FINANCIAL MARKET VOLATILITIES FOR CONSTRUCTION OF COMPOSITE RISK INDEX: EVIDENCES FROM INDIAN MARKET

Ph.D. Pre Submission Report
In Partial Fulfillment of the requirement for the
Degree of Doctor of Philosophy

by

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[Reg. No: 20/Ph.D./COM/09 Dt.01.12.2021]

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2024

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1. BACKGROUND OF THE STUDY

1.1 An Introduction of the Financial Market

1.1.1 Financial Market

Financial Market is a managed environment where a large number of participants get involved in the buying and selling of various kinds of securities in a controlled manner where there are fair pricing practices and transparency in transactions. It is a marketplace where the lenders and borrowers of funds participate in the trade of assets such as bonds, currencies, equity and derivatives.

It is also a source of interconnection between various nations, as individuals or institutions of various nations participate in the transaction of the securities. Funds flow from various participants of various countries across their national boundaries. Financial Market also helps in the determination of the prices, mobilization of the funds, liquidity and sharing of the risk.

The global economy witnessed an unprecedented financial openness over the past decades in terms of the movement of commodities, stocks, currency. The world today has become much more independent due to liberalisation, privatisation, and globalisation. The policy changes have facilitated the process of the interdependence of financial markets since the possibility of a greater level of cash inflows across international borders and amongst various sectors of domestic markets have increased.

1.1.2 Introduction to the Indian Financial Market

Chandran (2016) stated that India, an emerging economy has a robust Capital Market which has undergone tremendous developments in the last two or more decades and has emerged as the most sustainable of all the emerging markets. Indian Financial Market plays a vital role in the growth of industry and commerce of a country, which eventually affects the economy of the country. It has encouraged investments among the common people and has become a major source of raising resources by the corporates. A better performance by the financial market will direct resources to their most productive uses. Investing in the Capital Market has risk associated with it and consists of risk, which can be controlled, and risk, which cannot be controlled but can be guided.

Financial Market is considered volatile, and Volatility plays a key role in measuring the risk-return trade-off. An investor focuses on the objective of maximizing the returns and minimizing the risk of his/her portfolio and a better understanding of the risk helps the investors in making a good decision.

1.2. Overview of Volatility

Volatility is the fluctuation that happens in the price of a security. It can be the increase or decrease in the value. Volatility is considered a measure of risk. Volatility measures the riskiness of investment and is also used to price the assets.

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, risk.

Volatility has become important for investors, regulators, brokers, and there is an impact on the smooth functioning of economic performance and business investment. A high level of volatility is associated with high-risk levels in the market, *Kumar & Gupta (2009).*

1.2.1 Volatility in the Financial Market

The Financial sectors play a key role in mobilizing resources. Financial Markets helps in providing liquidity, mobilizing savings, and allocating investment. *Tanty & Patjoshi (2016)* stated that "Financial Market Volatility represents a measure of risk exposure in the investment." and Volatility in the market creates uncertainty and instability, hampering investment decisions. Policymakers take market volatility as a barometer of the vulnerability of the economy, (*Vijayalakshmi & Gaur 2013).*

Volatility in the Financial Market is not consistent, it is time-varying. A high level of volatility is seen as a threat and leads to reducing the confidence of the investors. Higher volatility is naturally associated with greater potential for larger losses. *Kumar P. & Patil S, (2016)* states that Volatility is associated with risk and return, the higher the volatility the more unstable the Financial Market but the risk is associated with returns, i.e. if the return is high, the risk associated is also high, (*William & Vimala 2015)*.

1.3. Overview of Volatility Index

(CBOE VIX Index)The VIX Index introduced by Chicago Board of Exchange is a well-known indicator recognized as a global predictor of risk that is used to forecast volatility followed by a diverse group of stakeholders. The VIX Index computation uses the mid-quote call and put prices of the S&P 500 index to derive an estimate of the 30-day constant anticipated volatility of the Equity Market.
(National Stock Exchange) INDIA VIX (*Volatility Index*) is a risk index introduced by the National Stock Exchange in 2008. VIX measures only the volatility or the fluctuation of Indian market based on the Nifty50 Index options contract and indicates the investor's future perception about the equity market volatility. The VIX Index does not reflect the riskiness of other subsegments of securities and lacks in the proper representation.

2. REVIEW OF LITERATURE

2.1 Introduction

Literature Review is a thorough study of the work done on the particular topic. It helps in the stronger foundation of the base of study relating to a topic. There are many literatures focused on the study of Volatility, and numerous studies of relationship between the Indian and global markets as well as in the various financial submarkets. Especially some are concentrated on the overall volatility pattern of Global and Indian Stock Market; few are exploring the modeling of the specific sectors such as Banking, IT etc., even some of the studies are conducted on the inter segment of the financial market such as Cash and Derivatives and Options (F&O) segment.

2.1.1 Review Relating to the Study of Volatility:

Study of the review has been done based on international study of Volatility and within India with reference to Commodity, Equity and Currency Market.

(a). Review relating to the study of Volatility in International Market -

Wang, (2009) examined the linkages of volatility in the 3 different markets i.e. money market, bond market and equity market through the analysis of Standard and Poor 500, Eurodollar Derivatives and 30 Year Treasury Bond Derivatives.

Liu & Zhang, (2015) stated that Economic Policy Uncertainty (EPU) is relevant in predicting the volatility and high volatility is lead due to the high uncertainty, which was also found in the Indian Market.

Chand, Kamal, & Ali, (2012) studies the Volatility structure of the Muslim Commercial Banks of Pakistan and stated that GARCH (Generalised Autoregressive Conditional Heteroskedasticity) was the most suitable model in capturing the volatility structure and volatility clustering which supported the results based on the Indian Market.

(b). Review relating to the study of Volatility within Indian Market –

Volatility is influenced by the global meltdown and due to the policies imposed by the financial regulatory authority by *Lakshmi P. (2013),* market fluctuations and macroeconomic situations by *(William & Vimala 2015).*

(c). Review relating to the study of Volatility in Indian Commodity Market –

Jore & Shrivastava, (2018) study the commodity market volatility and concluded the presence of volatility clustering when the study was conducted on metals like gold, silver and copper and also concluded the volatility to be persistent in the Commodity market.

Mukherjee & Goswami, (2017) conducted study on agricultural commodity (i.e. potato) and non-agricultural commodity (gold). Volatility in gold Derivatives had an increasing trend whereas potato Derivatives had a decreasing trend, and for menthe oil and crude oil, the volatility was high only for the far month contacts.

Thiyagarajan, Naresh, & Mahalakshmi, (2015) stated that the agricultural commodities index Dhannya in NCDEX is influenced by the news in the equity and foreign exchange market, indicating a correlational impact on the various markets.

(d). Review relating to the study of Volatility in Indian Equity Market-

Srivastava (2008) , *Nishad & Thomachen (2015)* and various others analyzed the Indian Stock Market volatility and its pattern in the individual stocks and indices Nifty of NSE and SENSEX of BSE.

Padhi, (2006) study resulted in the impact of the shocks on the volatility is decreased with time and past news has very little impact on present volatility.

Paramanik & Singhal, (2020) revealed that negative sentiment in the market cause large instability indicating the Indian market, to be a less developed market. Positive sentiment reduces the volatility whereas negative sentiment increases the volatility. The dominance of noise traders exists in the Indian stock market. The negative shocks or bad news has more impact on the volatility than the positive shock or good news, thereby bad news leading to more volatility and good news generating less volatility, which is also in convergence with the results of *(Nishad & Thomachen, 2015), (Joshi, 2014)*

Muthukamu, (2018) claims Past news or information does influence the current volatility along with the recent news claims and a positive relationship between returns and volatility and high volatility stocks give high returns.

Banumathy & Azhagaiah, (2015) volatility is sensitive to both old news and recent news, higher risk will not always lead to higher returns.

Kumar & Gupta, (2009) examined the volatility and its pattern in the individual stocks and concluded that many economic events influenced the financial markets leading to which there was the presence of high volatility and due to which the majority of the stocks studied were volatile. Though there was high volatility, the returns generated were low and negative. The results contradicted the risk-return trade-off.

Naveen & Mallikarjunappa, (2016) states stocks with higher beta values have higher volatility, and stocks with higher volatility earned higher returns along with moderate volatility stocks.

(d). Review relating to the study of Volatility in Foreign Exchange Market-

Kotai, (2013) attempts to find out which currency market is more volatile & sensitive, Volatility behaviour of the five exchange rates: INR/USD, JPY/USD, EURO/USD, GBP/USD, and CNY/USD was analysed by.

Khullar & Sethi, (2011) analysed the volatility of different currencies such as US Dollar, Japanese Yen and Euro in the Indian Foreign Exchange and concluded Euro had the highest volatility among the three currencies.

2.1.2 Review Relating to the Study of Nexus:

Review relating to the nexus study is bifurcated to International and Domestic Market study.

(a). Review relating to the study of Nexus in International Market -

Wulandari A. A., Harianto, Arifin, & Suwarsinah, (2019) examines the impact of Derivatives price volatility to the spot market of coffee in Indonesia and study resulted that the spot market is influenced by the Derivatives market and the emerging countries are more influenced by the foreign markets.

Amaoh, (2021) analysed the relation of commodity Derivatives and spot prices and concluded that there was no significant impact of spot nor Derivatives prices of the commodities on each other.

(b). Review relating to the study of Nexus within Indian Market-

The study of nexus within India is studied with reference to inter market and intra market.

Gulati & Kakhani, (2012) examined relationships between INR/Dollar exchange rate, SENSEX& NIFTY and stated that there is no relationship between exchange rates, the stock market had a correlation but showed a less positive relationship. *Kumar, (2013)* concluded that information is spread between the foreign exchange market and the stock market, and there is a presence of long-run relations between the stock price and the exchange rate.

Kaur & Arora, (2018) studied the long-term and short-term mutual interdependence of four financial (Equity, Commodity, Currency& G-Bonds) markets of India. The study results in no long-term association among the markets and stated that no two domestic financial markets co-move with each other.

(c). Review relating to the study of Nexus in Intra Market-

Sakthivel, Chittedi, Sakyi, & Anand, (2017) analysed the effect of the volatility of spot exchange rates on derivatives of GBP, JPY, and EURO to INR concluded in asymmetric effect on the volatility of spot exchange rate returns. Currency Derivatives reduced volatility in spot exchange rate returns of Japanese Yen/INR and British Pond/INR and increase in volatility of exchange rate returns of INR/ Euro.

Kaura & Rajput, (2021) analysed the future–spot pricing relationship of most actively traded commodities traded on Multi Commodity Exchange of India and compares the pricing relations of three commodity segments (bullion and metal, energy and agricultural) and stated that bullion, energy metals behave close to each other, but the behaviour of agricultural commodities is quite different from non-agricultural commodities.

2.1.3 Review Relating to the Study of Construction of Composite Risk Index

Dharmawardena, Thattil, & Samita, (2015) The study aims to create a composite index for the Columbo district of Sri Lanka with the use of principal component analysis.

Abeyasekera, (2005) The study emphasizes the significance of utilizing the multivariate approaches in index construction and identification of the patterns.

Boudt, d'Errico, Luu, & Pietrelli, (2022) The study constructs the Resilience Capacity Index to assess the resilience of food poverty at household with the use of principal component analysis.

C. Vieira, Neto, Roque, & Rocha, (2022) the socio-economic status index named "Social Vulnerability Index" is constructed for the San Francisco River Basin, Brazil based on the Principal Component Analysis. Principal Component was extracted based on the correlation matrix.

Dolge, Anna, & Blumberga, (2020) conducted a study to construct a composite index "Energy Efficiency Index" to assess the efficiency of the Latvian industry sector.

Farrugia, (2007) examines the optimal components or circumstances for creating composite indices using several methods. The bank in Iran's performance was assessed using Data Envelopment Analysis

2.2 Research Gap

Based on the detailed systematic review of the literature, it has been identified, that volatility is an integral part of the Financial Market and impacts the smooth functioning of the financial system stated by *Joshi (2014). Kotai (2013), Ali (2016) and Jore & Shrivastava (2018)* did the study of the volatility on the measurement of volatility of Currency Market, Equity and Commodity markets respectively. *Gulati & Kakhani (2012) Kaura & Rajput (2021)* conducted a study on the inter-relationship of the financial markets. Literature is vastly available on the study of measuring and estimating the model of volatility in terms of single market (i.e.) Equity / Commodity / Currency, specific sector (i.e.) Banking, IT Etc., and the segment (i.e.) Spot and Derivatives markets. *Banumathy & Azhagaiah, (2015*) studied the modelling and estimation of the volatility and Chevallie & Ielpo, (2013)provide evidence of the inter-market linkage. There is a smaller amount of literature contributing to the combined study of volatility of the global and Indian markets of the Spot and Derivatives segments.

The study of segment (*Spot &Derivatives*) interconnection has been conducted with regard to specific markets only, as *Kaura & Rajput, (2021)* focused on Commodity Segment study, *Sakthivel & et.al (2017)* studied the impact of derivatives segment on the spot market volatility focused on Commodity Market and Ingalhalli, *Reddy, & Sahay, (2017)* analysed the impact of the 2008 crisis on the relation of Indian Markets. Therefore, there is a requirement to enlighten more about the collective study of volatility of sub-markets (*Equity, Commodity & Forex*) and it's part of the integral segments (*Spot & Derivatives*) of Indian Financial Markets.

2.3 Objective of the Study

The broad objective of the study is the computation of the Composite Risk Index which will represent the risk of whole Financial **(Equity, Commodity and Forex)** Market in India.

The specific objectives of the study are**:**

1. Generation of volatility series in various Financial **(Equity, Commodity and Forex)** Market in India.
2. Analysis of volatility interconnectedness (long term and short term) among the Indian Financial **(Equity, Commodity and Forex)** Market.
3. Computation of the **Composite Financial Market Risk Index** (CFMRI) for Indian Financial Market.

2.4. Research Data Description

The present study consists of the various submarkets (i.e. *Equity, Commodity and Forex*) of Indian financial market. The following market broad indices / indicators are using a proxy to measure the respective market volatility is shown in table 1.

Table 1: **Research Data Set, Source of Data and Period of the Study**

	Submarket	Segment	Proxy Variable	Source	Data Available on	Study Period
FINANCIAL MARKETS	Equity	Spot	Nifty50 Spot	NSE	Apr 22, 1996	01 / 01 / 2016 to 31 / 12 / 2023 8 Yrs.
		Derivatives	Nifty Futures	NSE	Jun 12, 2000	
	Commodity	Spot	BCOMSP-IND	Bloomberg	Jun 30, 2014	
		Derivatives	iCOMDEX Composite	MCX	Dec 31, 2015	
	Foreign Exchange	Spot	USD/INR Spot Rate	RBI	Aug 25, 1998	
		Derivatives	USD/INR Futures	NSE	Aug 29, 2008	

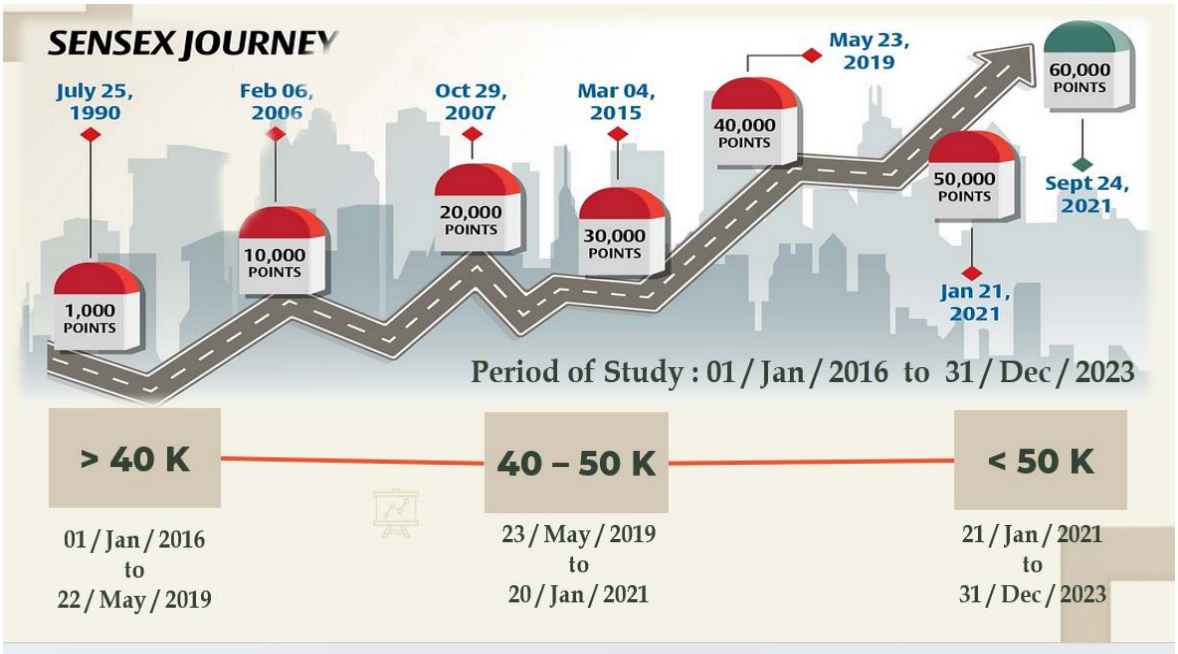
[Source: Created by the Researcher]

In the Equity Market, 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 segment. Therefore, the study intends using the Nifty 50 Spot and Derivatives (near month contract) non-overlapping daily closing value as a proxy variable to measure the volatility of the Indian Equity Market. Likewise in the Commodity Market, due to the non-availability of the spot market index to capture the volatility, the Bloomberg Commodity Spot Price BCOMSP: IND has been used and the Commodity Derivatives segment volatility will be observed through the MCX: iCOMDEX Composite Index. In both commodity spot and future index, the daily closing value of the index will be engaged for the computation of volatility of the Indian Commodity Market. In the Currency Market, the RBI USD/INR reference rate will act as the spot rate whereas for the Derivatives market, USD/INR Derivatives near month non-overlapping closing values will be used to compute the volatility of the Indian Forex Market.

2.5 Period and Source of Data

The overall study period starts from 1st January 2016 to 31st December 2023. Whereas, the keen interest is to study the temporal effect of volatility based on the incremental movement of every 10,000 points of the BSE benchmark Sensitivity Index (SENSEX) from 30,000 points. The detailed temporal break of the data period is exhibited below in figure 1:

Figure 1: **Period of Study with Temporal Break**



[Source: Based on the BSE SENSEX Data, Created by the Researcher]

3. GENERATION OF VOLATILITY SERIES

3.1 Research Intention

In the study, the main aim is the measurement of the volatility in the various Financial Markets, which will provide a clear picture of the generated volatility series. The segment is done with regard to the following pattern: Various methods of volatility is used for Volatility measurement and measuring the volatility for the different Financial Markets. The outcomes of the chapter are the efficiency of the Volatility measurement method, the trend of the Volatility Series and to analyze the volatility pattern in various Financial Market.

The first objective measures the volatility by using the different methods of various submarkets (Equity, Commodity and Forex) and its segments (Spot and Derivatives) of the market. Secondary data from various websites has been collected. Different techniques of Volatility measurement are used for the calculation of Volatility.

For the measurement of the volatility measures such as - the historical volatility method, time-variant volatility measures are used. The volatility series generated will be compared with the various methods in a segment of a market (e.g. Cash Segment of Equity Market, F & O Segment of Commodity Market, etc.) and a comparative analysis has been done as to which method is the best.

3.2 Relevant Literature and Research Gap

Large portion of literature contributes to the topic of linkages of volatility in different markets of international significance such as Standard and Poor 500, Eurodollar etc. *Mallikarjuna & Rao, (2017),* examination of volatility and its pattern in the individual stocks, *Kumar & Gupta, (2009), Nishad & Thomachen, (2015)* on the broad Index of Indian Stock Market, *Liu & Zhang, (2015)* evaluates the uncertainty in predicting the volatility. The study of *Padhi, (2006)*, on the impact of the shocks on the volatility, along with indices *Srivastava, (2008)* analysis of the spillover of volatility and relationship of Indian Stock Markets with international markets such as *Mukherjee & Mishra, (2008)* compared with other 12 Asian Stock Markets, *Mishra & Rahman, (2010)* analysed the volatility of the stock market of India and Japan. *Bose & Mukherjee, (2005)* compared the performance of the Indian Stock Market with other developed countries. *Mehta & Sharma, (2011)* focused on measuring the volatility and characteristics of the Indian Stock Market focused on the NSE index Nifty and Vasudevan *& Vetrivel, (2016)* forecasts the volatility of SENSEX. *Mukherjee & Goswami, (2017)* studies the volatility of commodity market in India with reference to Derivatives of agricultural and non-agricultural commodities whereas *Paramanik & Singhal, (2020)* studies the impact of sentiment in the market of India and impact of information on the volatility is studied by *Muthukamu, (2018).*

Topic of Volatility measurement and forecasting have been extensively studied at both international and national levels making significant contributions to the subject of financial market volatility. The study found a gap regarding an allocative study of the Indian financial market volatility combining the segmental group of the submarket considering which the chapter contributes in combined study of the submarket *(Equity, Commodity & Foreign Exchange)* Market volatility and also considering its segments *(Spot & Derivatives)*.

3.3 Data and Method

The data of the variables have been sourced from the respective websites and sorted, the data has been selected based on the common functioning date of the various submarkets and the uncommon working dates have been eliminated. Making the variables working dates to be a match.

At the outset, the study emphasizes on the generation of volatility series and consequently takes into consideration the daily return series of the variables that are of interest, and the returns are computed in accordance with the formula:

$$\text{Returns } [r_t] = \frac{\text{Today price } [p_n] - \text{Pervious day price } [p_{n-1}]}{\text{Pervious day price } [p_{n-1}]} \ldots\ldots\ldots\ldots\ldots\ldots \text{(Eq 1)}$$

Excel spreadsheet was used in the process and in addition to the calculation of the return series, the *Standard Deviation* (SD) volatility series, *Autoregressive Conditional Heteroskedastic* (ARCH) Volatility Series and *Generalized Autoregressive Conditional Heteroskedastic* (GARCH) Volatility series were formed.

The Standard Deviation is congruent to the square root of the value of return series' variance and is heeded as a yardstick of risk. The rolling standard deviation is a metric often used for assessing historical volatility.

$$\text{Standard Deviation } (\sigma) = \sqrt{\frac{(x_i - \mu)^2}{N}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(Eq. 2)}$$

The value of the standard deviation has been derived from the value of the returns of the variables.

The ARCH Model set up by Engle (1982) was applied in the study to create the volatility series applying an equation as follows:

$$\text{ARCH Model: } \sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \ldots + \alpha_p \varepsilon_{t-p}^2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(Eq. 3)}$$

The GARCH model proposed by Bollerslev in 1986 is a valuable extension of the ARCH Model and is now the most extensively used model. The weights assigned to prior squared residuals are expected to decrease exponentially at a rate that may be computed based on the available data, *Karmakar (2005)*.

The GARCH (p,q) model is as :

$$\sigma_t^2 = w_o + \sum_{i=1}^{p} \beta_{i=1}^{a_i} h_{t-i} + \sum_{j=1}^{q} \alpha_j \varepsilon_{t-j}^2 \quad \text{.....(Eq. 4)}$$

Where w, α_1, α_n, β_1, β_n are parameters, p is the number of past volatility lags and q is the number of square error term lags in the model.

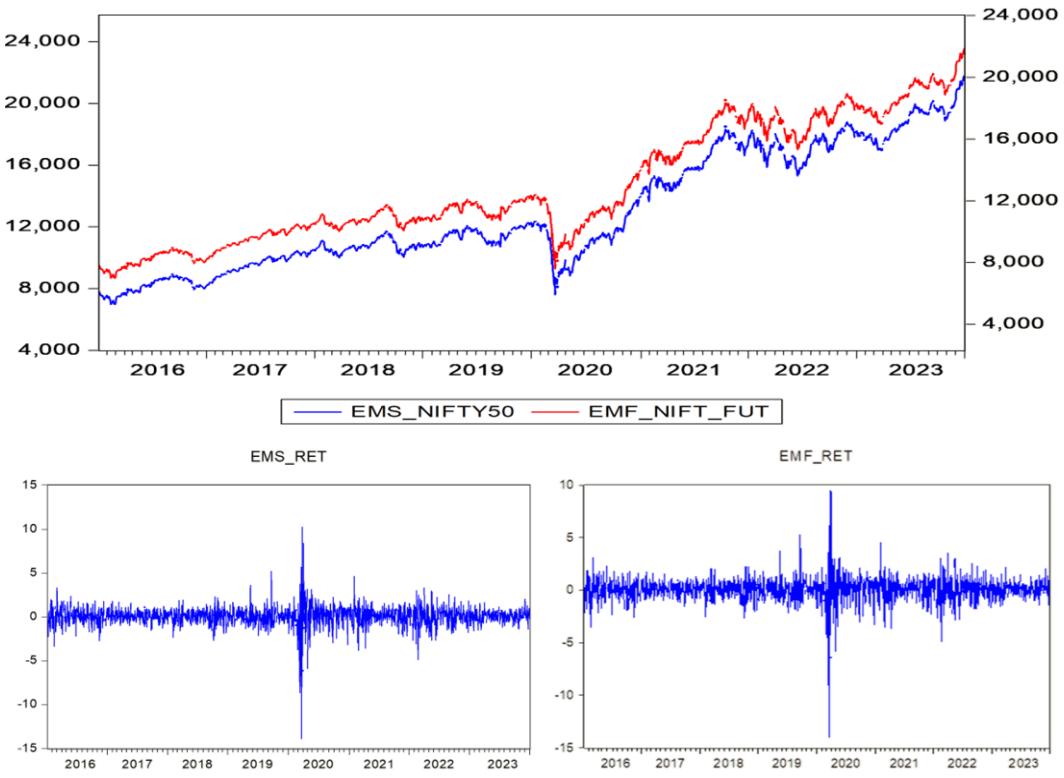
ARCH term denoted as ε2 t−1 and one GARCH term denoted as ht−1. For the variance to remain well behaved, some restrictions needed to be imposed: $\eta > 0$, $\alpha \geq 0$, and $\beta \geq 0$. The sum of the ARCH coefficient and GARCH coefficient governs the persistency of volatility shocks. Their sum should be less than the unit ($\alpha + \beta < 1$) to ensure that series εt is stationary and the variance is positive].

3.4 Results & Discussion

3.4.1. Temporal Analysis of Price and Return of the Indian Financial Market

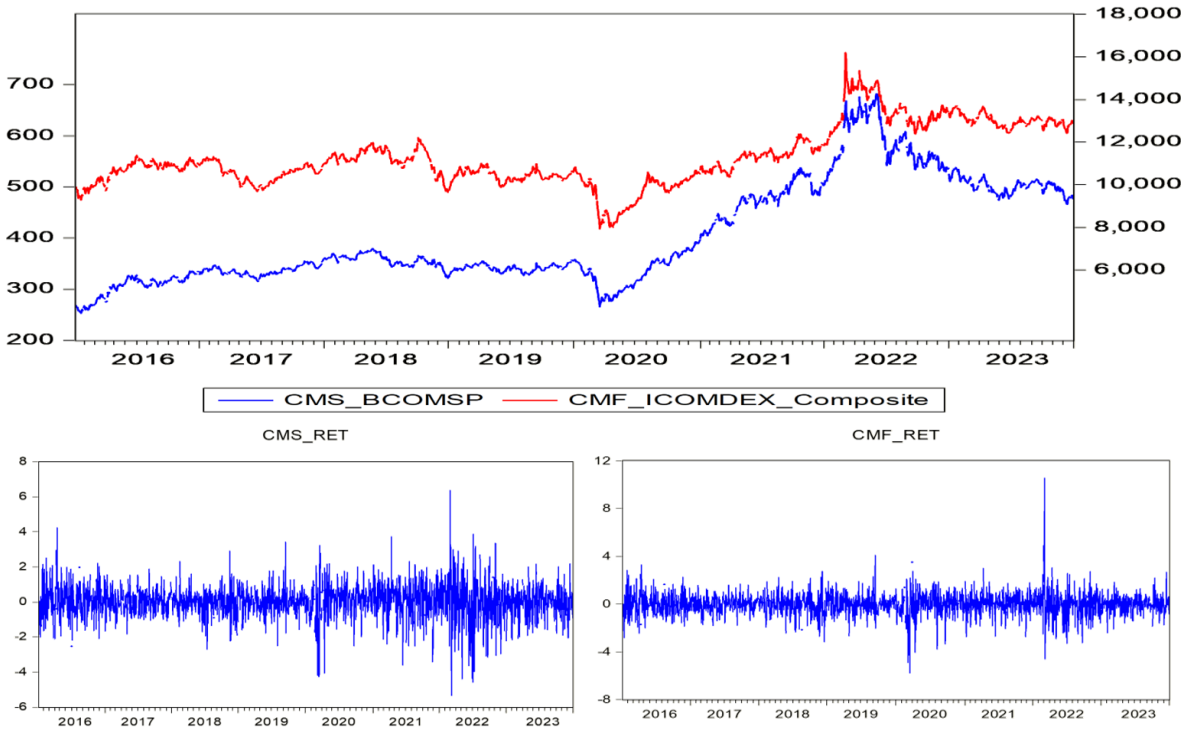
Before generating the volatility series of the Indian financial markets and its segments by using various computation methods such as SD, ARCH and GARCH to visualise the price and return trend structure as whole, the researcher begins with the pictorial representation of Indian Financial (Equity, Commodity and Forex) Market and its segments of (Spot and Derivatives) price as well as the returns in the following figure 2 to 4

Figure 2: **Price and Return Series of Equity (Spot & Derivatives) Market 2016 – 2023**



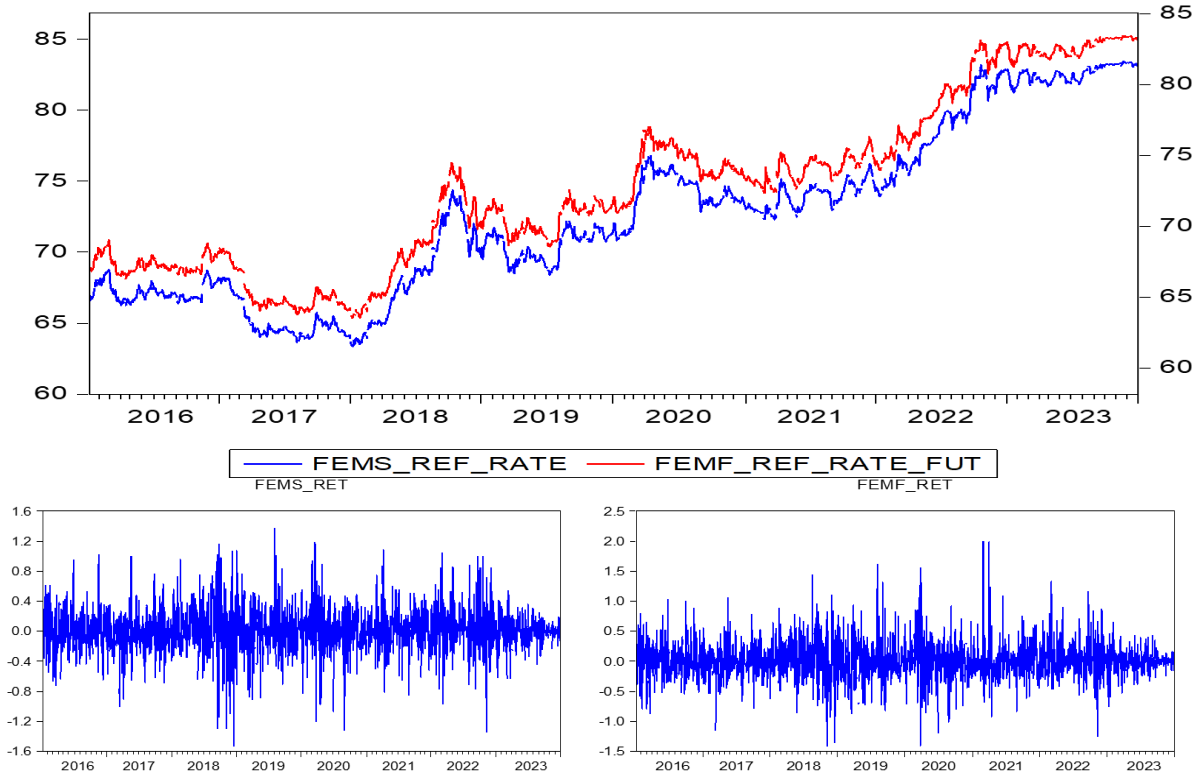
[Source: Created by the Researcher]

Figure 3: **Price and Return Series of Commodity (Spot & Derivatives) Market 2016 – 2023**



[Source: Created by the Researcher]

Figure 4: **Price and Return Series of Forex (Spot & Derivatives) Market 2016 – 2023**



[Source: Created by the Researcher]

Even though after visualization of the return series of the Indian financial markets and its segments; furthermore, evidences are required to understand the behaviour of Indian Financial Market return series therefore, the researcher uses the exploratory data analysis to describe the nature of the return series of the Indian financial markets and its segments. The results of the same is exhibited in the below table 2.

Table 2: **Temporal Break-Wise Descriptive Analysis of Segment Wise (i.e., Spot & Derivatives) Indian Financial (i.e., Equity, Commodity & Forex) Markets Return**

Temporal Break Descriptive Statistics on Return of Financial Markets 01/01/2016 to 31/12/2023		Equity Market		Commodity Market		Foreign Exchange Market	
		Spot	Derivatives	Spot	Derivatives	Spot	Derivatives
		NIFTY50	NIFTY Futures	BCOMSP: IND	ICOMDEX	USD/INR	USD/INR Futures
Sensex Rally 30k - 40k [n=792]	Min	-3.373	-3.555	-2.713	-3.151	-1.535	-1.418
	Mean	0.052	0.052	0.029	0.006	0.006	0.005
	±SD	0.793	0.803	0.794	0.856	0.337	0.337
	Max	3.625	3.725	4.246	3.299	1.168	1.435
Sensex Rally 40k - 50k [n=396]	Min	-13.904	-14.026	-4.271	-5.766	-1.318	-1.408
	Mean	0.056	0.055	0.049	0.008	0.012	0.012
	±SD	1.741	1.768	0.935	1.055	0.328	0.371
	Max	10.231	9.478	3.425	4.086	1.374	1.622
Sensex Rally >50k [n=691]	Min	-4.896	-4.908	-5.343	-4.595	-1.347	-1.258
	Mean	0.057	0.058	0.022	0.027	0.019	0.019
	±SD	0.950	0.964	1.194	1.049	0.275	0.293
	Max	4.633	4.578	6.382	10.566	1.089	2.001

[Source: Computed by the Researcher]

3.4.2. Generation of Volatility Series

Based on the return series of the equity, commodity and forex markets and its spot and derivatives segments, the researcher generates the volatility series by using the various computation methods such as SD, ARCH and GARCH. The structure of the generated volatility series of Indian Financial (Equity, Commodity and Forex) Market and its segments is exhibited in the figure 5.

Figure 5: **Structure of the Generated Volatility (SD, ARCH, GARCH) Series for Indian Financial (Equity, Commodity and Forex) Market and its segments**

Date	Equity Market						Commodity Market						Forex Market					
	Spot			Derivatives			Spot			Derivatives			Spot			Derivatives		
	S	A	G	S	A	G	S	A	G	S	A	G	S	A	G	S	A	G
07/01/2016	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
* * *	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
31/12/2020	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
* * *	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
31/12/2023	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Note: S: - SD; A: - ARCH; G: - GARCH based volatility series [Source: Computed by the Researcher]

After generating the required volatility series based on the SD, ARCH, GARCH methods furthermore for clarification on description of the data, the researcher uses the exploratory data analysis to describe the nature of the various volatility series of the Indian financial (equity, commodity, and forex) markets and its segments. The results of the same is exhibited in the below table 3 to 5.

Table 3: **Descriptive Analysis of Equity Market Segments (Spot & Derivatives) Volatility Series (i.e. SD, ARCH, GARCH) :: 1st Jan 2016 - 31st Dec 2023**

Descriptive Statistics	Equity Market					
	SPOT (Proxy: NIFTY50)			FUTURES (Proxy: NIFTY Futures)		
	Computation Method of Volatility			Computation Method of Volatility		
	SD	ARCH	GARCH	SD	ARCH	GARCH
Max.	0.1330	0.0779	0.0610	0.1371	0.0770	0.0717
Min	2.34E-06	0.0089	0.0064	2.36E-06	0.0090	0.0064
Mean	0.0071	0.0104	0.0094	0.0073	0.0105	0.0098
Median	0.0049	0.0094	0.0083	0.0049	0.0095	0.0086
Std. Dev.	0.0088	0.0036	0.0043	0.0091	0.0036	0.0049
Skewness	5.6139	8.8995	6.3422	5.7445	8.8503	6.3655
Kurtosis	55.795	121.076	56.455	58.938	118.943	58.764
JB Test [Sig.]	227857.3***	1116342.0***	236317.7***	255178.7***	1077000.0***	256146.6***

[Source: Computed by the Researcher]

Table 4: **Descriptive Analysis of Commodity Market Segments (Spot & Derivatives) Volatility Series (i.e. SD, ARCH, GARCH) :: 1st Jan 2016 - 31st Dec 2023**

Descriptive Statistics	Commodity Market					
	SPOT (Proxy: BCOMSP: IND)			Derivatives (Proxy: ICOMDEX Composite)		
	Computation Method of Volatility			Computation Method of Volatility		
	SD	ARCH	GARCH	SD	ARCH	GARCH
Max.	0.0521	0.0321	0.0293	0.0956	0.0574	0.0443
Min	7.76E-06	0.0090	0.0062	2.13E-06	0.0086	0.0067
Mean	0.0071	0.0099	0.0097	0.0069	0.0097	0.0093
Median	0.0053	0.0093	0.0089	0.0051	0.0090	0.0086
Std. Dev.	0.0066	0.0018	0.0030	0.0065	0.0021	0.0027
Skewness	1.8827	4.4104	2.2862	2.9287	8.5519	4.9145
Kurtosis	7.9697	32.177	10.284	26.141	149.934	45.130
JB Test [Sig.]	3042***	72741.7***	5790.6***	44587.1***	1713184***	146529.3***

[Source: Computed by the Researcher]

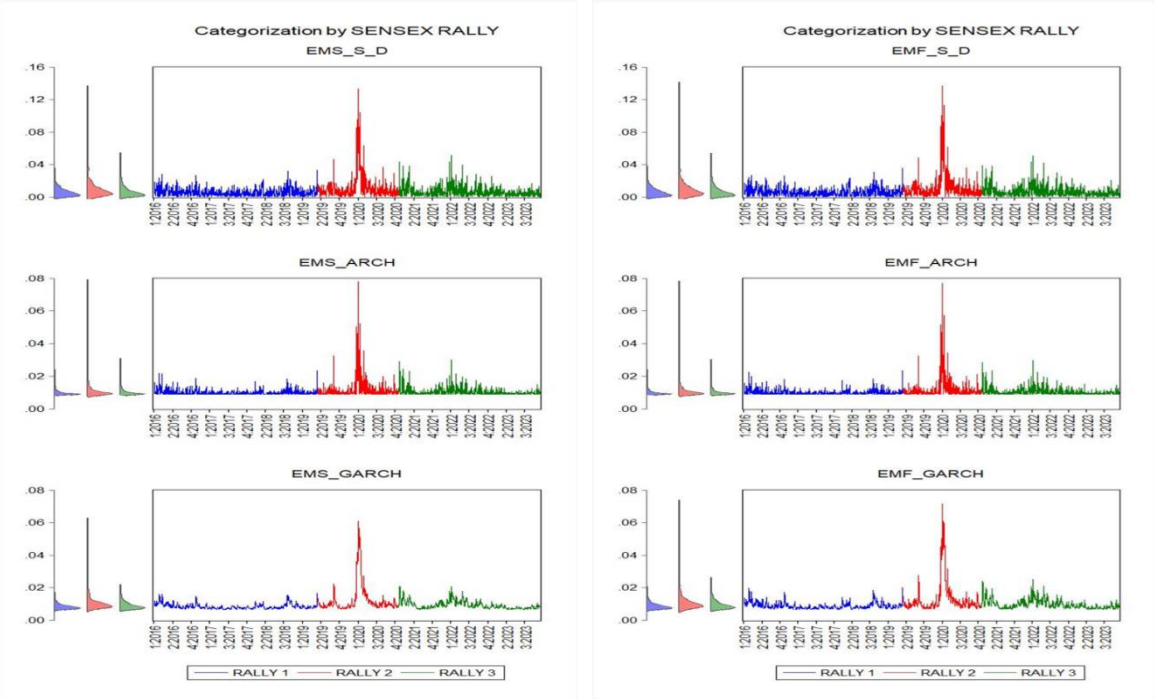
Table 5: **Descriptive Analysis of Forex Market Segments (Spot & Derivatives) Volatility Series (i.e. SD, ARCH, GARCH) :: 1st Jan 2016 - 31st Dec 2023**

Descriptive Statistics	Forex Market					
	SPOT (Proxy: USD-INR Reference Rate)			Derivatives (Proxy: USD-INR Futures)		
	Computation Method of Volatility			Computation Method of Volatility		
	SD	ARCH	GARCH	SD	ARCH	GARCH
Max.	0.0164	0.0087	0.0096	0.0185	0.0087	0.0112
Min	2.93E-07	0.00271	0.001678	1.82E-07	0.003165	0.002367
Mean	0.0023	0.0031	0.0031	0.0025	0.0034	0.0033
Median	0.0017	0.0029	0.0027	0.0018	0.0032	0.0030
Std. Dev.	0.0022	0.0007	0.0012	0.0023	0.0005	0.0010
Skewness	1.9011	3.2933	1.7737	1.9160	4.7355	2.6139
Kurtosis	8.1459	16.691	6.8886	8.8515	36.751	13.558
JB Test [Sig.]	3203.3***	18073.0***	2169.1***	3828.4***	96208.3***	10867.7***

[Source: Computed by the Researcher]

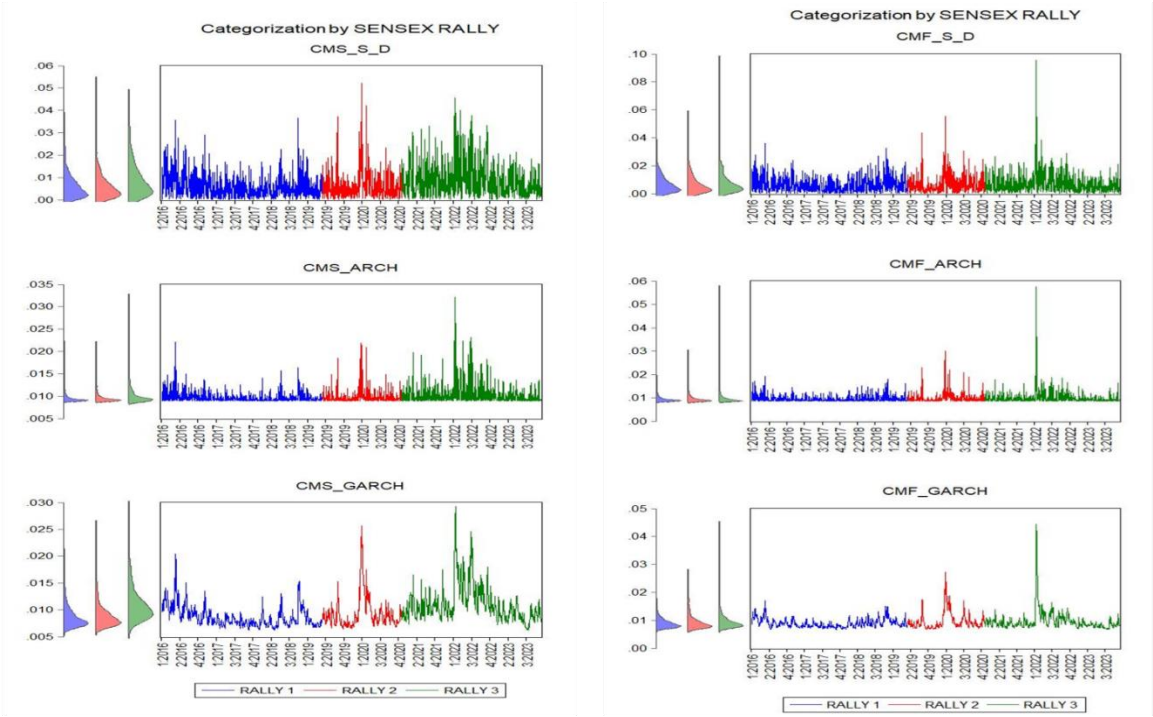
For the better understanding of the behaviour of the various volatility series based on the SD, ARCH, GARCH methods of different submarkets of financial market (i.e. equity, commodity and forex) and its segments (i.e. Spot and Derivatives) is exhibited in the pictorial representation with the temporal break as per the Sensex rally movement is exhibited in following figure 6 to 8.

Figure 6: **Temporal Break of Generated Volatility (SD) Series for Indian Financial (Equity, Commodity and Forex) Market and its segments (Spot and Derivatives)**



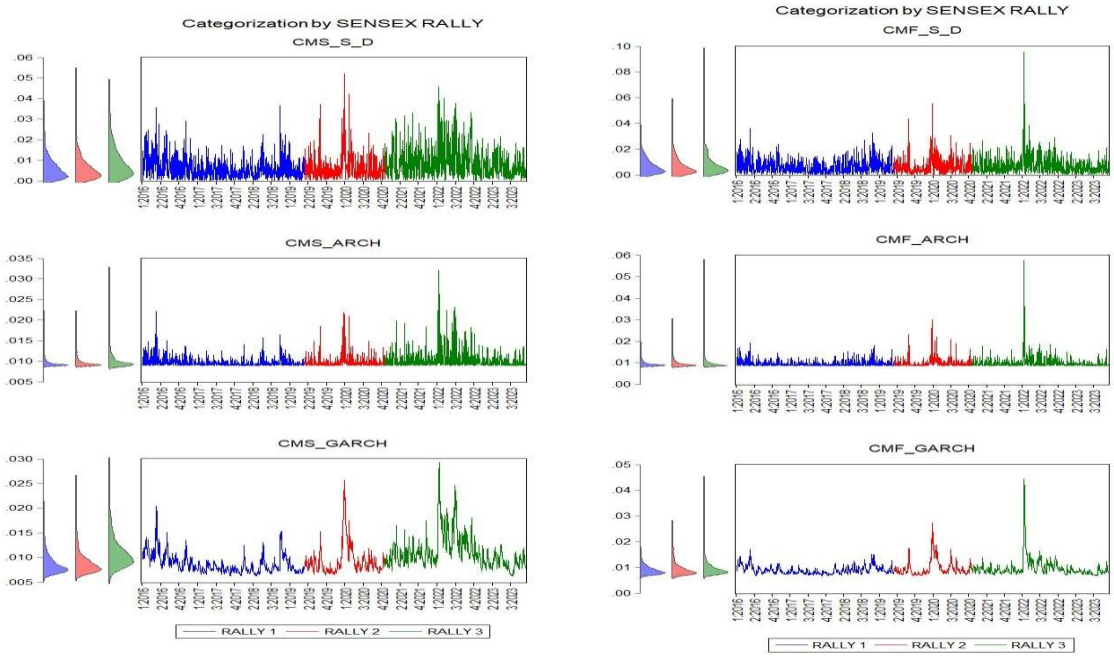
[Source: Created by the Researcher]

Figure 7: **Temporal Break of Generated Volatility (ARCH) Series for Indian Financial (Equity, Commodity and Forex) Market and its segments (Spot and Derivatives)**



[Source: Created by the Researcher]

Figure 8: **Temporal Break of Generated Volatility (GARCH) Series for Indian Financial (Equity, Commodity and Forex) Market and its segments (Spot and Derivatives)**



[Source: Created by the Researcher]

The research analyses the Equity, Commodity and Forex Markets in India focusing on the vulnerability to volatility in segments spot and Derivatives. The volatility series construction involves the use of standard deviation, (ARCH) *Autoregressive Conditional Heteroskedastic* and (GARCH) *Generalized Conditional Heteroskedastic* model. The price series, return series and volatility series has been evaluated through descriptive statistics and the positive negative returns has also been evaluated year wise and rally wise (*temporal break*). The study analyses the characteristics of the generated volatility series and found the existence of volatility clustering. The Equity Market had a wider range of variation in the year 2020, the commodity market in the year 2022, and the Forex market during the year 2019 and 2021.

4.MARKET VOLATILITY INTERCONNECTEDNESS

4.1. Research Intention

This objective deals with finding relationships in the various Indian Financial Market (Equity, Commodity and Foreign Exchange) with respect to**:** Long-term Relationship - which includes the study of Inter Market and Intra Market Nexus and Short-term Relationship-which includes the study of Inter / Submarket *(i.e. Equity, Commodity and Forex)* Market and Intra / Segmental *(i.e. Spot and Derivatives)* Market Nexus. The study focuses on analysis of cointegration and causal analysis of the various Financial Submarkets and its segments to ensure the connectiveness in the long run and short run co-movement within the submarket and with respect to different segments.

4.2 Relevant Literature and Research Gap

As per the literature reviewed, studies of *Apte, (2001), Victor, K K, Bhaskar, & Naz, (2021), Mishra & Swain, (2007), Bhuvaneshwari & Ramya, (2017)* analyses the relation of the foreign exchange market and the stock market and the examination of the spillover .The linkages of volatility in the 3 different markets i.e. money market, bond market and equity market at international level was examined by *Wang, (2009).*Researchers such *Kaura & Rajput, (2021)* analysed the future–spot pricing relationship of most actively traded commodities traded on Multi Commodity Exchange of India. *Amaoh (2021)* analysed the relation of commodity Derivatives and spot prices. *Srinivasan & Ibrahim, (2012)* evaluates the spot & Derivatives segment of the Indian Gold Markets. *Srinivasan P. , (2010)* study the lead-lag relationship in the Indian Financial Market Segments Spot and Derivatives. The impact of Derivatives price volatility to the spot market of coffee in Indonesia is examined by *Wulandari A. E., Harianto, Arifin, & Suwarsinah, (2019). Kaur & Arora, (2018)* studied the long-term and short-term mutual interdependence of four financial (*Equity, Commodity, Currency & G-Bonds*) markets of India. *Mukherjee & Mishra, (2008),* study volatility integration and spillover with respect to India and other developing and emerging Asian nations, *Bose & Mukherjee, (2005)* study inter connection with the Markets of the Developed Countries. *Ashiq AM & Shanmugasundaram, (2017)* aims to find the

relationship between Exchange Rate, Stock Market and Crude Oil Price on international platform, *Sri ram, (2017)* investigates the dependence of Commodities Market, Stock Market and Foreign Exchange Market in India and along with *Maitra & Dawar, (2019) Vasantha, (2021)* investigated the Return and Volatility Spillover in the Stock, Commodity and Foreign Exchange Markets of Indian market.

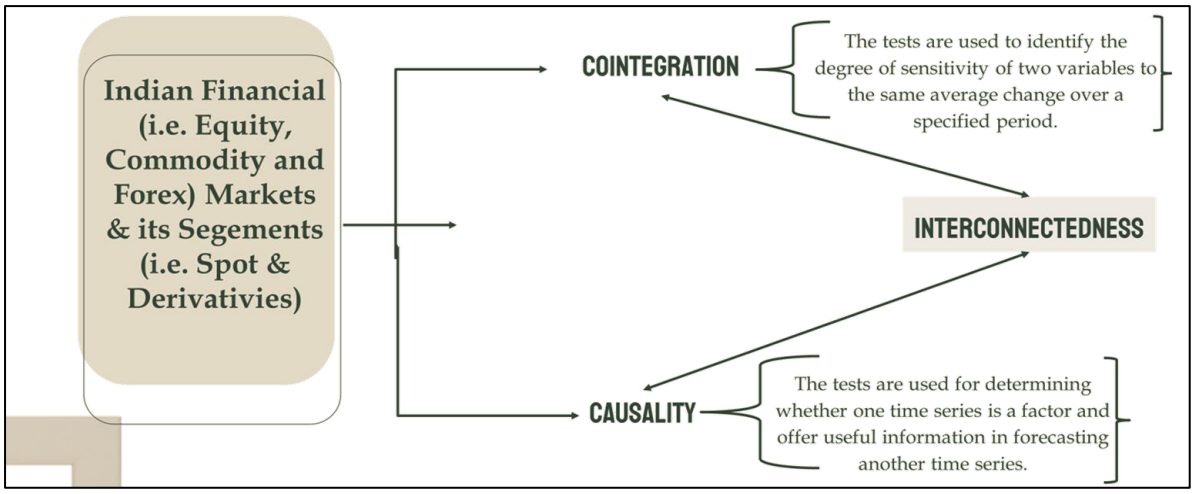
Apte, (2001), Ashiq AM & Shanmugasundaram, (2017) focuses on study of relationship between two or three specific submarkets. The focus is on the study of the prices and does not focus on the volatility and does not consider the study of segments. *Srinivasan P. , (2012)* studies the segment relation but regarding one specific market i.e., gold market. Rarely, studies have contributed in respect to a combined study of all types of Financial Markets with their segments regarding Indian Scenario. Therefore, the present study attempts to analyse the interconnections of the Spot and Future segments of the various Financial (Equity, Commodity & Forex) markets.

4.3 Data & Method

The second objective is to analyze the volatility relationship of the various Indian Financial Markets**.** The volatility relationship will be studied for the segment and sub-market. In the Intra-market (segment) study, the spot market and future market of the respective Markets is studied. The Nifty50 Index has been considered as a proxy for Equity Market Cash Segment, Nifty50 Derivatives as a proxy for Equity F&O, Bloomberg Commodity Spot Index as a proxy for Commodity Market, iCOMDEX Composite as a proxy for Commodity F&O, USD/INR Reference rate as a proxy for Currency Market and USD/INR Derivatives as a proxy for Currency F&O.

Analysis of the nexus has been bifurcated into long- and short-term relationships. The study analyzes both long- and short-term relationship among the various financial submarkets (i.e. Equity, Commodity, and Currency) as well as the sub (Spot and Derivative) segments. The methodological illustration is exhibited in the in following figure 9

Figure 9: **The Methodological Illustration of Examine the Financial Market Interconnectedness**



[Source: Created by the Researcher]

A cointegration test is used to establish if there is a correlation between several time series in the long term. The concept was first introduced by Nobel laureates Robert Engle and Clive Granger in 1987. To identify scenarios where two or more non-stationary time series are integrated together in a way that they cannot deviate from equilibrium in the long term. The tests are used to identify the degree of sensitivity of two variables to the same average change over a specified period.

The Johansen test is used to test cointegrating relationships between several non-stationary time series data. Compared to the Engle-Granger test, the Johansen test allows for more than one cointegrating relationship. Johansen's test comes in two main forms, i.e., Trace tests and Maximum Eigenvalue tests.

Johansen's Trace tests evaluate the number of linear combinations in a time series data, i.e., K to be equal to the value K0, and the hypothesis for the value K to be greater than K0.

$$H_0: K = K0$$

$$H_1: K > K0$$

When using the trace test to test for cointegration in a sample, we set K0 to zero to test whether the null hypothesis will be rejected. If it is rejected, we can deduce that there exists a cointegration relationship in the sample.

An Eigenvalue is defined as a non-zero vector which, when a linear transformation is applied to it, changes by a scalar factor. The Maximum Eigenvalue test is like the Johansen's trace test. The key difference between the two is the null hypothesis.

$$H_0: K = K0$$

$$H_0: K = K0 + 1$$

In a scenario where K=K0 and the null hypothesis is rejected, it means that there is only one possible outcome of the variable to produce a stationary process. However, in a scenario where K0 = m-1 and the null hypothesis is rejected, it means that there are M possible linear combinations.

Therefore, the long-term relationship is measured using the Johansen co-integration. It indicates whether a pair (or a group) of individual series are tied together in the long run. Duly after satisfying the required preliminary condition whether series are integrated of order 1 [I (1)] or stationary at first difference. If not stationary at first difference do the required data transmission to make the series at stationary at first differences. The same procedure will be followed throughout the various financial submarkets *(i.e. Equity, Commodity, and Forex)* as well as its segments *(Spot and Derivative)*.

The following broad hypothesis has been framed and tested through the following framework of analysis.

H_O: There is no co-integrating equation between the various submarkets. (Equity, Commodity, Currency)

H_O: There is no co-integrating equation between the various segments. (Cash and F&O)

The volatility series which were found stationary at levels, analysis of Long-term relationship among the volatility series is analysed through Regression Analysis

Ho: There is no significant relationship between the various generated Volatility Series

Therefore, the null hypothesis should be rejected to confirm the existence of a cointegration relationship in the sample.

The Granger causality test is a statistical hypothesis test for determining whether one time series is a factor and offer useful information in forecasting another time series. Null hypotheses of y(t) does not Granger-cause x(t). If the coefficients of the lagged values of variable X in the equation for dependent variable Y are jointly statistically significant, then **X is said to Granger cause Y** and vice versa. Therefore, the short-term relationship is measured by using the Granger Casualty Test. It states that, if past values of a variable Y significantly contribute to forecast the value of another variable Xt+1 then Y is said to Granger cause X. It helps to analyse the degree, direction, and magnitude of the causal relationship between all the variables and also help in identifying the lead-lag relationship among the various financial submarkets *(i.e. Equity, Commodity, and Forex)* and its segments *(Spot and Derivatives)*. The following broad hypothesis has been framed and tested through the following framework of analysis.

H_O: Various submarket (Equity, Commodity, Currency) does not Granger Cause each other.

H_O: Various segments (Cash and F&O) does not Granger Cause each other.

4.4 Results & Discussion

The focus of the study is to analyze the relationship within and across markets. The volatility series generated in the section 3 is utilized and evaluated for its interconnectedness.

4.4.1. Long Term Relationship Among the Indian Financial Markets and its Segments

The Results of Long-Term Relationship Analysis of Financial (Equity, Commodity and Forex) & Its Segments (Spot and Derivatives) is exhibited in the table 6

Table 6: **Results of Long-Term Relationship Analysis of Financial (Equity, Commodity and Forex) & Its Segments (Spot and Derivatives)**

Financial (Equity, Commodity and Forex) & its Segments (Spot and Derivatives)		Hypothesized No. of CE(s)	Eigen value	Trace Test	Max-Eigen Test
Equity Spot	**Equity Derivatives**	**None***	0.0636	123.41**	123.25**
		At most 1	8.38E-05	0.1572	0.1572
Commodity Spot	**Commodity Derivatives**	**None**	0.0051	11.72	9.5797
		At most 1	0.0011	2.138	2.1384
Forex Spot	**Forex Derivatives**	**None***	0.1783	368.55**	368.54**
		At most 1	5.55E-06	0.0104	0.0104
Equity Spot	**Commodity Spot**	**None**	0.0024	4.8495	4.5898
		At most 1	0.0001	0.2597	0.2597
Equity Spot	**Commodity Derivatives**	**None**	0.0055	10.52	10.40
		At most 1	6.13E-05	0.1150	0.1150
Equity Spot	**Forex Spot**	**None**	0.0036	8.0026	6.7192
		At most 1	0.0007	1.2835	1.2835
Equity Derivatives	**Forex Derivatives**	**None**	0.0031	7.1781	5.7654
		At most 1	0.0008	1.4127	1.4127
Equity Derivatives	**Commodity Spot**	**None**	0.0024	4.8516	4.5286
		At most 1	0.0002	0.323	0.323
Equity Derivatives	**Commodity Derivatives**	**None**	0.0055	10.5854	10.432
		At most 1	8.14E-05	0.1530	0.1530
Equity Derivatives	**Forex Spot**	**None**	0.0036	8.0338	6.6941
		At most 1	0.0007	1.3398	1.3398
Equity Derivatives	**Forex Derivatives**	**None**	0.0030	7.1451	5.6657
		At most 1	0.0008	1.4793	1.4793
Commodity Spot	**Forex Spot**	**None**	0.0026	5.6734	4.9623
		At most 1	0.0004	0.7111	0.7111
Commodity Spot	**Forex Derivatives**	**None**	0.0030	6.4702	5.5309
		At most 1	0.0005	0.9393	0.9393
Commodity Derivatives	**Forex Spot**	**None**	0.0038	7.1356	7.0584
		At most 1	4.11E-05	0.0772	0.0772
Commodity Derivatives	**Forex Derivatives**	**None**	0.0037	7.0431	6.9434
		At most 1	5.31E-05	0.0997	0.0997

[Source: Computed & Tabulated by the Researcher]

The results show that the long-term linkage in the price series has been found between the Equity Market spot and Equity Derivatives, along with the Forex Market Spot and Forex Derivatives co-integrated. There is no inter market cointegration along with no evidence of cointegrating link in the Commodity market in the long term.

The Results of Long-Term Relationship Analysis of Financial (Equity, Commodity and Forex) & Its Segments (Spot and Derivatives) wise volatility series is exhibited in the table 6

Table 7: **The Long-Term Relationship Analysis of Different Volatility Series (SD, ARCH, GARCH) of Financial (Equity, Commodity & Forex) Market and its Segments (Spot and Derivatives) Form 1st January 2016 to 31st December 2023**

DV ↓ / IV →			Equity Spot	Equity Derivatives	Commodity Spot	Commodity Derivatives	Forex Spot	Forex Derivatives
Equity Spot	**SD**	**β [S.E]**	**NA**	0.887*** [0.01]	0.01 [0.015]	0.002 [0.015]	0.056 [0.042]	0.029 [0.041]
	ARCH	**β [S.E]**	**NA**	0.959*** [0.009]	0.023 [0.021]	-0.014 [0.017]	0.037 [0.057]	-0.082 [0.085]
	GARCH	**β [S.E]**	**NA**	0.841*** [0.006]	0.043*** [0.013]	0.042*** [0.016]	0.014 [0.038]	0.025 [0.046]
Equity Derivatives	**SD**	**β [S.E]**	0.927*** [0.01]	**NA**	0.006 [0.015]	0.011 [0.016]	0.044 [0.043]	0.078 [0.042]
	ARCH	**β [S.E**	0.901*** [0.008]	**NA**	-0.004 [0.02]	0.028 [0.017]	0.037 [0.055]	0.193*** [0.083]
	GARCH	**β [S.E]**	1.076*** [0.008]	**NA**	-0.021 [0.015]	-0.005 [0.018]	0.03 [0.043]	0.042 [0.052]
Commodity Spot	**SD**	**β [S.E]**	0.024 [0.036]	0.014 [0.035]	**NA**	0.531*** [0.02]	-0.057 [0.066]	0.039 [0.063]
	ARCH	**β [S.E]**	0.027 [0.025]	-0.005 [0.026]	**NA**	0.436*** [0.016]	-0.055 [0.062]	0.006 [0.09]
	GARCH	**β [S.E]**	0.130*** [0.04]	-0.051 [0.036]	**NA**	0.831*** [0.02]	-0.200*** [0.066]	-0.208*** [0.081]
Commodity Derivatives	**SD**	**β [S.E]**	0.004 [0.035]	0.024 [0.035]	0.508*** [0.019]	**NA**	0.153** [0.065]	0.118 [0.062]
	ARCH	**β [S.E]**	-0.026 [0.031]	0.055 [0.032	0.661*** [0.024]	**NA**	0.134 [0.077]	0.191 [0.11]
	GARCH	**β [S.E]**	0.087*** [0.033]	-0.008 [0.03]	0.568*** [0.014]	**NA**	0.265*** [0.054]	0.235*** [0.066]
Forex Spot	**SD**	**β [S.E]**	0.017 [0.013]	0.012 [0.012]	-0.007 [0.008]	0.020** [0.008]	**NA**	0.284*** [0.021]
	ARCH	**β [S.]**	0.006 [0.009]	0.007 [0.01]	-0.008 [0.009]	0.012 [0.007]	**NA**	0.672*** [0.031]
	GARCH	**β [S.E]**	0.005 [0.014]	0.009 [0.013]	-0.025*** [0.008]	0.048*** [0.01]	**NA**	0.878*** [0.02]
Forex Derivatives	**SD**	**β [S.E]**	0.009 [0.013]	0.024 [0.01]	0.005 [0.008]	0.017 [0.00]	0.309*** [0.023]	**NA**
	ARCH	**β [S.E]**	-0.006 [0.006]	0.015*** [0.006]	0 [0.006]	0.008 [0.005]	0.298*** [0.014]	**NA**
	GARCH	**β [S.E]**	0.006 [0.012]	0.008 [0.01]	-0.017*** [0.007]	0.028*** [0.008]	0.589*** [0.013]	**NA**

[Source: Computed & Tabulated by the Researcher]

Equity (spot) market volatility is not influenced by Forex (spot & derivatives) Market volatility and Commodity (spot & derivatives) market volatility. Likewise, equity (derivatives) market volatility has no long run linkage with Commodity (spot & derivatives) market volatility and the forex (spot & derivatives) market volatility.

Volatility of commodity (spot) market, is found to be independent on Forex (spot & derivatives) volatility and equity (spot & derivatives) volatility, Commodity (derivatives) market volatility, is significantly dependent on forex (spot) market volatility and commodity (spot) market volatility. Volatility of Forex (spot) market is only dependent on the Forex (derivatives) market volatility and the commodity (derivatives) market volatility. Similarly, Forex (derivatives) market is significantly dependent only on Forex (spot) market volatility.

4.4.2. Short Term Relationship Among the Indian Financial Markets and its Segments

To understand the short-term relationship is essential and helps in navigating the immediate movements in the financial markets and evaluation of immediate cross over and market influences between the two pairs of timeseries.

its pave the way to analysis the short-term relationship of price series along with the various volatility series (SD, ARCH, GARCH) of Financial (Equity, Commodity & Forex) Market and its Segments (Spot and Derivatives). The results of the same is exhibited in the table 8

Table 8: **The Short-Term Relationship Analysis of Price and Different Volatility Series (SD, ARCH, GRACH) of Financial (Equity, Commodity & Forex) Market and its Segments (Spot and Derivatives) Form 1st January 2016 to 31st December 2023**

	Equity Spot	**Equity Derivatives**	**Commodity Spot**	**Commodity Derivatives**	**Forex Spot**	**Forex Derivatives**
Price Series						
Equity Spot		(3.506)** [0.397]^{NS}	(3.065)** [2.254]^{NS}	(2.358)^{NS} [3.312]**	(4.274)** [5.636]**	(2.772)^{NS} [2.226]^{NS}
Equity Derivatives			(1.900)^{NS} [2.285]^{NS}	(1.628)^{NS} [3.331]**	(4.282)** [5.549]**	(3.140)** [2.320]^{NS}
Commodity Spot				3.065)** [2.254]**	(0.121)^{NS} [4.459]**	(0.095)^{NS} [1.993]^{NS}
Commodity Derivatives					(0.563)^{NS} [7.424]**	(0.520)^{NS} [4.388]**
Forex Spot						(349.622)** [1.771]^{NS}
Forex Derivatives						

Table 8: **The Short-Term Relationship Analysis of Price and Different Volatility Series (SD, ARCH, GRACH) of Financial (Equity, Commodity & Forex) Market and its Segments (Spot and Derivatives) Form 1st January 2016 to 31st December 2023**

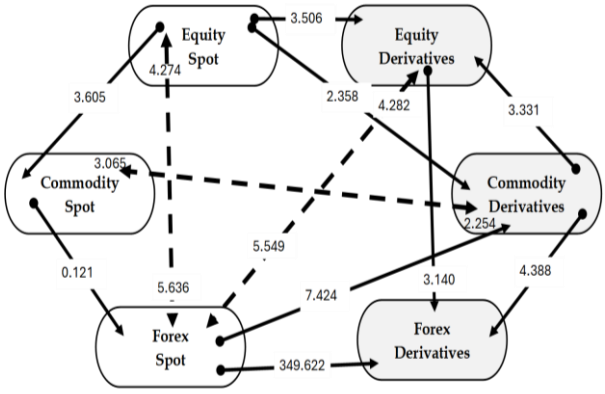
SD Based Volatility Series						
	Equity Spot	**Equity Derivatives**	**Commodity Spot**	**Commodity Derivatives**	**Forex Spot**	**Forex Derivatives**
Equity Spot	NA	(0.037)^{NS} [6.160]**	(11.262)** [13.232]**	(14.215)** [17.465]**	(3.560)** [6.245]**	(4.450)** [15.967]**
Equity Derivatives		NA	(11.940)** [12.107]**	(16.438)** [18.286]**	(4.031)** [6.431]**	(5.147)** [14.098]**
Commodity Spot			NA	(16.085)** [6.478]**	(0.940)^{NS} [7.453]**	(2.073)^{NS} [4.154]**
Commodity Derivatives				NA	(1.493)^{NS} [16.760]**	(6.251)** [5.637]**
Forex Spot					NA	(17.238)** [19.788]**
Forex Derivatives						NA
ARCH Based Volatility Series						
	Equity Spot	**Equity Derivatives**	**Commodity Spot**	**Commodity Derivatives**	**Forex Spot**	**Forex Derivatives**
Equity Spot	NA	(21.338)** [19.779]**	(8.366)** [17.868]**	(4.950)** [17.304]**	(2.148)^{NS} [8.101]**	(1.371)^{NS} [22.760]**
Equity Derivatives		NA	(9.362)** [16.859]**	(6.617)** [16.394]**	(2.961)** [8.727]**	(1.566)^{NS} [20.972]**
Commodity Spot			NA	(24.007)** [1.773]^{NS}	(0.538)^{NS} [8.285]**	(0.095)^{NS} [7.275]**
Commodity Derivatives				NA	(0.666)^{NS} [9.953]**	(2.028)^{NS} [7.198]**
Forex Spot					NA	(35.028)** [6.251]**
Forex Derivatives						NA
GARCH Based Volatility Series						
	Equity Spot	**Equity Derivatives**	**Commodity Spot**	**Commodity Derivatives**	**Forex Spot**	**Forex Derivatives**
Equity Spot	NA	(23.376)** [21.818]**	(10.594)** [2.817]^{NS}	(11.304)** [5.365]**	(1.859)^{NS} [3.302]**	(0.426)^{NS} [17.463]**
Equity Derivatives		NA	(12.582)** [3.338]**	(13.493)** [4.941]**	(1.936)^{NS} [3.966]**	(0.606)^{NS} [16.630]**
Commodity Spot			NA	(2.818)^{NS} [5.828]**	(0.047)^{NS} [5.111]**	(0.577)^{NS} [6.382]**
Commodity Derivatives				NA	(0.631)^{NS} [10.363]**	(1.418)^{NS} [8.296]**
Forex Spot					NA	(44.244)** [7.495]**
Forex Derivatives						NA

*Note: (1). Results within (*) are representing relationship between Row → Column; whereas Results within [*] are representing relationship between Column → Row. (2). Shaded cells are indicating the Bidirectional relationship, and the remaining significant flagged (i.e. **) cells are indicating the unidirectional relationship. [Source: Computed & Tabulated by the Researcher]*

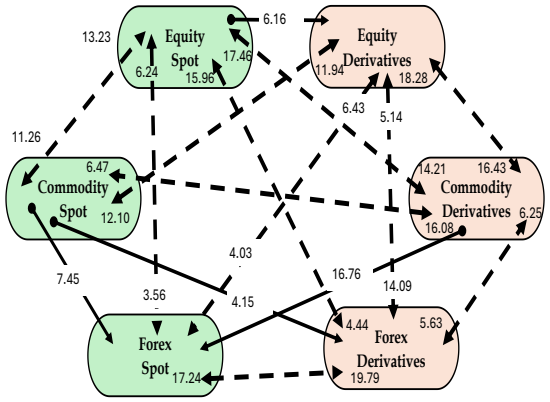
The Graphical representation of short-term relation among the various financial submarkets and its segments are exhibited below in the figure 10

Figure 10: **The Graphical representation of the Short-Term Relationship of Price and Different Volatility Series (SD, ARCH, GRACH) of Financial (Equity, Commodity & Forex) Market and its Segments (Spot and Derivatives)**

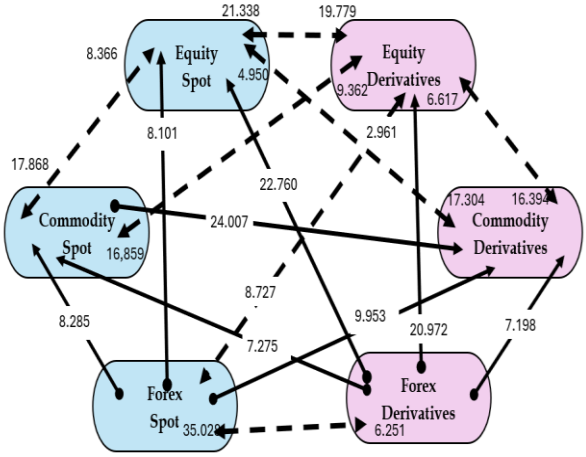
Price Series



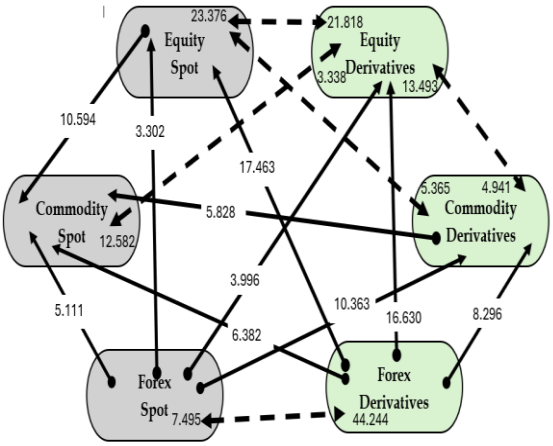
SD Based Volatility Series



ARCH Based Volatility Series



GARCH Based Volatility Series



Note: (1). Dotted lines are representing the Bidirectional relationship, and the normal lines are indicating the unidirectional relationship.
[Source: Computed & Designed by the Researcher]

The summary of the short-term relationship among the price series and various types of volatility series of financial (equity, commodity, forex) and its segments (spot and derivatives) are reported in the table 9

Table 9: **The Short-Term Relationship Analysis of Price and Different Volatility Series (SD, ARCH, GARCH) of Financial (Equity, Commodity & Forex) Market and its Segments (Spot and Derivatives) Form 1st January 2016 to 31st December 2023**

Financial Market(i.e. Equity, Commodity & Forex) & its Segments (i.e. Spot & Derivatives)	@ Level	SD	ARCH	GRACH
Equity *Spot* Granger-cause **Equity** *Derivatives*	←	→	↔	↔
Equity *Spot* Granger-cause **Commodity** *Spot*	←	↔	↔	←
Equity *Spot* Granger-cause **Commodity** *Derivatives*	→	↔	↔	↔
Equity *Spot* Granger-cause **Forex** *Spot*	↔	↔	→	→
Equity *Spot* Granger-cause **Forex** *Derivatives*	NS	↔	→	→
Equity *Derivatives* Granger-cause **Commodity** *Spot*	NS	↔	↔	↔
Equity *Derivatives* Granger-cause **Commodity** *Derivatives*	→	↔	↔	↔
Equity *Derivatives* Granger-cause **Forex** *Spot*	↔	↔	↔	→
Equity *Derivatives* Granger-cause **Forex** *Derivatives*	←	↔	→	→
Commodity *Spot* Granger-cause **Commodity** *Derivatives*	↔	↔	←	→
Commodity *Spot* Granger-cause **Forex** *Spot*	→	→	→	→
Commodity *Spot* Granger-cause **Forex** *Derivatives*	NS	→	→	→
Commodity *Derivatives* Granger-cause **Forex** *Spot*	→	→	→	→
Commodity *Derivatives* Granger-cause **Forex** *Derivatives*	→	↔	→	→
Forex *Spot* Granger-cause **Forex** *Derivatives*	←	↔	↔	↔

[Source: Computed & Tabulated by the Researcher]

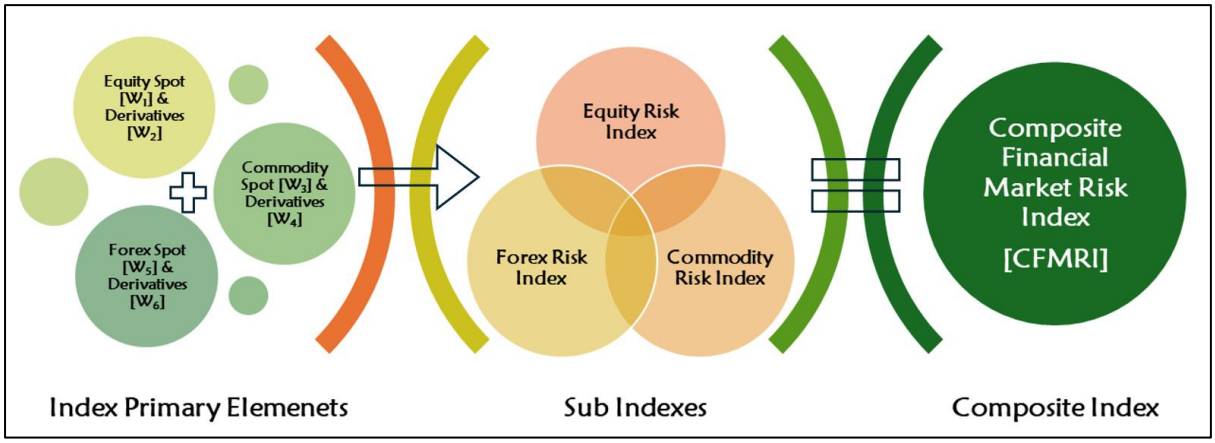
The short-term analysis or the cause-and-effect evaluation exhibits that all the volatility series SD, ARCH, GARCH granger cause the financial market segments either in unidirectional or bidirectional. SD series has a higher amount of bidirectional flow which includes both inter and intra cause and effect relationship among the submarket segments and which is not the same for ARCH and GARCH Volatility series. Intra Market cause and effect is visible in the short-term analysis among the Equity, Commodity and Forex Market and inter market granger cause between Equity and Commodity Market segments is found evident in the results.

5.CONSTRUCTION OF COMPOSITE RISK INDEX

5.1 Research Intention

This segment comprises of Construction of the **Composite Financial Market Risk Index** (CFMRI), that represents the combined risk of various Financial Markets of India. The third objective of the study is the construction of the composite risk index for the Indian Financial Markets (**Equity, Commodity and Currency**). The conceptual model of the composite risk index is exhibited in the figure 11

Figure 11: **The Conceptual Model of Composite Risk Index**



[Source: Designed by the Researcher]

The weights of the variables will be calculated through various methods and will be assigned after which the variables are multiplied with the assigned weights. The summation of the product i.e. variables multiplied by weights is divided by the sum of the overall weights, which will result in the constructed value of the **Composite Financial Market Risk Index** (CFMRI).

5.2 Relevant Literature and Research Gap

Studies of *Boudt, d'Errico, et.al., (2022)* developed the Resilience Capacity Index through Principal Component Analysis to assess the resilience of food insecurity at the household level. *C. Vieira, Neto, et al (2022)* constructed a Social Vulnerability Index (SVI) for the San Francisco River Basin. *Dharmawardena, Thattil, & Samita, (2015)* created composite indices for the Columbo district of Sri Lanka natural variability. *Dolge, Anna, et.al.(2020)* focuses on creation of a composite index Energy Efficiency Index for analyzing the efficiency of the industrial sector of Latvia. *Figueira, et al., (2023)* focused on constructing a composite indicator for assessing the covid period in Portugal. *Gerundo, Marra, & Salvatore, (2020)* generated composite vulnerability index for the Italian Municipality by employing fuzzy logic in its construction to identify susceptible areas and measures of mitigation for the geographical areas that are at a danger of deterioration. *Gupte, Venkatarami, & Gupta, (2012)* develops a financial index pertaining to the context of India. *M.A.C.S.S Fernando, (2012)* creates urbanization index for population density. Pavithra, et.al., (2019) established a Food Grain Production Index for 30 districts in the state of Karnataka, India. *Roy, Biswas, & Sinha (2015)* using Principal Component Analysis (PCA), created the Financial Condition's Composite Indicator (FCCI) and evaluates the association between the economic activities and financial conditions in India. *Salisu & Akanni (2020)* aims on constructing a global fear index for the covid period based on reported cases and reported deaths of the majorly affected countries. *Krishnan(2010)* study is based on the creation

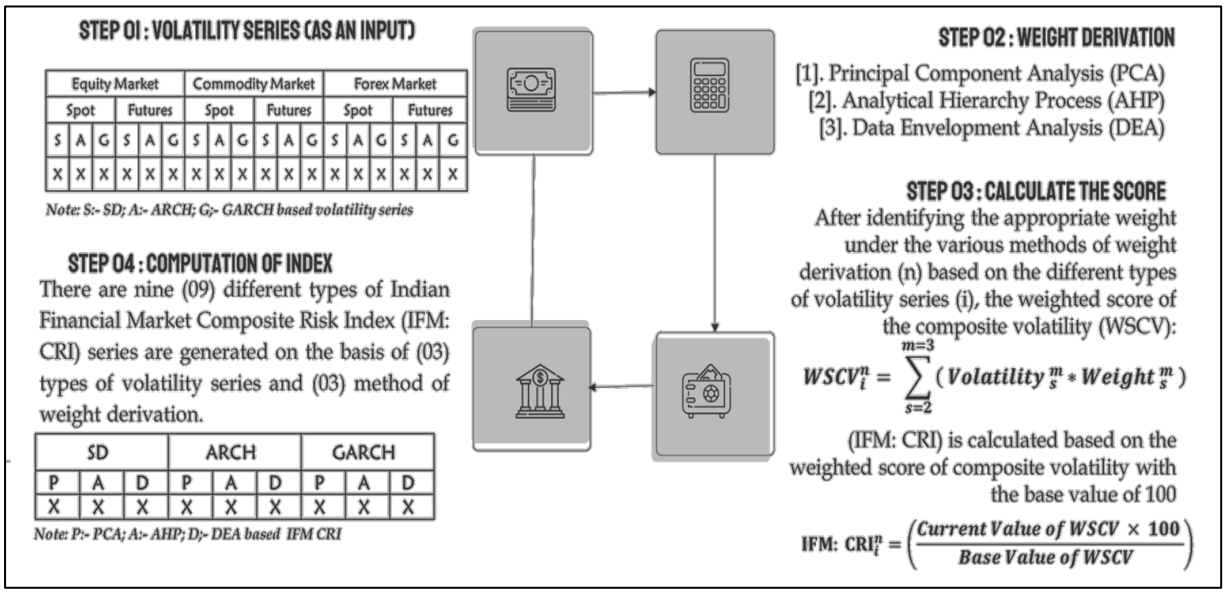
of socioeconomic index with the use of standardization procedures, *C. Vieira, et.al, (2022)* Constructs socioeconomic status indices (Social Vulnerability Index) for the area of San Francisco River Basin Brazil.

The composite index, which is created by combining many indices using different weighting procedures for analyzing the characteristics such as population density, national economic performance and social vulnerability has been extensively researched. An array of indices that have been developed making use of diverse weighting techniques. The absence of a composite index in the field of financial market risk research is noteworthy, and can be claimed that no composite index has been constructed in the realm of risk analysis within the financial market. It is equally important to completely understand the volatility of the Indian Financial Market. The research aims to address the problem of insufficient risk representation in the submarkets of the Indian Financial Market and creation of a Composite Risk Index as a potential solution.

5.3 Data & Method

The generated SD, ARCH, GARCH volatility series has been adopted and the study has been processed further for the construction of the composite financial market risk index. The Weights have been generated for which various methods such as *Factor Analysis* (FA) based on *Principal Component Analysis* (PCA), *Analytic Hierarchy Process* (AHP) and *Data Envelopment Analysis* (DEA) has been used to find the value of weights of the variables of the Indian Financial Market. The computational procedures of the composite risk index is exhibited in the figure 12

Figure 12: **The Computational Procedures of Composite Risk Index**



[Source: Designed by the Researcher]

The PCA is a method of simplifying a complex dimensional data. It transforms complex data into fewer dimensions or reduces the number of variables of the data set which is called Principal Component. The weight derivation through Factor Analysis method has been evaluated in the SPSS Software. The factor weights are derived by aggregating the total and cumulative proportion of explained variance. The Principal Component Approach was employed to construct a Rotated Component Matrix by utilizing diverse Volatility Series (SD, ARCH and GARCH) from Indian Financial Market submarkets (Equity, Commodity and Forex) and their segments (spot & Derivatives) respectively to establish the weights. The excel worksheet is utilised to calculate larger explained variance ratios, showing the more significant effect on the total variance and it is considered more influential when choosing the weights for the composite index. The factor weights are determined based on the sum and the overall percentage of explained variation. For determining the weights of each independent variable, the rotated component matrix values have been utilised which should add up to either 1 or 100.

The weights derived as per the Analytic hierarchy process has been performed in excel sheet. The correlation matrix of the corresponding variable is regarded as a substitute for the pairwise stakeholder's opinion comparison table. The weight derivation through the *Analytic Hierarchy Process* (AHP) focuses on establishing a prioritization matrix. The matrix is used to assign weights to the volatility series using the correlation matrix the priority value of each component is determined.

The weight derivation through the Data Envelopment has been performed in the DEA Solver Learner Version 8. The market segment wise weights have been calculated for the various volatility series (SD, ARCH, GARCH) using CCR (*Charnes, Cooper and Rhodes*) method. The scores have been calculated and is utilized after a conversion of a value of 100. The volatility series average value has been regarded as outputs and the price series is regarded as output. The obtained score for the various volatility series of a market segment contains 9 different combinations which are allotted a score value and are converted into a value of 100.

The ultimate score of weights for the construction of the composite risk index has been calculated with the help of the following equation Where, I = Types of Volatility Series; n = Method of Weights derivation; m = financial submarkets; s = segment of the market.

$$\mathrm{WSCV}_i^n = \sum_{s=2}^{m=3} (\mathrm{Volatility}_s^m * \mathrm{Weight}_s^m) \quad \text{(Eq. 5)}$$

The construction of the composite index CFMRI has been computed with the help The ultimate score of weights for the construction of the composite risk index has been calculated with the help of the following equation Where, I = Types of Volatility Series; n = Method of Weights derivation; m = financial submarkets; s = segment of the market.

$$\mathrm{WSCV}_i^n = \sum_{s=2}^{m=3} (\mathrm{Volatility}_s^m * \mathrm{Weight}_s^m) \quad \text{(Eq. 6)}$$

The following equation which is constructed based on the value of the scores derived in equation above and the base value which is regarded to be 100.

$$\mathrm{CFMRI}_i^n = \left(\frac{\text{Current Value of WSCV} \times 100}{\text{Base Value of WSCV}}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{(Eq. 7)}$$

After the formation of the Composite Index, it has been compared with the India Volatility Index (VIX). The significant mean difference has been evaluated before which the normality test has been conducted based on which the method for the evaluation of the mean difference has been selected.

5.4 Results & Discussion

The focus of the present session is to construction of the Composite Risk Index by using the financial submarkets and its segments. The volatility series generated in the section 3 is utilized for construction of the composite risk index.

5.4.1. Construction of Composite Risk Index

The pre cursor for the construction index is to identify the appropriate weight by deriving through the various methods such as *Factor Analysis* (FA) based on *Principal Component Analysis* (PCA), *Analytic Hierarchy Process* (AHP) and *Data Envelopment Analysis* (DEA). They have been used to find the value of weights for the variables of the Indian Financial Market. The weight of various methods are reported in the table 10

Table 10: **The Summary of Weights of Financial Submarkets (i.e., Equity, Commodity and Forex) & its Segments (i.e., Spot &Derivatives)**

Method of		Equity Market		Commodity Market		Forex Market		Total Weight
Weight Derivation	Volatility Calculation	Spot	Futures	Spot	Futures	Spot	Futures	
[1]. Principal Component Analysis	[1.1]. SD	18.134	18.116	16.607	16.448	16.033	14.662	100
	[1.2]. ARCH	17.757	17.736	16.645	16.27	16.117	15.475	100
	[1.3]. GARCH	16.726	16.673	15.565	15.443	17.918	17.675	100
[2]. Analytical Hierarchy Process	[2.1]. SD	18.205	18.133	15.686	16.366	15.353	16.257	100
	[2.2]. ARCH	18.141	18.057	15.312	16.808	15.33	16.352	100
	[2.3]. GARCH	17.884	17.859	15.57	17.316	15.398	15.973	100
[3]. Data Envelopment Analysis	[3.1]. SD	16.547	16.787	32.076	1.257	16.392	16.941	100
	[3.2]. ARCH	18.028	15.306	32.175	1.158	16.081	17.252	100
	[3.3]. GARCH	16.308	17.025	32.141	1.192	16.373	16.961	100

[Source: Computed & Tabulated by the Researcher]

After deriving the respective weights from the various methods, the various sub-indices are generated to build the 9 different composite risk indexes based on the three types of volatilities computation methods such as, SD, ARCH and GARCH and by using 03 Weight derivation techniques

of PCA, AHP and DEA. After developing the 09 different variants of Composite Financial Market Risk Index, they underwent data profiling through the detailed Exploratory Data Analysis and the results of the same is exhibited in the below table 11 to 13.

Table 11: **Descriptive Analysis of PCA Based Composite Financial Market Risk Index (CFMRI) using Various Volatility (SD, ARCH, GARCH) Series**

Descriptive Statistics	PCA Based Composite Financial Market Risk Index (CFMRI)			
	VIX	Computation Method of Volatility		
		SD	ARCH	GARCH
Max.	83.608	762.81	395.64	399.08
Min	10.135	8.846	84.391	65.990
Mean	17.127	79.819	96.228	93.476
Median	15.693	65.216	91.134	86.167
Std. Dev.	6.710	60.307	19.251	28.756
Skewness	3.969	3.800	6.918	4.790
Kurtosis	27.855	28.763	75.058	36.517
JB Test [Sig.]	53355.2***	56456.09***	421503.1***	95138.35***

[Source: Computed by the Researcher]

Table 12: **Descriptive Analysis of AHP Based Composite Financial Market Risk Index (CFMRI) using Various Volatility (SD, ARCH, GARCH) Series**

Descriptive Statistics	AHP Based Composite Financial Market Risk Index (CFMRI)			
	VIX	Computation Method of Volatility		
		SD	ARCH	GARCH
Max.	83.608	770.81	400.94	406.19
Min	10.135	8.699	84.326	66.414
Mean	17.127	79.981	96.198	93.874
Median	15.693	65.411	91.090	86.491
Std. Dev.	6.710	60.618	19.465	29.286
Skewness	3.969	3.855	7.000	4.863
Kurtosis	27.855	29.452	76.584	37.224
JB Test [Sig.]	53355.2***	59403.76***	439266.8***	99107.14***

[Source: Computed by the Researcher]

Table 13: **Descriptive Analysis of DEA Based Composite Financial Market Risk Index (CFMRI) using Various Volatility (SD, ARCH, GARCH) Series**

Descriptive Statistics	DEA Based Composite Financial Market Risk Index (CFMRI)			
	VIX	Computation Method of Volatility		
		SD	ARCH	GARCH
Max.	83.608	732.743	378.791	389.987
Min	10.135	5.090	83.000	63.715
Mean	17.127	77.599	94.254	92.130
Median	15.693	64.503	89.279	85.035
Std. Dev.	6.710	58.208	17.983	28.349
Skewness	3.969	3.473	6.675	4.503
Kurtosis	27.855	25.516	73.158	33.999
JB Test [Sig.]	53355.2***	43447.62***	399317.9***	81583.39***

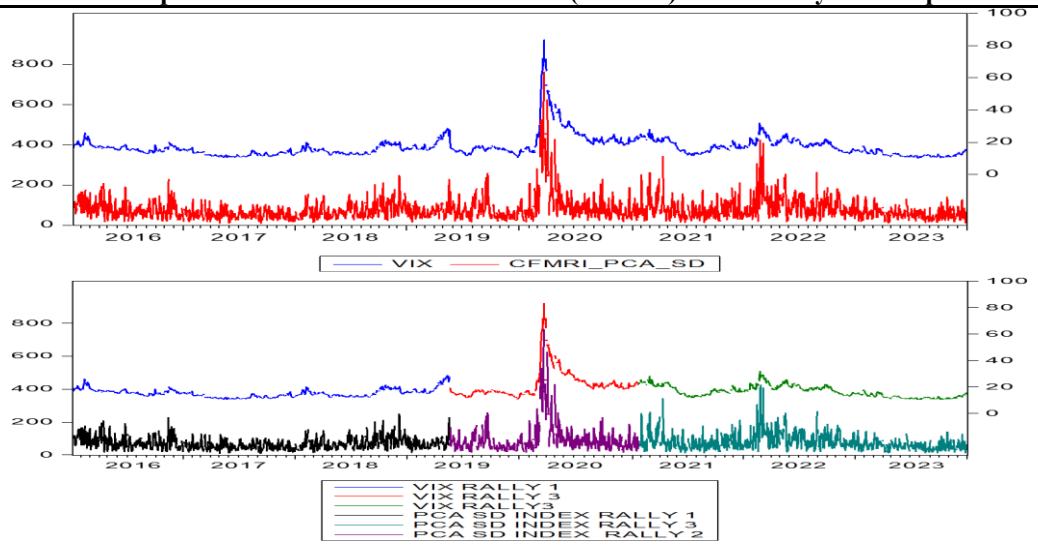
[Source: Computed by the Researcher]

For the better understanding of the behaviour of the various Composite Financial Market Risk Index, series are based on different methods of derivation of weights and using the different types of volatility series. The basic data profiling of the above index series is exhibiting the portrayal of the different composite risk index. It helps to understand the performance of the series and efficiently organizes and exhibits data from an enormous dataset into a form that is swiftly utilized to derive conclusions and contributes to decision making. The skewness values are positive and greater than 0 and the kurtosis value are higher than 3 indicating non normal distribution and right skewed and leptokurtic.

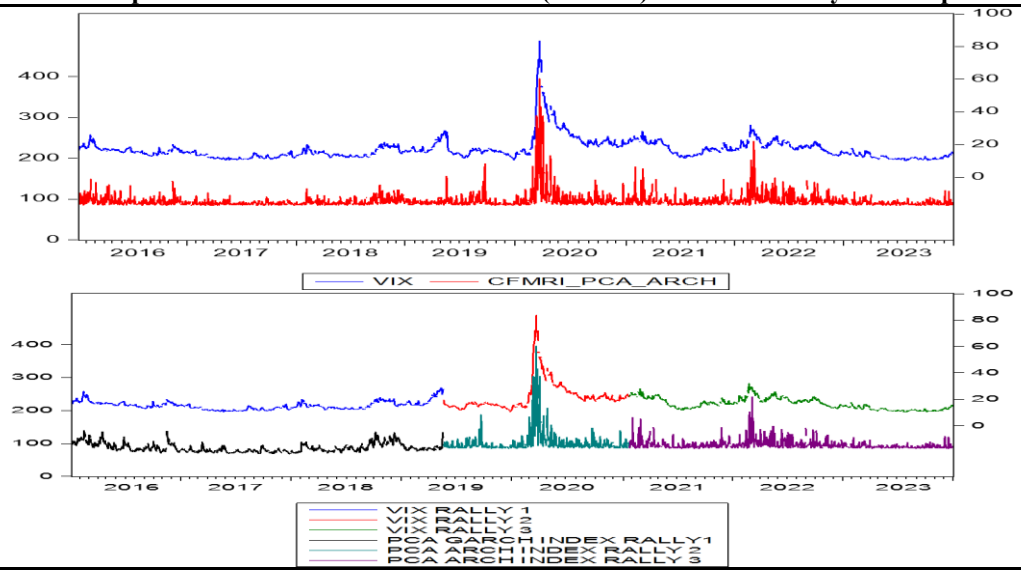
The basic data profiling of the above index series exhibits the portrayal of the different composite risk indexes along with VIX is exhibited in following figure 13 to 15. The graphs concludes that the research demonstrates a positive correlation between the Composite Risk Index and the India VIX, indicating variables are moving in sync.

Figure 13: **The Graphical representation of the PCA Based Composite Financial Market Risk Index (CFMRI) Using Different Volatility Series (SD, ARCH, GARCH) as an Input**

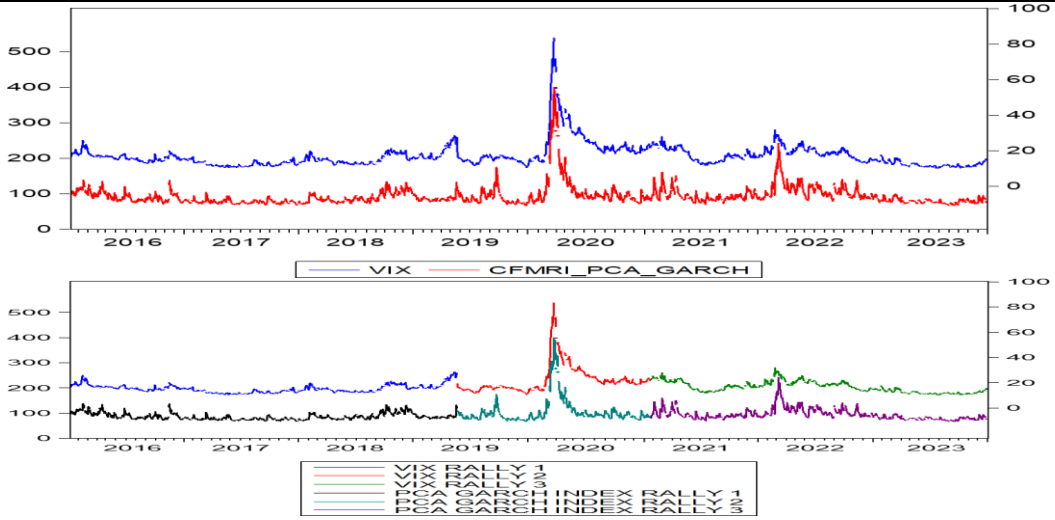
PCA Based Composite Financial Market Risk Index (CFMRI) SD Volatility as an Input Variable



PCA Based Composite Financial Market Risk Index (CFMRI) ARCH Volatility as an Input Variable



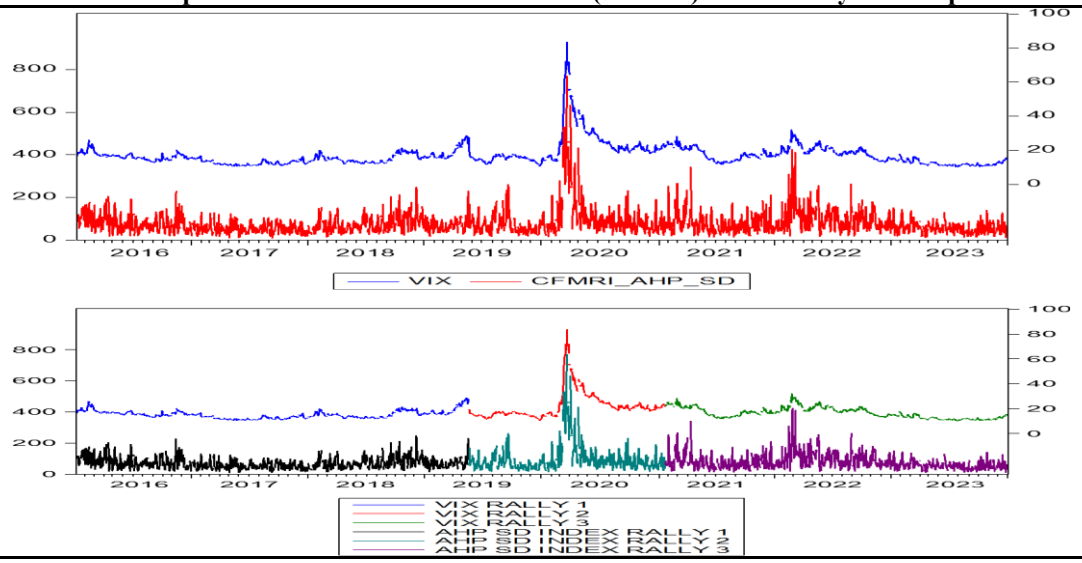
PCA Based Composite Financial Market Risk Index (CFMRI) GARCH Volatility as an Input Variable



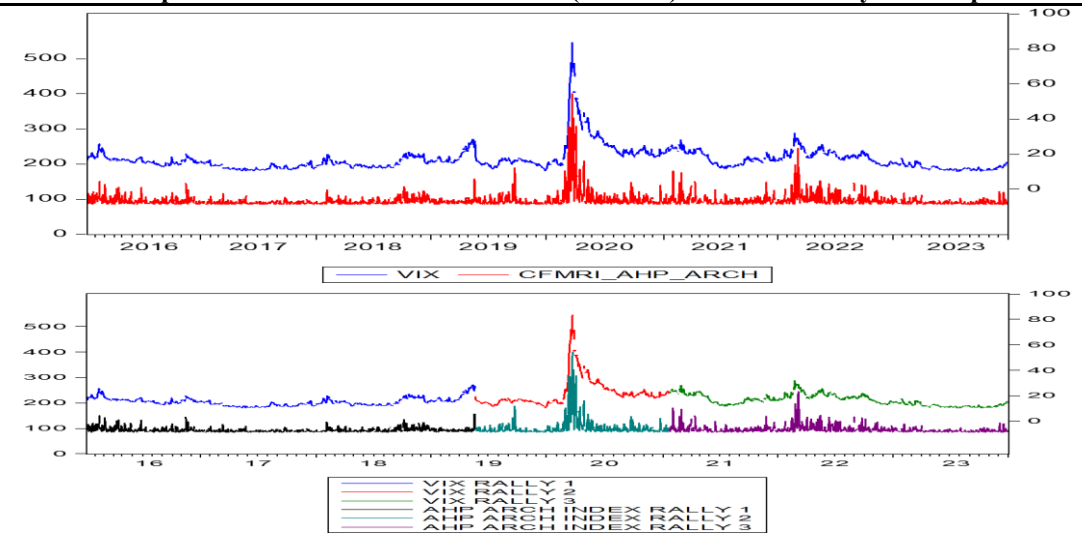
[Source: Computed & Designed by the Researcher]

Figure 14: **The Graphical representation of the AHP Based Composite Financial Market Risk Index (CFMRI) Using Different Volatility Series (SD, ARCH, GARCH) as an Input**

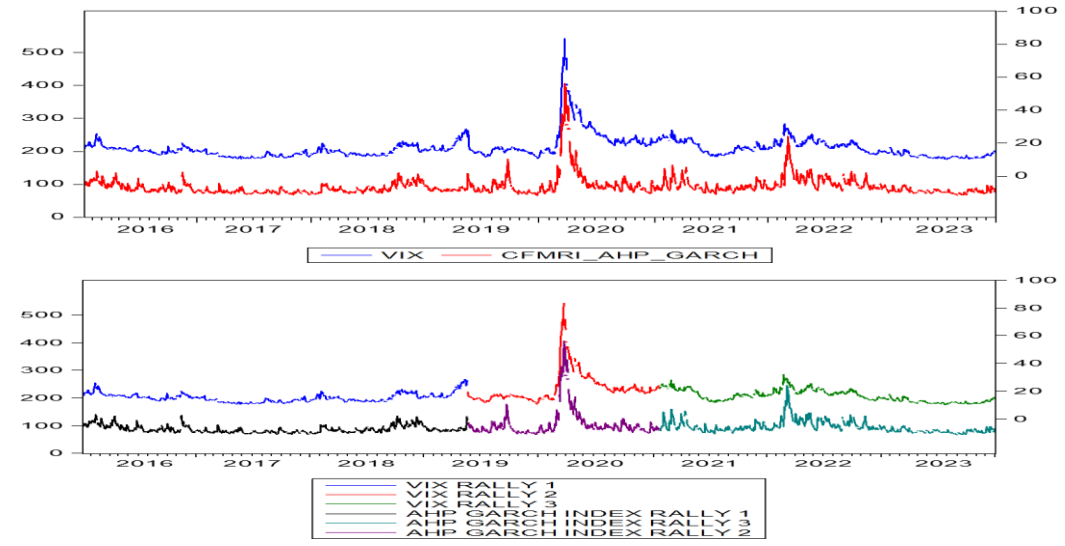
AHP Based Composite Financial Market Risk Index (CFMRI) SD Volatility as an Input Variable



AHP Based Composite Financial Market Risk Index (CFMRI) ARCH Volatility as an Input Variable



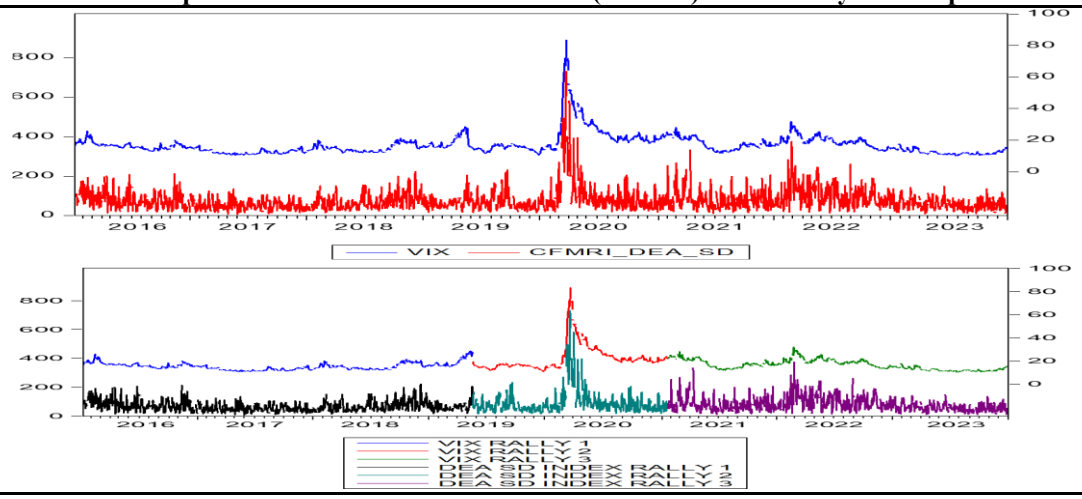
AHP Based Composite Financial Market Risk Index (CFMRI) GARCH Volatility as an Input Variable



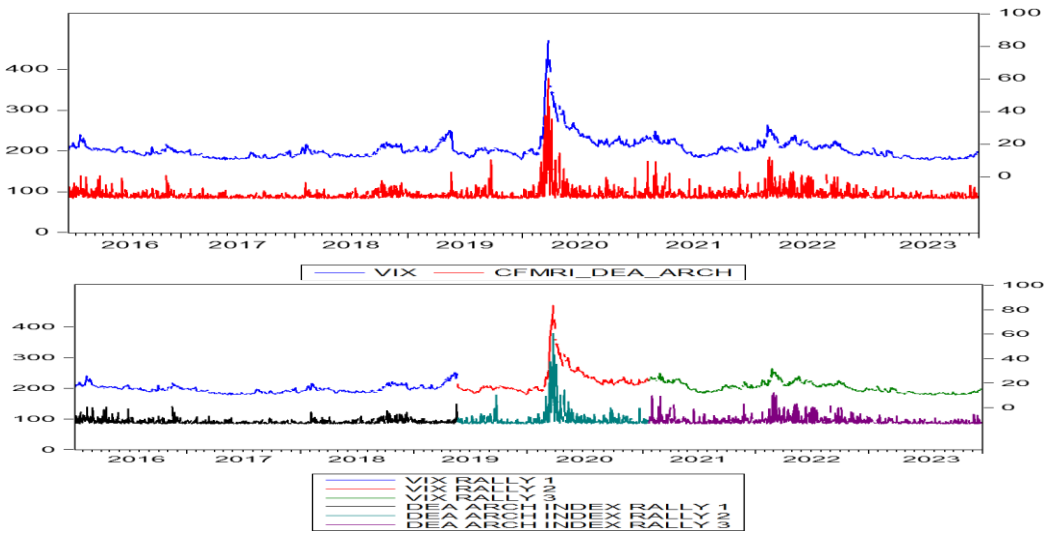
[Source: Computed & Designed by the Researcher]

Figure 15: **The Graphical representation of the DEA Based Composite Financial Market Risk Index (CFMRI) Using Different Volatility Series (SD, ARCH, GARCH) as an Input**

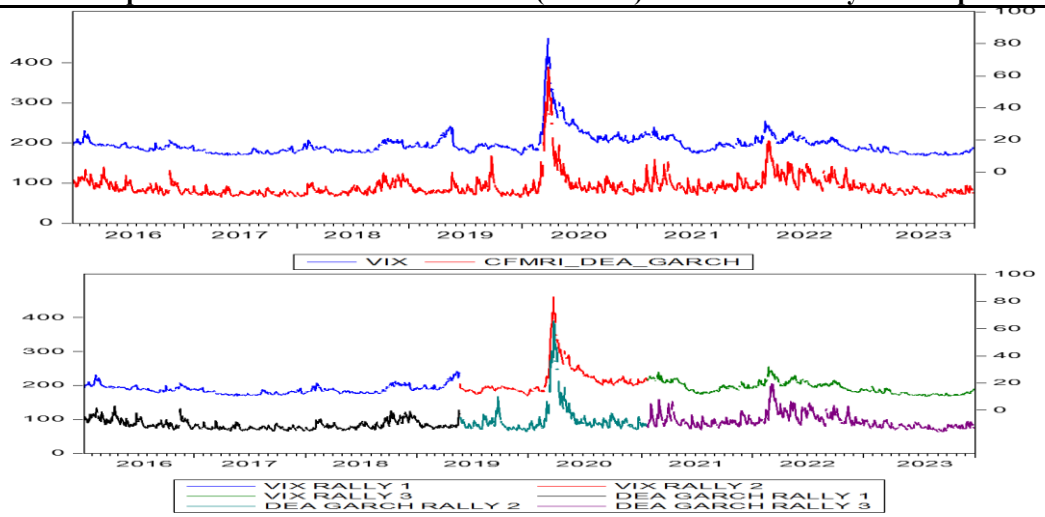
DEA Based Composite Financial Market Risk Index (CFMRI) SD Volatility as an Input Variable



DEA Based Composite Financial Market Risk Index (CFMRI) ARCH Volatility as an Input Variable



DEA Based Composite Financial Market Risk Index (CFMRI) GARCH Volatility as an Input Variable

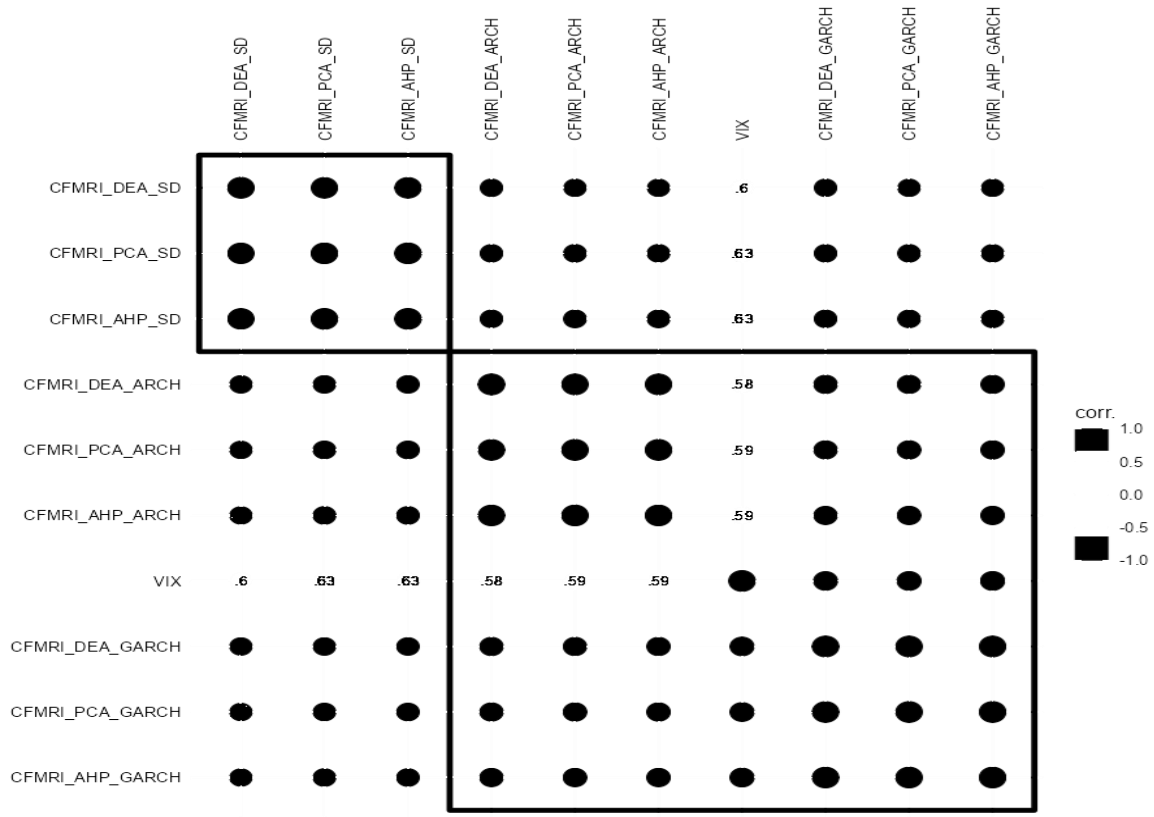


[Source: Computed & Designed by the Researcher]

5.4.2. Testing of Composite Risk Index

After construction of various Composite Financial Market Risk Index are based on different methods of *derivation of weights* and using the different *types of volatility series*. The similarity test with existing VIX and the Nine CRI model inter and intra comparations to help to identify and understand better the reliable index to capture the volatility movements from the Indian Financial Market. In this backdrop, the correlation-based cluster classification test is deployed to understand the similarity among the various Composite Financial Market Risk Index based on different methods of *derivation of weights* and using the different *types of volatility series* along with VIX. The result of the similarity test is presented in the figure 16

Figure 16: **Similarity Diagram of Various Composite Financial Market Risk Index & VIX**



[Source: Computed & Designed by the Researcher]

In addition to that, the researcher used the statistical test to check the significant mean divergence among the various Composite Financial Market Risk Index series based on different methods of *derivation of weights* and using the different *types of volatility series*. The results of mean divergence and convergence of Various Composite Risk Indexes of Indian Financial Market are reported in the table 14

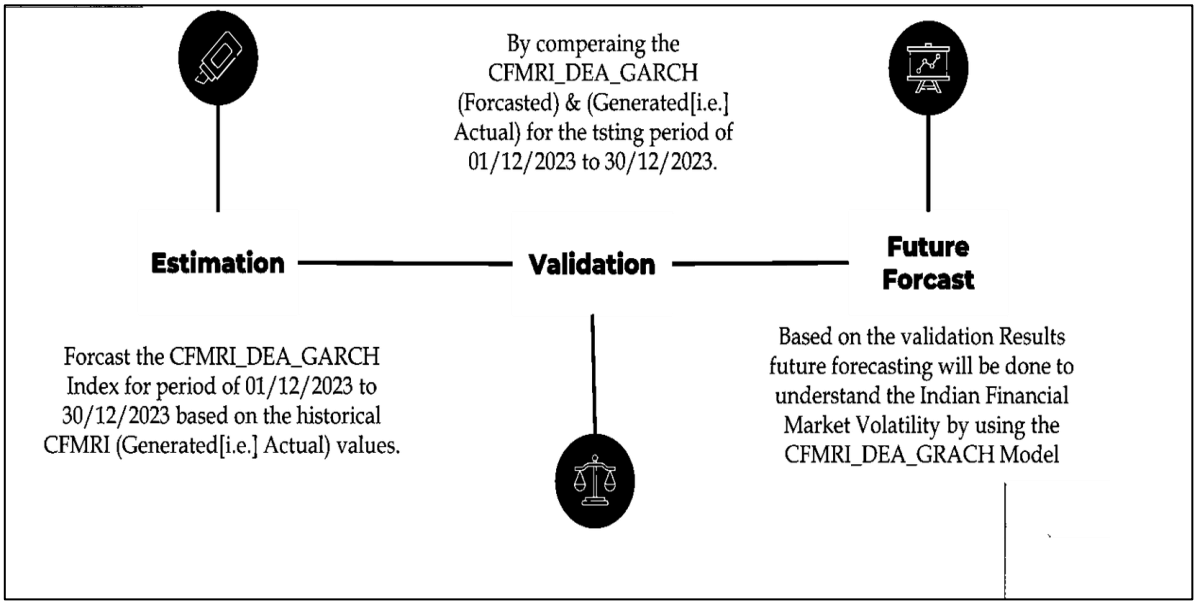
Table 14: **Inter & Intra model Comparation of Various Composite Risk Indexes of Indian Financial Market**

Inter and Intra Comparation of Mean Significant Difference		Types of volatility as input variable			Test Stat [Sig]
		[1] SD	[2] ARCH	[3] GARCH	
Method of Assigning the Weights	[1] PCA	79.819^{a} [.628**]	96.228^{bi} [.630**]	93.476^{ci} [.603**]	782.387**
	[2] AHP	79.981^{a} [.592**]	96.198^{bi} [.594**]	93.874^{ci} [.040]	771.390**
	[3] DEA	77.599^{a} [.041]	94.254^{bii} [.821**]	92.130^{cii} [.804**]	788.992**
Test Stat. [Sig]		3.394^{NS}	109.753**	17.658**	

*Note: (1). Numerical subscript indicates the cluster formation based on type of volatility & alphabet subscript indicates the cluster formation based on method of weight derivation; (2). values stated in [*] are bi-variate correlation of respective index with India VIX; (3). ** indicates at 5% Level of Significance (LOS)*
[Source: Computed & tabulated by the Researcher]

To analyse the reliability of the DEA based Composite Financial Market Risk Index using GARCH Volatility series as input variable the historical back-testing procedure is used. The image below explains the historical back-testing process in the figure 17

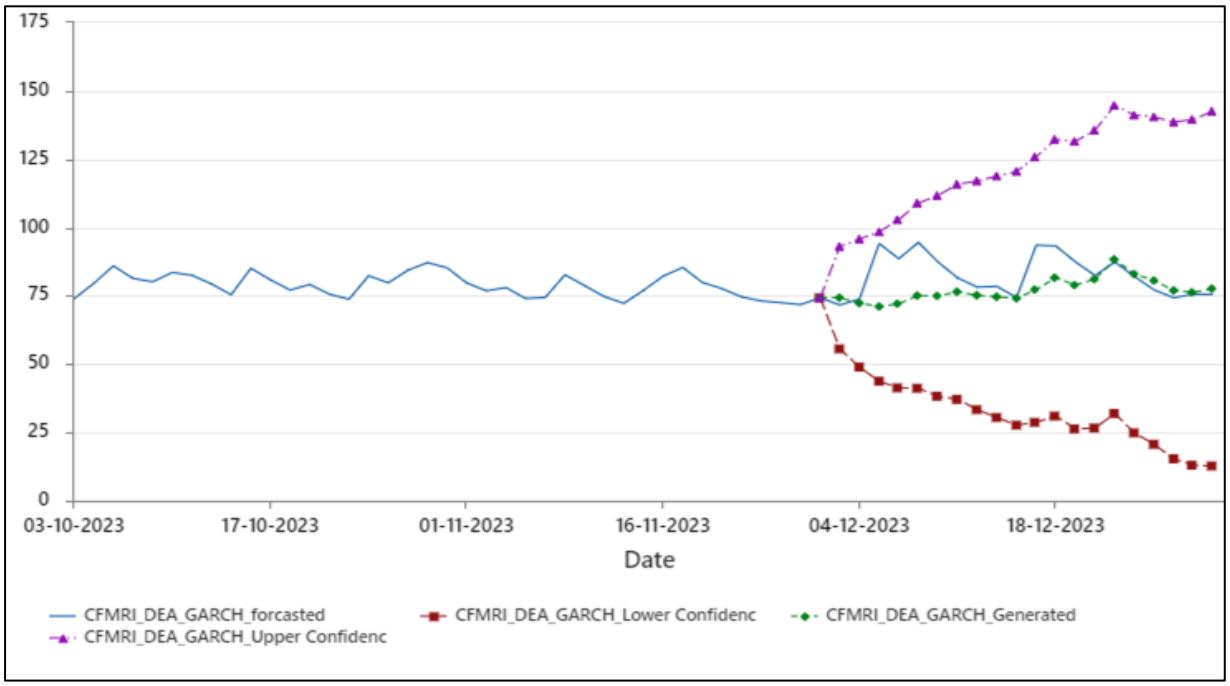
Figure 17: **Historical Back Testing Procedure for the Composite Financial Market Risk Index**



[Source: Designed by the Researcher]

The results of the historical back-testing process are exhibited in the below figure 18

Figure 18: **Results of Historical Back Testing Procedure for the Composite Financial Market Risk Index**



[Source: Computed by the Researcher]

The methodology used for the derivation of the weights are Principal Component Analysis (PCA), Analytic Hierarchy Process (AHP), and Data Envelopment Analysis (DEA). GARCH volatility series is considered being the series with less error comparatively as per the error diagnostic criteria. The results state that among the SD based CFMRI of the various methods are found to be non-significant stating a similarity in the SD based CFMRI irrespective of the method used. The ARCH and GARCH based composite index across the various methods of weight derivation are found significantly different in the various constructed index.

The GARCH based composite risk index constructed as per the different methods of weight PCA and AHP show a similar level of volatility compared to the composite risk index based on DEA exhibiting the better volatility results. The final selected index, CFMRI, DEA, GARCH has been back tested for a month period and compared its performance with the forecasted performance. The comparison stated that phenomena of geopolitical events led to the deviation in the performance of the volatility which cannot be suppressed and since we have taken into focus the performance of the market and not the external influences impact on the market. Yet, a similarity in movement of the CFMRI is also visible, concluding that the constructed composite index can be utilized for future performance evaluation.

6.SUMMARY OF FINDINGS AND CONCLUSION

6.1. Findings & Recommendation

The volatility was generated based on various volatility measurement tools and as per the evaluation of the volatility along with the performance of returns in the various submarket of Indian Financial Market it was fond that, the Equity Market had a wider range of variation in the year 2020, the commodity market in the year 2022 and the Forex market during the year 2019 and 2021.

. Long-term linkage in the price series has been found between the Equity Market variables equity spot and equity derivatives, along with the Forex Market Variables Forex spot and Forex derivatives is co-integrated. There is no inter market cointegration along with no evidence of cointegrating link in the Commodity market in the long term. Intra Market relation is found to be more significant for volatility series in all the submarkets than the inter market relation.

The equity (spot) market to commodity (derivatives) market; equity (derivatives) market to equity (spot) market; commodity (spot) market to equity (spot) market, commodity (spot) market, commodity (derivatives), forex (derivatives) to forex (spot) market and forex (derivatives) market to equity (future) market possess the unidirectional short – term relationship. Whereas, there is a bi-directional relationship found in the following pairs of markets such as, equity (spot) market to forex (spot) market; equity (derivatives) market to forex (spot) market; equity (derivatives) market to forex (spot) market and commodity (spot) market to commodity (derivatives) market.

Unidirectional influence is found more in the prices series between the financial submarkets and Bidirectional relation has been found more in terms of inter and intra comparison among the various financial market in terms of the SD volatility series and ARCH & GARCH states the intra market bidirectional relation existence in Equity, Commodity and Forex Market.

The GARCH based Composite Risk Index based on the different methods made evident that a higher level of correlation exists inter alia to explain the same phenomena of the market volatility. The GARCH based composite risk index constructed as per the different methods of weight, PCA and AHP show the slight same level of volatility compared to the composite risk index based on DEA exhibiting the better volatility results.

6.2. Conclusion

The financial market had wider fluctuations in the current scenario indicating the fear and uncertain decisions taken by investors in the market during the times of uncertainty. Instant reaction is found visible in the Equity Market due to massive participation. The commodity market had an ability of resilience to manage economic uncertainty caused by pandemic (i.e. COVID – 19) and other scenarios such as uncertainty of demand and supply due to natural calamities has a greater involvement in the volatility of commodity markets. The effects of any uncertainty stay longer in forex market. It was more uncertain before and after 2020, found highly sensitive, reactive by the way of market corrections taking longer duration. Preventive actions are found before the crisis and continued.

The volatility series has been evaluated for the short term and long-term relationship and it was found that in the evaluation of the long-term relationship analysis, the Equity, Commodity & Forex intra market relationship is found significant, whereas in the case of inter market relationship, GARCH volatility series is found significant compared to its counterpart of SD, ARCH volatility series. In case of the short-term relationship, mixed *(bidirectional and unidirectional)* relationship exists among the volatilities of submarket *(i.e. equity, commodity and forex)* and its segments *(i.e. spot and derivatives)*. Standard Deviation based volatility series shows more bidirectional relation in terms of the GARCH based volatility series.

The constructed volatility index CFMRI intends to analyze the risk present in the three submarkets (i.e. equity, commodity and forex) of Indian Financial Market and the method of GARCH model is found relevant according to the error diagnostic criteria. Further evidences on the basis of the similarity and mean divergence test exhibit that the weight derived through Data Envelopment Analysis is the best fit to construct the Composite Financial Market Risk Index.

The study has taken into focus the volatility movements of the predominant market indices of the respective market to construct the composite risk index for the representation of the consolidated risk for the Indian Financial Market. The historical back testing procedure, evidences that, the Composite Financial Market Risk Index deriving the weight through Data Envelopment Method and using the GARCH model-based volatility series as input (i.e. CFMRI DEA_GARCH) performs better. It can be stated as a better alternative to VIX for evaluating the volatility of the Indian Financial (Equity, Commodity & Forex) Market assuming that other external shock of Economic / Geopolitical events is neutralized. In this backdrop the present model of Composite Financial Market Risk Index based on DEA using GARCH based volatility will act as a proxy risk barometer to better capture and make a viable forecast of the Indian financial market volatility.

6.3. Scope of Future Study

The present study covers only the Equity, Commodity and Forex markets; But Indian Financial Market equally comprises of other markets such as Money Market, Corporate Bond Market, Government Securities Market. The future researchers can consider these other markets also.

The present study used only the predominant market representative index as proxy to capture the market volatility; whereas some of the Macro and Micro Economic factors and Geopolitical factors also affect the market movements therefore the future researcher may include such variable to construct and validate the Composite Risk Index.

The present study uses only the base variant of ARCH and GARCH model to generate the volatility series; as an input variable to construct the Composite Risk Index. The future researcher may use to the different variants of ARCH, GARCH and another sophisticated tools. It will vigorously increase the validity of the Composite Risk Index.

RESEARCH PAPER PRESENTATION & PUBLICATION

Paper Presentation in National Seminar

Indian Council of Social Science Research

Azadi Ka Amrit Mahotsav

ICSSR Sponsored National Seminar on
The Indian Economy and Business Since Independence
Organised by the PG and Research Dept. of Management Studies,
St. Joseph's Institute of Management (JIM), St. Joseph's College, (Autonomous), Tiruchirappalli
09 and 10 September 2022

CERTIFICATE OF PAPER PRESENTATION

This is to certify that **Ms. SUSMITA SUBBA, RESEARCH SCHOLAR,** from **SIKKIM UNIVERSITY** presented a paper titled **"Volatility Forecasting of the Indian Financial Market: Apropos to the COVID-19 Pandemic"** in the ICSSR Sponsored National Seminar on *"The Indian Economy and Business Since Independence"*, held during 09 - 10 September 2022, at St. Joseph's Institute of Management (JIM), Tiruchirappalli.

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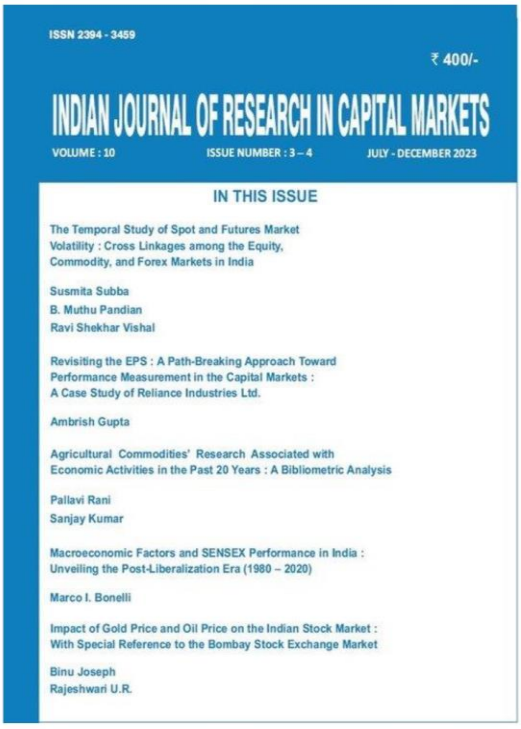

ISSN 2394 - 3459

₹ 400/-

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Volume 18, Issue 3 (2024) Pages

Special Issue from The Fourth Annual International Capital Markets Conference

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