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Evaluating Volatility Spillover and Decay in Spot and Futures Markets: A Cross-Country Analysis

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ABSTRACT
Investment selection is critical for Investor Decision Making criteria, especially in volatile markets. The study aims to assess whether an investor should invest in the spot or futures markets amid volatility in these markets. The existing literature has extensively explored, volatility spillover amongst the spot and futures indices but the use of decay in volatility is very limited. This study exclusively focuses on the decay in volatility of, the spot and futures markets across 5 major economies of the world USA, China, Germany, India, and Japan; being the top 5 economies in the world.
By analyzing daily closing prices of the spot and futures indices of the economies from April 1, 2011, to September 30, 2024, this study employs the GARCH(1,1) Model to measure the degree of volatility spillover. The findings reveal that there is no significant difference in the decay in volatility amongst the spot and futures stock index prices of the 5 countries. This implies that in terms of volatility decay, investors face similar risk profiles whether they invest in spot or futures markets. The paper brings out a novel criterion of decision-making that is seldom used in research i.e. decay in volatility. The findings help investors and portfolio managers in strategizing whether to invest in the spot or futures markets through its assessment of Decay in Volatility and Volatility Persistence.

Keywords: Spot market, futures market, portfolio diversification, risk trade-off, GARCH model, Volatility Persistence, Decay in Volatility

1. INTRODUCTION

The impact of Globalization has led to an increased interest in the assessment of the impact of the financial markets on each other. The last three decades have seen lots of uneasiness in the financial markets, due to various events like COVID-19, Russia-Ukraine War, etc. The multiple dimensions of volatility spillover have been analyzed in prior studies (Diebold and Yilmaz, 2012), in a phased analysis (Mensi et al., 2022) found that during expansion phases the selected international markets significantly impact the Indian Market. The patterns of volatility transmission amongst highly traded companies in the US and UK were analyzed by (Saadaoui and Ghadhab, 2023) using multivariate fractional models.

Various studies (Bonato, 2019) measuring international financial transmission amongst stocks, bonds, money markets, exchange rates are referred to in the studies for the exploration of the opportunities for investment in the future and spot markets available in the top 5 economies. To address the problem of the study, the empirical approach is followed by exploring the different amounts of risk of investment possible in the case of future and spot markets so that corrective recommendations might be provided to the investors for mitigating the risk in the future. Further, the application of the informed exploration of the stationary and non-stationary traits available in the time series trend of future and spot markets is explored in the view of investors for enhancing the acceptance of the deliverable.

This study adds to the literature on Volatility spillover amongst spot and futures indices by systematically assessing the decay in volatility and its relevance in investor decision-making. Various author's have used volatility spillover in their studies (Gupta.H (2025); Younis et al (2024a);Nepal et al (2024)).The use of 'Decay in Volatility' as a variable to assess the volatility is very exclusive by Yadav et. al (2023) for the investigation of volatility spillover of energy commodities amongst the Chinese and European Stock Markets. The paper extensively uses the R software to determine the volatility clustering on the 3396, 2961, 2428, 3344, and 3306 observations of the USA, China, Germany, India, and Japan, respectively and applies the GARCH(1,1) model on the data to assess the volatility spillover.

The remaining paper is structured as follows: section 2 conducts a detailed review of the volatility spillover and econometric methods used to assess the same amongst the international markets. Section 3 discusses the data and the econometric method applied, while Section 4 discusses the empirical results and Section 5 outlines conclusion and policy implications.

There is no dearth of literature on the exclusive study of Spot and Futures markets, but studies directly comparing the two using an integrated model remain scarce. The performance of spot markets is prone to be more sensitive because of the provision for immediate or fast settlement and trading speculation while a hedging-based risk mitigation approach or practice is noticed in future contracts. The periods in which larger volatility is noticed in the spot or future options are clustered together preceding or followed by the period having a lesser degree of volatility. The variation in the sensitivity of the spot and futures market might affect the risk-free and investment efficiency of investors for maximizing return. The availability of the significant interaction of macroeconomic factors and regulatory policies with the sensitivity of futures and spot markets affects their volatility in terms of price and this ultimately affects respective trading. The investors mainly gain the benefits from reducing the uncertainty as compared to the spot markets as well as making the future more effective for the strategic investment options. The availability of the significant interaction of macroeconomic factors and regulatory policies with the sensitivity of futures and spot markets simultaneously affects their volatility in terms of price and this ultimately affects respective trading.

The combination of futures and spot investments can help investors in the diversification of their portfolio but the degree of effectiveness relies on the stability in the macroeconomic factors, liquidity in the market, and the correlation between assets. This comparative analysis with both developed and emerging economies is critical due to the varied economic and regulatory conditions and institutional structures (Floros, 2009; Alizadeh, Brandt, & Diebold, 2002). The dual market and multi-country approach will make this study meaningful for academia and researchers alike.

2. LITERATURE REVIEW

Volatility spillover i.e. spread of volatility from one market to another or from an asset to another can be directional, non-directional, asymmetric, etc (Gupta.H (2023); Gupta & Katoch (2024)).

Multiple studies have been conducted on the volatility spillover amongst different markets, Unidirectional volatility spillover was observed from the United States to the Indian Stock Market by Siddiqui S.; Roy P. (2019) and in studies conducted amongst multiple markets Gong et al. Examined the asymmetric volatility spillover effect using realized measures across 22 international stock markets and suggested a high connectedness among global equity markets, with downside risk spillover significantly higher than upside risk spillover over time and Horpestad et al. (2018) Confirmed that the stock market indices around the world exhibit an asymmetric volatility effect, with a stronger effect for US and European Markets, after studying the effect on 19 equity indices, using the GARCH class models.

Studies also have suggested the impact of news and other variables on market volatility, Haidan Zhu (2019) suggested a significant leverage effect in the spot market, the index spot response to good news and bad news is asymmetric, and the impact of bad news on the spot market is greater. Also Zhou et al. (2021) found significant and bidirectional volatility spillover effects between the Chinese index spot and futures prices and further suggested that public information flows have a significant and positive association with the dynamic conditional correlation between the index spot and futures markets.

The spillover effect between the spot and futures markets of a country studied by Fan, X., & Du, D. (2017) suggested that the mean spillover from the CSI 500 stock index futures market to the underlying spot market is significant in case of falling markets and vis a vis the rising markets. Zhou et al. (2021), Paul and Kimata (2016), Zhu and Wu (2016), Li (2015), and Zhou and Chong (2014), have found bidirectional volatility between spot and futures markets; Zhu (2019) state that there is cointegration among the Chinese spot and futures markets; Sehgal et al. (2015) in context of volatility spillover between spot and futures markets of NSE 50 concluded that in short run the presence of bidirectional volatility and in long term spot market dominates the futures market. Sukhonpitumart, et al., (2020) analyzed volatility spillover in the Thai Financial Exchanges among SET 50 Index future and its underlying Index through the use of the GJR-GARCH model. The results affirmed the presence of Bi-directional volatility spillover, but the spillover from the future market to the spot market is more evident.

While trying to assess The Impact of Index Futures on Market Efficiency and Volatility of Spot Index amongst BRICS economies, Tarique J. and Malik I. R. (2018) suggested that the relationship exists between market efficiency and volatility, which implies that markets will have to bear the cost (in terms of increase in volatility) for potential gains (increase in the level of market efficiency).

The use of 'Decay in Volatility' as a variable to assess the volatility is very exclusive by Yadav et. al (2023) for the investigation of volatility spillover of energy commodities amongst the Chinese and European Stock Markets.

RESEARCH GAP

The studies performed till now explore the theoretical aspects of the investment opportunities in spot and futures markets because of which investors are found inefficient in using the insight appropriately in the real investment and this declines the success of the deliverable (Baule, Frijns and Tieves, 2018). Studies have been done to assess the volatility spillover amongst various countries, Unidirectional volatility spillover was observed from the United States to the Indian Stock Market by Siddiqui S. and Roy P. in 2021. The applicability-related research gap in the existing literature is bridged in the study by using statistical validation for the sentiments of future and spot markets in different situations for augmenting respective acceptance in real investment, by determining the "decay in volatility" amongst the spot and futures markets of top 5 economies in the World namely USA, China, Germany, India, and Japan and assess whether it can be used as a variable for better decision making by the investors. This dual market and multi-country approach will make this study meaningful in estimating how different markets react in the absorption of news and risk, offering a novel methodological outlook and for investors in assessing the risk and optimizing the portfolio, regulators and policymakers in establishing a regulatory framework and bringing financial stability in the market.

RESEARCH OBJECTIVES

- To determine the existence of volatility persistence amongst the spot and futures markets of the top 5 economies in the world.
- To analyze volatility decay to identify investment opportunities in spot and futures markets across the World's top 5 economies.

3. DATA AND METHODOLOGIES

Strategy and Data Collection

Quantitative strategy is adopted for the exploration of investment opportunities in futures and spot markets for enhancing the statistical validation of the determined hypothesis and this is conducted along with following interpretivism philosophy and deductive approach (Diebold and Yilmaz, 2012). Secondary data is collected about the price of different indices in futures and spot markets in the top 5 economies for the validation of the change in the volatility and sensitivity of the derivative markets. This study considers the indices of the top 5 economies of the World. To check the volatility in returns the Daily closing prices of the spot and futures indices are taken from Investing.com. Table 1 indicates the description of the data.

Country	Underlying Spot Index	Underlying Futures Index	Data Period	No. of Observations
USA	S&P 500	S&P 500 Futures	April 1, 2011 to September 30, 2024	3396
China	CSI 300	CSI 300 Futures	April 1, 2011 to September 30, 2024	2961
Germany	DAX	DAX Futures	April 1, 2011 to September 30, 2024	2428
India	Nifty 50	Nifty 50 Futures	April 1, 2011 to September 30, 2024	3344
Japan	NIKKEI 225	NIKKEI 225 Futures	April 1, 2011 to September 30, 2024	3306

As per Table 1, the daily adjusted closing prices of all stocks were converted into daily log returns after the test of stationarity of the stock prices.

DATA ANALYSIS METHODOLOGY

The study uses SGARCH to determine the decay in volatility, converting the price set into return estimation (Gupta & Gupta), 2023, applying the formula.

$R_t = \ln (P_t / P_{t-1})$ …1

Figures show the volatility clustering in the return series for all 10 variables.

Post-checking the preconditions of Stationarity on the returns and volatility clustering, all the return series were checked for ARCH EFFECTS.

The analysis for the paper is done using R, for which the following steps were applied.

Step 1 Volatility Clustering

After checking the stationarity of the return series, the volatility clustering was checked through the plotting of the return series

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>plot.ts(series name)
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Step 2 ARCH Test was applied to the return series to check the ARCH effects

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>Arch Test(series name)
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Step 3 Determination of ARCH GARCH Order

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Thereafter, the ARCH GARCH order was determined.
The volatility of the selected spot and future indices was determined using GARCH (1,1) (Rastogi and Srivastava, 2011).
The GARCH(1,1) model estimates conditional variance (volatility) as:
$\sigma_t^2 = \omega + \alpha_1 \epsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2$

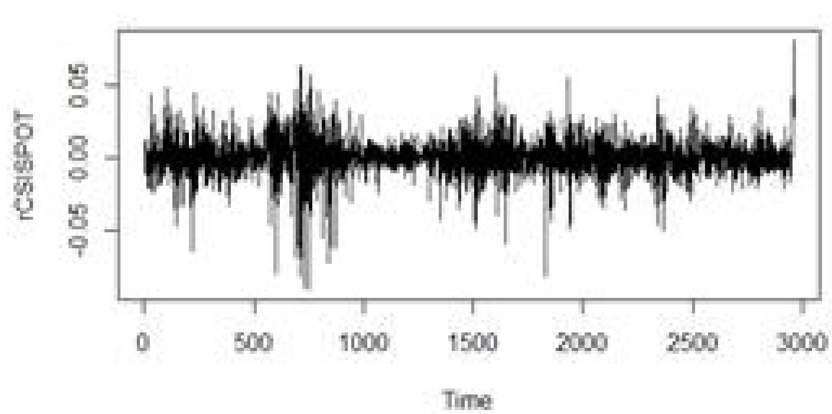
Where:
ω (omega): Long-run average variance.
α1 (alpha): Reaction of volatility to shocks (ARCH term).
β1 (beta): Persistence of volatility (GARCH term).
μ (mu): Mean return.
The GARCH Models developed have many extensions like EGARCH, and TGARCH but the GARCH(1,1) Model has been used due to its simplicity and usability on a wide range of financial data. On application of ARCH GARCH, the decay in volatility was determined which is 1-α- β

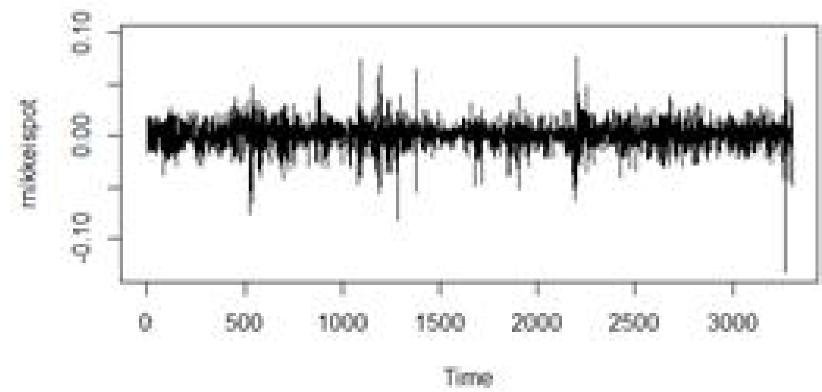
4. EMPIRICAL RESULTS AND ANALYSIS.

Volatility Clustering was observed in all the return series of the index prices the results of which are depicted as follows:

RESULT

In order to examine the investment opportunities between spot and future markets in the top five economies, quantitative analysis like GARCH (Generalized Autoregressive Conditional Heteroskedasticity) is performed for enhancement of the applicability of the deliverables in the view of both organizational and individual investors. The key findings derived from the quantitative assessment of the numerical data are interpreted below in the context of the defined objectives.
The illustration in Figure 1 is developed for understanding the volatility clustering of returns of the spot markets of India, China, Japan, USA, and Germany. After the conversion of the raw series into log return series in a bid to remove the stochastic trend, it seems that each series is mean reverting.

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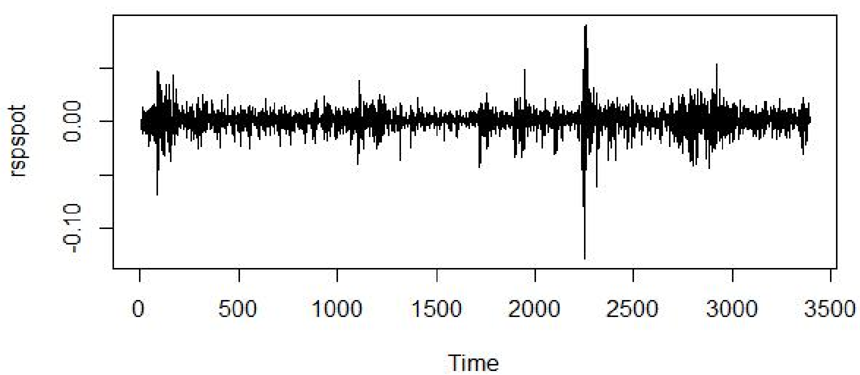
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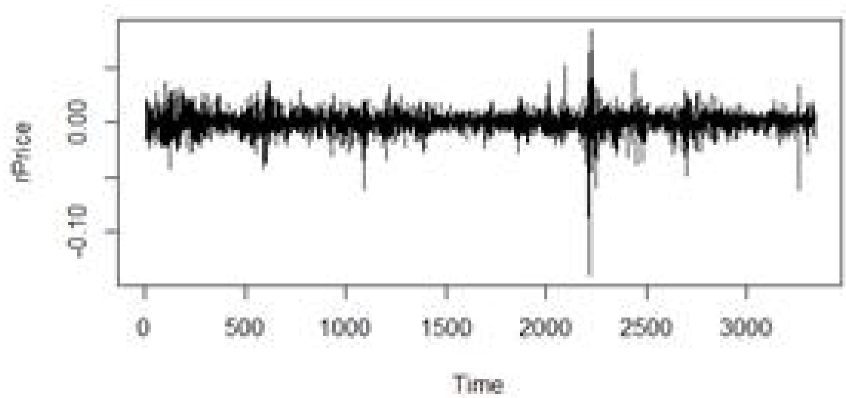
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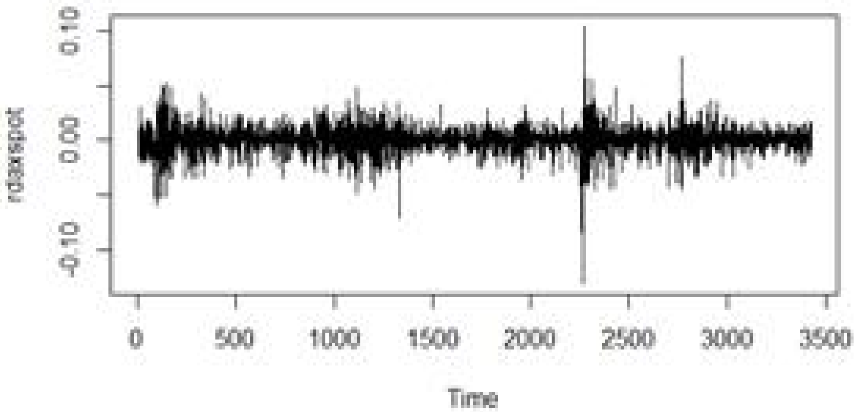
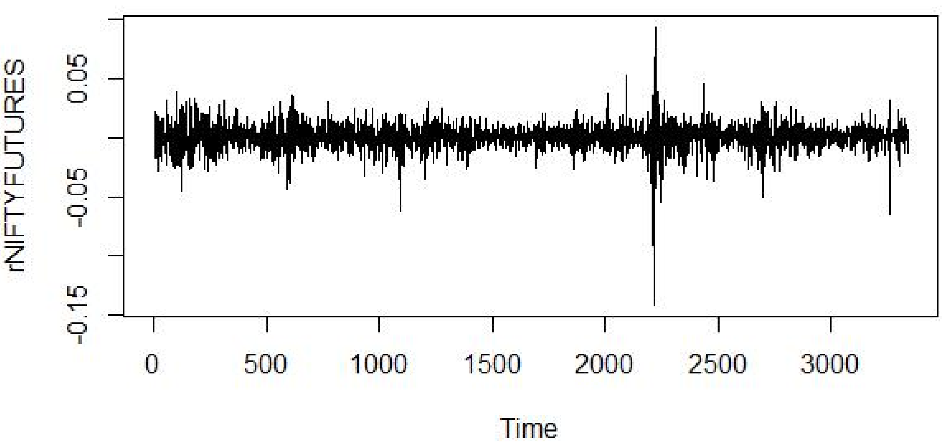


Figure 1: Volatility Clustering of Spot of NIFTY, CSI, NIKKEI, S&P, and DAX; Source: Author's Calculation

As per the illustration in Figure 1, there is noticed significant degree of volatility type of clustering in both the spot price and the future price and this might be the result of the availability of adverse and frequent changing macroeconomic factors like interest rate and the sentiment of the markets. The availability of a similar type of clustering pattern in terms of volatility in both futures and spot markets of Nifty indicates that there is no significant difference in the amount of decay in the related volatility in the two options and this is justified by the volatility trend identified in GARCH.

Figure 2 reflects the volatility clustering of returns of the futures markets of India, China, Japan, USA, and Germany.



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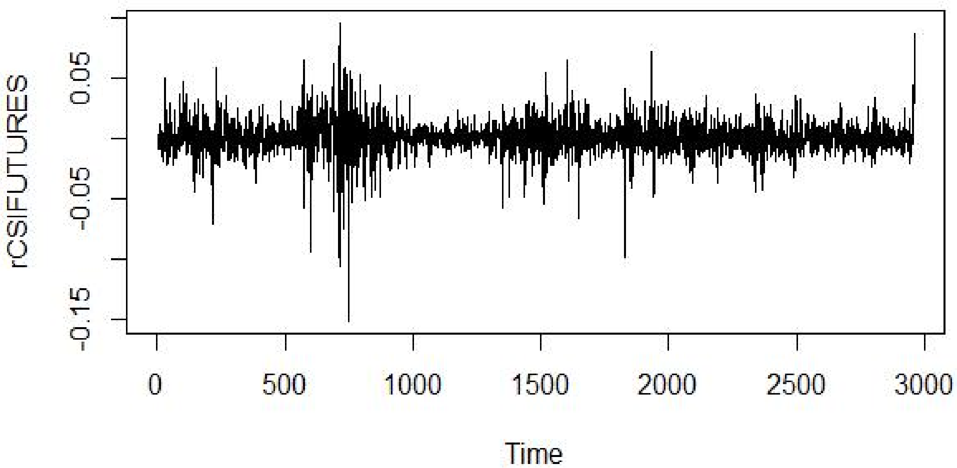

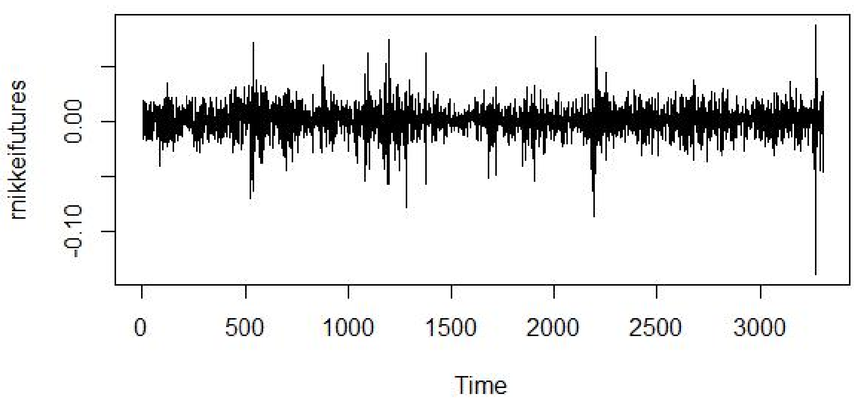

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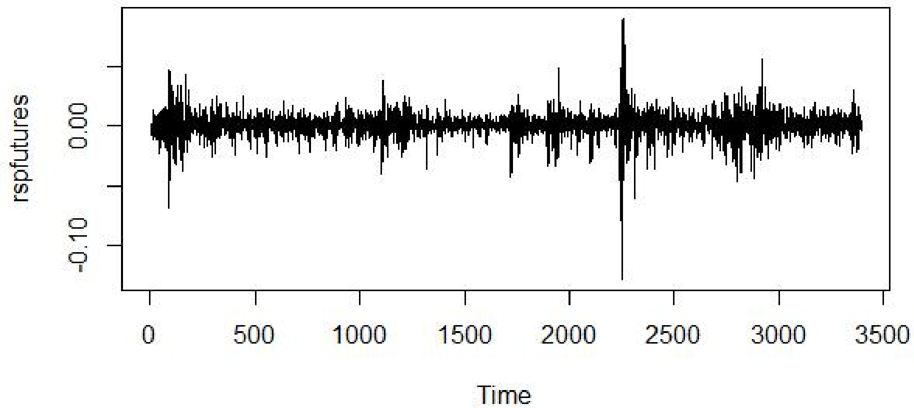

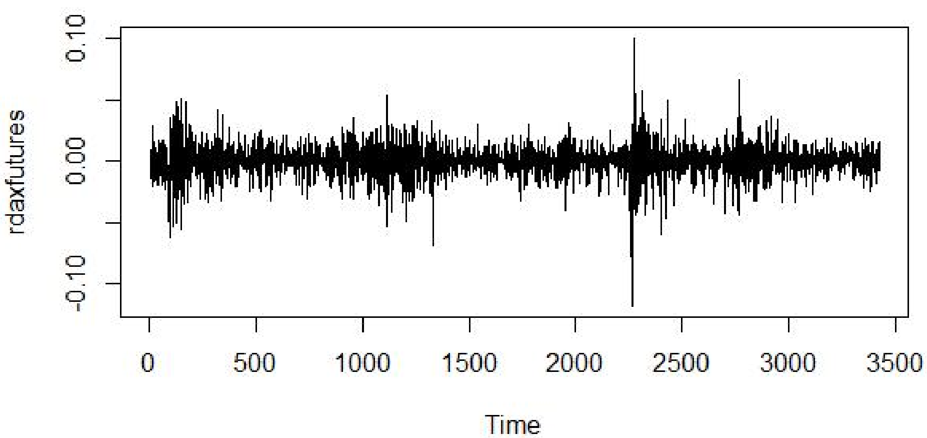

Figure 2: Volatility Clustering of futures of NIFTY, CSI, NIKKEI, S&P and DAX; Source: Author's Calculation

As per the GARCH illustration in Figure 2, there is noticed sudden downward or upward in the value of return with the identification of a larger volatility period and this indicates the trend of volatility possible in a normal time series dataset. The periods in which larger volatility is noticed in the spot or future options are clustered together preceding or followed by the period having a lesser degree of volatility. Further, as per the GARCH modeling, both quiet periods and the time of volatility spikes are prone to coincide between the future and spot markets and this indicates a respective similar type of reaction towards the market sentiment. It means that the return of the future and spot markets have the trait of behaving almost in similar patterns in case of any marginal change in the events and news and this highlights the greater degree of significant association in the volatility-related behavior. The GARCH volatility in the spot market is noticed significantly higher in the comparison to future market as the clustering of the higher volatility period is more frequent in the case of the former over the latter. It means that there is a greater possibility for investors to have marginally higher returns from the future market option in comparison to the spot market because of the difference in the respective reactiveness towards the market sentiment (Baule, Frijns, and Tieves, 2018).

The understanding of the return generation trend of both future and spot markets is developed through the time series-based illustration and this is conducted by assuming the value of the investment alternative on the y-axis and the time horizon on the x-axis. As per the visual inspection, there is a mixed but progressive trend in the return generation and maximization capability of both markets and this highlights the availability of growth trend on average in the respective underlying assets. Figure 3 shows the Analysis of the Time Series of Prices and Futures,

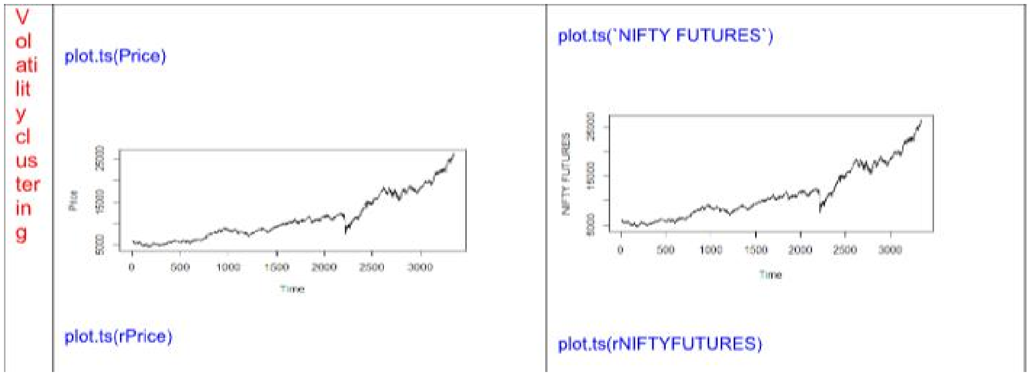

Figure 3: Time Series Analysis of Nifty Price and Futures; Source: Author's Calculation

Figure 3 highlights the availability of a similar type of upward trend in both markets and this is evidenced by the existence of the same period for the major troughs and peaks in both the future and spot markets. The existence of a similar period of significant troughs and peaks in both markets indicates future price as a derivation from the spot price. On the other hand, there are some predictability trends justified through GARCH modeling in the movement of future prices for the prediction of the trend of spot price and this is also validated by the theoretical insight about the inherited nature of the future market in reflecting the possible change in spot price in future.

To understand the availability of stationary-related traits within the historical price trend of both the future and spot markets, an ADF test is performed and this is conducted at a 95% confidence interval and 5 % significance level. In Table 1, the findings achieved on the execution of the ADF test are presented as follows along with respective interpretations.

Table 1: ADF Test for Spot and Future

ADF TEST	T Statistic	P Value	T Statistic	P Value
	Price		Returns	
Nifty Spot	-0.70831	0.9698	-14.677	Smaller than 0.01
Nifty Futures	-0.65192	0.9749	-14.65	0.01
DAX Spot	-3.4178	0.05033	-14.456	Smaller than 0.01
DAX Futures	-3.3612	0.06008	-14.414	Smaller than 0.01
CSI Spot	-2.2562	0.4699	-13.417	Smaller than 0.01
CSI Futures	-2.3064	0.4486	-14.374	Smaller than 0.01
NIKKEI Spot	-2.9648	0.1698	-15.287	Smaller than 0.01
NIKKEI Futures	-2.9681	0.1684	-15.155	Smaller than 0.01
S&P Spot	-2.9648	0.1698	-15.287	Smaller than 0.01
S&P Futures	-2.9681	0.1684	-15.194	Smaller than 0.01

Source: Author's Calculation

In Table 1, the ADF (Augmented Dickey-Fuller) test is performed to confirm the availability of stationarity related to the historical price series of both the markets including future and spot markets. The calculated test statistic for the spot price series is -0.70831 while the related p-value is 0.9698 which represents the rejection of the alternative hypothesis and acceptance of the null hypothesis. It means that there is non-stationary movement in the price of the spot market over the period. The same results apply to other price series.

The stationary trend within the price series of the markets is achieved by finding the stationary trait within the log return and this is justified with the respective lesser p-value (0.01) than the defined significance level and this can be leveraged for the modeling in the future.

As per the estimation, the calculation ADF test statistic for the "DAX Spot Market" is -3.4178 while the associated p-value is closer to (0.05033) significance level (0.05) and this confirms the rejection of the alternative hypothesis. It means that the price or return generation trend of the DAX Spot market highlights the non-stationary nature. The stationary trend within the price series of the DAX Spot market is achieved by finding the stationary trait within the log return and this is justified with the respective lesser p-value (0.01) than the defined significance level. In other words, investors might select either a future market or a spot market for the investment without concerning respective volatile behavior (Kara, Anbrar, and Arabacis, 2021).

Before applying the SGARCH model on the time series the presence of ARCH effects needs to be affirmed, therefore ARCH LM Test was conducted on the return series data.

Table 2 includes the ARCH-LM test result

Table 2: ARCH-LM Test; Source: Author's Calculation;

ARCH-LM Test	Chi-Squared Test	P Value
NIFTY SPOT	877.77	0.01***
NIFTY FUTURES	927.93	0.01***
CSI SPOT	372.22	0.01***
CSI FUTURES	442.95	0.01***
NIKKEI SPOT	509.25	0.01***
NIKKEI FUTURES	452.08	0.01***
S&P SPOT	1283.8	0.01***
S&P FUTURES	1281.9	0.01***
DAX SPOT	646.63	0.01***
DAX FUTURES	624.43	0.01***

Table 2 is developed for examining the possibility of the ARCH effect in case of return in the future and spot indices available in the top 5 economies and this is achieved by estimating the ARCH-LM test. The statistical test is conducted for measuring if there is the possibility of volatility clustering in the time series data of future and spot market prices and this is achieved by the calculation of the ARCH effect through the ARCH LM test.

The calculated p-value for the ARCH-LM test is lesser (***2.2e-16) than the defined significance level (0.05) which indicates the rejection of the null hypothesis and the acceptance of the alternative hypothesis. It means that there is the existence of volatility clustering in the return generation trend of the spot market (Basu, 2020).

This means that there is a greater possibility of the existence of the ARCH effect in the series of returns in the future and spot indices available in the top 5 economies i.e. US, Germany, Japan, China, and India. As per the estimation, it is interpreted that the entire indices are noticed exhibiting the ARCH effect which indicates the availability of higher clustering and volatile fluctuation in the prices despite the change in the market like the economies (Kara, Anbar and Arabaci, 2021).

GARCH (1,1) Estimation Results

Table 3 depicts the findings of the GARCH (1,1) model for each of the 5 markets for both spot and futures indices. The results of the descriptive statistics are given below:

Table 3 GARCH (1,1) Results

Indices	Spot	Futures
Nifty	Optimal Parameters-------------------------------------- -------------Estimate Std. Error t value Pr(>|t|) mu 0.000718 0.000144 4.9803 0.000001 omega 0.000002 0.000001 2.2300 0.025749 alpha1 **0.089631** 0.011257 7.9623 0.000000 beta1 **0.889780** 0.012618 70.5187 0.000000	Optimal Parameters--Estimate Std. Error t value Pr(>|t|) mu 0.000754 0.000145 5.1965 0.000000 omega 0.000002 0.000001 2.0465 0.040707 alpha1 **0.093592** 0.012481 7.4985 0.000000 beta1 **0.888260** 0.013684 64.9101 0.000000
DAX	Optimal Parameters---Estimate Std. Error t value Pr(>|t|) mu 0.000639 0.000166 3.8392 0.000123 omega 0.000004 0.000002	Optimal Parameters--- Estimate Std. Error t value Pr(>|t|) mu 0.000616 0.000169 3.6493 0.000263 omega 0.000004 0.000002 1.5322 0.125483 alpha1

	1.6590 0.097121 alpha1 **0.100041** 0.010868 9.2052 0.000000 beta1 **0.875033** 0.018119 48.2927 0.000000	**0.088690** 0.009909 8.9503 0.000000 beta1 **0.887270** 0.017727 50.0514 0.000000
CSI	Optimal Parameters--Estimate Std. Error t value Pr(>|t|) mu 0.000271 0.000192 1.4089 0.15887 omega 0.000002 0.000001 1.4334 0.15175 alpha1 **0.081782** 0.012472 6.5573 0.00000 beta1 **0.913543** 0.012159 75.1321 0.00000	Optimal Parameters-- - Estimate Std. Error t value Pr(>|t|) mu 0.000345 0.000198 1.7460 0.080809 omega 0.000002 0.000001 1.8465 0.064820 alpha1 **0.084206** 0.011205 7.5151 0.000000 beta1 **0.910349** 0.010887 83.6184 0.000000
NIKKEI	Optimal Parameters----------------------------------- -------------------- Estimate Std. Error t value Pr(>|t|) mu 0.000700 0.000189 3.7069 0.00021 omega 0.000007 0.000001 7.2560 0.00000 alpha1 **0.118304** 0.009699 12.1975 0.00000 beta1 **0.846164** 0.008830 95.8276 0.00000	Optimal Parameters--- - Estimate Std. Error t value Pr(>|t|) mu 0.000699 0.000191 3.6614 0.000251 omega 0.000009 0.000001 12.7475 0.000000 alpha1 **0.138824** 0.010374 13.3823 0.000000 beta1 **0.816173** 0.010092 80.8760 0.000000
S&P	Optimal Parameters-- Estimate Std. Error t value Pr(>|t|) mu 0.000793 0.000128 6.1727 0.000000 omega 0.000004 0.000002 1.9338 0.053139 alpha1 **0.183443** 0.016523 11.1020 0.000000 beta1 **0.785299** 0.020791 37.7703 0.000000	Optimal Parameters--- - Estimate Std. Error t value Pr(>|t|) mu 0.000804 0.000129 6.2478 0.000000 omega 0.000004 0.000002 1.7922 0.073095 alpha1 **0.189655** 0.017896 10.5975 0.000000 beta1 **0.778494** 0.022348 34.8344 0.000000

The table shows the mean return (mu) and variance (omega) for all the indices of the 5 markets, for both spot and futures. The slope of error term squared i.e. alpha1 which denotes whether any news is captured, and Volatility persistence is denoted by beta1 for the range of data.
For the results observed, the mean return (mu) is small but statistically significant for all the markets, the baseline variance is also low and the ARCH term (alpha1) is higher in futures markets as in these markets the involvement of Institutional and speculative traders is high such traders being more aware than individuals react promptly to any news or arbitrage possibilities (Kawaller et al., 1987), The volatility persistence drawn from the Table 3 is reflected in Table 4 separately. In all the markets Beta 1 is positive and significant (as reflected by P values) which denotes that there is volatility persistence.

Volatility Persistence (Beta 1)

Country	Index	Spot	Futures
USA	S&P	0.785299	0.778494
China	CSI	0.913543	0.910349
Germany	DAX	0.875033	0.887270
India	Nifty	0.889780	0.888260
Japan	NIKKEI	0.846164	0.816173

The data is stationary and is again developed through the sum of alpha1 and beta1 which is less than 1 at a 5% level of significance.
The concept of decay in volatility although not directly attributable derives from the work of the core contributors of the field. The idea that volatility is variable with time and reacts to past shocks was developed by Robert F. Engle when he came up with the ARCH model in 1982. This model was further extended to GARCH (Generalized ARCH) by Tim Bollerslev, In GARCH(1,1), the sum of Alpha1 + Beta1 determines how long the impact of a volatility shock lasts, that is volatility decay.

Decay in Volatility ($1 - \alpha_1 - \beta_1$)

Country	Index	Spot Decay	Futures Decay
USA	S&P	0.031258 (3.13%)	0.031851 (3.19%)
China	CSI	0.004675 (0.47%)	0.005445 (0.54%)
Germany	DAX	0.024926 (2.49%)	0.02404 (2.40%)
India	Nifty	0.020589 (2.06%)	0.018148 (1.81%)
Japan	NIKKEI	0.035532 (3.55%)	0.045003 (4.50%)

Spot and Futures Comparison
The decay in volatility is slightly on the higher side for futures markets except DAX and S&P, where it's almost the same. This reflects that futures may react quicker to news but revert to mean a bit faster, this might be due to speculative activity or price discovery rapidness.

Markets Comparison
While comparing the markets, on checking the persistence ranking
In Spot Market:
Highest Decay: Nikkei > S&P > DAX > Nifty > CSI
This reflects that Nikkei (Japan) has the lowest persistence and China (CSI) has the highest persistence. This can be due to herding behavior that retail markets like India and China are prone to (Floros, 2009).
In Futures Market:
Highest Decay: Nikkei > S&P > DAX > Nifty > CSI
The reflection remains similar to Spot markets.
Regional Comparison
Western Markets both S&P and DAX show stable behavior because of a stable investor base, and efficiency in trading systems for markets that are fast in information diffusion.
Asian Markets Nikkei shows the fastest decay while CSI shows the slowest decay, which can be due to state influence, and policy uncertainty.

Empirical Analysis
The GARCH analysis of the volatility clustering in the spot and even in the case of the future markets of the major global mainly provides NIFTY, CSI, NIKKEI, S&P, and DAX which provides the effective level of the fluctuations in the case of the pricing movements. The time-series plots mainly provide the spot markets which focus on the higher level of volatility with the occasional large spikes because of the effective market shocks and even the news events. In this case, the future markets mainly describe relatively more stable behavior which suggests that they mainly serve as the better instrument in the case of risk management with the help of the hedging strategy. For example, the spot market of the Nikkei shows a high degree in the case of price fluctuation which implies increased investment risk due to unpredictable movements (Kara, Anbar, and Arabaci, 2021).
In this case, assessing the stationarity of the price series, the "Augmented Dickey-Fuller (ADF) test was conducted in the different indices. The results mainly indicate that the raw price series are non-stationary which means their mean and even the variances mainly change over the period. This provides suggestions about the financial markets which exhibit the random walks and also provides support to the hypothesis of the market efficiency (Basu, 2020). The log-differenced price series were found to be stationary across all of the indices and mainly implying the levels of price which are unpredictable and even their returns exhibit the mean-reverting behavior. The findings mainly indicate that the NIFTY, CSI, and DAX

strengthen this conclusion. The p-values for the spot as well as the future of the price series were above 0.05 which provides confirmation of the non-stationarity. After differencing, the p-values drop down to 0.01 which provides confirmation about the stationarity in the returns. This was mainly consistent with the effective financial theory which states that the movement of the price mainly follows the random walk which returns often exhibit predictable patterns over a short period.
Further to assess the volatility clustering the ARCH Test application on the return series reflected on the presence of volatility clustering in the data and the Alternate hypothesis was accepted.
The assessment of Volatility persistence and decay Vanilla GARCH was applied to the data, with $\alpha_1 + \beta_1$ less than 1 for all the time series, it was resonated that the return series are stationary, and the results showed the existence of volatility persistence in all the series with beta value being positive and significant.
The decay in volatility is on the higher side for the futures markets which signifies that these markets are better as investment opportunities than the underlying spot markets.

5. CONCLUSION

It is summarized that there is a significant variation in the price trend of futures and spot markets with the change in the economies as they have different macroeconomic situations like inflation rate and interest rate justified through the GARCH test. In GARCH modeling is noticed stationary nature of the price trend of both the futures and spot markets evidenced by the higher p-value (0.0051) than the determined significance level (0.05) which confirms the direct association between them. It is interpreted that there is a predictability trait within futures and spot markets for the forecasting of the variation in the spot markets and this is because of the marginal interdependency in terms of reaction to market trends, this dual-market perspective wherein both the markets are studied in tandem using the GARCH(1,1), with the focus on the top 5 economies in the World, makes the study stand out amongst the traditional studies conducted on volatility modeling (Kavussanos & Nomikos, 2000; Brooks et al., 2001) There is the presence of volatility persistence in all the markets for both spot and futures and the Japanese market seems to be the best for investors with the best decay in volatility rate and Chinese market with the lowest decay in volatility is the most volatile. The Western markets seem pretty stable vis a vis their Asian counterparts highlighting quick reactivity and assimilation of fresh information (Floros, 2009; Alizadeh et al., 2002), the study provides a grasp into the global volatility dynamics. Futures markets due to the probable reasons of rapid price discovery or speculative activities react faster to the news and the volatility decays faster in their case as compared to spot making them the better option for investors. The use of ‘Decay in Volatility’ as a variable for investor decision-making has brought novelty to the research and can be assessed by researchers and academia for further advancement and theoretical development. Such insights into volatility decay and persistence can help investors strategize and optimize the risk-return trade-off. Such findings can help the policymakers and regulators in assessing the risks and making macroprudential policies support the financial markets’ efficiency through the assessment of volatility dynamics and strengthen liquidity by aiding transparency.

6. SCOPE OF FUTURE RESEARCH

Only Univariate analysis has been conducted using the variable “Decay in Volatility”, there is scope for multivariate analysis, combining the variable with others for future research. More international markets can also be incorporated. The research powered with GARCH analytics lacks the perception of end users like institutional investors towards the investment opportunity between futures and spot markets in the major economies and this limits the applicability of the derivable. Hence, in the future, it will be focused on using both statistical and primary data analysis for enhancing the subjective and objective inferences about the risk-free investment possibility in futures and spot markets.

REFERENCES

1. Ahn, K., Bi, Y. and Sohn, S. (2018). Price discovery among SSE 50 Index-based spot, futures, and options markets. Journal of Futures Markets, 39(2), pp.238–259. doi:https://doi.org/10.1002/fut.21970.
2. Alizadeh, S., Brandt, M. W., & Diebold, F. X. (2002). Range-based estimation of stochastic volatility models. The Journal of Finance, 57(3), 1047–1091
3. Basu, S. (2020). Spot and futures markets – Scope for integration. IIMB Management Review. doi:https://doi.org/10.1016/j.iimb.2020.10.001.
4. Baule, R., Frijns, B. and Tieves, M.E. (2018). Volatility discovery and volatility quoting on markets for options and warrants. Journal of Futures Markets, 38(7), pp.758–774. doi:https://doi.org/10.1002/fut.21900.
5. Bonato, M. (2019). Realized correlations, betas, and volatility spillover in the agricultural commodity market: What has changed? Journal of International Financial Markets, Institutions and Money, 62, pp.184–202. doi:https://doi.org/10.1016/j.intfin.2019.07.005.

6. Diebold, F.X. and Yilmaz, K. (2008). Measuring Financial Asset Return and Volatility Spillovers, With Application to Global Equity Markets. SSRN Electronic Journal. Doi:https://doi.org/10.2139/ssrn.956918.
7. Diebold, F.X. and Yilmaz, K. (2012). Better to give than to receive: Predictive directional measurement of volatility spillovers. International Journal of Forecasting, [online] 28(1), pp.57–66. doi:https://doi.org/10.1016/j.ijforecast.2011.02.006.
8. Floros, C. (2009). Modeling volatility using GARCH models: Evidence from Egypt and Israel stock exchanges. Middle Eastern Finance and Economics, 3(1), 31–41
9. Gupta, H. (2023). Analysing volatility patterns in emerging markets: symmetric or asymmetric models? Journal of Economic and Administrative Sciences. https://doi.org/10.1108/JEAS-07-2023-0186
10. Gupta, H. (2025). Asymmetric volatility in stock market: Evidence from selected export-based countries. The Indian Economic Journal, 73(2), 311-330.
11. Gupta, H., & Katoch, R. (2024). How do Carbon Emissions Spillovers Reshape Metal Market Dynamics? Time–Frequency Insights on Precious and Non-precious Metals. Studies in Microeconomics, 23210222241284389.
12. Jain, S., Agarwalla, S.K., Varma, J.R. and Pandey, A. (2018). Informed trading around earnings announcements—Spot, futures, or options? Journal of Futures Markets, 39(5), pp.579–589. doi:https://doi.org/10.1002/fut.21983.
13. Kara, E., Anbar, A. and Arabaci, Ö. (2021). VOLATILITY SPILLOVER BETWEEN BIST 30 FUTURES and SPOT MARKETS: A DCC-GARCH ANALYSES. YönetimBilimleriDergisi. doi:https://doi.org/10.35408/comuybd.827041.
14. Kavussanos, M. G., & Nomikos, N. K. (2000). Constant vs. time-varying hedge ratios and hedging efficiency in the BIFFEX futures market. Transportation Research Part E: Logistics and Transportation Review, 36(3), 229–248.
15. Kawaller, I. G., Koch, P. D., & Koch, T. W. (1987). The temporal price relationship between S&P 500 futures and the S&P 500 index. The Journal of Finance, 42(5), 1309–1329. https://doi.org/10.1111/j.1540-6261.1987.tb04368.x
16. Li, S. (2015). "Volatility Spillovers in the CSI300 Futures and Spot Markets in China: Empirical Study Based on Discrete Wavelet Transform and VAR-BEKK-bivariate GARCH Model." Procedia Computer Science, 55, 380–387. doi:10.1016/j.procs.2015.07.085
17. Mensi, W., Yousaf, I., Vo, X.V. and Kang, S.H. (2022). Asymmetric spillover and network connectedness between gold, brent oil, and EU subsector markets. Journal of International Financial Markets, Institutions and Money, 76, p.101487. Doi:https://doi.org/10.1016/j.intfin.2021.101487.
18. Mishra, A. K., Agrawal, S., & Patwa, J. A. (2022). Return and volatility spillover between India and leading Asian and global equity markets: an empirical analysis. Journal of Economics, Finance and Administrative Science, 27(54), 294-312.
19. Nepal, R., Yadav, M. P., Katoch, R., Gupta, H., & Kumar, A. (2024). Co-movement between carbon emissions and forex market: a tale of COVID-19 outbreak and Russia-Ukraine invasion. Resources Policy, 90, 104853.
20. Rastogi, S. and Athaley, C. (2019). Volatility Integration in Spot, Futures and Options Markets: A Regulatory Perspective. Journal of Risk and Financial Management, 12(2), p.98. doi:https://doi.org/10.3390/jrfm12020098.
21. Saâdaoui, F., and Ghadhab, I. (2023). Investigating volatility transmission across international equity markets using multivariate fractional models. International Transactions in Operational Research, 30(5), 2139-2157.
22. Siddiqui S. & Roy P.(2019) "Asymmetric information linkages across select futures and spot indices: Evidence using wavelet-based GARCH model." Journal of Advances in Management Research, 17(3), 397-419. DOI 10.1108/JAMR-10-2019-0197
23. Sukhonpitumart, Purichita; Jaroenjitrkam, Anutchanat; Maneenop, Sakkakom; Padungsaksawasdi, Chaiyuth. (2020) Return and volatility spillovers between stock and futures markets in Thailand, Academy of Accounting and Financial Studies Journal; London Vol. 24, Iss. 2, (2020): 1-14.
24. Tarique, J. and Malik, I. R. (2020). "The Impact of Index Futures on Market Efficiency and Volatility of Spot Index: An Empirical Evidence from Emerging Economies (BRICS)." FUJBE, 5(2), 1 - 17.
25. Yadav, M. P., Sharif, T., Ashok, S., Dhingra, D., & Abedin, M. Z. (2023). Investigating volatility spillover of energy commodities in the context of the Chinese and European stock markets. Research in International Business and Finance, 65, 101948. https://doi.org/10.1016/j.ribaf.2023.101948
26. Younis, I., Gupta, H., Du, A. M., Shah, W. U., & Hanif, W. (2024a). Spillover dynamics in DeFi, G7 banks, and equity markets during global crises: A TVP-VAR analysis. Research in International Business and Finance, 70, 102405. . DOI: 10.1016/j.ribaf.2024.102405
27. Younis, I., Gupta, H., Shah, W. U., Sharif, A., & Tang, X. (2024b). The effects of economic uncertainty and trade policy uncertainty on industry-specific stock markets equity. Computational Economics, 64(5), 2909-2933. https://doi.org/10.1007/s10614-024-10552-1
28. Zhou, B. & Wu, C. (2016) "Intraday dynamic relationships between CSI 300 index futures and spot markets: a high-frequency analysis." Neural Comput & Applic 27, 1007–1017. https://doi.org/10.1007/s00521-015-1915-y

29. Zhou, X., Zhang, W. and Zhang, J. (2012). Volatility spillovers between the Chinese and world equity markets. Pacific-Basin Finance Journal, 20(2), pp.247–270. doi:https://doi.org/10.1016/j.pacfin.2011.08.002.