A STUDY ON MODELLING VOLATILITY OF EXCHANGE TRADED FUNDS USING SYMMETRICAL GARCH MODELS

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Abstract

This study tries to analyze the volatility persistence and risk return relationships in Exchange Traded Funds as the objectives. For this purpose, returns of 5 ETFs: Nifty Bees ETF, Motilal Oswal ETF, IDBI Gold ETF, Junior Bees ETF, and Infra Bees ETF are taken. Symmetrical GARCH models GARCH (1, 1) and GARCH-in-Mean are used to capture the volatility in the market. Modeling volatility using these models gives strong evidence for the volatility persistence in the ETF returns. We are able to conclude the presence high volatility persistence and also that taking risks in ETF trading will provide higher rewards to the investors.

Keywords:- ETF Return; Volatility, GARCH (1, 1); GARCH-in-mean; Volatility persistence.

Finance is the lifeblood of business. Finance is a term for the management, creation, and study of money and investments. It involves using credit and debt, securities, and investment to finance current projects using future income flows.From the name itself, financial markets are a type of marketplace that provides an avenue for selling and purchasing assets such as bonds, stocks, foreign exchange, and derivatives. The four types of financial markets are currency, money, derivative, and capital. Capital markets are used to sell equities (stocks) and debt securities. The term stock

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market refers to several exchanges in which shares of publicly held companies are bought and sold. Such financial activities are conducted through formal exchanges and over-the-counter (OTC) marketplaces that operate under a defined set of regulations. "stock market" and "stock exchange" are often used interchangeably. Traders in the stock market buy or sell shares on one or more of the stock exchanges that are part of the overall stock market.

Financial markets create securities products that provide a return for those with excess funds (Investors/lenders) and make these funds available to those needing additional money (borrowers). Stock market volatility is the rate at which the price of a stock increases or decreases over a particular period. Stock market volatility measures how much the stock market's overall value fluctuates up and down. Beyond the market as a whole, individual stocks can also be considered volatile. More specifically, we can calculate volatility by looking at how much an asset's price varies from its average price. Standard deviation is the statistical measure commonly used to represent volatility.

An exchange-traded fund (ETF) is a pooled investment security that operates like a mutual fund. Typically, ETFs will track a particular index, sector, commodity, or other assets, but unlike mutual funds, ETFs can be purchased or sold on a stock exchange the same way a regular stock can. An ETF can be structured to track anything from the price of an individual commodity to a large and diverse collection of securities. ETFs can even be structured to follow specific investment strategies.

This study tries to analyze the presence of volatility in the ETF returns using five selected ETFs from NSE viz. Nifty Bees ETF, Motilal Oswal ETF, IDBI Gold ETF, Junior Bees ETF and Infra Bees ETF. The focus of the study lies on three objectives: first, to examine the nature of volatility patterns in exchange-tradedfunds; second, to determine the risk-return relationship in exchange-traded funds and third, to examine the persistence of exchange-traded funds in the stock market.

2. Review of Existing Literature

Some of the research studies that have influenced the preparation of this research work substantially are discussed in this section. A literature review is a selected analysis of existing research relevant to the topic, showing how it relates to this study.The following are a few studies undertaken by different researchers in the past to study the stock market volatility on exchange-traded funds**.**

Circle, U et.al (2012) this paper suggests a straightforward trading model for assets that are part of Exchange Traded Funds (ETFs) based on the Kyle (1985) framework. According to the model, trading in ETFs will make the stocks that make up those funds more volatile, and volatility spillovers will make equities that make up those funds less liquid and hold them proportionally. The outcomes agree with both trading-based and positive volume-volatility relationships. Market practitioners, government authorities, and investors are increasingly involved.

Trainor & Carroll (2013) Using a GARCH (1, 1) volatility estimate argues that prolonged holding periods can be

justified depending on volatility levels and an investor's willingness to accept a specific amount of decay. They also claim that actual decay is frequently underestimated by GARCH (1, 1) volatility estimates.For all funds until 2007, except the -3x fund, the average justified holding duration typically surpassed four months. The length of justified holding periods shrunk significantly during the financial crisis. To determine the maximum holding durations given an investor's decay threshold in different volatility situations, this study quantifies these factors' tradeoffs on decay. While most of the studies recommend brief holding times for leveraged ETFs.

Narend & Thenmozhi (2014) Tracking error, active returns, and Jensen's alpha are the three metrics used in this empirical research of the performance of exchange-traded funds and index funds from their respective creation to July 2013. According to this data, tracking inaccuracy is greater for ETFs than index funds.The active returns of the analysis show that while the index fund has underperformed and outperformed, ETFs consistently exceeded their underlying index.This analysis also shows that index funds perform better with Jensen's alpha than ETFs. Overall, the study shows that while ETFs have outperformed index funds in terms of active returns, index funds have outperformed them in terms of lower tracking error and higher Jensen's alpha.

Atoi (2014) This study estimated first-order symmetric and asymmetric volatility models to select the best forecasting volatility model with the most appropriate error distribution using the Nigerian all-share index from January 2, 2008, to February 11, 2013. This study showed that applying an appropriate error distribution in a volatility model enhances the model's efficiency.Based on root mean square error, the last twenty-eight days of out-of-sample forecast determined Power-GARCH (1,1,1) to be the best predictive model.The study thus advises empirical studies to consider various error distributionsto develop a volatility forecasting model that could ensure appropriate policy decisions.

Ben David et.al (2015)According to this study, ETFs are likely to be a trigger for noise traders because of their remarkable liquidity, and this noise can spread to the underlying assets through the arbitrage channel.The study takes advantage of exogenous index membership changes and discovers that stocks with increased ETF ownership exhibit noticeably higher volatility.Additional time series data indicates that ETFs create additional market noise rather than just redistributing existing market noise among assets.

Koima & Nassiuma (2015) The primary goal of this work is to use GARCH models to analyze the nature, characteristics, and stylized facts of Kenyan stock market volatility. A symmetric volatility model called the GARCH model was applied to assess the stock return volatility. The Kenyan stock market's volatility and its stylized facts, such as volatility clustering, fat tails, and mean reverting, are better explained by GARCH (1, 1). The findings demonstrate that stock return volatility varied during the sampled period. In light of the foregoing, it can be concluded that negative return shocks

are more volatile during a financial crisis than positive return shocks.

Vasudevan & Vetrivel (2016) The article uses daily data covering the period from July 1, 1997, to December 31, 2015, to model and forecast the volatility of the BSE SENSEX index returns of the Indian stock market. Asymmetric GARCH models and symmetric GARCH models were considered as forecasting models.The findings of this study support the existence of the leverage effect by demonstrating that asymmetric GARCH models outperform symmetric GARCH models in predicting conditional variance of the BSE-SENSEX returns.

Geetha & Hawaldar (2020) This study intends to track the data from the index and analyze the performance of the Exchange Traded Funds most actively traded shares and any influences. The study also examines currency fluctuations and their effects on index and ETF returns and volatility. The equities ETF that tracks NASDAQ (NDX 100) is chosen for the study, and statistical techniques, including correlation, regression, and the GARCH model, are used to analyze the data. The study evaluates the impact of currency rates on the NDX (NASDAQ) using data on USD, GBP, and INR exchange rates from 2013 to 2018. The study focuses on determining if the ETF is insensitive to changes in exchange rates when viewed as a basket of securities.

Liebi (2021) this report proves that exchange-traded funds are among the investment products with the greatest growth rate in the world. In just 15 years, total assets invested in ETFs have increased 20-fold, topping $3.7 trillion at the end of 2018.The major benefits of ETFs are rising demand for passive investments, strong liquidity, and cheap transaction costs. The 2010 flash crash prompted regulators to extensively research how ETFs affect the financial system.This literature reviewthoroughly analyzes how exchange-traded funds (ETFs) affect underlying assets' liquidity, price discovery, volatility, and comovement.

3. Data and Methodology

3.1 Data and Scope of the study

The nature of the study is analytical. The secondary data were collected for a period of ten years from 1-4-2013 to 31-3-2023. Data have been collected from the NSE website. The scope of the study is various ETFs selected viz.Nifty Bees ETF, Motilal Oswal ETF, IDBI Gold ETF, Junior Bees ETF, and Infra Bees ETF. Mean, Median, Skewness, Kurtosis, and Jarque-Bera Test results were used to analyze the nature of the data. To examine the effect of volatility in ETF returns, Symmetrical GARCH Models viz. GARCH (1,1), GARCH (3,1), and GARCH in Mean models were used.

Returns are calculated using the formula:

$$R_t = Ln\left(\frac{P_t}{P_{t-1}}\right) * 100$$

Where,

R_t is the return at time t, P_t is the closing price at time t, and P_{t-1} is thelagged value of the closing price at time t.

3.2 Models Used:

GARCH (1,1) MODEL

In GARCH models, the ARCH term indicates the squared previous day error

term, and the GARCH term is the lagged variance term. When ARCH term and GARCH term coefficients are significant, it indicates that conditional variance depends not only on the lagged squared residuals square term at the previous period but also on the lagged variance term. The sum of ARCH and GARCH terms is close to 1, which means that volatility is persistent in selected ETFs.

The formula of the GARCH (1,1) model is

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta \sigma_{t-1}^2$$

Where,

σ_t^2 is the conditional variance at time t

u_{t-1}^2 lagged squares of error terms

σ_{t-1}^2 Conditional variance of lagged terms

GARCH-IN-MEAN MODEL

GARCH-in-Mean model is propounded by Engle, Liliens, and Robin for framing risk-return trade-offs. It is an extension of GARCH model including the conditional volatility generating risk premium as the portion of anticipated return (Engle et al.,1987).

The formula

$$y = \mu + \delta_{t-1} + u_t$$

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta \sigma_{t-1}^2$$

Where,

σ_t^2 is the conditional variance at time t.

u_{t-1}^2 lagged squares of error terms

σ_{t-1}^2 conditional variance of lagged term.

δ risk premium

4. Analysis of Data

4.1 Descriptive Statistics of Returns

Table 4.1 shows the descriptive statistics of the returns of the closing price of ETFs. The average daily return of Motilal Oswal ETF (Mon 100) shows the highest mean (0.00080), and IDBI Gold ETF shows the lowest mean (0.0002). IDBI Gold ETF has the highest standard deviation (0.022), and lowest standard deviation is for Nifty Bees (0.011). All the five ETFs are negatively skewed or at the left side of the distribution. Kurtosis value is greater than 3 for all the five ETFs, thus forming the leptokurtic distribution. The Jarque Bera test is used to test the non-

Table 4.1

Descriptive Statistics of ETFs Based on Returns

ETFs	Mean	Median	Min	Max	SD	skewness	kurtosis	JB (p-Value)
Nifty Bees	0.0005	0.00076	-0.13	0.139	0.011	-0.69302	29.289	87586.2 (0.0000)
Mon100	0.0008	0.00133	-0.13	0.103	0.015	-0.38162	7.0661	5145.89 (0.0000)
IDBI Gold ETF	0.0002	0.0000	-0.16	0.162	0.022	-0.01372	7.1077	5146.68 (0.0000)
Junior Bees	0.0005	0.00146	-0.1	0.064	0.012	-0.84414	6.6804	4836.89 (0.0000)
Infra Bees	0.0003	0.0006	-0.11	0.111	0.016	-0.24893	6.1398	3865.7 (0.0000)

Source: Computed Data

normality. The null hypothesis is that there is no non-normality. Jarque Bera test shows a p-valueof less than 0.05 for all shares. It indicates that the returns of ETFs are not normal, which is typical of financial time series

Timeseries Plot of ETF Returns

Figure 1 to Figure 5 shows the time series plotsof returns of selected ETFs.

UNIT ROOT TEST

Unit root test is an econometric approach that tests whether the mean and variance change over time, considering the autoregressive structure of the time series. A unit root test tests whether a time series variable is non-stationary and possesses a unit root which is the null hypothesis .The Augmented Dickey-Fuller Test (ADF) is used to checkdata stationarity.

Figure 1
Returns of Nifty Bees ETF

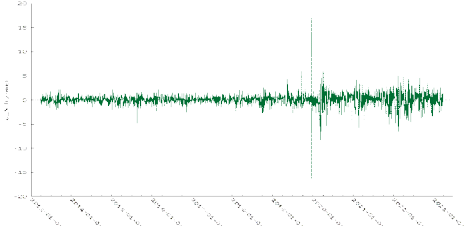


Figure 2
Returns of Motilal Oswal ETF

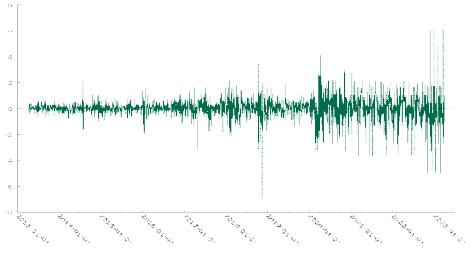


Figure 3
Returns of IDBI Gold ETF

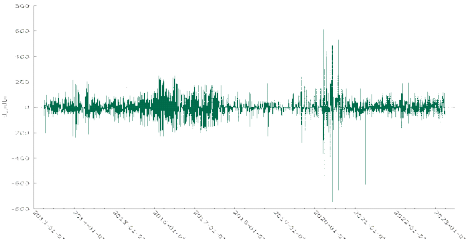


Figure 4
Returns of Junior Bees ETF

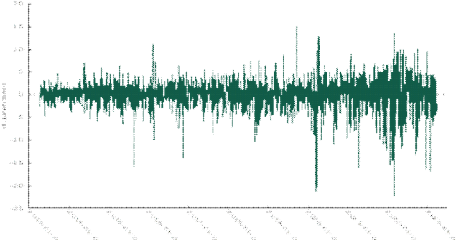
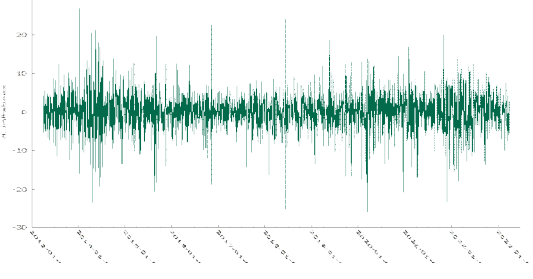


Figure 5
Returns of Infra Bees ETF



Augmented Dickey Fuller test results in Table 4.2 show a p-value less than 0.05, indicating the rejection of the null hypothesis that the data series has a unit root. The test result shows that the return series of all selected ETFs gives a p-value less than 0.05, indicating that the null hypothesis is rejected at a 5 per cent significance level. It means that all data series are stationary. Therefore, it can be used for further analysis.

ARCH LM TEST

Engle's (1982) ARCH-LM test is the standard test to detect autoregressive conditional heteroscedasticity. ARCH-LM test is used to check the presence of heteroscedasticity in time series data. If the p-value is less than 0.05, it indicates that the null hypothesis (No ARCH Effect) will be rejected. It means that time series has an ARCH effect.

Table 4.3 gives the results of the ARCH-LM test, which shows that the p-values have the ARCH effect. The test results show a p-value of less than 0.05, indicating the rejection of the null hypothesis (no ARCH effect). It means that the returns of all the selected ETFs have an ARCH effect. This confirms that all data series have autoregressive conditional heteroscedasticity. So, GARCH models can be used to analyze volatility persistence in ETFs in NSE.

TESTING OF VOLATILITY

To capture the persistence of volatility in ETF returns, GARCH (1,1) and GARCH-IN-MEAN models are used. The GARCH (1,1) model was used to

Table 4.2

ADF Test Results

Exchange Traded Funds	ADF TEST	
	Test Statistic	p-value
Nifty Bees	-58.62	0.00
Mon100	-53.98	0.00
IDBI Gold	-23.37	0.00
Junior Bees	-47.02	0.00
Infra Bees	-58.62	0.00

Source: Computed data

Table 4.3

ARCH LM Test Results

ARCH LM TEST		
ETFs	**Test stat**	**p-value**
IDBI GOLD	418.1239	0.0000
INFRABEES	330.321	0.0000
JUNIORBEES	77.9338	0.0000
MON 100	112.1326	0.0000
NIFTY BEES	5.8267	0.02

Source: Computed Data

analyze the volatility for Nifty Bees, Motilal Oswal ETF, IDBI Gold ETF, and Junior Bees.

The results of the GARCH (1,1) model estimation are displayed in Table 4.4. When the volatility of returns of all five ETFs is modeled using GARCH (1,1), significant coefficients for both ARCH and GARCH terms are obtained. These results show that conditional variance depends on the lagged variance term and the lagged squared residuals square term from the previous period. This indicates that the share returns are volatile.

GARCH (3,1) results of Infra Bees give significant coefficient values of ARCH and GARCH terms, which means that today's risk will impact future returns. The sum of ARCH and GARCH terms of Infra bees (.96) is close to 1, indicating volatility persistence in the returns of Infra bees.

The sum of ARCH and GARCH terms is used to check the volatility in persistence in the returns of shares in the stock market, and if the sum of these two terms is close to 1, it indicates that volatility is persistent in the stock market. The result shows that the sum of these two terms is close to 1 for all shares, meaning that the volatility is persistent in the Indian stock market.

Diagnostic Tests

To check the robustness of the results, two diagnostic tests viz. Ljung Box Test and ARCH LM test are used.

Table 4.4

GARCH (1,1) & GARCH 3,1 Output

SHARES	GARCH (1,1) RESULTS				Diagnostic Test Results	
	Intercept (p-value)	ARCH (p-value)	GARCH (p-value)	ARCH + GARCH	Ljung Box Test Q stat (p-value)	ARCH LM Test F stat (p-value)
Nifty Bees	0.0000 (0.0000)	0.13 (0.0000)	0.7527 (0.0000)	0.88	0.1245 (0.72)	0.12422 (0.72)
Mon100	0.0000 (0.0000)	0.145372 (0.0000)	0.7814 (0.0000)	0.92672	1.2372 (0.26)	1.2648 (0.26)
IDBI Gold	0.0000 (0.0000)	0.177631 (0.0000)	0.789 (0.0000)	0.96666	1.5102 (0.22)	1.5074 (0.22)
Junior Bees	0.0000 (0.0000)	0.110011 (0.0000)	0.8067 (0.0000)	0.91675	0.9015 (0.34)	0.8996 (0.34)
Infra Bees	0.0000 (0.0000)	0.108 (0.0000)	0.849 (0.0000)	0.957	9.4837 (0.09)	9.4976 (0.23)
	GARCH (3,1) RESULT					
	Intercept (p-value)	ARCH (p-value)	GARCH1 (p-value)	GARCH2 (p-value)	GARCH3 (p-value)	ARCH + GARCH
Infra Bees	0.0000 (0.0000)	0.15 (0.0000)	0.22 (0.0000)	0.29 (0.0000)	0.293 (0.0000)	0.96

Source: Computed Data

a. The Ljung Box Test

It is a statistical test of whether a group of autocorrelations of a time series differs from zero. If the p-value is less than .05, we can fail to reject the null hypothesis.

The test result of the Ljung Box test after modeling volatility using GARCH (1,1) model on returns shows a p-value greater than 0.05 for all shares except Asian Paints and Bharati Airtel,which indicates that the null hypothesis that there is no autocorrelation in the residuals cannot be rejected for returns of ICICI, SBI, Kotak, Reliance, HDFC Bank, HUL, Bajaj and ITC shares. The test result also shows that Asian Paints and Barat Ltd returns give a p-value of less than 0.05, indicating the presence of autocorrelation in the residuals. The Ljung Box test results show that the GARCH (1,1) model is appropriate for measuring volatility persistence.

b. ARCH-LM test

ARCH-LM test is used to check the heteroscedasticity. For a suitable model, the null hypothesis of the ARCH -LM test must not be rejected. It is to prove that there is no after-modelling volatility using the GARCH (1,1) model. The test result of the ARCH-LM test after modeling volatility using the GARCH (1,1) model shows a p-value greater than 0.05 for all shares except Bharti Airtel and Asian Paints, which indicates that the null hypothesis of No ARCH effect cannot be rejected. The GARCH (1,1) model is appropriate for capturing volatility.

ANALYSIS OF RISK RETURN RELATIONSHIP IN ETFs

The GARCH-In-Mean model was used for analyzing the risk-return relationship for the selected Exchange Traded Funds Nifty Bees, IDBI Gold ETF, Motilal Oswal ETF, Junior Bees, and Infra Bees.Table 4.5 shows the results of the GARCH-in-Mean model.

Modeling the volatility of all ETF returns using GARCH-in-Mean gives significant coefficients for both ARCH and GARCH terms, which indicate that conditional variance not only depends on the lagged squared residuals square term at the previous period but also on the lagged variance term, which indicates that today's risk has an impact on future returns. It means volatility is present in the returns of all selected ETFs.

Table 4.5

GARCH in Mean Results

								GARCH In Mean term	
ETFs	Intercept	p-value	ARCH	p-value	GARCH	p-value	ARCH+ GARCH	test stat	p-value
Nifty Bees	0.00	0.0000	0.13	0.0000	0.753	0.0000	0.88	0.0656	0.0008
Mon100	0.00	0.0000	0.15	0.0000	0.781	0.0000	0.927	0.0643	0.0013
IDBI Gold	0.00	0.0000	0.18	0.0000	0.789	0.0000	0.967	0.0185	0.287
Junior Bees	0.00	0.0000	0.11	0.0000	0.807	0.0000	0.917	0.0832	0.0000
Infra Bees	0.00	0.0000	0.11	0.0000	0.847	0.0000	0.957	0.0374	0.0509

Source: Computed Data

The sum of ARCH and GARCH terms is used to check the persistence of volatility in the ETF returns. The results reveal that the sum of these two terms (.967) is close to 1 for all ETFs, which indicates that the volatility is persistent in all the selected ETF returns.

The GARCH term value in the mean equation indicating the risk-return relationship gives a significant coefficient value for Nifty Bees (0.0008), Motilal Oswal ETF(0.0013), and Junior Bees ETF(0.00) at a 5 per cent level of significance, which suggests that increased volatility in ETF has the potential to generate higher returns. The GARCH term value indicating the risk-return relationship gives an insignificant coefficient value for IDBI Gold ETF (0.287) and Infra Bees ETF (0.051), which is higher than 0.05, which indicates that increased risk does not necessarily produce high returns.

5. Findings

It was found that the returns of all the selected ETFs have an ARCH effect. This confirms that GARCH models can be used to analyze volatility persistence in ETFs in NSE. For volatility persistence the sum of ARCH and GARCH terms is used to check the volatility in persistence are close to 1, it confirms that volatility is persistent in the EFTs. In order to measure the risk return series, the GARCH in Mean Model was employed which gave significant coefficient values for Nifty Bees, Motilal Oswal ETF, and Junior Bees ETFc The GARCH term value indicating the risk-return relationship gives an insignificant coefficient value for IDBI Gold ETF and Infra Bees ETF, which indicates that increased risk does not necessarily produce high returns. It is thus suggested that in majority of the ETFs raking risk will yield in greater returns.

6. Conclusion

Today's investors may easily acquire information to keep up with their financial portfolios. They often concentrate on two critical aspects of investments: risk and return. It is difficult to evaluate risk and volatility in a particular task. To assess the volatility of certain stocks and experimentally investigate the presence of risk-return trade-offs in these financial time series, this study employs two symmetric models, namely GARCH (1, 1) and GARCH-in-mean models.For efficient investment planning, volatility forecasting is essential.. According to their respective coefficient sums, the persistence of shocks is highest for IDBI Gold ETF returns and lowest for Nifty Bees ETF returns.

7. Scope for further study

- More EFFs could be added to the study.
- A comparison between ETFs and Mutual fund may be employed
- Period can be fifteen or thirty years.
- Asymmetric GARCH models can also be used to study volatility.

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