The Temporal Study of Spot and Futures Market Volatility : Cross Linkages among the Equity, Commodity, and Forex Markets in India

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Abstract

Purpose : The article attempted to generate a volatility series and evaluate its inter & intra relationships across various sub-markets and divisions of the Indian financial market, namely the commodity, equity, and foreign exchange markets.

Methodology : The autoregressive conditional heteroskedastic (ARCH) and generalized autoregressive conditional heteroskedastic (GARCH) models were used in the study together with the conventional approach of standard deviation to produce the volatility series. The overall and segment-specific association was analyzed using a correlation matrix.

Findings : The analysis revealed a favorable association with the intra-market of the respective markets, although a negative correlation was identified between the equity and commodity spot market and the forex market.

Practical Implications : The study aimed to enhance stakeholders' knowledge of intermediary and inter-market volatility and to investigate the relationship between the Indian financial (equity, commodity, and currency) submarkets.

Originality : The study sought to examine the volatility of the Indian market and the interrelationship of volatility among the various submarkets within the Indian financial submarkets using a temporal break based on the incremental movement of every 10,000 points of the BSE sensitivity index (SENSEX).

Keywords : **volatility, standard deviation, ARCH, GARCH, correlation**

JEL Classification Codes : E44, G10, G19

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The financial market plays a crucial role in allocating resources efficiently and capital formation. Financial markets help in providing liquidity, mobilizing savings, and determining the allocation of investment. The presence of market volatility in the market introduces uncertainty and instability, complicating the

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process of determing suitable investment decisions. Volatility has gained significance in finance since a long time ago as it is a crucial factor as a means to quantify risk. There is a greater importance to understanding the concept of volatility, and it is also regarded as an opportunity-seeking period, where portfolio adjustments are done on a volatile market and are also used for the price discovery process of securities. The price of a securities might fluctuate, either increasing or decreasing in value, and this is known as volatility. In addition to being used to determine asset prices, volatility assesses the riskiness of an investment. When volatility is used in the pricing of financial assets, it helps to estimate fluctuations that are likely to occur over the short term. Volatility is associated with unpredictability, uncertainty, and risk. Volatility has become important for financial market stakeholders, and it has an impact on the smooth functioning of economic performance and business investment. There is a direct correlation between high market risk and high volatility. The financial market's volatility fluctuates over time and is never constant. A high degree of volatility lowers investor confidence and is perceived as a threat. Naturally, higher volatility increases the possibility of both bigger gains and losses.

Both internationally and domestically, volatility has been measured and forecasted, and a large number of writers have made significant contributions to the study of financial market volatility. In order to determine the relationship between the volatility of the Malaysian stock market and the exchange rate as well as the price of crude oil, Lim and Sek (2013) used symmetric and asymmetric generalized autoregressive conditional heteroskedastic (GARCH) models. The study concludes that both the GARCH and TGARCH models are better performers in times of pre-crisis. More precisely, the TGARCH model performed superior performance during post-crisis, while the GARCH model exhibited better performance during crisis periods.

The Indian stock market's wide index has been used to study the volatility and pattern of the Indian equities market, as reported by Nishad and Thomachen (2015) and related studies. The Indian stock market's wide index was used in (Nishad & Thomachen, 2015) extensive research on the pattern and volatility of the Indian equities market. The study conducted by Vasudevan and Vetrivel (2016) uses both symmetric and asymmetric GARCH models (Exponential GARCH (1,1) and threshold GARCH (1,1) models) to forecast the volatility of the SENSEX. The GARCH (1, 1) model performed better than all other models and showed a higher capacity for volatility prediction, according to the study's findings.

The most frequently traded commodities on the Multi Commodity Exchange of India were the subject of an analysis by Kaura and Rajput (2021) that looked at the relationship between futures and spot prices. The pricing correlations of three commodity segments—agricultural, energy, and metals and gold—are compared by the researcher. It was found that bullion and energy metals demonstrate similar patterns, but the behavior of agricultural commodities is quite different from non-agricultural commodities.

The impact of futures price volatility on Indonesia's spot coffee market is investigated in a study by Wulandari et al. (2019). The findings showed that overseas markets have a greater influence on emerging nations and that the futures market affects the spot market. Amoah (2021) examined the connection between commodity futures and spot prices and found that neither the spot nor the futures prices of the commodities had any discernible effects on the other. Kaur and Arora (2018) investigated the reciprocal dependency of the four Indian financial markets (equity, commodities, currency, and G-bonds) over both the short and long terms. The analysis found no evidence of a long-term relationship between the markets and concluded that there is no comovement between the two local financial markets. The volatility behavior of the BSE's sectoral indices, including those for autos, banks, FMCG, IT, healthcare, and energy, was examined by Mallikarjuna and Rao (2017). Volatility is modeled using GARCH, TGARCH, and EGARCH. The FMCG, IT, and healthcare sectors showed no leverage effect, according to the research. It was discovered that the indices' average was positive and had a strong persistence in volatility.

Ajoy Kumar and Shollapur (2015) examined the correlation between spot and futures prices of soy oil in India's futures market. It assesses the efficacy of the futures market in determining prices. The study used cointegration, the vector error correction model, and the bivariate BEKK-GARCH model to analyze daily spot and futures pricing data. A correlation between long-term stability and the futures market has been identified as

the primary determinant of price setting. In the near term, both futures and spot prices exhibited significant volatility. Karthikeyan and Karthika (2016) investigated the impact of futures trading on the volatility of the CNX Nifty. To assess returns prior to and following the start of futures trading, the GARCH model was applied. The results demonstrated that the introduction of index futures trading resulted in a reduction in the volatility of CNX Nifty. Savadatti (2018) examined the possibility of volatility transmission between the Indian stock market and the US stock market. It analyzes the weekly market returns from 1997 to 2018 using the Dow Jones and BSE SENSEX indexes.

The findings indicate a clear and statistically significant transfer of volatility from the American stock market to the Indian stock market. Specifically, the BSE SENSEX exhibits a high degree of enduring volatility. Faniband and Faniband (2021) developed the broad total return index (BTRI), which provides a fresh dataset for Indian government bond pricing. The effects of volatility on government bonds and the stock market are analyzed using GARCH data from 2004 to 2019. No evidence of a lead-lag link or Granger connection between BTRI and Nifty was discovered by the analysis. When considering the variation from Nifty to BTRI, there was no observed alteration in the coefficient of squared residuals for Nifty. This study is beneficial for those who engage in purchasing both equities and government bonds.

Nirmala and Deepthy (2018) examined the volatility of the Indian commodities market by analyzing the prices of MCX AGRI, MCX METAL, MCX ENERGY, and MCX COMDEX from 2013 to 2018. The analysis considered both symmetric and asymmetric ARCH family models and observed that all of the indexes had a significant level of volatility consistency. The leverage impact was observed only in the MCX ENERGY index among the imbalanced models. For MCX AGRI and MCX ENERGY, the EGARCH (1, 1) model exhibited best performance. For MCX Metal, the TARCH(1, 1) model produced the best results, whereas GARCH(1, 1) proved to be the most successful for MCX COMDEX.

Thiyagarajan et al. (2015) stated that the agricultural commodities index "Dhaanya" in NCDEX is influenced by news in the equity and foreign exchange market, indicating a correlational impact on the various markets. Mukherjee and Goswami (2017) studied the volatility of the commodity market in India with reference to futures of agricultural and non-agricultural commodities potato, gold, crude oil and menthe oil. The standard deviation is used for the calculation of the daily volatility. The study stated that there will be a continuation of the uncertainty of the market in the future period.

It has been identified that volatility impacts the active functioning of the financial system, thereby making it an integral part of the financial market. Literature is vastly available on topics such as the study of measuring and estimating the model of volatility in terms of a single market, volatility study with respect to various incidences such as the crisis of 2008, introduction of new instruments, characteristics and the spill-over of the various financial markets. Nevertheless, only a small number of studies have addressed the volatility of the BSE or NSE index SENSEX and Nifty50 over time, as well as the joint analysis of volatility in the global and Indian markets for the spot and derivatives divisions. The interconnectedness of the cash and derivatives segments has only been studied with reference to particular markets. One of the essential parts (cash and derivatives) of the Indian financial markets is the demand for a collective examination of the volatility of sub-markets (equity, commodities, and currency).

Only the spot and derivatives (futures) of the Indian financial markets were included in the selection of variables, and the study was restricted to the analysis of the Indian Financial Market. It did not compare the volatility with other nations.

The various submarkets of different nations can be studied collectively to comprehend volatility and its impact, and the combined study impact of different volatility methods in the various markets and its influence on the relationship can also be analyzed. A similar study can be carried out with regard to an international scenario.

Data and Method

The purpose of this secondary data study paper is to generate the volatility series of the Indian equities, commodity, and Forex markets. The study is based on the broad indices of the three sub financial markets as well as its spot and derivative segments, focused on the futures. NSE is the leading stock exchange in India on the basis of an enormous amount of trade occurring in a day in both the spot and derivatives segments. The variables used for the study are daily adjusted Nifty50 and Nifty50 futures as a proxy for the equity market. The daily USD/INR reference rate value and the non-overlapping value of near-month USD/INR futures have similar implications for the Forex market.

Regarding the commodity market, the Bloomberg commodity spot index (BCOMSP: IND) is meant to be used as a stand-in for the commodity spot market, where the closing value is utilized, and the daily closing of the MCX Index ICOMDEX value is chosen for the future market. This is because there is not a specific commodity spot market index in India. The period of the study is from January 1, 2016, to March 31, 2022, which has been obtained from the websites of the National Stock Exchange, Multi-Commodity Exchange, Bloomberg, Investing.com, and the Reserve Bank of India.

In addition to the return series, standard deviation, ARCH, and GARCH series were generated with the aid of Excel. The study takes into account the daily return series of the relevant variables. Returns were computed as the first difference logarithms of the close prices of the proxy variables.

$$Returns = 100 * \log(Closing\ Price\ X / Closing\ Price\ X(-1)) \quad \ldots\ldots\ldots (1)$$

↳ ***Standard Deviation.*** It is a measure of risk and is the square root of the variance of the return series. Rolling standard deviation is a common method used for measuring historical volatility.

$$SD(\sigma) = \sqrt{(x_i - \mu)^2 / N} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

The model proposed by Engle (1982) is the auto-regressive conditional heteroscedastic model. The ARCH model equation is :

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon^2_{t-1} + \alpha_2 \varepsilon^2_{t-1} + \ldots + \alpha_p \varepsilon^2_{t-1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

The use of the price series of the variables has generated the ARCH series. The returns have been calculated as Returns = (Present Price – Previous Price)/Previous Price. The computation of the average, variance, and standard deviation follows the creation of the return series. In the first step, the return series' variance is referred to as omega, and the average return is treated as a constant value. The squared residual and lag residual series are produced after initializing alpha to zero and utilizing [return + constant] to calculate the residual.

The conditional variance is calculated by using (unconditional variance + alpha *lagged squared residual). The log-likelihood series is generated through :

$$L(\mu, \omega, \alpha) = 1/V_t \sqrt{2\pi} * e\ \hat{}\ -\varepsilon_t^2 / 2V_t^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

where, L = logarithm, V = conditional variance, e = exponent, and ε = squared residuals.

The total of all the log-likelihood series will be used to estimate the log-likelihood function. The data solver is utilized for the optimization work inorder to adjust the parameters, which include the constant, variance, alpha coefficient, and variance, and to reach the optimal value. After the change of the parameters, the square root of the squared residual is used to calculate the realized volatility and the ARCH volatility series [= square root of the conditional variance].

The generalized variance of ARCH was developed by Tim Bollerslev (1986) and is known as the generalized autoregressive conditional heteroskedastic model (GARCH).

The model relies on the assumption that the volatility of today depends on a constant, yesterday's variance and yesterday's news about variance. The GARCH (1,1) model can be written as:

$$\sigma_t^2 = a + \alpha_1\varepsilon^2_{t-1} + \beta\sigma^2_{t-1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(5)$$

The use of the price series of the variables has generated the GARCH series. The returns have been calculated as Returns = (Present Price – Previous Price)/Previous Price. After the generation of the return series, the average, variance, and standard deviation are calculated. The variance of the return series is referred to as omega (unconditional variance) at the beginning stage, and the average return is regarded as constant. Squared residual and lag residual series are produced after initializing alpha and beta to zero in order to compute the residual using the return + constant (initial).

The conditional variance is calculated by using unconditional variance + alpha *lagged squared residual + beta* conditional variance (–1).

The log-likelihood series is generated through the formula

$$L(\mu, \omega, \alpha) = 1/V_t\sqrt{2\pi} * e \wedge -\varepsilon_t^2/2V_t^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(6)$$

where, L = logarithm, V = conditional variance, e = exponent, and ε = squared residuals.

Then, the log-likelihood function will be estimated by the sum of all the log-likelihood series. For the change of the parameters, the data solver is used for the optimization so that we can obtain the optimal value and change the parameter value, which includes the constant, alpha and beta and the total of alpha + beta. The alpha and beta values must be between zero and one, and the addition of the alpha and beta values must be less than 1. After all the parameters are changed, the realized volatility is calculated as the square root of the squared residual and for the GARCH volatility series = square root of the conditional variance.

Table 1. ***Descriptive Statistics of Price, Return, and Volatility Series of Equity Market Segments During January 2016 – March 2022***

Particulars	**EQUITY MARKET**									
	SPOT (Proxy : Nifty 50)					**FUTURES (Proxy : Nifty 50 Futures)**				
	Price (@Level)	**Returns (1^{st} Δ)**	**Volatility**			**Price (@Level)**	**Returns (1^{st} Δ)**	**Volatility**		
			SD	**ARCH**	**GARCH**			***SD***	**ARCH**	**GARCH**
Mean	11408.3	0.055	0.007	0.010	0.010	11424.70	0.055	0.007	0.010	0.010
Median	10825.6	0.079	0.005	0.009	0.008	10837.72	0.082	0.005	0.009	0.008
Max	18477.0	10.23	0.133	0.083	0.072	18495.4	9.477	0.137	0.082	0.068
Min	6970.6	–13.90	0.000	0.008	0.005	6968.5	–14.02	0.000	0.008	0.006
Std. Dev.	2790.5	1.153	0.009	0.004	0.005	2793.11	1.169	0.009	0.004	0.005
Skewness	0.891	–1.073	5.637	8.348	5.856	0.890	–1.074	5.877	8.261	5.879
Kurtosis	3.001	27.18	53.44	107.2	49.39	2.997	26.711	62.30	104.44	49.127
JB Test	194.0	35921.6	162742.6	679059	139493.1	193.3	34554.1	222638.1	643591.4	138039.6
***P*-Value**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
N	1,464	1,463	1,462	1,462	1,462	1,464	1,463	1,462	1,462	1,462

Table 2. ***Descriptive Statistics of Price, Return, and Volatility Series of Commodity Market Segments During January 2016 – March 2022***

Particulars	COMMODITY MARKET									
	SPOT (Proxy : BCOMSP : IND)					FUTURES (Proxy : ICOMDEX)				
	Price Level (@Level)	Returns (1^{st} ∆)	Volatility			Price Level (@Level)	Returns (1^{st} ∆)	Volatility		
			SD	ARCH	GARCH			*SD*	ARCH	GARCH
Mean	365.7	0.057	0.006	0.009	0.009	10730.7	0.026	0.006	0.009	0.009
Median	344.6	0.097	0.004	0.008	0.008	10685.0	0.052	0.005	0.008	0.008
Max.	668.3	6.381	0.052	0.031	0.026	16201.7	10.566	0.095	0.060	0.051
Min.	252.5	–5.342	0.000	0.008	0.006	7926.9	–5.766	0.000	0.008	0.006
Std. Dev.	71.41	0.934	0.006	0.001	0.002	937.9	0.982	0.006	0.002	0.002
Skewness	1.59	–0.206	2.091	5.050	2.855	0.730	0.415	3.278	8.692	5.685
Kurtosis	5.394	7.526	9.477	41.637	14.378	7.523	14.720	30.613	141.908	56.263
JB Test	969.9	1259.42	3621.8	97156.7	9873.831	1378.556	8416.4	49068.4	1193828.	180698.5
***P*-Value**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
N	1,464	1,463	1,462	1,462	1,462	1,464	1,463	1,462	1,462	1,462

Table 3. ***Descriptive Statistics of Price, Return, and Volatility Series of Forex Market Segments During January 2016 – March 2022***

Particulars	FOREX MARKET									
	SPOT (Proxy : USD/INR Reference Rate)					FUTURES (Proxy : USD / INR Futures)				
	Price Level (@Level)	Returns (1^{st} ∆)	Volatility			Price Level (@Level)	Returns (1^{st} ∆)	Volatility		
			SD	ARCH	GARCH			*SD*	ARCH	GARCH
Mean	70.067	0.008	0.002	0.003	0.003	70.182	0.008	0.007	0.003	0.003
Median	70.237	0.001	0.001	0.003	0.002	70.361	–0.019	0.005	0.003	0.003
Max.	76.923	1.374	0.016	0.008	0.007	77.130	2.001	0.137	0.008	0.008
Min.	63.348	–1.535	0.000	0.002	0.002	63.517	–1.418	0.000	0.003	0.002
Std. Dev.	3.800	0.327	0.002	0.000	0.001	3.790	0.347	0.009	0.001	0.001
Skewness	–0.072	–0.049	1.809	3.280	1 .907	–0.076	0.538	5.877	4.746	2.837
Kurtosis	1.702	4.912	7.637	16.533	7.392	1.704	6.110	62.301	36.472	15.121
JB Test	103.970	223.51	2108.54	13778.5	2062.2	103.79	660.57	222638.1	73743.3	10912.2
***P*-Value**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
N	1,464	1,463	1,462	1,462	1,462	1,464	1,463	1,462	1,462	1,462

For the specification of the properties of the level, first difference, returns and the volatility series for the study period, the descriptive statistics are reported in Table 1, Table 2, and Table 3. The average, standard deviation, maximum, minimum, skewness, and kurtosis are all displayed. E-views nine econometrics have been used to help with the study.

In order to examine the temporal impact of volatility, the maximum and minimum are computed for each year from 2016 to 2021. Additionally, the return variation is broken down year-by-year and break-wise, based on the

movement of the Bombay Stock Exchange index SENSEX, which is updated every 10,000 points starting at 30,000 points. The paper will make use of the following temporal breaks, as shown below.

Period 1 spans the period from January 1, 2016, to May 22, 2019, and represents the BSE SENSEX movement from 30,000 points to 40,000 points. The rise from 40,000 points to 50,000 points occurs during Period 2 (May 23, 2019, to January 20, 2021), while Period 3 (January 21, 2021, to March 31, 2022) is the movement above 50,000 points. The evaluation of the relationship is conducted with the help of correlation analysis.

The hypotheses of the correlation are as follows:

- **H01 :** There is no significant relationship between the submarkets (equity, commodity, and foreign exchange) of the Indian financial market.
- **H02 :** There is no significant relationship between the submarket divisions (spot and futures) of the Indian financial market.
- **H03 :** There is no significant relationship between the different volatility series (*SD*, ARCH, and GARCH) of Indian financial market submarkets.

Analysis and Results

The variables' standard deviation, ARCH, and GARCH indicate the price series, return series, and volatility series, respectively. The graph shows the following: Commodity market spot (CMS) BCOMSP: IND, commodity market future (CMF) ICOMDEX, Forex market spot (FMS) USD/INR reference rate, Forex market future (FMF) USD/INR (Fut), and equity market spot (EMS) NIFTY50, and equity market future (EMF) NIFTY50 (Fut). Figures 1 to 6 show the graphs of the price series and the return series of the variables. Figures 7 to 9 include the graph plots of the various volatility series segregated with regard to the temporal period break. The plot of the return series indicates that there has been a constant fluctuation around the value of zero, where the value varies on both the positive and negative sides. There is a presence of volatility clustering, where high volatilities follow high volatilities and low volatilities are followed by low volatilities.

Figure 1. ***Graph of the Equity Market (Spot) Segment Price and Return Series***

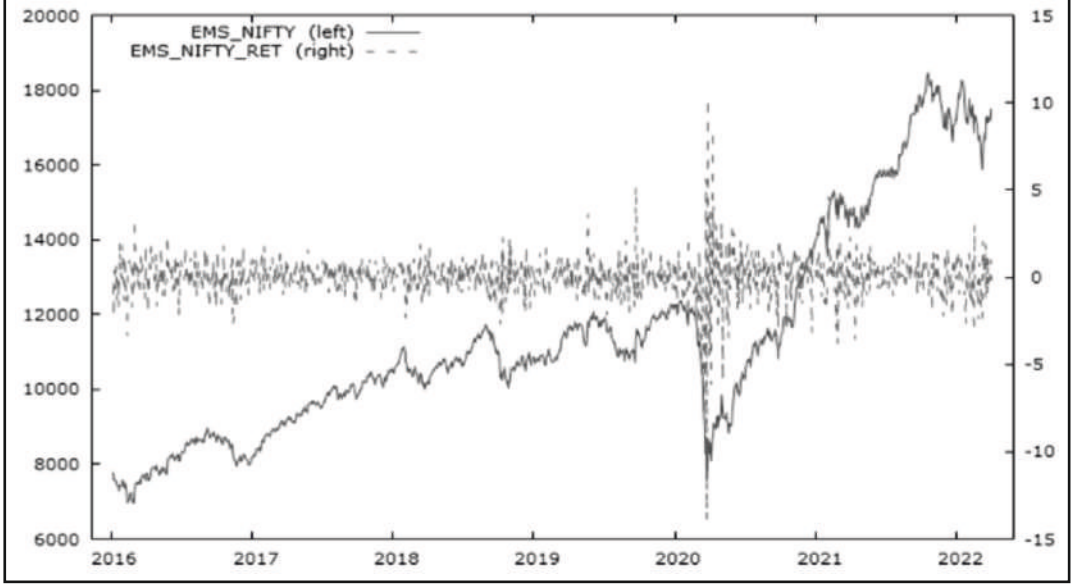


Figure 2. ***Graph of the Commodity Market (Spot) Segment Price and Return Series***

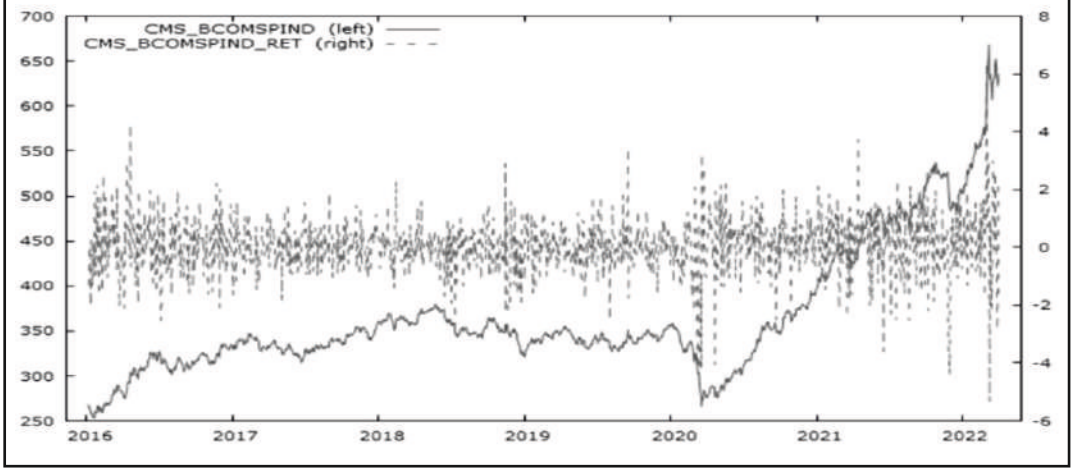


Figure 3. ***Graph of the Forex Market (Spot) Segment Price and Return Series***

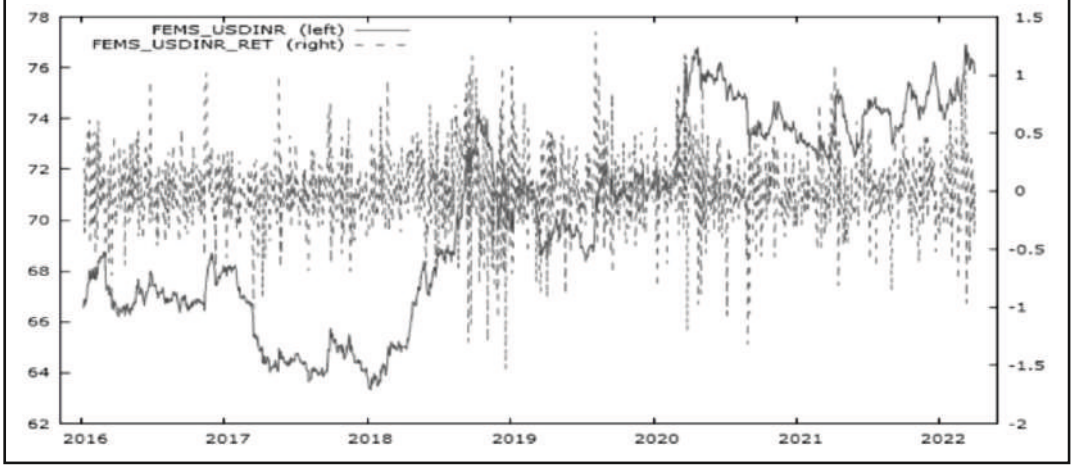


Figure 4. ***Graph of the Equity Market (Derivative) Segment Price and Return Series***

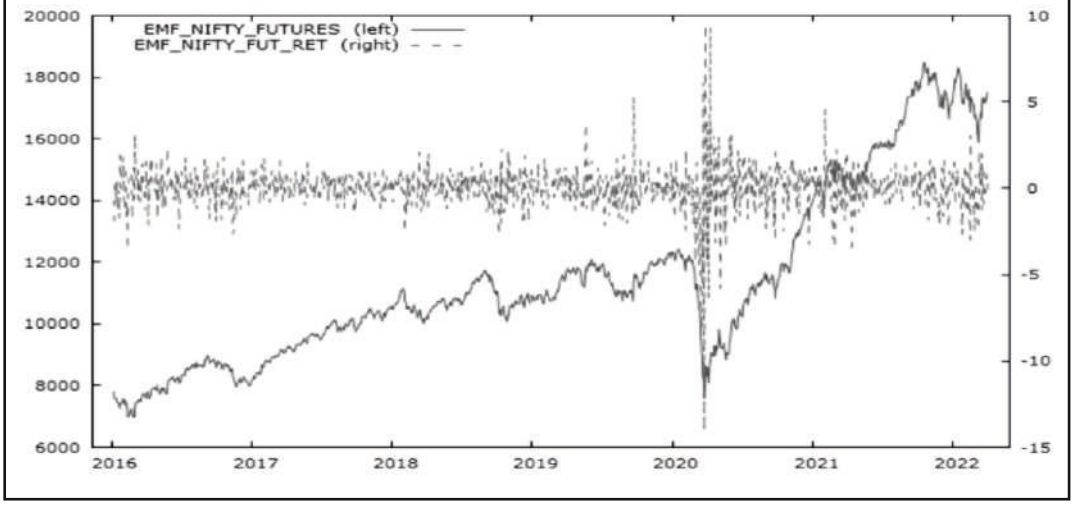


Figure 5. ***Graph of the Commodity Market (Derivative) Segment Price and Return Series***

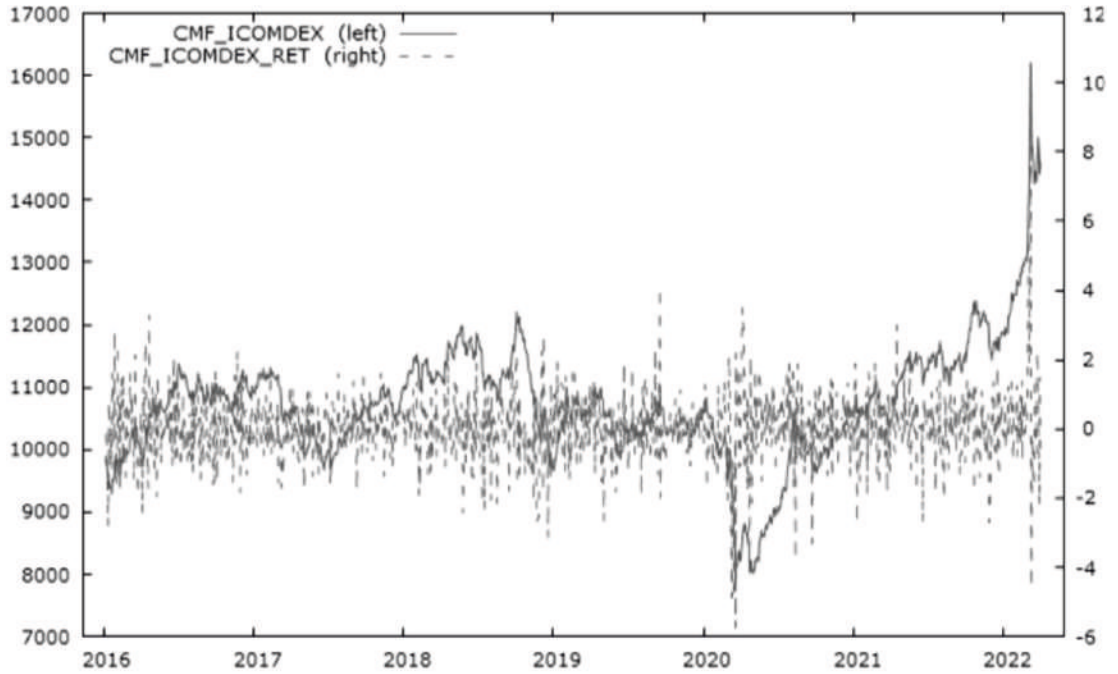


Figure 6. ***Graph of the Forex Market (Derivative) Segment Price and Return Series***

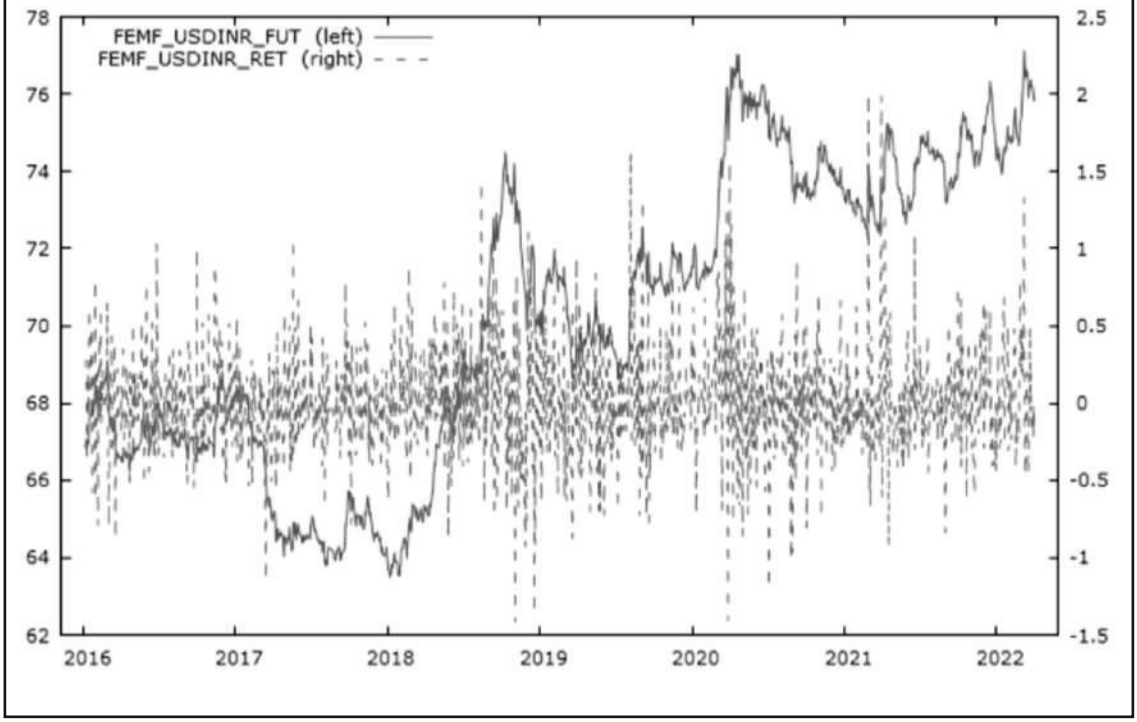


Figure 7. ***Graph of the Volatility Series of Equity Market (Spot and Derivatives Segment)***

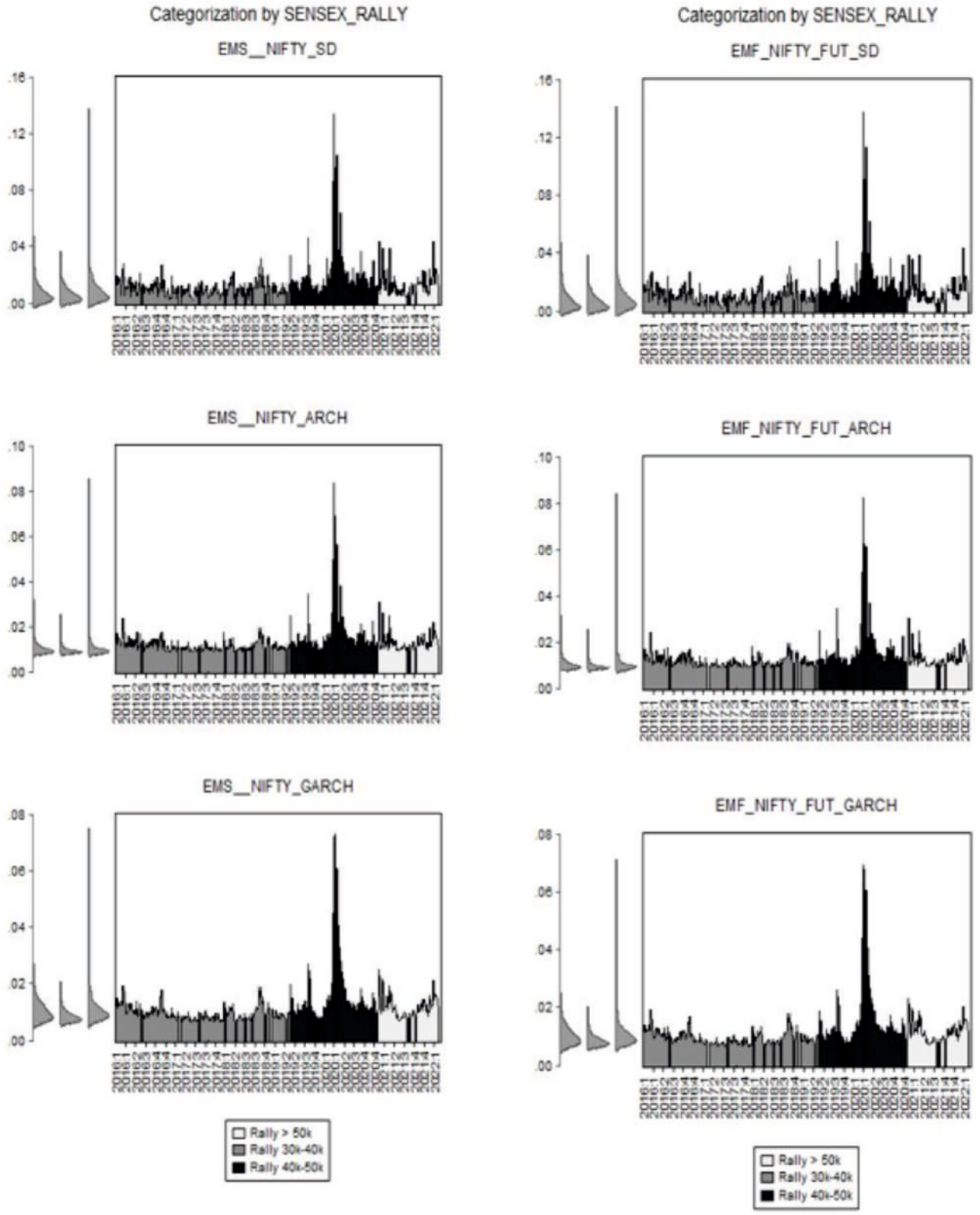


Figure 8. ***Graph of the Volatility Series of Commodity Market (Spot and Derivatives Segment)***

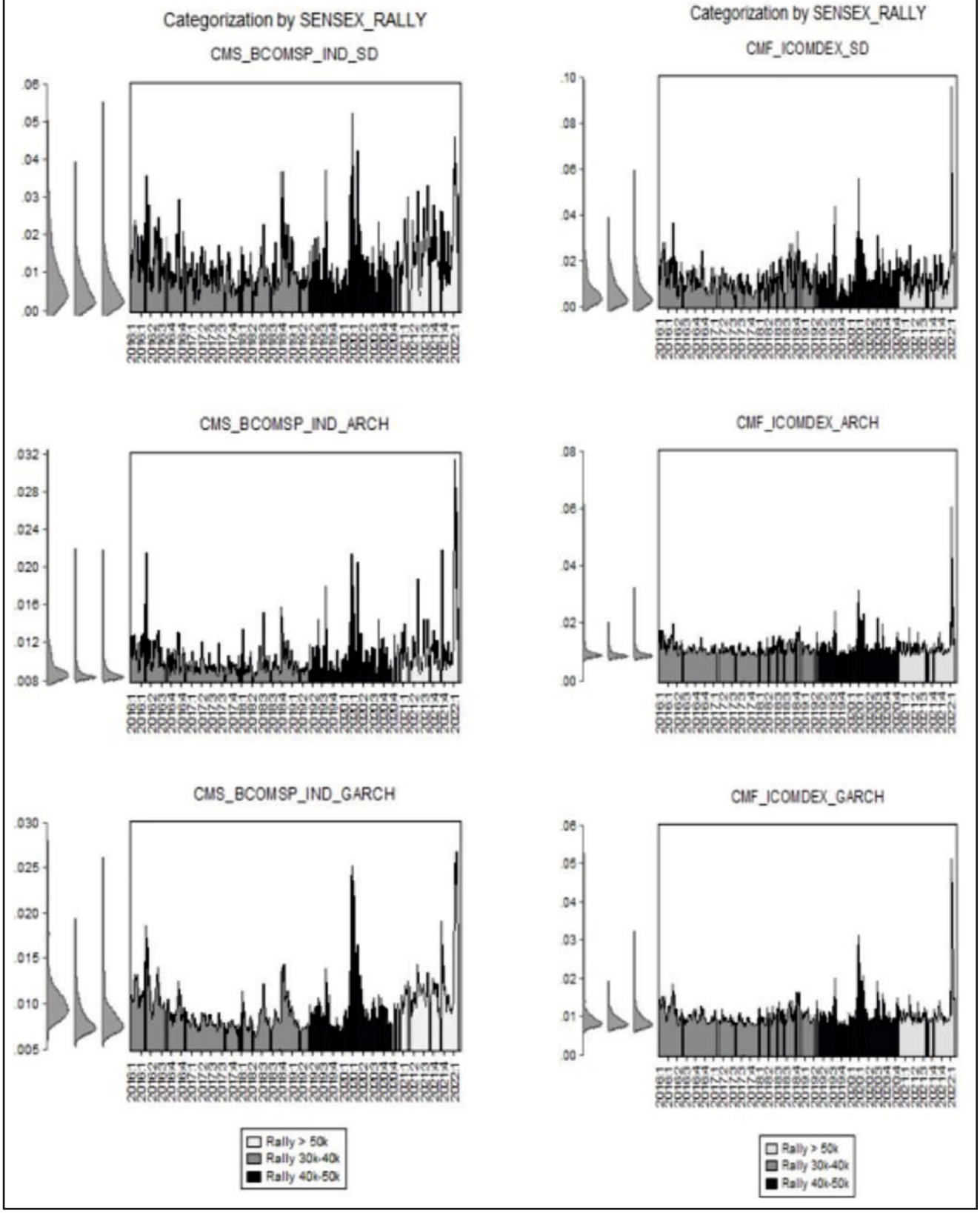


Figure 9. ***Graph of the Volatility Series of Forex Market (Spot and Derivatives Segment)***

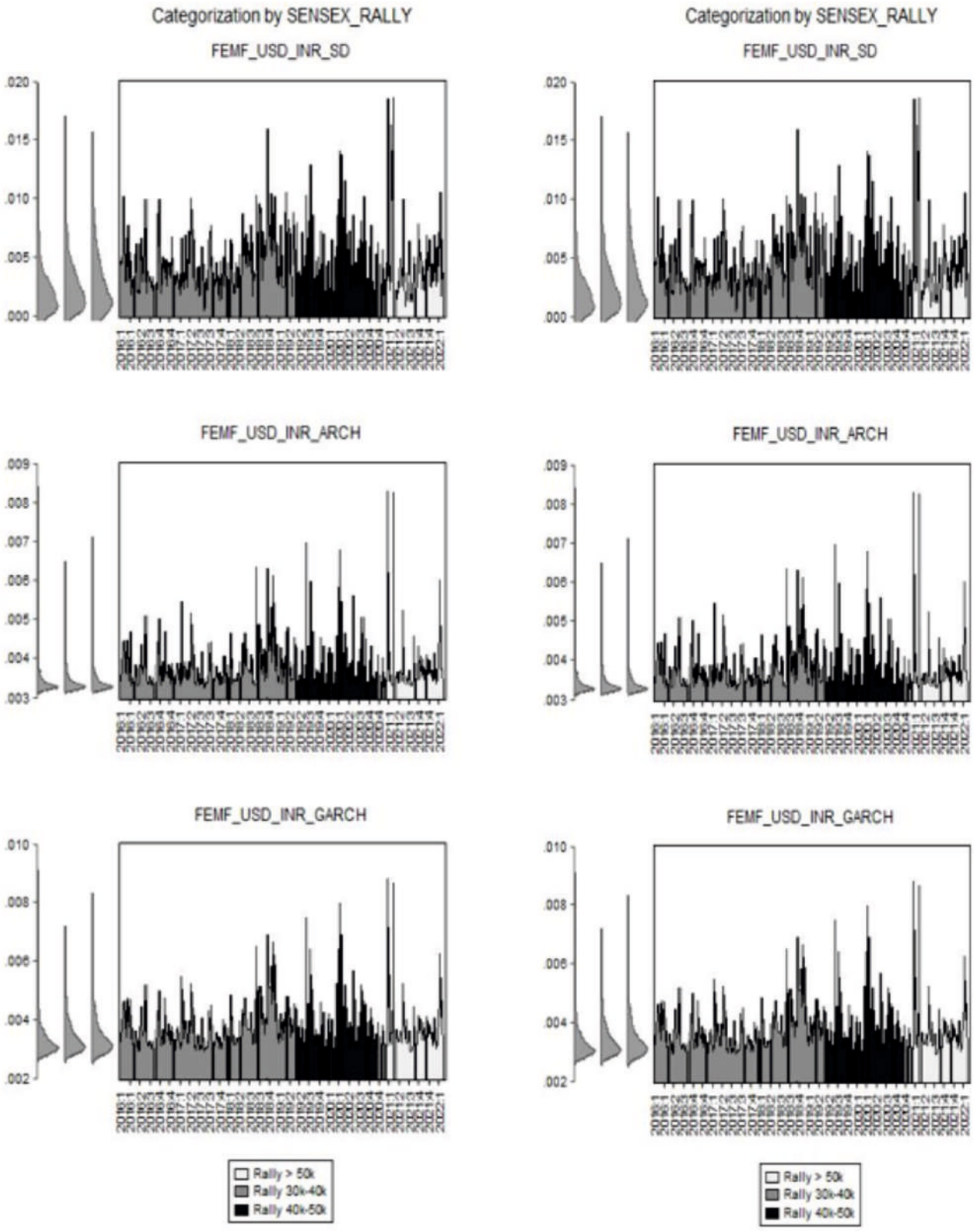


Table 4 displays the highest and minimum values for the variables' positive and negative returns broken down by year. There are two categories for the variable returns: positive return values and negative return values. Due to the fact that the year 2022 data only includes 57 data observations as of March 31, 2022, it has not been taken into consideration here. It will not provide an accurate year analysis.

Table 4. ***Positive and Negative Risk and Return of Indian Financial Markets (Equity, Commodity, and Forex)***

With the respective segments of (Spot and Derivatives) during 2016 – 2021 *+VE : Positive Return – VE Negative Return*

Particulars		Equity Market				Commodity Market				Foreign Exchange Market			
		SPOT		FUTURES		SPOT		FUTURES		SPOT		FUTURES	
		+VE	–VE	+VE	–VE	+VE	–VE	+VE	–VE	+VE	–VE	+VE	–VE
2016	**Max.**	3.311	–0.0006	3.091	–0.002	4.245	–0.019	3.299	–0.01	1.02	–0.002	1.031	–0.007
[*n*=232]	**Mean**	0.661	–0.71	0.723	–0.687	0.833	–0.710	0.796	–0.710	0.227	–0.212	0.250	–0.208
	± *SD*	0.609	0.65	0.584	0.667	0.724	0.578	0.651	0.567	0.188	0.165	0.218	0.180
	Min.	0.0006	–3.37	0.012	–3.555	0.040	–2.54	0.0009	–2.82	0.001	–0.726	0.003	–0.875
	n	125	107	117	115	121	111	116	116	117	115	110	122
2017	**Max.**	1.795	–0.0009	1.773	–0.003	1.888	–0.01	1.697	–0.003	0.99	–0.002	1.064	–0.003
[*n*=235]	**Mean**	0.518	–0.388	0.473	–0.412	0.506	–0.49	0.481	–0.514	0.187	–0.210	0.214	–0.196
	± *SD*	0.38	0.363	0.375	0.351	0.381	0.377	0.369	0.425	0.168	0.190	0.188	0.170
	Min.	0.008	–1.568	0.005	–1.549	0.002	–1.83	0.001	–1.80	0.001	–1.010	0.003	–1.149
	n	129	106	138	97	124	111	122	113	109	126	98	137
2018	**Max.**	2.297	–0.006	2.261	–0.0004	2.914	–0.004	2.738	–0.02	1.16	–0.001	1.435	–0.003
[*n*=234]	**Mean**	0.5986	–0.702	0.618	–0.690	0.506	–0.611	0.631	–0.754	0.336	–0.299	0.345	–0.278
	± *SD*	0.474	0.571	0.494	0.585	0.473	0.536	0.564	0.665	0.245	0.292	0.258	0.262
	Min.	0.0009	–2.704	0.006	–2.708	0.006	–2.71	0.004	–3.15	0.001	–1.535	0.003	–1.418
	n	129	105	126	108	118	116	118	116	124	110	119	115
2019	**Max.**	5.182	–0.0004	5.310	–0.009	3.425	–0.0002	4.085	–0.006	1.37	–0.002	1.622	–0.003
[*n*=236]	**Mean**	0.657	–0.626	0.682	–0.629	0.504	–0.49	0.581	–0.592	0.268	–0.246	0.292	–0.252
	± *SD*	0.690	0.456	0.712	0.463	0.476	0.439	0.574	0.491	0.238	0.197	0.274	0.197
	Min.	0.011	–2.161	0.003	–2.177	0.003	–2.50	0.003	–2.6	0.003	–0.915	0.003	–0.877
	n	124	112	122	114	127	109	127	109	117	119	114	122
2020	**Max.**	10.23	–0.001	9.477	–0.003	3.232	–0.004	3.502	–0.003	1.18	–0.004	1.558	–0.003
[*n*=238]	**Mean**	1.111	–1.446	1.113	–1.481	0.660	–0.892	0.775	–0.940	0.252	–0.248	0.285	–0.260
	± *SD*	1.306	1.99	1.344	2.03	0.577	0.944	0.613	1.08	0.229	0.259	0.284	0.260
	Min.	0.029	–13.90	0.008	–14.02	0.013	–4.28	0.0005	–5.76	0.001	–1.318	0.003	–1.408
	n	140	98	141	97	144	94	130	108	123	115	118	120
2021	**Max.**	4.633	–0.005	4.577	–0.008	3.730	–0.003	3.00	–0.004	1.08	–0.007	2.001	–0.006
[*n*=231]	**Mean**	0.756	–0.745	0.759	–0.745	0.773	–0.825	0.632	–0.707	0.223	–0.193	0.256	–0.205
	± *SD*	0.635	0.725	0.630	0.723	0.620	0.837	0.514	0.626	0.201	0.166	0.329	0.173
	Min.	0.008	–3.836	0.004	–3.737	0.004	–4.39	0.004	–2.73	0.002	–0.856	0.003	–0.925
	n	129	102	129	102	134	97	131	100	111	120	107	124

Table 5. ***Temporal Break Wise Risk and Return of Indian Financial Markets (Equity, Commodity, and Forex)***

With the respective segments of (Spot and Derivatives) during 2016 – 2021 *+VE : Positive Return –VE Negative Return*

Particulars		Equity Market		Commodity Market		Foreign Exchange Market	
		SPOT Proxy : Nifty 50	FUTURES Proxy : Nifty 50 Futures	SPOT Proxy : BCOMSP : IND	FUTURES Proxy : ICOMDEX	SPOT Proxy : USD/INR Ref. Rate	FUTURES Proxy : USD/INR Futures
SENSEX Rally	**Max.**	3.625	3.725	4.245	3.299	1.167	1.435
30k – 40k	**Mean**	0.052	0.052	0.030	0.007	0.005	0.005
[*n* = 790]	**± *SD***	0.793	0.802	0.793	0.855	0.337	0.337
	Min.	–3.37	–3.55	–2.71	–3.15	–1.535	–1.418
SENSEX Rally	**Max.**	10.23	9.477	3.425	4.085	1.374	1.622
40k – 50k	**Mean**	0.051	0.051	0.045	0.002	0.012	0.012
[*n* = 396]	**± *SD***	1.693	1.721	0.946	1.068	0.328	0.367
	Min.	–13.9	–14.0	–4.28	–5.76	–1.318	–1.408
SENSEX Rally	**Max.**	4.633	4.577	6.381	10.56	1.089	2.001
> 50k	**Mean**	0.066	0.065	0.153	0.114	0.012	0.012
[*n* = 277]	**± *SD***	1.071	1.075	1.234	1.173	0.300	0.345
	Min.	–3.83	–3.73	–5.34	–4.59	–0.968	–0.925

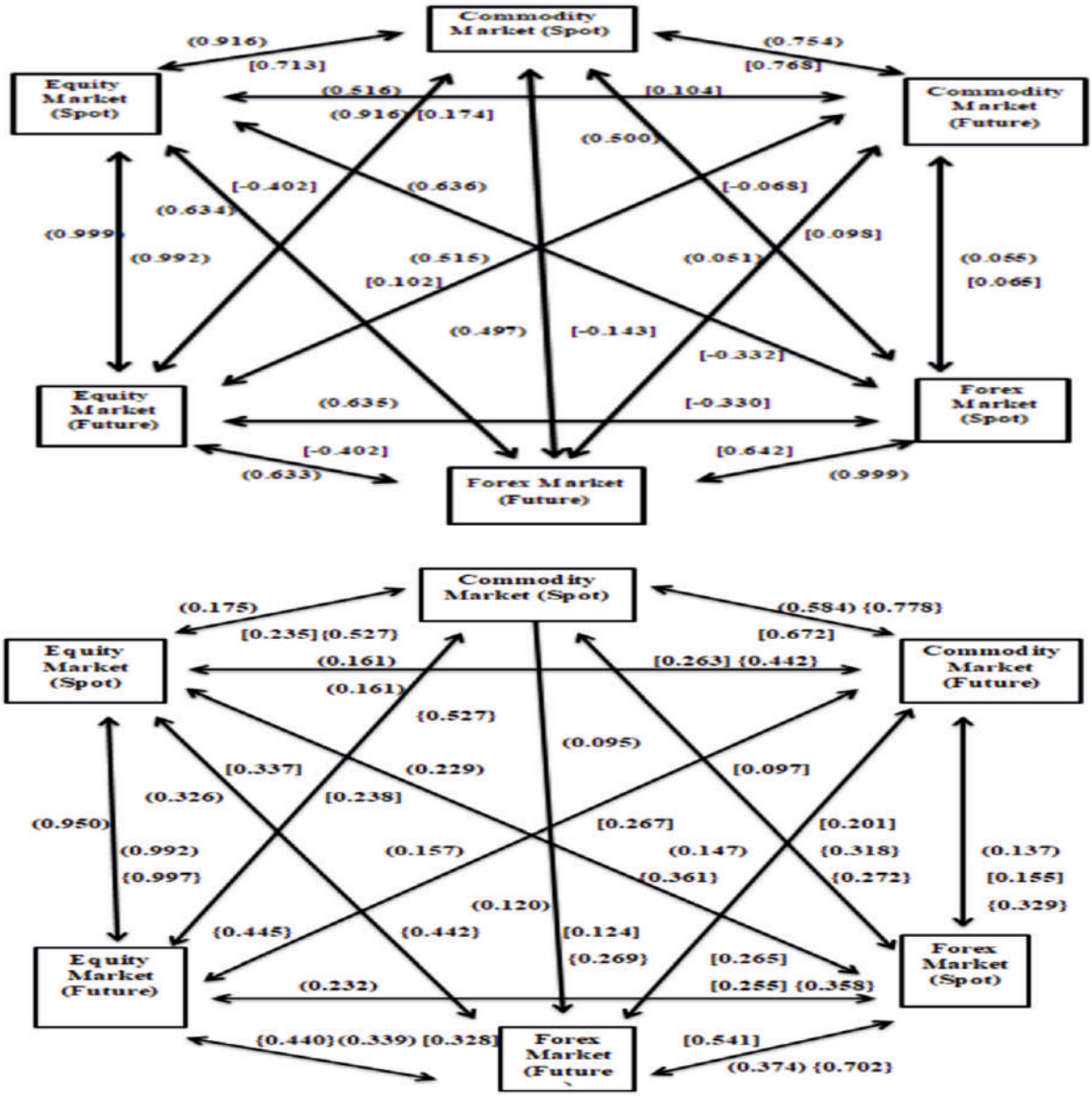
The greatest and minimum values of the variable return, based on the movement of the Bombay Stock Exchange Index SENSEX, are displayed in Table 5. Movements from 30,000 to 50,000 and beyond have been segregated every 10,000. The division was created on the basis of the idea that, in comparison to all other exchanges now in operation, the Bombay Stock Exchange has the longest history in both India and Asia. The financial market's level variables' inter- and intra-market correlation values, return, and different volatility series are shown in Figure 10, which has also been shown in tabular format in Table 6, indicating the intra and inter-market correlation.

Table 6. ***Correlation Value of the Indian Financial Markets (Equity, Commodity, and Forex) with Respective Intra and Inter Market Analysis (Spot and Derivatives) during 2016 – 2021***

Markets	@ Level	@ 1st Δ	Volatility Series		
	(Price)	(Return)	Historical (*SD*)	Time In - variant (ARCH)	Time Variant (GARCH)
Inter (Spot) Market Relationship					
NIFTY50 ↔ BCOMSP : IND	0.916	0.173	0.175	0.235	0.527
BCOMSP : IND ↔ USD/INR	0.500	–0.068	0.095	0.097	0.272
USD/INR ↔ NIFTY50	0.636	–0.332	0.229	0.265	0.361
Inter (Derivatives) Market Relationship					
NIFTY50 ↔ ICOMDEX	0.516	0.104	0.157	0.267	0.445
ICOMDEX ↔ USD/INR	0.051	0.098	0.147	0.201	0.318
USD/INR ↔ NIFTY50	0.633	–0.405	0.339	0.328	0.44
Inter Market (Spot & Futures) Relationship					
NIFTY50 ↔ ICOMDEX	0.515	0.102	0.161	0.263	0.442
NIFTY50 ↔ USD/INR	0.634	–0.402	0.326	0.337	0.442

BCOMSP : IND ↔ NIFTY50	0.916	0.174	0.161	0.238	0.527
BCOMSP : IND ↔ USD/INR	0.497	–0.143	0.12	0.124	0.269
USD/INR ↔ NIFTY50	0.635	–0.33	0.232	0.255	0.358
USD/INR ↔ ICOMDEX	0.055	0.065	0.137	0.155	0.329
		Intra Market (Spot & Futures) Relationship			
NIFTY50 ↔ NIFTY 50	0.999	0.992	0.95	0.992	0.997
BCOMSP : IND ↔ ICOMDEX	0.754	0.768	0.584	0.672	0.778
USD/INR ↔ USD/INR	0.999	0.642	0.374	0.541	0.702

Figure 10. ***Intra and Inter-Market Correlation of Price Series @ Level, Returns Series 1st Δ] and Volatility Series Standard Deviation, ARCH, and GARCH***



Intra Cash and Derivative Market

Equity Market (Cash and Derivatives)

Figures 1 and 2 show the cash segment variables Nifty50 for the equity market and the derivative segment variable NIFTY50 (Fut). In terms of its prices and returns, there is a very comparable movement. A plot of the volatility's temporal break-wise division has been created. Figures 7 and 8 show that there is more variation in the SENSEX rally for both the spot and futures throughout the 40,000-point to 50,000-point period. Table 1 displays the descriptive statistics for the equities market (cash and derivatives), and it can be seen that the prices, returns, and volatility series of the equity market all have positive average values. The stock market's standard deviation at price levels (2790.5 and 2793.11) and returns (1.153 and 1.69) is more than 1. The series is leptokurtic, with thick tails, if the Kurtosis value for each variable is larger than 3. The return of stock market segments is adversely skewed, whereas price level and volatility are positively skewed. Given that the *p*-value is less than 0.05, the price, return, and volatility series do not pass the Jarque–Bera test of normality.

Table 4 shows that the year 2020 has a greater variance for the NIFTY50 spot, with a maximum positive value of 10.231, a minimum negative value of –13.90, and a lowest positive value of 0.029. The highest standard deviation value is also in the same year (1.306 for positive and 1.993 for negative). In terms of NIFTY50 futures, the larger proportion of the difference in min–max was again seen in the year 2020, where the positive max – min value was 9.477 and 0.008, and the negative max min value was –0.003 and –14.025. Therefore, it can be derived that there is a wider fluctuation in the movement of the returns in the NIFTY50 spot & futures during 2020. Table 5 shows that the NIFTY50 spot and futures had higher movement during the rally 40k–50k break-up, with the spot's highest maximum and lowest minimum values being 10.231 and –13.903 and the futures' 9.477 and –14.025, respectively.

Commodity Market (Cash and Derivatives)

Commodity market cash segment variables BCOMSP: IND and derivative segment variable ICOMDEX at a level and return series have been plotted in Figures 3 and 4, respectively. The movements of both the segments at the level (price series) were at a constant level and had an upward trend post the first quarter of 2020. The value of the return series reverts to the value zero, concluding the presence of volatility clustering. Figure 9 displays a wider range of fluctuation in the commodity spot BCOMSP: IND standard deviation volatility series. For all volatility series, the 40k–50k and 50k–plus rallies are quite volatile. Comparatively, the ICOMDEX is fluctuating but does not have the same level of fluctuation as the BCOMSP: IND. The futures section of the commodity market exhibits more volatility throughout the separate temporal breaks of the 40k–50k and over 50k rallies. It concludes that the spot market moves more than the futures market. Table 2 depicts that there is a positive average value for the prices, returns, and volatility series of the commodity market segment. The standard deviation of the commodity market is more than one at the price level for both the spot (71.41) and futures (937.9), indicating stronger swings. The returns and volatility series' standard deviations are both less than 1. The Kurtosis values are greater than 3, indicating the series to be leptokurtic, having thick tails. The Skewness value of commodity spot returns is negatively skewed whereas positively skewed and greater than the value 0 for the return series and the volatility series.

According to the data shown in Table 4, BCOMSP: IND has the greatest fluctuation in the positive max–min values in 2016 (4.245 and 0.040) and the negative max–min values in 2021 (–0.003 and –4.396). In the commodity market, there was a wider range of movement observed in the spot market between 2016 and 2021 and in ICOMDEX in 2019. A high level of movement was found in 2019 for the variable ICOMDEX, as the positive max–min return value is 4.085 and 0.003. For the negative returns, more movement was seen during

2020, with the max–min values –0.003 and –5.766. With reference to Table 5, both the cash and derivative segments had major movement in the rally above 50k, where the max–min values were 6.381 and –5.342 and 10.566 and –4.595, respectively.

Forex Market (Cash and Derivatives)

Figures 5 and 6 show a similar tendency in the price series of the Forex market variable USD/INR reference rate and USD/INR future. Even the two segments' return series is circling their average value. A higher degree of movement can be seen in the rally of 30–40k in the spot market and futures market, according to the temporal movement evaluation shown in Figures 8 and 9. On the other hand, there is higher fluctuation in the standard deviation, ARCH, and GARCH volatility series during the surge over 50k. The Forex market is more volatile than the other markets due to the higher level of fluctuation in all volatility series than the equities and commodity markets.

Table 3 indicates that there are positive average values for the prices, returns, and volatility series of the Forex market. The standard deviation at price levels (3.80 and 3.79) is greater than 1 for both the USD/INR reference rates and futures, indicating higher fluctuations. For returns and volatility series, the standard deviation values are less than 1. The Kurtosis values for price level are less than 3, indicating the price series is platykurtic, and they are greater than 3 for returns and volatility, indicating the series is leptokurtic with thick tails. The Skewness value of the price and return series of the reference rate is negatively skewed along with the price level of the USD/INR futures. In contrast, for various volatility series, it is positively skewed and greater than the value 0.

The max–min value for the positive returns in 2019 was 1.374 and 0.003, whereas the max–min value for the Forex market in 2021 was 2.001 and 0.003, showing a greater fluctuation in the market. The maximum and lowest minimum values for the reference rate spot and futures in 2018 were –0.001 and –1.535, respectively, for the spot and –0.003 and –1.418, respectively, for the futures. This wide variance in max–min values was observed for the negative returns.

Inter Market

The inter- and intra-market correlation values have been presented in Figure 10. Figure 10 has the values for the correlation of the price and the return series. The price series correlation value has been allocated in the ( ) and the return correlation in the [ ]. Figure 10 displays the correlation values of the various volatility series, i.e., standard deviation ( ), ARCH [ ], and GARCH { }.

- ***Equity Market and Commodity Market (Cash Segment).*** According to Figure 10, where the price series has a value of 0.916 and returns (0.173), there is a positive correlation between the equity market Nifty50 and the commodity market BCOMSP: IND. According to Figure 10, the correlation between the volatility series and the S.D. series is positive (0.175) ; whereas, the GARCH series exhibited a strong correlation (0.527).

- ***Commodity Market and Forex Market (Cash Segment).*** There is mixed evidence with regard to the correlation between the BCOMSP: IND and USD/INR reference rate, as the price series has a positive relation (0.500), and the return series has a negative relation (–0.068) in Figure 10. Figure 10 shows that there is a strong correlation between the volatility series in the GARCH series (0.272).

- ***Equity Market and Forex Market (Cash Segment).*** Figure 10 shows that the correlation value between the USD/INR reference rate and the Nifty50 is not entirely consistent, with the price series showing a positive correlation (0.636) and the return series showing a negative correlation (–0.332).

- ***Equity Market and Commodity Market (Derivative Segment).*** Equity and commodity future segments NIFTY50 (Fut) and ICOMDEX are positively related as the value of correlation at the level (prices) and the first difference (returns) is positive (0.516 & 0.104).

- ***Commodity Market and Forex Market (Derivative Segment).*** A positive relationship exists between the ICOMDEX and USD/INR (Fut).

- ***Equity Market and Forex Market (Derivative Segment).*** A mixed result is found between the USD/INR (Fut) and NIFTY50 (Fut), as the price series has a positive relation (0.633) and the return series has a negative relation (–0.405).

- ***Equity Market (Cash Segment) and Commodity Market (Derivative Segment).*** A positive relationship exists between the ICOMDEX and NIFTY50 as both the prices and return series have a positive correlation value (0.515 and 0.102).

- ***Equity Market (Cash Segment) and Forex Market (Derivative Segment).*** A negative relationship between the NIFTY50 and USD/INR (Fut) return series is found; whereas, its price series has a positive relation.

- ***Equity Market (Derivative Segment) and Commodity Market (Cash Segment).*** The BCOMSP: IND and NIFTY50 (Fut) have a positive value of correlation (0.916 and 0.174).

- ***Commodity Market (Cash Segment) and Forex Market (Derivative Segment).*** A negative relationship exists between the BCOMSP: IND and USD/INR (Fut) return series as the correlation value is (–0.413), and there is a positive relationship between the price series.

- ***Equity Market (Derivative Segment) and Forex Market (Cash Segment).*** A contradictory conclusion is drawn from the correlation value since there is a positive relationship (0.635) between the price series and the return series of the USD/INR Reference rate and NIFTY50 (Fut) but a negative relationship (–0.330) between the two.

- ***Commodity Market (Derivative Segment) and Forex Market (Cash Segment).*** The price and return series of the USD/INR reference rate and ICOMDEX have a positive correlation. The GARCH volatility series exhibits a higher degree of correlation.

The correlation has been found to be significant at the 0.01 significance level and 0.05 significance level and the *p* - values being less than 0.05, indicating the rejection of the null hypothesis H01, H02, and H03, resulting in a significant relationship between the submarkets (equity, commodity, and foreign exchange) of the Indian financial market; there is a significant relationship between the submarket divisions (spot and futures) and a significant relationship between the various volatility series (*SD*, ARCH, and GARCH).

Conclusion

The article analyzes the volatility of the commodity, equity, and foreign exchange market in India. The standard deviation, ARCH, and GARCH have been used to generate the volatility series. The linear relationship is analyzed with the help of the correlation. The study concludes that the market segment has a positive degree of movement. Still, in the overall scenario, the equity market is negatively correlated with the Forex market in both the segments' spot and futures. The commodity market spot BCOMSP: IND has a negative relation with the Forex market. The variation is consistently reflected in the equity market faster in both sectors as well as the future segments of the commodity market than in other variables in the study. The reference rate and USD/INR (futures)

fluctuate more than before the crisis time in 2019 and after the crisis period in 2021, indicating that the fluctuation is either delayed or anticipated. Throughout the study period, the Forex market exhibited higher volatility than the sub-markets that are the subject of the investigation. The GARCH volatility series shows the highest correlation value for the Indian financial market.

Authors' Contribution

The study's design and concept were both aided by Dr. B. Muthu Pandian. Susmita Subba collected materials from multiple websites, extracted articles, filtered the data, and then confirmed the study's analytical techniques using the concepts and codes that were produced and pertinent to the study design. The final text of the paper was reviewed by Dr. Ravi Shekhar Vishal, who also conducted a transcription of the writing and grammar. Excel spreadsheets and E-view software were used to perform the numerical calculations. With input from each author, Susmita Subba wrote the manuscript.

Conflict of Interest

The authors declare that they are not associated with or financially benefit from any company, organization, or individual having a vested interest in the topic or contents of this work.

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