Modelling Asymmetric Volatility and Leverage Effect of Nifty PSE (Public Sector Enterprises) Index Stocks

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Abstract:
This research paper is organized to estimate the volatility and measure the effect of good and bad news on the volatility of the Nifty PSE index stocks. In order to achieve this objective the daily closing price of all the stocks listed in Nifty PSE index was considered. The data is collected for a period of 9 years i.e., from 1st January 2011 to 31st December 2019. Augmented Dicky Filler and Phillips-Perron test are used to check the stationarity of the return series. The standard GARCH models were applied to study the volatility behavior during the study period and two commonly used asymmetric volatility models i.e. EGARCH and TGARCH were employed to analyze the leverage effect. The study reveals the presence of volatility clustering and persistence. It was found that the stocks selected for the study react to the bad news and good news asymmetrically. The research concludes that the negative shocks delivers more volatility for majority of the PSE index stocks than the positive shocks of the same magnitude.
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Introduction

The Government has selectively been disinvesting its holdings in public sector enterprises since 1991. With a view to provide regulators, investors and market intermediaries with an appropriate benchmark that captures the performance of this segment of the market, as well as to make available an appropriate basis for pricing forthcoming issues of PSEs, NSE Indices has developed the Nifty PSE Index comprising of 20 public sector stocks. In the recent past, there is a growing importance for estimating and analyzing volatility and extensive research has been done on the modeling of financial time series. Estimation of volatility and leverage effect is very much needed to govern the issues in the risk management and this helps to manage portfolio efficiently. Several studies have shown the modeling of the stock market volatility of developed and developing countries. Many researchers have attempted to model and measure the volatility patterns of banking stocks, major sectoral index and some selected commodities but there is no research done on public sector stocks. This attracts the attention of the researchers to study the nature and extent of volatility and the impact of leverage effect experienced by the Nifty PSE index stocks.

Madhusudan Karmakar (2005): made an attempt to estimate the conditional volatility of the Indian Stock Market. The analysis has been done for 14 and half years from July 1990 to December 2004. It was found that there was a strong evidence of time varying volatility - a tendency of periods of high volatility followed by another period of high volatility and low volatility followed by another period of low volatility and a high volatility persistence in the Indian stock market. The study concludes that GARCH family models provide absolute forecasts of volatility and are useful for portfolio allocation and for valuation of options.

Puja Padhi (2006): the research studies the volatility of individual stocks and indices using ARCH, GARCH and ARCH in Mean model for daily price data from January 1990 to November 2004. The analysis revealed that the volatility in the case of aggregate indices and five different sectors such as electrical, machinery, mining, non-metallic and power plant sector were identical. The GARCH (1,1) model performed well for all the five indices and individual stocks.

Saleem (2007): had conducted a study to find the varying volatility and asymmetry of Karachi Stock Exchange. The author had examined the time varying volatility by using GARCH(1,1) and EGARCH model and found that, in KSE-100 Index stocks positive returns are associated with higher volatility than negative returns.

Kumar and Dhankar (2010): conducted a study to estimate the conditional heteroscedasticity and asymmetric effect on volatility, the research also tested the association between stock returns with expected volatility and unexpected volatility. The data relating to the daily opening and closing prices of S&P 500 and NASDAQ 100 for the period January 1990 to December 2007 were used and they applied GARCH (1,1), and T-GARCH (1,1) to examine the heteroscedasticity and the asymmetric nature of stock returns respectively. The result of their study

suggested the presence of the heteroscedasticity effect and the asymmetric nature of the stock returns.

Banumathy and Azhagaiah (2015): empirically investigated the volatility pattern of Indian stock market based on time series data which consisted of daily closing prices of S & P CNX Nifty index for 10 years from January2003 to December 2012, by using both symmetric and asymmetric models of GARCH. The study proved that the models like GARCH (1,1) and TGARCH (1,1) were found to be the most appropriate models to capture the symmetric and asymmetric volatility patterns. The study also rendered evidence that the asymmetric effect captured by the parameters of EGARCH (1,1) and TGARCH (1,1) models showed that negative shocks had significant effect on the volatility.

Data and methodology

The primary objective of this research study is to investigate the volatility pattern of Nifty PSE index Stocks using GARCH family models and to ascertain the presence of leverage effect in the daily return series of stocks using asymmetric models. To achieve this objective, daily closing prices of the stocks were collected from nseindia.com. The study is descriptive in nature. The date were collected for a period 9 years i.e. JAN-2011 to DEC-2019.
Following are the stocks listed in Nifty PSE Index.

- Bharat Electronics Limited (BEL)
- Bharat Heavy Electricals Limited (BHEL)
- Bharat Petroleum Corporation limited (BPCL)
- Coal India (COAL INDIA)
- Container Corporation of India Limited (CONCOR)
- Gail (India) Limited (GAIL)
- General Insurance Corporation of India (GICRE)
- Hindustan Petroleum Corporation Limited (HIND PETRO)
- Indian Oil Corporation Limited (IOC)
- National Aluminium Company Limited (NATIONALUM)
- NHPC Limited (NHPC)
- The New India Assurance Company Limited (NIACL)
- NMDC Limited (NMDC)
- NTPC Limited (NTPC)
- Oil India Limited (OIL)
- Oil and Natural Gas Corporation Limited (ONGC)
- Power Finance Corporation Limited (PFC)
- Power Grid Corporation of India Limited (POWERGRID)
- REC Limited (RECL)
- Steel Authority of India Limited (SAIL)

A. Tools for analysis:

➢ ***Descriptive statistics:*** Arithmetic mean of daily returns of the stock is calculated to know the average return of the stock. For this purpose, the daily closing prices of the PSE index stocks were collected and this closing prices were adjusted for the corporate activities like bonus issue, stock split, etc. These adjusted closing prices were used to calculate the daily returns. Descriptive statistics like Average, Standard deviation, Skewness, Kurtosis & Jarque-Bera statistics are used in the study to understand the distributional properties of the Nifty PSE stocks.

$$R_t = \text{In} \ (P_t \ / \ P_{t-1})$$

Where R_t is the natural log daily return on the selected stock for time t, P_t is the closing price of the selected stock at time t and P_{t-1} is the corresponding price in the period at time t-1.

➢ ***Econometrics model:***

1. **Unit root test**: For any further analysis the financial time series data used in any study must be stationary in nature. Hence, to test the stationary of the selected financial time series, the following test were employed in this study.
   - Augmented Dickey Fuller test (ADF)
   - Phillips – Perron test (PP)
2. **Test for ARCH effect in the return series**: Before estimating volatility by using GARCH family models, it was necessary to identify whether there was substantial evidence for the presence of heteroscedasticity (ARCH effect) in the residuals of return series of the stocks selected for the study. In order to test whether the ARCH effect exists or not in the residuals of the return series, residual diagnostics test were conducted using lag range multiplier test for autoregressive conditional

heteroscedasticity (ARCH) in the residuals.

3. **Volatility measurement and estimation techniques**: In order to explore the most suitable model to specify the level of symmetric volatility of the selected stocks, GARCH models with various order like GARCH(1,1), GARCH(1,2), GARCH(2,1) and GARCH(2,2) were employed. In the process of selecting the best fitting model, as per the decision rule, the Akaike Information Criterion (AIC) and Schwarz Information Criterion (SIC) values are taken into consideration along with the log likely hood value wherever need arises. The results revealed that the GARCH(1,1) is the most suited model to understand the symmetric nature and extent of volatility of the stocks selected for the study (therefore in data analysis part only GARCH(1,1) model data has been discussed). For modelling asymmetric volatility EGARCH(1,1) & TGARCH(1,1) were employed.

4. To test the adequacy of the selected GARCH(1,1) model and to deduct whether ARCH effect exists or not in the residuals of the return series after the estimation of the GARCH(1,1) model, ARCH-LM test was conducted by using the residuals obtained after the application of GARCH(1,1) model. The obtained results from ARCH-LM test should show no evidence of remaining ARCH effect in the residuals, which is a necessary condition to indicate that the selected model is a perfect choice and has modeled the volatility pattern better than any other model.

5. In a financial market, if bad news has a more effect on volatility than good news of the same magnitude, such asymmetry is termed as Leverage effect, and then the symmetric specification such as GARCH is not appropriate and could not capture the asymmetric effect, since only squared residuals enter the equation and the signs of the residuals or shocks have no effect (by squaring the lagged error in GARCH, the sign is lost) on the conditional volatility. In other words, the model assumes same effect for good and bad news. But, the fact of financial volatility is that negative shocks tend to have larger impact on volatility than positive shocks. The main drawback of the symmetric GARCH model is that the conditional variance is unable to respond asymmetrically to rise and fall in the stock returns. Hence to examine the asymmetric effect of the financial time series data, Exponential GARCH (EGARCH) and Threshold GARCH (TGARCH) model were applied. In order to account for the leverage effect observed in return series of the selected stocks, the asymmetric models which include EGARCH (1,1) and TGARCH(1,1) were employed.

Results and discussions

Table 1: Descriptive statistics of NIFTY-PSE Index stocks

Sl. No	Name of the Stock	Mean Return	Standard deviation	Skewness	Kurtosis	Jarque Bera	p value
1	**BEL**	0.000284	0.020459	0.505744	8.808546	3222.756	0.0000
2	**BHEL**	-0.000887	0.024787	-0.114555	9.649597	4104.163	0.0000
3	**BPCL**	0.000673	0.021399	-0.559157	9.955554	4601.148	0.0000
4	**COAL INDIA**	-0.000183	0.017746	0.139384	6.218889	967.7785	0.0000
5	**CONCOR**	0.000338	0.017991	0.377773	5.170308	489.6006	0.0000
6	**GAIL**	-8.07E-05	0.018195	-0.155197	6.480916	1132.258	0.0000
7	**GICRE**	-0.001225	0.022530	1.907220	14.77896	3429.951	0.0000
8	**HIND PETRO**	0.000494	0.024382	-0.620947	12.03229	7706.336	0.0000
9	**IOC**	0.000158	0.019736	-0.262818	7.528730	1927.006	0.0000
10.	**NHPC**	-8.60E-05	0.017891	-1.370775	31.89183	78083.94	0.0000
11.	**NMDC**	-0.000355	0.021042	-0.161725	5.995093	841.3471	0.0000
12	**NTPC**	-0.000148	0.015865	-0.263979	7.537895	1934.937	0.0000
13	**NATIONALUM**	-0.000363	0.024278	0.335023	5.613110	674.6669	0.0000
14	**NIACL**	-0.001884	0.023995	2.353409	17.44703	5040.678	0.0000
15	**ONGC**	-0.000231	0.018668	-0.226008	7.456320	1860.017	0.0000
16	**OIL**	-0.000276	0.016857	-0.220184	5.760597	724.4987	0.0000
17	**PFC**	-0.000119	0.026514	0.050796	4.736773	280.6004	0.0000
18	**POWERGRID**	0.000297	0.013731	-0.159692	6.393393	1077.004	0.0000
19	**RECLTD**	-8.71E-06	0.025643	-0.137120	5.068465	403.6295	0.0000
20	**SAIL**	-0.000664	0.024669	0.155185	4.299533	165.4951	0.0000

Table 1 presents the descriptive statistics of daily returns of the Nifty PSE index stocks. The arithmetic average of the return (mean return) of only six stocks are positive, indicating that the price of only six stocks have increased substantially during the study period and remaining stocks have yielded negative return during the study period. Negative returns delivered by majority of the stocks have confirmed the fact that the PSE index stocks have underperformed extremely during the study period. BPCL (0.000673) has delivered highest return, followed

by HINDPETRO (0.000494), CONCOR (0.000338), POWERGRID (0.000297), BEL (0.000284) and IOC (0.000158) respectively. The values of standard deviation are comparatively high for PFC (0.026514) followed by RECLTD (0.025643), BHEL(0.024787), SAIL (0.024669), HIND PETRO (0.024382) and NATIONALUM (0.024278) and it is low for POWERGRID (0.013731), NTPC (0.015865), OIL (0.016857), and COAL India (0.017746). The descriptive statistics also shows that out of 20 stocks, 12 stocks are negatively skewed and this indicates that the return series decrease more often than increase and there is high probability of earning returns lesser than the mean return. The kurtosis data depicted in the table shows that all the stocks selected for the study are having K value greater than 3, which implies that the return series are fat tailed and they do not follow a normal distribution. This is further confirmed by the p values of Jarque-Bera test statistics which are less than 0.05 ($p<0.05$) and significant at 1% level and this rejects the assumption of normality in the selected financial time series

Table 2: Tests for unit root problem in the NIFTY PSE Index stocks

Sl. No	Name of the Stock	Augmented Dickey Fuller Test			Phillips-Perron Test		
		Intercept	Trend and Intercept	None	Intercept	Trend and Intercept	None
1	BEL	-44.92843	-44.91845	-44.93035	-44.89081	-44.88059	-44.89324
2	BHEL	-43.50908	-43.49928	-43.46770	-43.45262	-43.44265	-43.42144
3	BPCL	-45.09304	-45.08292	-45.05993	-45.08468	-45.07362	-45.03931
4	COALINDIA	-47.10526	-47.10393	-47.11072	-47.42018	-47.43490	-47.41908
5	CONCOR	-46.80284	-46.79562	-46.79689	-46.89747	-46.89066	-46.86252
6	GAIL	-46.61826	-46.61085	-46.62773	-47.37553	-47.37176	-47.38487
7	GICRE	-21.69892	-21.68688	-21.66389	-21.66501	-21.65100	-21.64104
8	HINDPETRO	-47.37388	-47.36376	-47.36458	-47.49803	-47.48739	-47.47500
9	IOC	-46.51940	-46.50900	-46.52670	-46.57693	-46.56581	-46.58334
10	NHPC	-45.02944	-45.02584	-45.03865	-44.99557	-44.99165	-45.00501
11	NMDC	-47.04109	-47.06149	-47.03860	-47.04408	-47.06556	-1.940966
12	NTPC	-48.97107	-48.96469	-48.97743	-49.11195	-49.10713	-49.11584
13	NATIONALUM	-45.95920	-45.95766	-45.95897	-45.94460	-45.94300	-45.94410
14	NIACL	-19.67436	-19.65700	-19.59677	-19.58660	-19.56810	-19.53213
15	ONGC	-46.63969	-46.63154	-46.64322	-47.04005	-47.03832	-47.03248
16	OIL	-30.44597	-30.44320	-30.43656	-47.98612	-47.95983	-47.96174
17	PFC	-47.17443	-47.17537	-47.18408	-47.17459	-47.17546	-47.18422
18	POWERGRID	-50.41512	-50.40508	-50.40128	-51.21113	-51.20449	-51.10871
19	RECLTD	-46.44481	-46.43876	-46.45526	-46.44474	-46.43870	-46.45520
20	SAIL	-45.77825	-45.78203	-45.75602	-45.76984	-45.77285	-45.75965

(Test critical values @ 5% level is **-2.862638** for Intercept ; @5% level is **-3.411829** for Trend and Intercept; @5%level is **-1.940966** for None, p values for all the above observations are < 0.05).

Table 2 shows the calculated test statistic values (at level) for all the selected stocks of Nifty PSE index using Augmented Dickey Fuller Test (ADF) and Philips Perron Test (PP). As per the decision rule to reject the null hypothesis that the return series has unit root problem, the calculated absolute test statistic values for all the stocks are much higher than the absolute test critical values (both signs should be ignored, Test critical values at 5 per cent level is - 2.862638 for Intercept ; at 5 per cent level is -3.411829 for Trend and Intercept; at 5 per cent level is -1.940966 for None, p values for all the above observations are < 0.05) and hence, it is confirmed that all the selected series are stationary in nature, which is basic condition to estimate the volatility by applying the Auto Regressive Conditional Heteroskedasticity model (ARCH model).

Table 3: Testing the Heteroscedasticity (ARCH) effect in the return series of NIFTY PSE Index stocks

Sl. No	Name of the Stocks	*F*-statistic	Prob. F	Obs*R-squared	Prob.chi-square
1	**BEL**	20.82157	0.0000	20.64684	0.0000
2	**BHEL**	26.80668	0.0000	26.51098	0.0000
3	**BPCL**	138.0228	0.0000	130.0677	0.0000
4	**COALINDIA**	11.23644	0.0000	11.18997	0.0000
5	**CONCOR**	26.67993	0.0000	26.38711	0.0000
6	**GAIL**	6.324885	0.0000	6.312609	0.0000
7	**GICRE**	4.543764	0.0335	4.522302	0.0335
8	**HINDPETRO**	171.4124	0.0000	159.2793	0.0000
9	**IOC**	222.9434	0.0000	202.7966	0.0000
10	NHPC	12.380701	0.0000	12.381085	0.0000
11	NMDC	4.306268	0.0381	4.301807	0.0381
12	NTPC	13.715082	0.0000	13.712220	0.0000
13	**NATIONALUM**	29.87402	0.0000	29.50424	0.0000
14	**NIACL**	140.5353	0.0000	111.1051	0.0000
15	**ONGC**	13.08380	0.0000	13.01892	0.0000
16	**OIL**	53.77714	0.0000	52.55364	0.0000
17	**PFC**	44.74185	0.0000	43.89819	0.0000
18	**POWERGRID**	7.302767	0.0000	7.285396	0.0000
19	**RECLTD**	11.60496	0.0000	11.55506	0.0000
20	**SAIL**	16.86153	0.0000	16.74960	0.0000

Before applying the GARCH family models to specify the volatility, it is necessary to confirm whether ARCH effect exists or not in the financial time series for the stocks selected for the analysis. Table 3 exhibits the calculated coefficient values and the probability values of the stocks selected for the study and show that all the calculated F statistic values are higher than the observed R square values and P values are significant at 1% level for all the stocks which is a necessary condition to reject the null hypothesis of No ARCH effect in the return series. Hence it is proved that there is a heteroscedasticity-ARCH effect in the time series of all the selected stocks and which demands the application of GARCH family models to understand the volatility in the stocks.

Table 4: Volatility estimation by using GARCH (1,1) model for NIFTY PSE Index stocks

Sl.No	Name of the stock	ω	α	β	α + β	AIC	SIC	Log Likelihood	Mean Reversion
1	**BEL**	2.43E-06	0.030185	0.964720	0.994905	5.06485	5.054590	5638.646	134.166
2	**BHEL**	4.47E-05	0.085601	0.843852	0.929453	4.62735	4.61709	5151.922	9.4734
3	**BPCL**	3.23E-05	0.092819	0.836090	0.928909	4.94056	4.93029	5500.369	9.4159
4	**COALINDIA**	8.35E-06	0.038761	0.935441	0.974202	5.26287	5.25261	5858.938	26.4516
5	**CONCOR**	4.46E-05	0.094223	0.769968	0.864191	5.234782	5.224524	5827.695	4.7672
6	**GAIL**	0.000260	0.117376	0.104394	0.22177	5.183728	5.173468	5770.898	0.4602
7	**GICRE**	0.000110	0.577100	0.342203	0.919303	5.01113	4.979205	1349.489	8.2434
8	**HINDPETRO**	0.000112	0.106304	0.696880	0.803184	4.670898	4.660638	5200.375	3.1509
9	**IOC**	4.12E-05	0.148200	0.753301	0.901501	5.090045	5.079784	5666.675	6.6860
10	**NHPC**	3.79E-05	0.165522	0.729184	0.894706	5.331260	5.321000	5935.027	6.2282
11	**NMDC**	1.94E-05	0.063976	0.892237	0.956213	4.94849	4.93823	5509.200	15.4588
12	**NTPC**	3.11E-05	0.082622	0.795887	0.878509	5.48127	5.47101	6101.916	5.3549
13	**NATIONALUM**	4.17E-05	0.089307	0.841672	0.930979	4.665970	4.655710	5194.892	7.6160
14	**NIACL**	3.75E-05	0.174504	0.777056	0.95156	4.86309	4.83057	1278.131	13.8436
15	**ONGC**	2.39E-05	0.085569	0.847732	0.933301	5.18014	5.16988	5766.902	10.0442
16	**OIL**	6.50E-05	0.167068	0.609261	0.776329	5.38933	5.37907	5999.631	2.7418
17	**PFC**	4.41E-05	0.070441	0.866912	0.937353	4.47506	4.46480	4982.509	4.8511
18	**POWERGRID**	3.59E-05	0.154903	0.661422	0.816325	5.78431	5.77405	6439.043	3.4154
19	**RECLTD**	6.83E-05	0.051580	0.844802	0.896382	4.50409	4.49383	5014.804	4.1078
20	**SAIL**	1.66E-05	0.046939	0.926317	0.973253	4.60433	4.59406	5126.311	9.0714

All the values are significant at 5% level

Table 4 shows the estimates of the GARCH (1,1) model for all the selected stocks of Nifty PSE index. The values of all the parameters (ω, α and β) are positive, which satisfy the condition ω ≥ 0, α ≥ 0, β ≥ 0 to declare that the selected model is well defined to understand the level of volatility. All the coefficients of lagged squared

residuals (α) are positive and significant at five percent level showing that the news about previous volatility (past squared residuals term) has an explanatory power on current volatility. All the coefficient (β) values of lagged conditional variance are also positive and significant at five per cent level and specify that the past volatility of stock returns is significantly influencing current volatility. The sum of ARCH and GARCH coefficient (α + β) values, which is a measure of persistence of variance, of all the selected stocks of PSE index is closer to unity (1) which implies that the shocks to the conditional variance are highly persistent and indicates that the Nifty PSE index stocks were having high volatility during the study period and the volatility persistence were lasting for many days except GAIL (0.221773), OIL (0.776617), HINDPETRO (0.802537), POWERGRID (0.816325), CONCOR (0.864679), NTPC (0.878587), NHPC (0.894678), and RECLTD (0.896322). The large sum of these coefficient values implies that a large positive or a large negative return, which will lead future forecast of the variance to be high for a prolonged period. The volatility persistence is very high in the case of BEL (134.166) followed by COALINDIA (26.4516) and NMDC (15.4588) and these are volatile stocks, any shocks to these stocks take longer time to die out and these stocks take longer period to revert to its long run average price level. The volatility persistence is low in the case of GAIL (0.4602), OIL (2.7418), HINDPETRO (3.1509), POWERGRID (3.4154), RECLTD (4.1078), CONCOR (4.7672), PFC (4.8511), NTPC (5.3549), NHPC (6.2282), IOC (6.6860), NATIONALUM (7.6160), and GICRE (8.2434) revealing very low level of volatility and is lasting for very short period of time, any shocks, either positive or negative, did not lasted for longer time period in these stocks.

Table 5: Testing the adequacy of GARCH (1,1) model using ARCH-LM test for PSE sector stocks

S. No	Name of the Stocks	*F*-statistic	Prob.F	Obs*R-squared	Prob.chi-square
1	**BEL**	2.206173	0.1376	2.205968	0.1376
2	**BHEL**	0.545597	0.4602	0.545945	0.4600
3	**BPCL**	27.18383	0.5500	26.87945	0.5502
4	**COALINDIA**	0.853130	0.3558	0.853570	0.3555
5	**CONCOR**	1.519477	0.2178	1.519806	0.2176
6	**GAIL**	0.300618	0.5836	0.300848	0.5834
7	**GICRE**	0.052462	0.8189	0.052653	0.8185
8	**HINDPETRO**	15.06726	0.0601	14.97925	0.0601
9	**IOC**	15.71909	0.0801	15.62272	0.0801
10	**NHPC**	0.549280	0.4587	0.549639	0.4585
11	**NMDC**	0.067983	0.7943	0.068042	0.7942
12	**NTPC**	0.299551	0.5842	0.299781	0.5840
13	**NATIONALUM**	0.654637	0.4185	0.655033	0.4183
14	**NIACL**	1.291582	0.2563	1.293334	0.2554
15	**ONGC**	1.311174	0.2523	1.311580	0.2521
16	**OIL**	1.622270	0.2029	1.622545	0.2027
17	**PFC**	0.920078	0.3376	0.920525	0.3373
18	**POWERGRID**	1.518971	0.2179	1.518300	0.2177
19	**RECLTD**	0.594251	0.4409	0.594627	0.4406
20	**SAIL**	0.892861	0.3448	0.893306	0.3446

Table 5 exhibits the results obtained after applying the ARCH LM test from the residuals of GARCH (1,1) model for the selected stocks. Since all the calculated F statistics values are lesser than the observed R square values and the probability values are greater than 0.05 (p > 0.05), the null hypothesis of No ARCH effect in the residuals" are accepted and confirms the absence of auto regressive conditional heteroscedasticity (ARCH) effect in the residuals of the return series after the estimation of GARCH (1,1) model.

Table 6: Leverage Effect Estimation using EGARCH (1,1) and TGARCH (1,1) Models

Name of the Stock		Mean Equation	Variance equation				AIC	SIC	Log likelihood
		M	Ω	α	β	γ			
BEL	EGARCH	0.000199	-0.111691	0.076780	0.992892	0.005548	5.060400	5.047574	5634.695
	TGARCH	1.20E-05	2.50E-06	0.031294	0.965044	-0.003635	5.064063	5.051238	5638.771
BHEL	EGARCH	-0.00103	-0.424002	0.146144	0.957616	-0.021557	4.628848	4.616023	5154.594
	TGARCH	-0.00098	3.98E-05	0.065256	0.858035	0.027347	4.627253	4.614427	5152.818
BPCL	EGARCH	0.000406	-0.656365	0.205354	0.935546	-0.027795	4.939550	4.926724	5500.250
	TGARCH	0.000498	2.81E-05	0.069233	0.854064	0.029735	4.940494	4.927668	5501.300
COAL INDIA	EGARCH	0.000106	-0.295327	0.086584	0.971401	0.014691	5.259306	5.246480	5855.978
	TGARCH	8.68E-05	8.30E-06	0.046628	0.936213	-0.017170	5.263024	5.250198	5860.115
CONCOR	EGARCH	0.000319	-1.428420	0.215193	0.842595	0.027344	5.238028	5.225202	5832.306
	TGARCH	0.000390	4.22E-05	0.101891	0.782101	-0.026938	5.234407	5.221581	5828.277
GAIL	EGARCH	0.000179	-5.805116	0.200549	0.295203	-0.042441	5.183144	5.170318	5771.248
	TGARCH	-0.00024	0.000104	0.035797	0.614366	0.076466	5.184843	5.172017	5773.137
GICRE	EGARCH	-.002658	-3.508185	0.784503	0.624241	0.109132	5.015129	4.975223	1351.562
	TGARCH	-0.00235	0.000110	0.690532	0.341843	-0.236437	5.011170	4.971263	1350.499
HINDPETRO	EGARCH	0.000382	-1.592902	0.242342	0.811842	-0.026297	4.663578	4.650752	5193.231
	TGARCH	0.000339	0.000102	0.079880	0.724863	0.033156	4.670588	4.657762	5201.029
IOC	EGARCH	0.000169	-1.389698	0.342733	0.857355	0.024123	5.097121	5.084295	5675.547
	TGARCH	3.30E-05	4.00E-05	0.168931	0.756496	-0.041788	5.090083	5.077257	5667.717
NHPC	EGARCH	-0.00026	-1.190984	0.335484	0.883357	-0.024292	5.330731	5.317905	5935.435
	TGARCH	-0.00026	3.63E-05	0.140924	0.739949	0.035607	5.331072	5.318246	5935.817
NMDC	EGARCH	-0.00042	-0.357427	0.125420	0.966155	-0.013061	4.944759	4.931933	5506.044
	TGARCH	-0.00048	1.97E-05	0.061470	0.891063	0.006095	4.947658	4.934832	5509.269
NTPC	EGARCH	-9.91E-05	-0.885315	0.162517	0.908206	0.026650	5.486722	5.473896	6108.978
	TGARCH	-0.00015	3.00E-05	0.104598	0.805713	-0.055894	5.482916	5.470091	6104.744
NATIONALUM	EGARCH	-0.00074	-0.708834	0.191315	0.924379	0.030039	4.672922	4.660096	5203.626
	TGARCH	-0.00073	4.20E-05	0.102707	0.840819	-0.027798	4.665886	4.653060	5195.798
NIACL	EGARCH	-0.00206	-0.919761	0.392944	0.916387	-0.073070	4.893197	4.852534	1287.018
	TGARCH	-0.00224	4.03E-05	0.126748	0.739628	0.204257	4.877444	4.836781	1282.890
ONGC	EGARCH	-0.00015	-0.665531	0.175633	0.933595	-0.014491	5.177573	5.164747	5765.050
	TGARCH	-0.00015	2.43E-05	0.079298	0.845871	0.014681	5.179428	5.166602	5767.133
OIL	EGARCH	-0.00045	-3.268355	0.376534	0.636664	-0.044608	5.387985	5.375159	5999.133
	TGARCH	-0.00041	6.99E-05	0.140262	0.587541	0.061426	5.389638	5.376812	6000.972
PFC	EGARCH	-0.00044	-0.590347	0.159184	0.935786	-0.025729	4.473841	4.461015	4982.148
	TGARCH	-0.00035	4.46E-05	0.062081	0.865294	0.019219	4.474722	4.461896	4983.128
POWERGRID	EGARCH	0.00011	-1.899966	0.297776	0.805887	-0.011290	5.784856	5.772030	6440.652
	TGARCH	6.37E-05	3.35E-05	0.128274	0.680411	0.041130	5.783961	5.771135	6439.656
RECLTD	EGARCH	-0.00011	-0.687480	0.108051	0.917505	-0.004720	4.50450	4.49167	5016.251
	TGARCH	-0.00015	7.70E-05	0.048185	0.840085	0.008785	4.503281	4.490455	5014.900
SAIL	EGARCH	-0.00097	-0.325102	0.108808	0.967417	-0.007131	4.60123	4.58840	5123.866
	TGARCH	-0.00091	1.42E-05	0.037190	0.932560	0.015619	4.604197	4.591372	5127.170

* γ values are significant at 5 per cent level.

Table 6 reports the results obtained from applying EGARCH (1,1) and TGARCH (1,1) model to capture the asymmetries in the return series of Nifty PSE index. The calculated values from EGARCH (1,1) model reveal that the leverage effect exists in the majority of the stocks during the study period. The calculated values of '**γ**' which is used to notify the leverage effect, are negative and statistically significant (P values are less than 0.05) for majority of the stocks which expresses that negative shocks have more impact than the positive shocks on the volatility except BEL, COAL INDIA, CONCOR, GICRE, IOC, NTPC and NATIONALUM these stocks are not affected by leverage effect and are not statistically significant (P values are more than 0.05) indicating that positive shocks have more impact than the negative shocks on these seven stocks. The calculated GARCH (β) values of all the stocks are positive and closer to unity (1) expressing the fact that the volatility persistence is explosive in Nifty PSE index stocks except GAIL (0.295203), GICRE (0.624241), OIL (0.636664), POWER GRID (0.805887), HIND PETRO (0.811842), CONCOR (0.842595), IOC (0.857355) and NHPC (0.883357).

The results obtained from an alternative model - TGARCH (1,1) also confirm that the leverage effect is

present in majority of the Nifty PSE index stocks during the study period. As per the decision rule, the calculated coefficient values of '**γ**' for majority of the stocks are positive and significant at 5 per cent level except BEL, COAL INDIA, CONCOR, GICRE, IOC, NTPC and NATIONALUM these stocks are not affected by leverage effect and are not statistically significant (P values are more than 0.05) indicating that positive shocks have more impact than the negative shocks on these seven stocks.. The calculated GARCH values (β) from this model also confirm that the volatility is persistent during the study period except the stocks like GICRE (0.341843), OIL (0587541), POWERGRID (0.680411), GAIL (0.614366), NIACL (0.739628), CONCOR (0.782101) and NTPC (0.805713). To select the best fit model to understand the leverage effect, the values of Akaike Information Criterion (AIC) , Schwarz Information Criterion (SIC) and Log likelihood for both EGARCH (1,1) and TGARCH (1,1) were compared with each other and was found that EGARCH (1,1) is the most suited one for the selected stocks, since the calculated AIC and SIC values from EGARCH (1,1) model are lower than the values from TGARCH (1,1) model for majority of the stocks.

Summary of findings and conclusion

- It is found that out of twenty return series only six stocks of Nifty PSE index are positive and do not have normal distribution. Majority of the stocks are negatively skewed and the kurtosis values are greater than 3, which imply that the return series are leptokurtic in nature. Among these stocks only BPCL (0.000673) has delivered highest return, followed by HINDPETRO (0.000494), CONCOR (0.000338), POWERGRID (0.000297), BEL (0.000284) and IOC (0.000158) respectively.

- It is found from the results of Augmented Dickey Fuller test and Philips-Perron test that the natural logarithmic values of daily return series of all the stocks selected for this study are stationary (at level) in nature. The calculated absolute test statistic values for all the stocks taken for the study are much higher than the absolute test critical values (McKinnon critical value) at 5 per cent level which reject the null hypothesis that the variable has unit root problem.

- The residual diagnostic tests conducted to find the presence of ARCH effect in the daily return series of all the selected stocks reveals that the ARCH effect exists in all the return series taken for this study. The calculated F-statistics values for all the selected stocks are well above the observed R square values and they are significant at one percent level. The null hypothesis is rejected and proves that the return series of all the stocks are having ARCH effect. This necessitates the application of GARCH family models to understand the volatility patterns of the selected stocks.

- This study attempted to study the volatility and return of the Indian equity market by considering the price behavior of Nifty PSE index. The daily closing price of the selected stocks were considered for the study and GARCH(1,1) model was applied to understand the volatility. The study found that the GARCH(1,1) model is well defined to understand the volatility of the stocks. The finding of this study is in line with the findings of the previous studies which are supporting the fact that the volatility and return are positively related.

- It is found from the ARCH-LM test conducted to find out the presence of heteroscedasticity in the residuals obtained after application of GARCH(1,1) model in all the selected stocks that there is no evidence of ARCH effect remaining in the return series. This is an indication of perfection of the model and there is no ARCH effect remaining that needs to be modeled by any other GARCH models.

- It is found that EGARCH(1,1) model is the most suited model to understand the leverage effect of all the selected Nifty PSE index stocks. It is also found from the calculated values of EGARCH(1,1) model that the leverage effect exists in majority of the stocks during the study period. The calculated values of '**γ**' are negative and statistically significant (P values are less than 0.05) for majority of the stocks which expresses that negative shocks have more impact than the positive shocks on the volatility of the selected stocks.

Conclusion

An attempt was made in this research work to frame a model for the volatility and leverage effect among the Nifty PSE index stocks. While estimating the symmetric volatility, GARCH(1,1) model was found to be a better model and the same was employed to address the volatility persistence. The findings of this study reports that the PSE index stocks exhibits the persistence of volatility and confirms that the majority of the selected stocks have experienced the high-level volatility during the study period. To investigate the presence of asymmetric volatility the leverage effect EGARCH(1,1) and TGARCH(1,1) models were employed. The results show that the coefficient has the expected sign both in the EGARCH (negative and significant) and TGARCH (positive and significant) models. The findings of the study reveal that the leverage effect exists in the PSE index stocks, where a negative shock causes more volatility than the positive shocks of the same magnitudes. In the process of selecting the best fitting model among these, to understand the leverage effect, AIC and SIC values were used and which proved that EGARCH (1,1) model is the best fitted model to capture the asymmetric volatility for majority of the selected

stocks. The findings of the study is in line with the findings of the previous studies which supports that volatility and return are positively related and negative shocks cause more volatile than positive shocks of the same magnitude.

Reference:

1. Madhusudan Karmakar (2005) "Modeling Conditional Volatility of the Indian stock Market", *Vikalpa*, Vol.30, No.3, pp. 21-37.
2. Karunanithy Banumathy and Ramachandran Azhagaiah (2015), "Modeling Stock Market Volatility: Evidence from India", *Spring, Managing Global Transitions*, Vol.13, No.1, pp.27-42.
3. Kashif Saleem (2007)," Modeling Time Varying Volatility and Asymmetry of Karachi Stock Exchange (KSE*)", International Journal of Economic Perspectives*, Vol.1, No.1, pp 01-09.
4. Puja Padhi (2006), "Stock Market Volatility in India: A Case of Selected Scrips", *Indian Institute of Capital Markets 9 the Capital Conference Paper*, Social Science Research Network.
5. Rakesh Kumar and Raj S Dhankar (2010), "Empirical Analysis of Conditional Heteroscedasticity in Time Series of Stock Returns and Asymmetric Effect on Volatility*" Global Business Review*, Vol.11, No.1, pp.21-31.
6. G. Arivalagan, and S. Rajamohan, (2016) "Volatility Modeling for SENSEX using ARCH Family" St. Theresa Journal of Humanities and Social Sciences, Vol.2, No.2, 2016, pp.52-63.
7. Suresh A.S, (2020), "Estimation of Stock Return and Volatility: A study with special reference to the Nifty PSE (Public Sector Enterprises) Index stocks of NSE", Research Journal of social science & Management, Vol.10, Issue.9.
8. Suresh A.S, (2020), "Volatility Modelling for Nifty Energy Index Stocks Listed in NSE", International Journal of Advanced Research in Management and Social Sciences, Vol. 10, Issue. 2, pp. 1-10.