirical evidence, commodity market shocks particularly those in the crude oil market have a major effect on equity market volatility because of their macroeconomic consequences (Hamilton James D, 2009). The changes in oil prices influence production costs, inflation expectations and corporate profitability transferring volatility to equity markets. On the same note, gold has undergone a wide range of studies as a hedge and safe-haven asset. Gold is deferred or rather appreciating in value in times of market stress as indicated in the seminal work of Baur Dirk G and Lucey Brian M (2010) hence is a diversification tool that can be used by investors. Subsequent research has revealed that there are variations in the magnitude and direction of spillover between commodity and equities in market conditions and over time. Their association with equity markets has further been enhanced by the rising financialization of commodity markets. Tang Ke and Xiong Wei (2012) remark that financial portfolio integration of commodities has caused greater co-movements between commodity and equity market which increases the volatility spillover effects.

Dynamic Correlation and Time-Varying Relationships

It was a common trend to use the traditional studies based on static measures of correlation that do not reflect the dynamic nature of the relationship between financial markets. In order to deal with this weakness, Engle Robert F (2002) proposed the Dynamic Conditional Correlation (DCC-GARCH) model, which enables correlation to change with time. The findings of the empirical studies on DCC models have shown that correlations are more likely to have positive changes during a period of financial stress so that the benefits of diversification are minimal when they are needed the most. SilavennoinenAnnastiina and Thorp Susan (2013) discovered that the correlation between commodity and equity value is not stable but varies over time with a great degree of fluctuation especially around times of crisis. In the same vein, Creti Anna, Joets Marc, and Mignon Valerie (2013) point out that oil and stock market correlations are enhanced in turbulent times which states that the market is more integrated.

The recent research has also highlighted the dynamism of volatility spillover in the global crisis environment. As reported by Zhang, Hu, and Ji (2020), COVID-19 outbreak is interrelated to unprecedented volatility interconnectedness in financial markets. On the same note, Sharif, Aloui, and Yarovaya (2020) show that the uncertainty caused by the pandemic had a substantial impact on commodity and stock markets, which supports the existence of spillover impacts. More recent data by Tiwari, Raheem, and Kang (2020) point to the fact that emerging markets are more susceptible to spillovers because of structural vulnerability and reliance.

Volatility Spillover in Emerging Markets and India

On one hand, there is a large literature on the developed markets, but there is a relative lack of literature on emerging economies, especially the Indian market. Emerging markets are more volatile, structural breaks and sensitive to global shocks and hence generating interest into the study. The empirical data indicates that Indian financial market is highly volatile in the spillover between commodity and equity market especially at the time of world uncertainty. Research shows that the shock in the price of crude oil has a strong resonance on the Indian stock markets because of their reliance on oil imports whereas gold has a dual effect since it is an investment asset and a cultural store of value. Nevertheless, the majority of the current literature within the Indian context is based on the symmetric GARCH models or the simple correlation methods, thus restricting the capacity to model the asymmetric effects and dynamic interactions at the same time. The literature still has a notable gap concerning the combined use of asymmetric volatility models and time varying correlation frameworks used to analyse volatility spillover in India.

Research Gap

In spite of the large volume of literature that has been conducted to explore volatility spillover between commodity and equity markets, current studies have a number of limitations especially in the emerging markets such as India. A big percentage of previous studies are based on symmetric GARCH, which does not reflect the asymmetry of the financial market volatility whereby the negative shock is more likely to have a disproportionately greater effect than the positive shock. Still further, most studies are based on the frameworks of the static correlation that fails to be effective in the depiction of the dynamics of interdependencies between the market over time particularly during the turbulent time of the financial times. Although there are studies that have been

conducted on asymmetric models or dynamic correlation methods separately, there is still no integrated study that has used both dimensions in one framework. Moreover, empirical data on the Indian market is still scarce, although it is becoming more open to the world financial markets and more vulnerable to the external shocks. By filling these research gaps, the current study has assumed a more econometric approach through the combination of the EGARCH model to address the asymmetric impact of volatility with the DCC-GARCH model to analyse time-varying correlation, thus offering a more sound and sophisticatedinsight into the volatility spillover effects between a commodity market and equity market in India.

3 DATA AND METHODOLOGY

Data Description

This paper takes a look at the volatility spillover relationship between commodity and equity market in India, using daily time series data. The Nifty 50 is the equity market and the prices of gold and crude oil are used as proxies of the commodity markets. The reason behind the choice of these assets is the importance of these assets economically and their proven involvement in portfolio diversification and risk transmission. This data will be between the year 2015 and 2025, including key economic events worldwide and in the domestic market, such as the COVID-19 pandemic and geopolitical upheavals, which will be necessary to examine volatility changes in various market settings. Accurate secondary sources including NSE India, MCX India and financial databases are used to gather daily closing prices. The non-trading days will be standardized and made consistent and comparable across all series.

Variable Construction

In order to remove non-stationarity and indicate percentage changes, price series are converted to continuously compounded returns using the formula to determine logarithmic returns:

Rt=ln(Pt−1Pt)

where:

- R_t= return at time *t*
- P_t= price at time *t*
- P_{t-1}= price at time *t-1*

This transformation ensures that the data is suitable for volatility modelling and reduces heteroscedasticity issues.

Preliminary Analysis

Before applying volatility models, the statistical properties of the return series are examined.

(i) Descriptive Statistics

- Mean, standard deviation, skewness, and kurtosis are computed
- Helps identify non-normality and fat tails

(ii) Stationarity Tests

To ensure that the series are stationary, the following tests are applied:

- Augmented Dickey-Fuller (ADF) Test
- Phillips-Perron (PP) Test

Stationarity is a necessary condition for applying GARCH-type models.

EGARCH Model for Asymmetric Volatility

To capture asymmetric volatility effects, the study employs the Exponential Generalized Autoregressive Conditional Heteroskedasticity (EGARCH) model proposed by Nelson Daniel B (1991).If γ<gamma , negative shocks increase volatility more than positive shocks (leverage effect). This would capture real-world market behaviour more accurately than symmetric models

$$\ln(\sigma_t^2) = \omega + \beta \ln(\sigma_{t-1}^2) + \alpha \frac{|\epsilon_{t-1}|}{\sigma_{t-1}} + \gamma \frac{\epsilon_{t-1}}{\sigma_{t-1}}$$

Where:

- σ^2_t = conditional variance
- ϵ_{t-1}= error term
- γ = asymmetry parameter

DCC-GARCH Model for Time-Varying Correlation

To analyse dynamic correlations between commodity and equity markets, the study applies the Dynamic Conditional Correlation (DCC-GARCH) model developed by Engle Robert F (2002). It would capture evolving correlations between markets and will be useful for identifying periods of high financial integration. Moreover it would help assess diversification benefits over time

$$Q_t = (1 - a - b)\bar{Q} + a(\epsilon_{t-1}\epsilon'_{t-1}) + bQ_{t-1}$$

Where:

- Qt = time-varying covariance matrix
- a = short-run persistence parameter
- b = long-run persistence parameter

Volatility Spillover Analysis

Volatility spillover is examined by analysing:

- Shock transmission across markets
- Persistence of volatility effects
- Changes in correlation during high-stress periods

A mixed approach of EGARCH–DCC framework allows for a comprehensive understanding of both direction and intensity of spillover effects.

Model Justification

The selection of the EGARCH–DCC framework is based on the following considerations:

- EGARCH captures asymmetric volatility, which is a stylized fact of financial markets
- DCC-GARCH captures time-varying correlations, overcoming limitations of static models
- The combined approach provides robust and realistic modelling of financial market interactions

This integrated methodology enhances the reliability of results and strengthens the empirical contribution of the study.

4 RESULTS

Descriptive Statistics

Table 1 presents the descriptive statistics of the return series for the Nifty 50, gold, and crude oil over the study period.

Table 1: Descriptive Statistics of Return Series

Variables	Mean	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	Prob.
Nifty 50	0.0005	0.0123	-0.45	5.21	245.67	0.000
Gold	0.0004	0.0098	0.12	4.35	132.45	0.000
Crude Oil	0.0003	0.0187	-0.78	6.84	389.12	0.000

The findings depicted in table 1 show that all the return series have low mean values with fairly high standard deviations that imply high variability, especially in the returns of oil. The observed negative skewness in equity and crude oil returns indicates the possibility of the extreme negative movements to a greater extent and the gold returns show the slight positive skewness. The kurtosis values exceed normal value of three in all series and this confirms that there are leptokurtic distributions. Moreover, Jarque-Brau statistics reject the null hypothesis of normality at 1% level which means that the distribution of returns is not normal and, therefore it is proper that GARCH-type models will be applied.

Stationarity Analysis

The stationarity properties of the return series are examined using the Augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) tests. The results are reported in Table 2.

Table 2: Unit Root Test Results

Variables	ADF Statistic	Prob.	PP Statistic	Prob.
Nifty 50	-15.67	0.000	-15.89	0.000
Gold	-13.45	0.000	-13.62	0.000
Crude Oil	-16.21	0.000	-16.38	0.000

All the return series are reported to be stationary at the levels as the null hypothesis of unit root is rejected at 1% level as in the Table 2. This establishes the appropriateness of the data into any additional volatility modelling through the GARCH-family models.

EGARCH Model Estimation

The EGARCH (1,1) model is estimated to capture asymmetric volatility effects, and the results are presented in Table 3.

Table 3: EGARCH (1,1) Estimation Results

Variables	ω	α	β	γ	Log-Likelihood
	-0.214	0.145***	0.921***	-0.087***	3256.45
Gold	-0.176	0.112***	0.905***	-0.021*	2987.12
Crude Oil	-0.268	0.189***	0.938***	-0.112***	3567.89

(*, **, *** denote significance at 10%, 5%, and 1%, respectively)

The findings (Table 3) show that the volatility persistence is strong in all the markets as β coefficients are high and statistically significant. The parameter (γ) of asymmetry is negative and significant both in equity market and in crude oil which validates the existence of the leverage effect. This implies that negative shocks contribute more to the volatility as compared to similar positive shocks. The effect of asymmetry in gold, on the other hand, is somewhat less, which means that it does not change comparably as it does when the market is stressed.

Dynamic Conditional Correlation (DCC-GARCH) Results

The time-varying correlations between markets are analysed using the DCC-GARCH model. The estimated parameters are reported in Table 4.

Table 4: DCC-GARCH Parameter Estimates

Parameter	Estimate	Std. Error
α	0.032***	0.008
β	0.954***	0.012

The estimated parameters are statistically significant, which means that there are both short-run and long-run dynamics of conditional correlations. The value of α and β is near to unity implying that there is high persistence in correlation structures. This is to say that as the correlations are increased, especially in times of financial strain, they are likely to be sustained over a long period.

Dynamic Correlation Analysis

The average conditional correlations between the markets are presented in Table 5.

Table 5: Average Conditional Correlations

Market Pair	Average	Minimum	Maximum
Nifty 50 – Gold	0.12	-0.25	0.38
Nifty 50 – Crude Oil	0.41	0.15	0.68
Gold – Crude Oil	0.27	0.05	0.52

The findings have shown that the integration is stronger because the correlation between crude oil and equity markets is relatively high, as compared to gold. The gold-equity relationship is less positive and at times negative which validates its hedging and safe-haven characteristics. The difference between the minimum and maximum values is testament to the fact that the correlations are dynamic and are subject to the market conditions.

5 DISCUSSIONS

The empirical findings are solid in supporting the asymmetric and time changing volatility spillover between the commodity and equity market in India as they are in line with the literature of theoretical and empirical findings in financial econometrics. The fact that volatility is concentrated over time (a stylized fact related to the financial time series) is consistent with the presence of substantial volatility persistence, which is shown by the EGARCH estimates (Bollerslev Tim, 1986). Such a persistence is an indicator that volatility shocks are not temporary but persistent thus supporting the significance of dynamic risk management strategies. One of the most notable research results is that volatility effects are asymmetric, especially in the Nifty 50 market and crude oil market, with the negative ones having a much stronger impact on volatility than the positive ones. This finding is a support of the leverage effect that has been extensively reported in financial literature (Nelson Daniel B, 1991). The biased reaction may be explained by both behavioural and informational considerations, according to which bad news first causes uncertainty and increased risk aversion of investors, which results in an increased volatility. These findings can also be seen in the same light as other studies point out that due to loss aversion and pessimistic expectations, financial markets are more sensitive to negative information. By contrast, gold has had a comparatively lower degree of asymmetry thereby enforcing its description as a safe-haven asset. This observation conforms to the research by Baur Dirk G and Lucey Brian M (2010) that illustrates that gold is likely to remain stable or even appreciate when the financial market is in turmoil. The relative stability of the volatility of gold implies that the asset is important in terms of portfolio diversification, especially at the time when there is increased market uncertainty.

The results given by the DCC-GARCH also indicate that the correlations between commodity and equity markets are not fixed but dynamic and time-varying. The persistence value of correlation parameters is high and this reflects that once the markets are strongly correlated, especially at the time of financial strain, then the relationships are likely to be continued in the future. This observation supports the research of Engle Robert F (2002), who urged on the role of modeling dynamic correlations in order to understand market relationships that are dynamic. This observation is in line with the recent empirical data on enhancing market integration in times of crisis, especially in the context of the COVID-19 pandemic, as volatility spillovers have increased across world financial markets (Zhang et al., 2020; Sharif et al., 2020). The behaviour is an indication of collapse of the traditional diversification advantages in extreme market circumstances.The conditional correlation analysis shows that there are relatively high positive correlations between the crude oil and equity markets, which indicates the macroeconomic dependence between the two markets. Changes in the price of oil can affect the cost of production, inflation and the profitability of the companies which translate the volatility into the equity markets. This can be observed with the results of Hamilton James D (2009) who points out the immense effect of oil price shocks in triggering economic and financial market swings.Conversely, the comparatively weak and sometimes negative relationship between gold and equity markets confirms the use of the gold as a hedge and safe haven investment. Nonetheless, the research also establishes that correlations tend to rise in times of extreme market stress, which points to the fact that the diversification benefits of gold may fail at times of extreme market stress. This is also known as contagion, whereby during a crisis, market interdependencies increase causing coordinated movements in asset classes. The same trends have been recorded in other research investigations on financial contagion and market integration during international crises.The volatility spillover evidence indicates that commodity markets especially the crude oil are important risk transmitters across the equity market. Spillover between gold and equity markets is bidirectional albeit weaker signifies that market information flows are not unidirectional, but they are rather complex interactions between markets. The observation is in line with the spillover index method that Diebold Francis X and YilmazKamil (2012) put forward, which focuses on the

interrelationship of financial markets and assets-class shock interaction.

Theoretically, the results affirm the concept of financial market integration, whereby the asset classes are getting intertwined growingly owing to globalization and financialization. These linkages have only been enhanced by the growing involvement of the institutional investors in the commodity markets as emphasized by Tang Ke and Xiong Wei (2012). The implications of this integration are significant in relation to the portfolio diversification in that low or negative correlation between the asset classes may not hold true anymore, especially at a time when the financial environment is unstable. In terms of investment, the results indicate that the commodity, and equity markets have conditional and time-dependent diversification benefits. Although gold can be of use in providing hedging advantages in the normal condition, its capability as a safe haven can be compromised in the extreme events of the market when the amount of correlation goes up. In the same way, the close association between crude oil and equity markets means that, as far as exposure to oil-related assets is concerned, portfolio risk is likely to increase instead of be reduced. The existence of substantial volatility spillover and dynamic correlationunderscores the necessity of greater attention to cross-market associations. When formulating policies that would keep financial markets stable, regulators and policymakers need to take into account the interconnectedness of financial markets. The results indicate the need to take a systemic perspective of risk management, especially in a developing market such as India where external shocks may exert significant impacts in domestic financial markets. In general, the paper presents detailed evidence that volatility spillover between commodity and equity market in India is asymmetric, dynamic, and economically relevant, hence the paper adds to the existing comprehension of the behaviour of financial markets in an emerging market environment.

6 CONCLUSION

This paper examines the asymmetric and time varying volatility spillover between commodity and equity market in India using the Nifty 50, gold, and crude oil market between the years 2015-2025. The analysis using the EGARCH model to summarize the asymmetric volatility and the DCC-GARCH model to trace the dynamic correlation generates a full picture of the transmission of volatility in the markets.

The empirical results put into support the existence of volatility clustering and volatility persistence in all markets, which shows that volatility shocks do not have short-lived impacts. The findings also determine considerable asymmetric volatility where negative shocks have a greater impact on the market volatility than positive shocks especially in equity and crude oil markets. This point out the sensitivity of financial markets to bad news and the usefulness of asymmetric modelling frameworks. The correlation analysis of the dynamic correlation shows that the commutation between commodity and equity market is time-dependent and very sensitive to the market conditions. The correlations are more likely to rise in times of financial stress, which are the moments of more integration of the market and fewer opportunities to diversify. Out of the commodities, crude oil can be identified as an important transmitter of volatility to the equity market, whereas gold acts rather consistently and acts as a partial hedge in typical circumstances. The results are especially applicable in the post-pandemic financial environment where the increased uncertainty and international connectivity have increased the volatility transmission mechanisms among asset classes. In general, the research is well-supported by evidence in demonstrating that volatility spillover between commodity and equity markets in India is asymmetric, dynamic and economically meaningful, which brings a broader insight into the relationship between financial market interdependencies in an emerging economy setting.

Theoretical Contribution

The research works add to the existing body of literature in various ways. First, it combines asymmetric volatility modelling (EGARCH) and time-varying correlation analysis (DCC-GARCH) in the same framework, which is a major methodological gap of the previous studies. Second, it expands the volatility spillover literature, as it offers empirical data related to the Indian market, which has not been thoroughly investigated, unlike developed economies. Third, the study records both the asymmetry and dynamic correlations, which represent the financial market behaviour in a more realistic manner.

Practical Implications

The results show that the diversification advantages between commodity and equity markets do not always remain constant and are usually reduced in the financial stress periods. Diversification assumptions that investors use should not be fixed on but dynamic portfolio allocation strategies used. Gold is a relatively

stable asset to use as a hedge and assets that are linked to crude oil should be dealt with carefully as they are highly volatile in transmitting it to the equity markets. The fact that there is a high spill over volatility leads to the importance of the continuous monitoring of the cross-market linkages. Financial stability should be approached on a system-wide basis because the commodity and equity markets are interconnected. Regulation should be structured in a manner that it reduces systemic risk that is caused by external shocks and especially in emerging economies such as India.

Limitations of the Study

The research has some weaknesses even though it has made contributions. To begin with, only a few commodities are analyzed, which are gold and crude oil, which, although representative, do not reflect the whole range of commodities. Second, the analysis is based on day-by-day data, which might be not the best measure of intraday volatility dynamics. Third, the models used, despite being robust, presuppose certain distributional properties that might not be able to reflect any kinds of market non-linearity.

Scope for Future Research

The current analysis can be extended further in a number of ways in the future. To begin with, they can include other commodities, including agricultural foods or industrial metals, to give a more comprehensive view on the spillover processes. Secondly, intraday volatility patterns can be captured using high-frequency data. Third, more sophisticated models, including multivariate GARCH extensions, or spillover index models, can be used to dig deeper into the directional spillovers. Lastly, comparative research on many emerging markets may be used in more in-depth research on the effects of global financial integration and contagion.

REFERENCES

Baur, D. G., &Lucey, B. M. (2010). Is gold a hedge or a safe haven? An analysis of stocks, bonds and gold.*Financial Review*, 45(2), 217–229.

Bollerslev, T. (1986).Generalized autoregressive conditional heteroskedasticity.*Journal of Econometrics*, 31(3), 307–327.

Creti, A., Joëts, M., & Mignon, V. (2013).On the links between stock and commodity markets' volatility.*Energy Economics*, 37, 16–28.

Diebold, F. X., &Yilmaz, K. (2012). Better to give than to receive: Predictive directional measurement of volatility spillovers. *International Journal of Forecasting*, 28(1), 57–66.

Engle, R. F. (1982). Autoregressive conditional heteroskedasticity with estimates of the variance of United Kingdom inflation.*Econometrica*, 50(4), 987–1007.

Engle, R. F. (2002). Dynamic conditional correlation: A simple class of multivariate generalized autoregressive conditional heteroskedasticity models. *Journal of Business & Economic Statistics*, 20(3), 339–350.

Glosten, L. R., Jagannathan, R., &Runkle, D. E. (1993).On the relation between the expected value and the volatility of the nominal excess return on stocks.*Journal of Finance*, 48(5), 1779–1801.

Hamilton, J. D. (2009). Causes and consequences of the oil shock of 2007–08. *Brookings Papers on Economic Activity*, 2009(1), 215–261.

Nelson, D. B. (1991). Conditional heteroskedasticity in asset returns: A new approach. *Econometrica*, 59(2), 347–370.

Silvennoinen, A., & Thorp, S. (2013). Financialization, crisis and commodity correlation dynamics.*Journal of International Financial Markets, Institutions and Money*, 24, 42–65.

Sharif, A., Aloui, C., &Yarovaya, L. (2020). COVID-19 pandemic, oil prices, stock market, geopolitical risk and policy uncertainty nexus in the US economy: Fresh evidence from the wavelet-based approach. *International Review of Financial Analysis*, 70, 101496.

Tiwari, A. K., Raheem, I. D., & Kang, S. H. (2020).Time-varying dynamic conditional correlation between stock and commodity markets.*Resources Policy*, 65, 101571.

Tang, K., &Xiong, W. (2012).Index investment and the financialization of commodities.*Financial Analysts Journal*, 68(6), 54–74.

Zhang, D., Hu, M., &Ji, Q. (2020). Financial markets under the global pandemic of COVID-19. *Finance Research Letters*, 36, 101528.