International Journal of Advanced Research in Commerce, Management & Social Science (IJARCMSS)
ISSN :2581-7930, Impact Factor : 7.270, Volume 08, No. 02(II), April-June, 2025, pp 106-114

Stock Returns Volatility of Select NSE – Listed Aluminum & Metal Sector stocks: an Empirical Study

Siddhartha Sankar Saha[1] | Tapas Kumar Tripathy[2*]

[1]Professor of Commerce, Former Head, Department of Commerce, Former Dean, Faculty Council for Post Graduate Studies in Commerce, Social Welfare and Business Management, Former Director, CUCSE-CEFM & Former Director, IQAC, University of Calcutta, Kolkata, West Bengal, India.
[2]Research Scholar, Department of Commerce, University of Calcutta and Assistant Professor of Commerce, P. K. College, Contai, West Bengal, India.

*Corresponding Author: tapastripathy2007@gmail.com

DOI: 10.62823/IJARCMSS/8.2(II).7577

ABSTRACT

Volatility is a critical measure of risk and plays a significant role in investment decision-making and portfolio management. The study empirically examines the volatility of stock returns for select aluminum and metal sector select companies listed on the National Stock Exchange (NSE) of India based on time series dataset taking into consideration of daily closing adjusted stock price from 2001-02 to 2015-16. The research study focuses on analyzing the time-varying nature of stock return volatility using econometric models such as ARCH and series of GARCH to capture clustering effects and asymmetric responses to market shocks. Main findings suggest that time varying volatility behavior of Indian stock market may be due to recent global financial meltdown which is originated from US sub-prime crisis. The results contribute to a deeper understanding of risk management strategies and investment decisions in the Indian stock market.

***Keywords**: Stock Returns, Volatility, Aluminum & Metal Sector, NSE, GARCH, Market Fluctuations, Risk Management.*

Introduction

Stock market volatility now-a-days is a fundamental aspect of financial markets, influencing investment decisions, risk management strategies, and overall market stability. In emerging markets, like India, sector-specific volatility analysis provides valuable insights into the behavior of stocks influenced by different macroeconomic factors, commodity price fluctuations, and industry-specific developments. The aluminium and metal sector plays a significant role in India's industrial and economic growth and sensitive to global demand-supply dynamics, raw material costs, and government policies, making it an interesting subject for volatility analysis. Stocks of companies in this sector are subject to fluctuations due to various factors, including global commodity prices, economic cycles, demand-supply dynamics, and policy changes. The National Stock Exchange (NSE) of India, being one of the largest and most liquid stock exchanges, provides a platform for trading these stocks, making it essential to analyze their volatility patterns. Considering the daily log returns of stock, the daily volatility is not directly observable from the return data because there is only one observation in a trading day. It can be defined as a statistical measure of the dispersion of stock price returns for a given security or market index and it can either be measured using the standard deviation or variance between returns from that same security or market index (John, et. al., 2016). Understanding stock return volatility is crucial for financial market participants, as it influences investment strategies, asset allocation, and risk assessment. A highly volatile stock may present opportunities for short-term traders but poses risks for long-term investors. Conversely, less volatile stocks may provide stability but offer lower returns. Volatility is useful for superior returns. Higher volatility causes higher risk (Kumar, 2016). There are several reasons for which estimation of stock price returns is important: (i) investment decision; (ii) assets pricing; (iii) expected returns and (iv) risk of various assets, etc. By analyzing the volatility of NSE-listed stocks, this study contributes to the academic literature on financial risk management and provides practical insights for investors, regulators, and financial institutions.

Past Studies and Research Gap

The Capital Asset Pricing Model (CAPM) by **Sharpe (1964)** and Black-Scholes option pricing model (1973) played a crucial role in understanding the relationship between risk and return. These models emphasize the importance of volatility in determining asset prices and investment risk. **Fama (1970)** proposed in his research paper the Efficient Market Hypothesis (EMH)**,** which suggests that stock prices fully reflect all available information. **Engle (1982)** introduced the Autoregressive Conditional Heteroskedasticity (ARCH) model**,** which was later extended by Bollerslev (1986) into the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model. **Rakesh (2014)** analyzed stock return volatility among different sectoral index like FMCG, Auto and CNX NIFTY index with their relationship. **Padhi (2006)** in the research paper 'Stock Market Volatility in India: A Case of Select Scripts' has investigated that market volatility at the individual script level and at the indices level to know how volatility changes in the same trend.

While existing studies provide insights into general market trends, there is a need for sector-specific analysis of different NSE-listed Aluminium and Metal stocks to better understand volatility patterns in major stock exchanges in India and to explore how volatility of individual script changes with respect to different time period in respect to different economic policies, incident, etc. and underlying different factors and shocks which can affect individual securities. Keeping in mind of this research gap, specific objectives of the current study are set.

Objectives of the Study

The following are major objectives of the current study:

- Exploring the volatility characteristics of select NSE listed Aluminum and Metal companies;
- Examining the presence of volatility in Aluminum and Metal companies daily return series adopting ARCH (1) model;
- Analysing volatility in select NSE listed Aluminum and Metal companies considering GARCH and T-GARCH Model;
- Measuring the volatility in Aluminum and Metal companies' daily returns series using E-GARCH Model.

Data and Methodology

Daily adjusted closing share price of select NSE-listed Aluminum and Metal sector companies collected from Capitaline corporate database and NSE official website as well, are considered here for calculation of daily stock price return series of each company and yearly stock returns volatility of them. The sample design follows the judgment sample technique based on market capitalization of sample top companies. It makes an attempt to measure volatility of diversified sector's top market capitalisation companies, which were listed and actively traded in NSE from 2000-01 to 2015- 2016. The study has been made considering the following two sample periods (Period I: pre-global financial recession period, which includes the study period from 1st April, 2001 to 6th August, 2007; and Period II: post-global financial recession period, which comprises the study period from 3rd April, 2009 to 31st March, 2016. Descriptive statistics, Autoregressive Conditional Heteroskedasticity (ARCH) Test, Generalized Autoregressive Conditional Heteroskedasticity (GARCH) Model, Threshold Generalized Autoregressive Conditional Heteroskedasticity (T-GARCH) Model and Exponential Generalized Autoregressive Conditional Heteroskedasticity (E-GARCH) Model are used in this study using EViews 8.0.

Statistical Tools used	Analysis to address stated objectives of the study
Descriptive statistics	To identify whether there is any difference in mean value, S.D., Variance, Skewness and Kurtosis of individual securities.
ARCH Test	To examine the presence of ARCH effect in sample companies daily return series using ARCH (1) model (**Decision Rule:** If p- value <0.05, then H_0 is rejected and vice versa).
GARCH Model	To explain the stock market volatility (conditional variance) at the individual script level from the select sample companies **(Decision Rule:** If the sum of

	the two estimated ARCH & GARCH coefficient is equal to one, it indicates volatility shocks are quite persistent).
T-GARCH Model	To explain the stock market volatility (asymmetry or leverage effect) at the individual script level from the select sample companies **(Decision Rule:** If leverage term (γ) is significant and positive, negative shocks have a larger effect on conditional volatility than the positive shocks).
E-GARCH Model	To explain the stock market volatility (logarithmic expression of the conditional variability effect) at the individual script level from the selected sample companies adjusted daily return series (**Decision Rule:** If γ is significant and negative, leverage effect exists in return series).

Results and Analysis

Descriptive Statistics Results

To assess the distributional properties of the daily adjusted closing price of stock returns, various descriptive statistics are summarized in terms of Average Daily Returns (Mean), Standard Deviation (S.D.), Variance, Skewness, and Kurtosis is applied for all select NSE listed companies as follows:

Table 1: Descriptive Statistics Results of Different Companies (Pre-Global Recession Period)

Company Name	Mean	S. D.	Variance	Kurtosis	Skewness
Hindalco	0.0007	0.02	0.0004	6.81	-0.42
Nat. Aluminium	0.001	0.02	0.0004	9.58	0.17
Hind.Zinc	0.08	0.26	0.067	6.7	0.57
Vedanta	0.0034	0.03	0.0009	5.92	0.77

Table 2: Descriptive Statistics Results of Different Companies (Post-Global Recession Period)

Company Name	Mean	S. D.	Variance	Kurtosis	Skewness
Hindalco	0.0003	0.03	0.0009	5.67	0.21
Nat. Aluminium	0.0002	0.028	0.0007	8.64	0.25
Hind.Zinc	0.0008	0.025	0.0006	7.78	0.6
Vedanta	0.0005	0.031	0.0009	7.03	0.34

Daily mean returns of Metal & Aluminum Sector companies are low in post-global financial meltdown period. The S.D. of return is found to be significant (Highest S.D. & Variance are 3.1% and .0009 in case of Vedanta) zinc stock price return. Skewness has been found to be negative..

Examining the presence of volatility in select NSE listed Metal & Aluminum Sector companies daily return series using ARCH (1) model

- **Precondition for Performing ARCH Test**
  - Assumption-1: Sample companies return series are not normal

Normality test is used to check whether the sample companies return series are distributed normally.

Hypothesis	• H_0: Return series of select stocks are normal; • H_1: Return series of select stocks are not normal.
Statistical Test	Jarque-Bera test
Test Statistic	Chi–Square
DF	n–1, where n= 2
Level of Significance	5%
Decision Rule	If P–Value is less than 0.05, H_0 is not accepted and vice versa

Table 3: Normality Test Result of Daily Adjusted Stock Price Returns

Aluminium & Metal Sector	Pre-global financial recession period		Post-global financial recession period		Decision Rule	Decision on H_0	Data series Normality
	J-B	P-Value	J-B	P–Value			
Hindalco	1013.87	0.000	187.9	0.000	P–Value<0.05	Rejected	Not normal

Nat. Aluminium	2884.2	0.000	1869.4	0.000	P–Value<0.05	Rejected	Not normal
Hind.Zinc	12578.0	0.000	1171.3	0.000	P–Value<0.05	Rejected	Not normal
Vedanta	728	0.000	1119.3	0.000	P–Value<0.05	Rejected	Not normal

It is observed that H_0 is rejected for all return series of select NSE listed Aluminium and Metal companies. Since, the JB test is significant at 1% level that means daily returns series are not normally distributed. The majority companies return series are not normally distributed. J-B Test for normality is consistent with the outcome provided by both statistical results of kurtosis and skewness.

- Assumption 2: Stationarity exists in Sample Companies' Daily Return Series

The Augmented Dickey Fuller (ADF) test is employed to infer the stationarity of the stock daily return series.

Unit Root Test for Stationarity Test

Hypothesis	• Null Hypothesis (H_0) : Daily stock return series has unit root; • Alternative Hypothesis (H_1): Daily stock return series has no unit root.
Test Statistics	Augmented Dickey Fuller (ADF) Test
Underlying Distribution	t- Test
Decision Rule	When t- statistics is lower than critical values and p- value <0.05, then, H_0 is rejected and vice versa.

Table 4: The Augmented Dickey-Fuller (ADF) Test results - At Level (Pre-Global Recession Period)

Aluminium & Metal Sector	None		Decision Rule	Null Hypothesis (H_0)	Data series stationarity
	t-Statistics & Prob.	C.V. (5%)			
Hindalco	33.75 (0.000)	-1.94	More negative test statistics than C.V. and P–Value<0.05	Rejected	Stationary series
Nat. Aluminium	-28.56 (0.000)	-1.94	More negative test statistics than C.V. and P–Value<0.05	Rejected	Stationary series
Hindustan Zinc	-24.13 (0.000)	-1.94	More negative test statistics than C.V. and P–Value<0.05	Rejected	Stationary series
Vedanta	-18.91 (0.000)	-1.94	More negative test statistics than C.V. and P–Value<0.05	Rejected	Stationary series

Table 5: The Augmented Dickey-Fuller (ADF) Test results - At Level (Post-Global Recession Period)

Aluminium & Metal Sector	None		Decision Rule	Null Hypothesis (H_0)	Data series stationarity
	t-Statistics & Prob.	C.V. (5%)			
Hindalco	-33.75 (0.000)	-1.94	More negative test statistics than C.V. and P–Value<0.05	Rejected	Stationary series
Nat. Aluminium	-28.56 (0.000)	-1.94	More negative test statistics than C.V. and P–Value<0.05	Rejected	Stationary series
Hind.Zinc	-24.13 (0.000)	-1.94	More negative test statistics than C.V. and P–Value<0.05	Rejected	Stationary series
Vedanta	-18.91 (0.000)	-1.94	More negative test statistics than C.V. and P–Value<0.05	Rejected	Stationary series

It is found that H_0 is rejected for daily stock return series and there is no unit root in return series of NSE listed Aluminum and Metal companies for all sample periods. Since, the ADF test is performed (using neither in the test regression or none) at level is significant at 5% level i.e., it is observed that the computed all test statistics are lower than critical values.

- **ARCH Test (Test for Heteroskedasticity)**

ARCH effect means heteroskedasticity, which is modelled as conditional variance of squared residuals obtained from mean equation as from AR (1) model. The results are as follows:

Table 6: Heteroskedasticity Test Results – ARCH (1) for Pre-Global Recession Period

Companies	F-statistic	Prob. F	Obs* R-squared	Prob. Chi-Square	Decision on Ho	ARCH effects are present or not
Hindalco	17.08	0.000	16.92	0.000	Rejected	ARCH effects are present
Nat. Aluminium	50.13	0.000	48.65	0.000	Rejected	ARCH effects are present
Hind.Zinc	0.0014	0.967	0.0014	0.966	Accepted	No ARCH effects
Vedanta	52.59	0.000	50.96	0.000	Rejected	ARCH effects are present

Table 7: Heteroskedasticity Test Results – ARCH (1) for Post-Global Recession Period

Companies	F-statistic	Prob. F	Obs* R-squared	Prob. Chi-Square	Decision on Ho	ARCH effects are present or not
Hindalco	241.76	.000	218.27	.000	Rejected	ARCH effects are present
Nat. Aluminium	220.51	.000	200.82	.000	Rejected	ARCH effects are present
Hind.Zinc	167.00	.000	155.48	.000	Rejected	ARCH effects are present
Vedanta	48.60	.000	47.60	.000	Rejected	ARCH effects are present

ARCH results comprise of F value, Probability of F value, obs. R squared value and probability of χ^2 value. If p value of T. R^2 statistics is less than 0.01 or 1%, null hypothesis (H_0) is rejected. Hence, it can be stated that there is in existence of ARCH effect. However, it is found the existence of ARCH effect of all sample companies excepting Hindustan Zinc in Pre-global recession period.

Analyzing Volatility in select NSE listed Aluminum and Metal Sector Companies using GARCH Model

GARCH model represents generalized ARCH processes in the sense that the squared volatility (σ_t^2) of the concerned period is allowed to depend on previous squared volatilities, as well as previous squared values of the process. The results are as follows:

Table 8: GARCH Model (Pre-Global Recession Period)

Company Name/ Sectors	Estimated Model with values				AIC	SIC	Log Likelihood	Decision (Decision Rule: Volatility of shocks is highly persistence when $\alpha_j+\beta_i=1$)
First Period - Coefficients - GARCH (1, 1)								
Aluminum & Metals	α_0	α_1	β_1	$\alpha_j+\beta_i$				
Hindalco	1.32	0.092	0.881	0.973	-5.01	-5	3776.7	Very high persistence value
Nat. Aluminium	5.67	0.18	0.76	0.94	-4.39	-4.37	3304.9	Comparatively low persistence value
Vedanta	9.93	0.169	0.760	0.929	-3.9	-3.8	2941.8	Comparatively low persistence value

Table 9: GARCH Model (Post-Global Recession Period)

Company Name/ Sectors	Estimated Model with values				AIC	SIC	Log Likelihood	Decision (Decision Rule: Volatility of shocks is highly persistence when $\alpha_j+\beta_i=1$)
First Period - Coefficients - GARCH (1, 1)								
Aluminum & Metals	α_0	α_1	β_1	$\alpha_j+\beta_i$				
Hindalco	2.2	0.072	0.903	0.975	-4.29	-4.3	4796.2	Very high persistence value

Nat. Aluminium	1.85	0.108	0.869	0.977	-4.58	-4.6	5111.9	Very high persistence value
Hind.Zinc	3.02	0.105	0.848	0.953	-4.63	-4.6	5167.4	Very high persistence value
Vedanta	2.9	0.107	0.869	0.976	-4.21	-4.2	4703.5	Very high persistence value

During the pre-recession period, Hindustan Zinc stock price return series has no ARCH effect and highest and lowest ARCH & GARCH combined values of this sector scripts returns series are ranges from .972 to .873 in remaining three scripts. During the post global financial recession time period, these values are near to one.

Analyzing Volatility in select NSE listed Aluminum & Metals Sector Companies using T-GARCH Model

The main target of T-GATCH model is to capture asymmetry in terms of negative and positive stocks and multiplicative dummy variable to check whether there are statistically significant differences when shocks are positive and negative. The results are as follows:

Table 10: T-GARCH Model (Pre-Global Recession Period)

Company Name	Estimated Model with values				AIC	SIC	Log Likelihood	Decision
First Period - Coefficients - GARCH (1, 1) with Threshold order 1								
Aluminum & Metals	α_0	α_1	γ	β_1				
Hindalco	1.25	0.102	-0.026	0.885	-5.01	-4.99	3777.66	Negative γ which implies positive shocks
Nat. Aluminium								
Vedanta	0.0001	0.153	0.043	0.57	-3.9	-3.88	2942.48	Positive γ which implies negative shocks is larger effect on volatility

Table 11: T-GARCH Model (Post-Global Recession Period)

Company Name	Estimated Model with values				AIC	SIC	Log Likelihood	Decision
First Period - Coefficients - GARCH (1, 1) with Threshold order 1								
Aluminum & Metals	α_0	α_1	γ	β_1				
Hindalco	1.87	0.043	0.055	0.91	-4.3	-4.28	4804.03	Positive γ which implies negative shocks is larger effect on volatility
Nat. Aluminium	1.82	0.099	0.021	0.868	-4.58	-4.56	5112.55	Positive γ which implies negative shocks is larger effect on volatility
Hind.Zinc	3.11	0.082	0.057	0.844	-4.63	-4.61	5171.03	Positive γ which implies negative shocks is larger effect on volatility
Vedanta	1.91	0.054	0.076	0.896	-4.22	-4.21	4715.23	Positive γ which implies negative shocks is larger effect on volatility

The coefficient (δ) measures TGARCH asymmetry or leverage parameter showed that only one companies under Metal & Aluminum Sector during post global financial meltdown period are found negative effect (Hindalco -.0303). T-GARCH results show that coefficient of leverage (δ) is positive in maximum cases (two companies for pre-recession period and all three companies during other period) and significant at 1% level, which led that negative shocks or bad news have a greater effect on the conditional variance than the positive shocks or good news.

Measuring Volatility in select NSE listed Aluminum & Metals Sector Companies using E-GARCH Model

The Exponential GARCH model is a GARCH variant that models the logarithm of the conditional variance process. In addition to modelling the logarithm, this model has additional leverage terms to capture asymmetry in volatility clustering. The results are as follows:

Table 12: E-GARCH Model (Pre-Global Recession Period)

Company Name/ Sector	**Estimated Model with values**				**AIC**	**SIC**	**Log Likelihood**	**Decision** (Decision Rule: If γ is significant & negative, then leverage effect exists in return series.)
First Period - Coefficients - GARCH (1, 1)								
Aluminum & Metals	α_0	α_1	γ	β_1				
Hindalco	-0.45	0.20	-0.009	0.96	-5.02	-5	3784.73	Leverage effect exists
Nat. Aluminium	-1.20	0.391	-0.045	0.873	-4.39	-4.37	3309.1	Leverage effect exists
Vedanta	-0.99	0.33	-0.017	0.890	-3.91	-3.88	2944.36	Leverage effect exists

Table 13: E-GARCH Model (Post-Global Recession Period)

Company Name/ Sector	**Estimated Model with values**				**AIC**	**SIC**	**Log Likelihood**	**Decision** (Decision Rule: If γ is significant & negative, then leverage effect exists in return series.)
First Period - Coefficients - GARCH (1, 1)								
Aluminum & Metals	α_0	α_1	γ	β_1				
Hindalco	-0.32	0.154	-0.05	0.972	-4.3	-4.28	4799.44	Leverage effect exists
Nat. Aluminium	-0.34	0.201	-0.005	0.973	-4.57	-4.56	5108.24	Leverage effect exists
Hind.Zinc	-0.53	0.228	-0.027	0.952	-4.63	-4.61	5170.28	Leverage effect exists
Vedanta	-0.35	0.195	-0.04	0.971	-4.22	-4.2	4714.1	Leverage effect exists

The β value (representing GARCH effect) in E-GARCH model in pre-global financial meltdown period indicate that only one company's β value is near to one and high level of persistence and low level of volatility exist in case of one company. The asymmetric effect captured by parameter (γ) in E-GARCH model is negative and statistically significant at 1% and 5% level of significance that provides the presence of leverage effect. Moreover, for all these select companies' β is distinctly lower during the pre-global financial meltdown period than β during the post-global financial meltdown period. This indicates that shocks are less persistent, decaying faster during pre-global financial meltdown period.

Conclusion

In GARCH model, it appears that the combined value or sum of coefficient of ARCH and GARCH value is around one, it indicates volatility clustering and persistency. However, T-GARCH model indicates that negative shocks or bad news has a greater effect on the conditional variance than the positive shocks or good news. Again, GARCH term results in TGARCH test found that in case of pre-global financial recession period are lower than post-global financial recession period. E-GARCH model indicates that positive shocks have less effect on conditional variance when compared to the negative shocks. During the pre-global financial recession period, Hindustan Zinc stock price return series has no ARCH effect and highest and lowest ARCH & GARCH combined values of this sector scripts returns series are ranges from .972 to .873 in remaining three scripts. During the post-global financial recession time period, these values are near to one.

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