AN EMPIRICAL ANALYSIS ON VOLATILITY ESTIMATION USING ECONOMETRIC MODELS ON TEN SELECTED COUNTRY'S INDICES

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Abstract

Stock markets in India are recently in news for all the bad reasons. The one important reason is unpredictable volatility observed for painful long period. Investors losing their money and traders getting into margin crisis have prompted the government institutions to relook the regulatory measures. However, this heavy fluctuation in Indian market is not a new story. It had its origin back in 1990's. All the types of interim measures did not solve this issue but continue to capture the limelight of all the newspapers. This gave us an idea that in a matured and developed stock market, this volatility would not disturb the investors. Hence, we thought of analyzing the volatility of stock and market volatility using powerful tools like econometrics. From this, we could be able to list out the reason why it is similar or dissimilar in different countries. Most the investors are looking for foreign investments in the recent past. Hence it becomes very important for an investor and for the business analyst to know the volatility fluctuation in the respective country index. For the present study we will consider index closing prices data for a period of one year 2020 January – 2020 December for selected countries including BSE Sensex. In order to test the data, we have followed tests like Ng-Perron test and ADF model for testing the existence of Stationary, further ARCH will be tested with Ljung-Box Q-Test as this is test is vibrant. In order to study the volatility dynamics in the data, we will incorporate the GARCH family models like, GARCH, EGARCH, TARCH and PGARCH.

Key Words: Volatility, GARCH, Econometric Models

JEL Classification: R15

Introduction

Volatility has been at historically low levels of late for a wide range of risky assets, not just in the United States but across most international markets. The broad-based nature of low volatility is not surprising given that volatility measures tend to track each other closely. Several factors could affect the volatility of global stock markets, including current economic conditions; conventional and unconventional monetary policies; economic, geopolitical, and policy uncertainty; and the expected probability of recessions. To capture these factors, the first is the problem of endogeneity between the drivers and volatility; for example, how are we sure that fear of a recession increases volatility and not the other way around? The second is the persistent nature of global volatility, or the fact that volatility is a slow-moving variable so that its value today is, in general, a very good guess of what it will be tomorrow. In order to find out the answers for these two questions the global index was considered for the present study which are European Markets, Asian Markets and Indian market. Since the Indian market is unstable it is important to study whether these global changes could impact the Indian market. The primary objective of this study is to find out the Volatility dynamics of selected global index of various markets including Indian stock market. The following are some of the important index which are considered for the study, India, Germany, Hang Seng, Jakarta, South Korea, Nikkie, Shanghai, Singapore, Europe and Taiwan. The past studies have studied few of these indexes however this study will be carried out to find out the overall performance of various markets. It is at-most important for an investor who wishes to invest in foreign countries to know how well the markets perform. The scope of this research paper will give a bird-eye view for the investors and the financial analyst.

Literature Review

Dangi V (2020), analyzed the Volatility dynamics of various Cryptocurrencies using advanced tools like GARCH Family and ADF Models. The author has incorporated rigor econometric tools to test the variables with high accuracy. The primary objective of the study is to analyze the volatility dynamics of selected cryptocurrencies which are traded with high volume. From the result it is clear that the returns from all the crypto currencies are stationary and ARCH effect is present. Further GARCH was sed to test the shocks which are there in these currencies, the study confirmed the presence of volatility in all the clusters. Further the author also incorporated PARCH, EGARCH and TARCH models to examine the asymmetries in the volatility, the result confirmed that asymmetries are present in all the currencies which are tested.

Identification of Research Gap

Above are the extensive literature review pertaining to Volatility dynamics in different areas including cryptocurrencies, stocks and derivative contracts. There are many literatures are available in the area of Volatility prediction and forecasting. Though there are many studies taken place, only few studies have tried to find out the Volatility of global markets with rigorous econometric tools. Hence, by this we would like to project the global volatility shocks for the various index from US, European and Indian markets. By this the investors and the financial analyst would be able to predict the stock prices and the Index movements which would help in their investment advice.

Research Methodology/Design

Research Objective (s)

- To analyze the classical mechanics of forces and their effects of Volatility in the selected indexes.
- To analyze the stationary and non-stationary effects on these indexes.

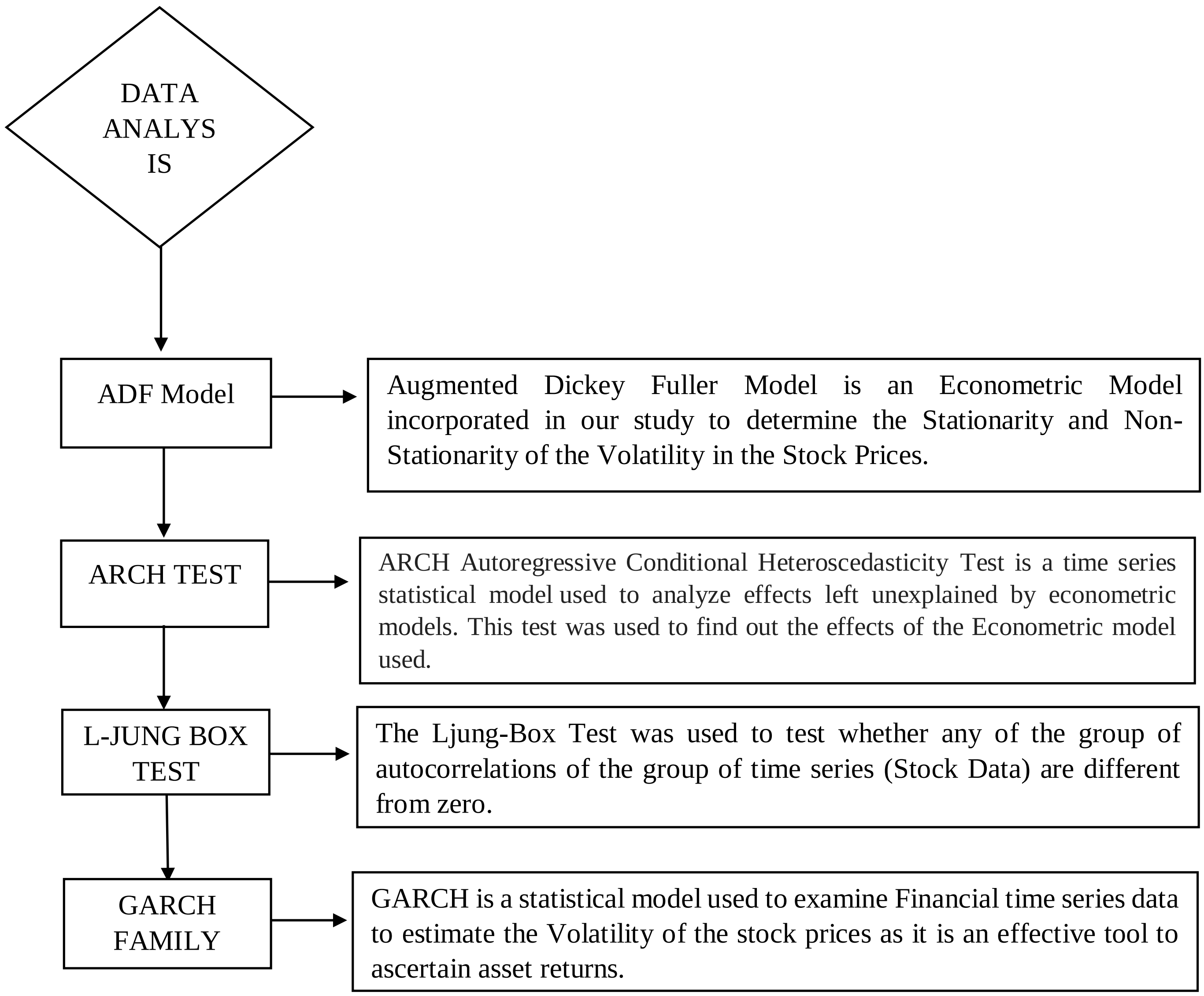
Data Collection

Secondary data is collected for the present study. Closing prices of all the index are considered from January 2020 to December 2020. This being the pilot study we wanted to analyze the data for one year, based on the results extensive research will be carried out.

Tools and Techniques

For the present study various Econometric tools were incorporated. Detailed information pertaining to the tests are given below. From the data obtained from various indexes, the log returns were calculated. Further in order to test the existence of stationary conventional Augmented Dickey Fuller test will be used and in order to check the validity and to support the ADF model, NgPerron test will be incorporate to have more clarity on the data set. Since the data is time series, it is also important to establish the stationary and to model the conditional mean equation. Once we test the stationary existence conditional mean, it is also important to check whether autocorrelation of these time series dataset different from zero, in order to test this Ljung-Box Q-statistics was applied to the dataset. IN order to find the best fit model for the dataset, we have chosen Engle's ARCH model to see if the we have the best fit data. In order to check the negative and positive shocks we have applied EGARCH Exponential Generalized Autoregressive Conditional Heteroskedasticity.

Flowchart of Tools Implemented to Study the Volatility for selected Indexes of 10 Countries.



The above flow chart depicts the implementation of various tests which was incorporated for the present study. The closing price of the major indexes for India, Germany, Hang Seng, Jakarta, South Korea, Nikkie, Shanghai, Singapore, Europe and Taiwan. were considered for the study.

For the present study the rate of return is considered to check the volatility dynamics of all the above-mentioned indexes. The closing prices of all the indexes were converted to return series by implementing the following formula:

$$R_{t\,=}\ (\text{In}\ P_t - \text{In}\ P_{t-1}\ )$$

Where

$R_t = is\ the\ index's\ return\ for\ the\ day\ "t"$

$P_t = is\ the\ closing\ price\ of\ the\ index\ for\ the\ day\ "t"$

$P_{t-1}\ \ = is\ the\ closing\ price\ of\ the\ index\ of\ previous\ trading\ day; and$

In is the natural log.

Before we test the volatility dynamics of the all the indexes, stationary existence was tested using Ng-Perron Test. Further, the conventional Augmented Dickey-Fuller test is employed to make sure the theory is well supported. As we have implemented the ADF and Ng-perron test, the data was tested with conditional mean equation as per the above-mentioned flow chart using Box Jenkin's methods. In order to check whether the autocorrelation time series is different from zero parameter, Ljung-Box Q statistics was applied to the data. The above mentioned was applied on the residual values not on the return series. Engle's ARCH test was used to test the autoregressive conditional heteroskedasticity for all the indexes. Finally, GARCH models were implemented to test volatility fluctuation of all the indexes. for all the tests the equations are mentioned below:

Actual EGARCH Estimation

$$\log \sigma_t^2 = \omega + \sum_{k=1}^{q} \beta_k g(Z_{t-k}) + \sum_{k=1}^{p} \alpha_k \log \sigma_{t-k}^2$$

Modified EGARCH Estimation

In $(h_t^2) = \infty_0 \alpha + \gamma(e_{t-1} h_{t-1}) + \lambda[(|e_{t-1}\ |/\ h_{t-1}) - (2/\pi)\ \text{^}0.5] + \beta$ In (h_{t-1}^2)

Where

h_t^2 = Conditional variance in index return series

λ= Systematic effect in index return series

β= Persistence level in conditional volatility

γ= Leverage effect in index return series and

∞_0 , γ *and* β are the parameters considered

Equation for TARCH Estimation

$$\sigma_t^\delta = \omega + \sum_{j=1}^{q} \beta j\ \sigma_t^\delta\ \sigma_{t-j}^\delta + \sum_{i=1}^{p} \infty_i\ (|\varepsilon_{t-i}| - \gamma\ \varepsilon_{t-1})$$

DESCRIPTIVE STATISTICS RESULTS

For the present study the closing price of all the county's index data are considered for the analysis. Basic average returns are calculated for the all the Stock Indexes. The below table depicts the descriptive statistics for the ten countries.

Descriptive Statistics of Stock Return Series (Table 1)

Descriptive Statistics	INDIA	GERMANY	HANG SENG	JAKARTA	SOUTH KOREA	NIKKIE	SHANGHAI	SINGAPORE	EUROPE	TAIWAN
Mean	1.0000	1.4066	1.4857	1.3236	1.1969	1.4666	1.2428	1.2475	1.2606	1.3967
Median	1.0000	1.4088	1.4869	1.3320	1.1994	1.4671	1.2340	1.2350	1.2646	1.3960
Maximum	1.0139	1.4206	1.4959	1.3376	1.2106	1.4774	1.2509	1.2620	1.2774	1.4075
Minimum	0.9917	1.3677	1.4670	1.2796	1.1517	1.4396	1.2311	1.2087	1.2172	1.3708
S.D	0.0019	0.0107	0.0065	0.0153	0.0096	0.0079	0.0037	0.0128	0.0134	0.0064
Kurtosis	13.9656	1.6128	-0.5555	-0.4650	4.0684	0.8838	0.0268	-0.2150	0.4681	1.3292
Skewness	1.5767	-1.3185	-5466	-1.0521	-1.7250	-0.9220	-0.2844	-1.1173	-1105	-0.8163
JB	16.8540	12.1500	13.0030	11.2090	13.1250	13.9070	13.7320	13.3250	13.2110	18.4250
Probability	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Source: Calculated from the Primary Analysis.

Hypothesis

(H0): The Return Series has the presence of Normal Distribution.

(HA): The Return Series does not have the presence of Normal Distribution.

The Descriptive Statistics of Stock Returns were calculated on the Stock Indexes of India, Germany, Hang Seng, Jakarta, South Korea, Nikkei, Shanghai, Singapore, Europe and Taiwan. The Daily Stock Index Data of all these countries were considered in the study from the period of June 2019 to June 2019.

Descriptive Statistics were calculated on the returns of all Stock Indexes and the results are as above.

The positive average statistics results of all Stock Indexes of 10 Countries exhibits the increase in returns over the same period. The positive values indicate high probability of returns in India but the Negative Skewness values in Germany, Hang Seng, Jakarta, South Korea, Nikkei, Shanghai, Singapore, Europe and Taiwan indicate high probability of earning Negative Returns.

The Kurtosis Statistical values of all the Stock Indexes are below 3 and are in Negative Values which means that they are Platykurtic except the Indian Stock Index's (BSE) Kurtosis Statistical value, as it is more than 3. Hence, it is Leptokurtic.

The Probability values of Jarque-Bera test of all the Stock Indexes of 10 Countries are zero.

By the above results from the Table 1, it is clearly Indicated that the Return Series of all the 10 Stock Indexes does not have the presence of Normal Distribution. Hench, the (H0) Null Hypothesis, can be rejected and he

(HA) Alternate Hypothesis, can be accepted as the Return series of all the 10 Stock Indexes does not have the presence of Normal Distribution.

Ng Perron Test is further used on the Return Series of India, Germany, Hang Seng, Jakarta, South Korea, Nikkie, Shanghai, Singapore, Europe and Taiwan to examine their Stationary.

Ng PERRON and Augmented Dickey Fuller.

Ng Perron and ADF are unit root tests that are used to test the stationarity of a dataset. These two tests were used to check the stationarity of the Data set of Stock indexes from 10 distinctive countries.

The following table shows the results of Ng Perron and ADF tests of 10 countries.

NG PERRON TEST RESULTS (Table 2)

Index	MZa	MZt	MSB	MPT
Europe	-3.71094	-1.35144	0.36418	6.59990
Taiwan	-15.9968	-2.80169	0.17514	1.62334
Singapore	-1.53990	-0.68011	0.44166	12.1665
Shanghai	-5.56319	-1.66433	0.29917	4.41252
Nikkei	-15.6060	-2.78061	0.17818	1.61455
South Korea	-5.02388	-1.55738	0.31000	4.93128
Jakarta	-8.22718	-1.94985	0.23700	3.24187
Hang Seng	-2.68146	-1.03637	0.38649	8.60470
Germany	-4.57667	-1.51016	0.32997	5.35699
India	-12.2451	-2.44455	0.19963	2.10771

Source: Calculated from the Primary Analysis.

The above results of Ng Perron test on returns of Stock Indexes of Europe, Taiwan, Singapore, Shanghai, Nikkei, South Korea, Jakarta, Hang Seng, Germany and India.

Hypothesis.

H0 = The Return Series of all 10 countries has a Unit Root.

HA = The Return Series of all 10 Countries does not have a Unit Root.

The above results clearly indicate that the Null Hypothesis(H0) cannot be rejected by all of the Ng Perron Results and the Return Series are Non-Stationary.

The results clearly indicate that the return series has the presence of Unit Root. Hence, (HA) can be Rejected.

The ADF test results are as follows:

ADF – TEST RESULTS (Table 3)

Index Name	t-statistic	Probability
Europe	-1.525182	0.4873
Taiwan	-2.395777	0.1639
Singapore	-0.900809	0.7563
Shanghai	-2.392318	0.1632
Nikkei	-2.741811	0.1009
South Korea	-2.543805	0.1322
Jakarta	-1.428632	0.5297
Hang Seng	-1.271695	0.6056
Germany	-1.854727	0.3396
India	-1.843914	0.3429

Source: Calculated from the Primary Analysis.

Hypothesis.

H0 = The Return Series of all 10 countries has a Unit Root.
HA = The Return Series of all 10 Countries does not have a Unit Root.

The ADF test is further applied to the returns of Stock Indexes of Europe, Taiwan, Singapore, Shanghai, Nikkei, South Korea, Jakarta, Hang Seng, Germany and India, to clearly determine the presence of Unit Root in the return series using the results of the Ng Perron tests.

The above Results in the table (1.3) indicate that the Null Hypothesis(H0) that the Return Series of all 10 Countries has a Unit Root, cannot be accepted as the Probability Values are not less than 0.05. Hence, the Alternate Hypothesis (HA) can be rejected as the Return Series of all Stock Indexes has a Unit Root and is Non-Stationary.

Ljung Box Test.

Ljung Box test is a statistical test which is used to test the presence of Autocorrelation in a Dataset. It is also used to test the presence of Heteroskedasticity in a residual series. Ljung Box Q statistics was obtained by applying this test on the return series of 10 selected stock indexes.

The following (table 4) depicts the results after the returns of Stock Indexes of 10 Distinctive countries were calculated using Ljung Box Test.

LJUNG BOX – Q-STATISTICS RETURNS FOR 10 SELECTED COUNTRIES

Lags	Hang Seng		Germany		India		Jakarta		South Korea		Nikkei		Shanghai		Singapore		Europe		Taiwan	
	Q-Stat.	Prob.	Q-Stat.	Prob.	Q-Stat.	Prob.	Q-Stat.	Prob.	Q-Stat.	Prob.	Q-Stat.	Prob.	Q-Stat.	Prob.	Q-Stat.	Prob.	Q-Stat.	Prob.	Q-Stat	Prob
1	0.3592	0.549	0.066	0.797	5.7005	0.017	2.4492	0.118	0.3288	0.566	2.0966	0.148	0.0118	0.913	9.2675	0.002	0.0155	0.901	0.4521	0.854
2	0.6222	0.733	4.041	0.133	6.4898	0.039	2.7455	0.253	12.450	0.002	7.9962	0.018	0.3698	0.831	12.898	0.002	6.1474	0.046	0.5421	0.654
3	3.0219	0.388	6.470	0.091	7.0068	0.072	11.301	0.010	14.198	0.003	7.9968	0.046	0.8970	0.826	14.542	0.002	7.7400	0.052	3.1265	0.548
4	5.0331	0.284	6.965	0.138	7.0349	0.134	12.072	0.017	14.199	0.007	9.2075	0.056	6.6140	0.158	15.177	0.004	8.8792	0.064	5.4879	0.569
5	7.2003	0.206	9.393	0.094	23.142	0.000	15.55	0.008	15.057	0.010	10.066	0.073	6.7530	0.240	18.378	0.003	9.9011	0.078	7.687	0.511
6	9.8781	0.13	14.91	0.021	38.356	0.000	17.217	0.009	15.623	0.016	11.595	0.072	6.7540	0.344	21.201	0.002	17.503	0.008	9.2154	0.19
7	11.318	0.125	24.88	0.001	50.565	0.000	17.689	0.013	15.625	0.029	15.236	0.033	6.7607	0.454	23.174	0.002	29.834	0.000	12.268	1.265
8	11.872	0.157	28.50	0.001	50.731	0.000	18.642	0.017	15.698	0.047	16.149	0.040	6.8081	0.557	23.553	0.003	34.969	0.000	11.154	0.845
9	13.37	0.147	29.32	0.001	51.295	0.000	27.148	0.001	15.702	0.073	17.032	0.048	6.9729	0.640	26.913	0.001	35.383	0.000	13.47	0.214
10	13.381	0.203	29.43	0.001	56.491	0.000	27.525	0.002	16.078	0.097	18.189	0.052	9.1020	0.522	27.181	0.002	36.099	0.000	13.145	0.421

*Source: Calculated from the Primary Analysis***.**

The above the results of Ljung Box Test applied on 10 Countries, showing the Q Statistics Returns for 10 selected countries.

Hypothesis.

(H0) = The Data Series does not have the presence of autocorrelation

(HA)= The Data Series has the presence of Autocorrelation.

The above results from Table 5 indicate that the Stock Index Returns of 10 counties that countries except Hang Seng, Germany, Jakarta, South Korea. Nikkei, Shanghai, Europe and Taiwan do not have the presence of Autocorrelation as their probability values are not less than 0.05. Hence, the Null Hypothesis of Autocorrelation cannot be rejected for Hang Seng, Germany, Jakarta, South Korea. Nikkie, Shanghai, Europe and Taiwan as their Probability Values are not less than 0.05. Whereas, Data sets of Stock Indexes of India and Singapore have the presence of Autocorrelation as their Probability Values are less than 0.05. Hence, Alternate Hypothesis (HA) for India, Singapore and Taiwan can be accepted as their probability values are less than 0.05.

The analysis results clearly show the clustering effects on the daily returns of the Stock Indexes. So, the econometric analysis of Europe, Taiwan, Singapore, Shanghai, Nikkei, South Korea,

Jakarta, Hang Seng, Germany and India, confirms that the period of less volatility is followed by a period of less volatility and vice versa in the return series of the Stock Indexes. Henceforth, the presence of

Heteroskedasticity and Autocorrelation effects in the datasets requires the need for the application of GARCH model on the Returns of the Stock Indexes of 10 selected countries.

Generalized Autoregressive Conditional Heteroskedasticity.

Generalized Autoregressive conditional Heteroskedasticity (GARCH) is a statistical modeling technique used to analyses time series data where the variance error is believed to be serially auto-correlated. This technique is typically used to estimate the volatility of returns of Stocks, Bonds and Market Indices. It is an effective tool used to assess the risk and expected returns for Financial Assets that usually have clustered periods of volatility in their returns. GARCH Model was estimated for the Returns of Stock Indexes of all 10 selected countries in order to assess the expected returns and measure the risk associated to them. Volatility Clustering Models were made and the results of the estimation are as follows:

GARCH MODEL ESTIMATION (Table 5)

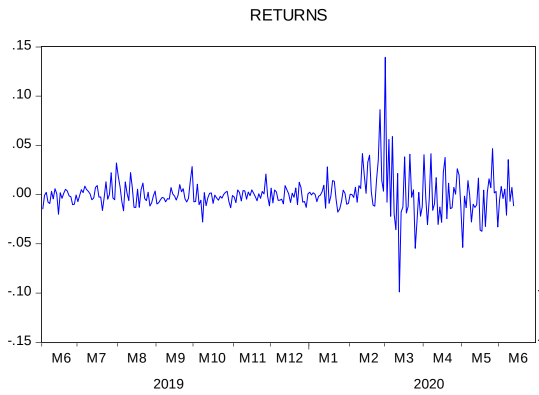
GARCH Model Estimation on selected ten Index's Return Series				
EQUATION: GARCH = C(2) + C(3)*RESID(–1)∧2 + C(4)*GARCH(–1)				
Variable	Coefficient	Std. Error	z-Statistic	Prob.
Dependent Variable: Germany Returns				
C	0.001214	0.000701	1.732207	0.0832
C(2)	0.000914	0.000718	1.272855	0.2031
C(3)	0.000542	0.000568	0.954891	0.3396
C(4)	0.000650	0.000618	1.052149	0.2927
Dependent Variable: India Returns				
C	0.000297	0.000591	0.502248	0.6155
C(2)	0.000308	0.000577	0.533332	0.5938
C(3)	0.000307	0.000673	0.456668	0.6479
C(4)	6.790005	0.000542	0.125212	0.9004
Dependent Variable: Jakarta Returns				
C	-0.000111	0.000570	-0.194302	0.8459
C(2)	-0.000131	0.000530	-0.247756	0.8043
C(3)	-0.000332	0.000462	-0.718964	0.4722
C(4)	-0.000138	0.000472	-0.292225	0.7701
Dependent Variable: South Korea Returns				
C	0.001019	0.000697	1.461713	0.1438
C(2)	0.000979	0.000714	1.371818	0.1701
C(3)	0.001089	0.000726	1.500962	0.1334
C(4)	0.000925	0.000647	1.429918	0.1527
Dependent Variable: Hang Seng Returns				
C	0.000104	0.000778	-0.133375	0.8939

C(2)	0.000238	0.000838	0.284217	0.7762
C(3)	4.200005	0.000754	0.055725	0.9556
C(4)	0.000214	0.000815	0.263033	0.7925
Dependent Variable: Shanghai Returns				
C	0.000674	0.000660	1.022411	0.3066
C(2)	0.062107	0.200145	0.310312	0.7563
C(3)	0.185364	0.084488	2.193966	0.0282
C(4)	0.423171	0.135570	3.121425	0.0018
Dependent Variable: Nikkei Returns				
C	0.001094	0.000736	1.485651	0.1374
C(2)	0.000895	0.000733	1.220718	0.2222
C(3)	0.000918	0.000638	1.440199	0.1498
C(4)	0.000975	0.000636	1.532529	0.1254
Dependent Variable: Europe Returns				
C	0.001222	0.000612	1.996919	0.0458
C(2)	0.001311	0.000590	2.221258	0.0263
C(3)	0.000913	0.000633	1.441430	0.1495
C(4)	0.000901	0.000472	1.909320	0.0562
Dependent Variable: Taiwan Returns				
C	0.000621	0.000716	0.866801	0.3861
C(2)	0.000553	0.000694	0.796942	0.4255
C(3)	0.000306	0.000670	0.456537	0.6480
C(4)	0.000907	0.000673	1.347950	0.1777
Dependent Variable: Singapore Returns				
C	0.000536	0.000815	0.759548	0.2158
C(2)	0.000628	0.000593	0.752654	0.4987
C(3)	0.000406	0.000753	0.526590	0.6954
C(4)	0.000702	0.000624	1.42154	0.2145

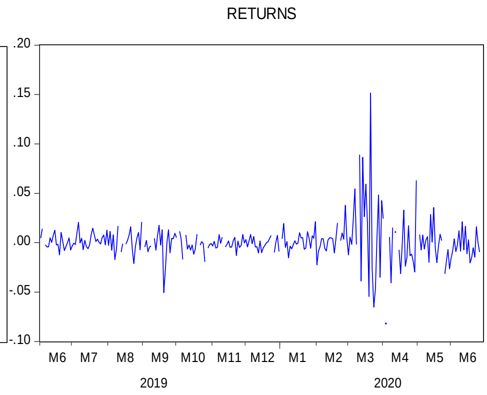
Source: Calculated from the Primary Analysis.

The following 10 Figures show the returns on GARCH.

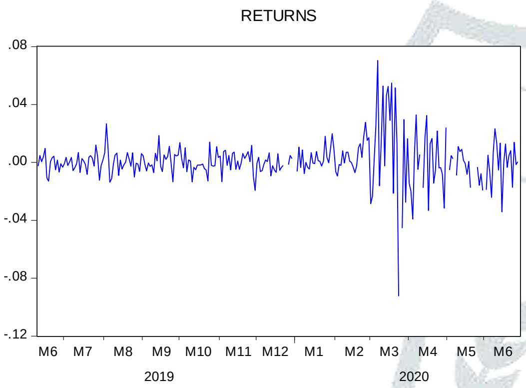
Germany



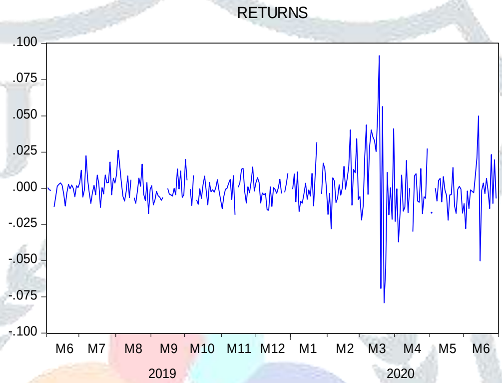
India



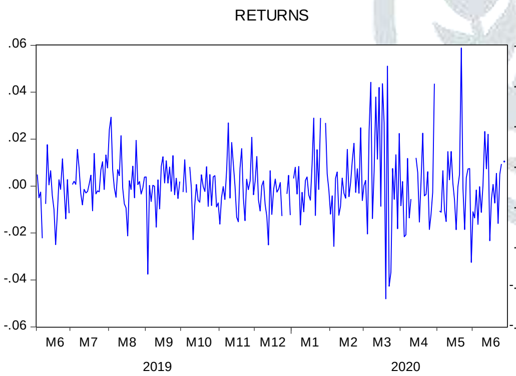
Jakarta



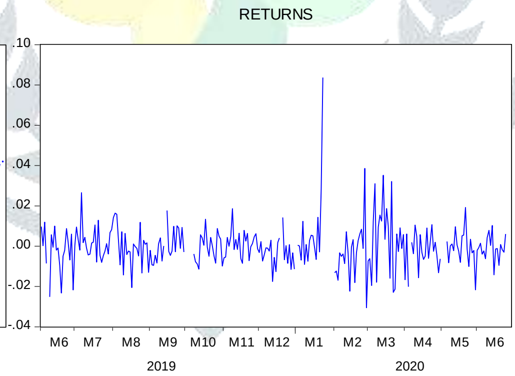
South Korea



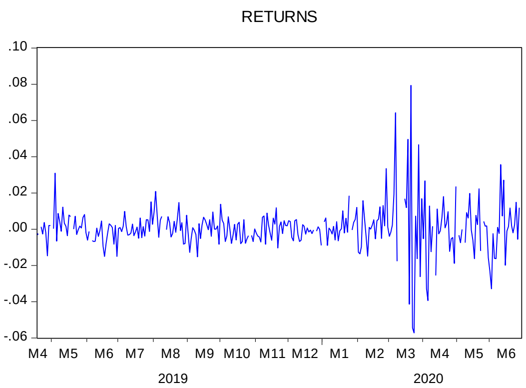
Hang Seng



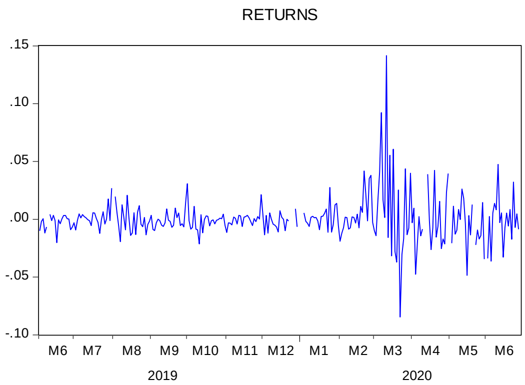
Shanghai



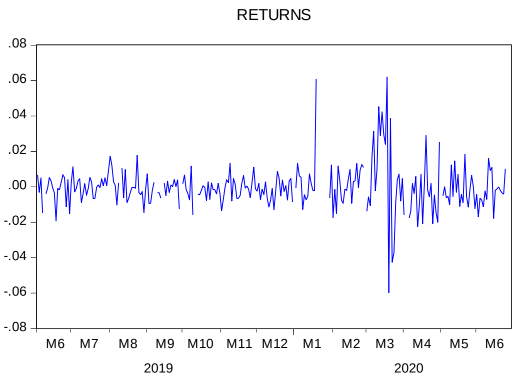
Singapore



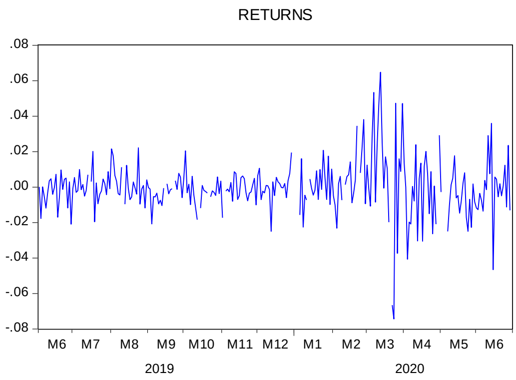
Europe



Taiwan



Nikkei



*Source: Calculated from the Primary Analysis***.**

Hypothesis.

H0: The Coefficients of the lagged squared residuals are statistically significant.

HA: The Coefficients of the lagged squared residuals are statistically insignificant.

The above table showing the results of the GARCH Model Estimation shows that the values of the coefficients of the lagged squared residuals (RESID (-1)^2) of Europe, Taiwan, Singapore, Shanghai, Nikkei, South Korea, Jakarta, Hang Seng, Germany and India Stock Index returns series, are statistically significant as their p-values are equal to or more than Zero. Similar is the case with the Lagged Conditional Variance term's coefficient. The coefficient of the lagged squared residuals and the lagged conditional variance is close to unity. Hence, The Hypothesis of the coefficients of the lagged squared residuals being statistically significant(H0), cannot be rejected as their p-values are equal to or more than Zero and the (HA), cannot be accepted as the p-values are not less than zero.

The results of the analysis prove the presence of Highly Persistent Shock to the Conditional Variance in the Returns Series of the 10 selected Stock Indexes. This large sum also implies that a large negative return or a substantial positive return will lead to high variance in the returns series in the future.

Estimation of Market Volatility using Returns of Stock Indexes of 10 Selected Countries in terms of Asymmetrical Response.

The Exponential Generalized Autoregressive Conditional Heteroskedasticity (EGARCH) model is used to capture the leverage effects of shocks that are caused by Policies, News, Information, Incidents, Events and Impactful Situations on the Financial Markets of the world. EGARCH Model allows the testing of Asymmetries in the Market Volatility. When there is Good news in the market, the volatility of financial assets tends to enter the state of Tranquility and with bad news, there is a turbulence phase for the Financial Assets and the volatility increases.

Return of Stock Indexes of 10 countries were subjected the test of Estimating the Market Volatility in terms of Responses that are Asymmetrical in nature and the EGARCH Model Estimation is as follows in the Table 6:

EGARCH Model Estimation on selected ten Index's Return Series				
EQUATION: Log(GARCH) = C(2) + C(3)*ABS(RESID(–1)/@SQRT(GARCH(–1))) + C(4)*RESID (–1)/@SQRT(GARCH(–1)) + C(5)*Log(GARCH(–1))				
Variable	Coefficient	Std. Error	z-Statistic	Prob.
Dependent Variable: Germany Returns				
C	0.000290	0.000751	0.386659	0.6990
C(2)	-0.246517	0.096354	-2.558457	0.0105
C(3)	0.137895	0.053478	2.578520	0.0099
C(4)	0.186883	0.023024	8.116950	0.0000
C(5)	0.983037	0.007939	123.8163	0.0000
Dependent Variable: India Returns				
C	-0.000613	0.000609	-1.005949	0.3144
C(2)	-0.276761	0.056120	-4.931640	0.0000
C(3)	0.130914	0.056600	2.312950	0.0207
C(4)	0.220917	0.025333	8.720608	0.0000
C(5)	0.979316	0.006024	162.5816	0.0000
Dependent Variable: Jakarta Returns				
C	-0.000547	0.000540	-1.012249	0.3114
C(2)	-0.422251	0.134729	-3.134079	0.0017
C(3)	0.213949	0.054263	3.942789	0.0001
C(4)	0.119468	0.030351	3.936223	0.0001
C(5)	0.971469	0.011644	83.43112	0.0000
Dependent Variable: South Korea Returns				
C	0.000254	0.000648	0.392156	0.6949
C(2)	-0.975049	0.218327	-4.466010	0.0000
C(3)	0.306786	0.070022	4.381247	0.0000
C(4)	0.210660	0.038068	5.533846	0.0000
C(5)	0.915660	0.021925	41.76318	0.0000
Dependent Variable: Hang Seng Returns				
C	-0.000717	0.000806	-0.889639	0.3737
C(2)	-0.267423	0.075098	-3.560989	0.0004
C(3)	0.034013	0.034493	0.986090	0.3241
C(4)	0.124739	0.028515	4.374473	0.0000
C(5)	0.971800	0.008303	117.0399	0.0000
Dependent Variable: Shanghai Returns				
C	0.000132	0.000573	0.229699	0.8183

C(2)	-3.252537	0.552478	-5.887178	0.0000
C(3)	0.113520	0.084170	1.348699	0.1774
C(4)	0.502128	0.062339	8.054844	0.0000
C(5)	0.658413	0.060438	10.89393	0.0000
Dependent Variable: Nikkei Returns				
C	0.000145	0.000627	0.231899	0.8166
C(2)	-0.100842	0.033191	-3.038192	0.0024
C(3)	0.005343	0.034242	0.156036	0.8760
C(4)	0.169240	0.027337	6.190851	0.0000
C(5)	0.988723	0.003882	254.6724	0.0000
Dependent Variable: Europe Returns				
C	-0.448253	0.115858	-3.868987	0.0001
C(2)	0.212570	0.047122	4.511009	0.0000
C(3)	0.214185	0.029233	7.326745	0.0000
C(4)	0.965691	0.009840	98.14420	0.0000
Dependent Variable: Taiwan Returns				
C	0.000292	0.000677	0.430966	0.6665
C(2)	-0.371438	0.163228	-2.275572	0.0229
C(3)	0.065227	0.071533	0.911835	0.3619
C(4)	0.132737	0.030891	4.296899	0.0000
C(5)	0.964383	0.013114	73.54052	0.0000
Dependent Variable: Singapore Returns				
C	-0.512149	0.326544	-3.562659	0.0001
C(2)	0.326566	0.024665	4.563265	0.0000
C(3)	0.451211	0.626533	7.154877	0.0000
C(4)	0.896254	0.002565	98.21546	0.0000

Source: Calculated from the Primary Analysis.

H0: The Returns series of the 10 Stock Indexes have Persistent Shocks in their Volatility.

H1: The Returns series of the 10 Stock Indexes do not have Persistent Shocks in their Volatility.

The above results from the Table shows that the EGARCH model estimation of all the Stock Indexes Returns of 10 Countries' parameter is close to one and zero. This implies that the shocks in volatility are persistent for all the 10 selected Stock Indexes and (H0) cannot be rejected as the p-values are not less than zero. Hence,(H1) cannot be accepted as the Returns series of all 10 Stock Indexes have Persistent Shocks with their p-values being more than Zero.

The Leverage Effect Term in the equation is C(4)*RESID(-1)/@SQRT(GARCH(-1)). The Leverage Terms are Positive for the all the Stock Indexes of 10 selected countries. This implies that the conditional variances of Return Series of Europe, Taiwan, Singapore, Shanghai, Nikkei, South Korea, Jakarta, Hang Seng, Germany and India's Stock Indexes have a larger reaction to past positive shocks as compared to the negative shocks of the equal magnitude. Furthermore, there is a need to find out the influence of these shocks on the Return series of the Stock Indexes. Hence, Threshold Autoregressive Conditional Heteroskedasticity is required for it's application.

Threshold Autoregressive Conditional Heteroskedasticity (TARCH)

To find out the influence of these persistent shocks on the Returns series of the Stock Indexes, TARCH model is further estimated on the returns series and the results of TARCH Model Estimation are as follows in the Table 7:

TARCH Model Estimation on selected ten Index's Return Series				
EQUATION: EQUATION = C(2) + C(3)*RESID(-1)^2 + C(4)*GARCH(-1)				
Variable	Coefficient	Std. Error	z-Statistic	Prob.
Dependent Variable: Germany Returns				
C	0.001214	0.000701	1.732207	0.0832
C(2)	6.58E-06	2.33E-06	2.821547	0.0048
C(3)	0.257313	0.059429	4.329761	0.0000
C(4)	0.759423	0.055309	13.73067	0.0000
Dependent Variable: India Returns				
C	0.000297	0.000591	0.502248	0.6155
C(2)	6.73E-06	3.71E-06	1.813391	0.0698
C(3)	0.271464	0.062375	4.352122	0.0000
C(4)	0.741571	0.061932	11.97392	0.0000
Dependent Variable: Jakarta Returns				
C	-0.000111	0.000570	-0.194302	0.8459
C(2)	5.86E-06	2.43E-06	2.411655	0.0159
C(3)	0.230425	0.057334	4.018970	0.0001
C(4)	0.739836	0.062723	11.79531	0.0000
Dependent Variable: South Korea Returns				
C	0.00174	0.000321	1.4254	0.1875
C(2)	3.126539	2.854621	1.154622	0.0065
C(3)	0.157888	0.065487	3.636987	0.0002
C(4)	0.785993	0.426552	20.21588	0.0000
Dependent Variable: Hang Seng Returns				
C	-0.000104	0.000778	-0.133375	0.8939

C(2)	4.37E-06	1.96E-06	2.230258	0.0257
C(3)	0.053004	0.016443	3.223450	0.0013
C(4)	0.926577	0.017566	52.74718	0.0000
Dependent Variable: Shanghai Returns				
C	0.000674	0.000660	1.022411	0.3066
C(2)	1.30E-05	5.15E-06	2.522351	0.0117
C(3)	0.197069	0.021633	9.109478	0.0000
C(4)	0.715229	0.046555	15.36323	0.0000
Dependent Variable: Nikkei Returns				
C	0.001094	0.000736	1.485651	0.1374
C(2)	4.76E-06	2.83E-06	1.679785	0.0930
C(3)	0.106894	0.029984	3.565002	0.0004
C(4)	0.872108	0.041730	20.89883	0.0000
Dependent Variable: Europe Returns				
C	0.001222	0.000612	1.996919	0.0458
C(2)	7.13E-06	1.88E-06	3.788007	0.0002
C(3)	0.318964	0.059642	5.347930	0.0000
C(4)	0.708591	0.052957	13.38053	0.0000
Dependent Variable: Taiwan Returns				
C	0.000621	0.000716	0.866801	0.3861
C(2)	1.10E-05	5.21E-06	2.111203	0.0348
C(3)	0.120426	0.039457	3.052040	0.0023
C(4)	0.791374	0.076456	10.35068	0.0000
Dependent Variable: Singapore Returns				
C	0.00154	0.000431	1.52654	0.1487
C(2)	4.761547	2.745421	1.659852	0.0659
C(3)	0.152154	0.032658	3.426599	0.0659
C(4)	0.785266	0.054989	20.21544	0.0000

Source: Calculated from the Primary Analysis.

(H0): The Volatility Shocks in the Returns series of all Stock Indexes has a significant influence.

(HA): The Volatility Shocks in the Returns series do not have a significant influence.

The above equation, C(2) + C(3)*RESID(-1)^2 + C(4)*GARCH(-1), used for the TARCH Model estimation on the Stock Index Returns of 10 Countries, imply that the persistent shocks in the dataset have a significant influence on the Returns series of the Stock Indexes as the p-values are more than Zero and less than one. Hence, the (H0) Hypothesis of the Returns series of all stock indexes having a significant effect because of the volatility shocks cannot be rejected but the (HA)Hypothesis of the Volatility Shocks not having a significant influence on the Stock Index Returns series of all 10 countries, cannot be accepted as the p-values are not less than zero.

The GARCH Family is based on the analysis of Standard Deviation and since the selected database of 10 Stock Index Returns Series have the presence of variances in them, there is a need to test the significance of these variances to clearly understand the Generalized Error Distribution.

Power Autoregressive Generalized Conditional Heteroskedasticity (PARCH)

PARCH is a Volatility Model used to test the significance of variances that are present in the Dataset. The PARCH Model was estimated on the Returns Series of the 10 Selected Stock Indexes and the results of the model estimation are as follows in the Table 8:

PARCH Model Estimation on selected ten Index's Return Series				
@SQRT(GARCH)^C(6) = C(2) + C(3)*(ABS(RESID(-1)) - C(4)*RESID(-1))^C(6) + C(5)*@SQRT(GARCH(-1))^C(6)				
Variable	Coefficient	Std. Error	z-Statistic	Prob.
Dependent Variable: Germany Returns				
C	3.35E-05	0.000579	0.057899	0.9538
C(2)	0.003498	0.006665	0.524761	0.5997
C(3)	0.065552	0.024711	2.652813	0.0080
C(4)	-0.977548	0.146004	-6.695336	0.0000
Dependent Variable: India Returns				
C	-0.000613	0.000544	-1.126435	0.2600
C(2)	0.005924	0.004142	1.430121	0.1527
C(3)	0.066170	0.025040	2.642517	0.0082
C(4)	-0.999887	0.001316	-759.8833	0.0000
Dependent Variable: Jakarta Returns				
C	-0.000475	0.000567	-0.837581	0.4023
C(2)	3.07E-06	1.90E-05	0.161242	0.8719
C(3)	0.202808	0.056365	3.598098	0.0003
C(4)	-0.240561	0.126242	-1.905560	0.0567
Dependent Variable: South Korea Returns				
C	0.000426	0.000554	0.767941	0.4425
C(2)	0.001471	0.001387	1.060144	0.2891
C(3)	0.101468	0.025039	4.052426	0.0001
C(4)	-0.991957	0.057092	-17.37471	0.0000
Dependent Variable: Hang Seng Returns				
C	-0.000691	0.000834	-0.829180	0.4070
C(2)	0.001004	0.003193	0.314558	0.7531
C(3)	0.053566	0.020726	2.584494	0.0098
C(4)	-0.972174	0.279376	-3.479810	0.0005
Dependent Variable: Shanghai Returns				
C	0.000165	0.000623	0.265183	0.7909
C(2)	0.001748	0.002800	0.624172	0.5325
C(3)	0.206237	0.226944	0.908760	0.3635
C(4)	-1.000000	1.773877	-0.563737	0.5729
Dependent Variable: Nikkei Returns				
C	0.000455	0.000609	0.748127	0.4544

C(2)	0.000961	0.001433	0.670804	0.5023
C(3)	0.065703	0.016649	3.946470	0.0001
C(4)	-0.999561	0.047920	-20.85897	0.0000
Dependent Variable: Europe Returns				
C	0.001222	0.000612	1.996919	0.0458
C(2)	0.002529	0.001560	1.621695	0.1049
C(3)	0.126754	0.021274	5.958286	0.0000
C(4)	-0.972860	0.055913	-17.39941	0.0000
Dependent Variable: Taiwan Returns				
C	3.30005	0.000579	0.057899	0.9538
C(2)	0.003498	0.006665	0.524761	0.5997
C(3)	0.065552	0.024711	2.652813	0.0080
C(4)	-0.977548	0.146004	-6.695336	0.0000
Dependent Variable: Singapore Returns				
C	3.35E-05	0.000579	0.057899	0.9538
C(2)	0.002549	0.002659	0.452658	0.5269
C(3)	0.061542	0.045422	2.125415	0.0000
C(4)	-0.874587	0.168985	-6.498751	0.0000

Source: Calculated from the Primary Analysis.

H0: The variances have a significance on the Returns Series of the 10 Stock Indexes

HA: The variances do not have a significance on the Returns Series of the 10 Stock Indexes.

The results from the above table indicate that the variances are persistent and so is their significance, for the returns series of the stock indexes as their p-values are well above zero and below one.

The leverage equation in the Model Estimation is, C(4)*RESID(-1) and the leverage terms are negative for all the stock index returns series and are statistically significant. This proves that there is an Inverse Leverage Effect for the Returns Series of all the Stock Indexes.

Criterion information for Akaike, Schwarz and Hannan-Quinn.

Criterions of Akaike, Schwarz and Hannan-Quinn were used to find out the best fitted model for the Dataset of the Returns series of the all the Stock Indexes.

The Table 9 below depicts the Criterion information for ARCH, GARCH, EGARCH, TARCH and PARCH Models.

Criteria of ARCH, GARCH, EGARCH, TARCH and PARCH Models					
Index Returns	GARCH	EGARCH	TARCH	PARCH	ARCH
Germany Returns					
Akaike Info Criterion	-5.254587	-5.236587	-5.738306	-5.813892	-5.733646
Schwarz Criterion	-4.262154	-5.111254	-5.684853	-5.733713	-5.653466
Hannan-Quinn Criterion	-53154256	-5.021545	-5.716839	-5.781692	-5.701445
India Returns					
Akaike Info Criterion	-5.298785	-6.248799	-5.823841	-5.938910	-5.814084
Schwarz Criterion	-4.254458	-4.265551	-5.768909	-5.856512	-5.731686
Hannan-Quinn Criterion	-5.985632	-5.147889	-5.801755	-5.905781	-5.780955
Jakarta Returns					
Akaike Info Criterion	-7.565985	-6.215489	-6.324699	-6.332229	-6.358977
Schwarz Criterion	-6.265478	-6.125489	-6.270370	-6.250735	-6.277483
Hannan-Quinn Criterion	-6.236669	-6.214877	-6.302865	-6.299479	-6.326227
South Korea Returns					
Akaike Info Criterion	-6.215888	-6.210025	-5.822098	-5.880405	-5.783770
Schwarz Criterion	-6.215873	-5.324879	-5.768909	-5.856512	-5.731686
Hannan-Quinn Criterion	-5.326998	-5.216599	-5.777020	-5.818536	-5.809016
Hang Seng Returns					
Akaike Info Criterion	-6.214444	-6.021557	-5.777020	-5.818536	-5.809016
Schwarz Criterion	-6.128893	-6.123330	-5.723133	-5.737706	-5.728185
Hannan-Quinn Criterion	-6.125478	-6.298889	-5.755372	-5.786064	-5.776543
Shanghai Returns					
Akaike Info Criterion	-6.154877	-6.157856	-6.271706	-6.356441	-6.311516
Schwarz Criterion	-6.100025	-6.012365	-6.216774	-6.274044	-6.229119
Hannan-Quinn Criterion	-6.169776	-6.032988	-6.249620	-6.323313	-6.278388
Nikkei Returns					
Akaike Info Criterion	-6.215482	-6.259877	-5.926625	-6.010187	-5.930491
Schwarz Criterion	-6.265987	-6.128874	-5.872146	-5.928470	-5.848773
Hannan-Quinn Criterion	-5.326985	-5.215556	-5.904729	-5.977343	-5.897647
Europe Returns					
Akaike Info Criterion	-5.265987	-5.126987	-5.875840	-5.961018	-5.864382
Schwarz Criterion	-6.216885	-6.297896	-5.822098	-5.880405	-5.783770
Hannan-Quinn Criterion	-6.298772	-6.269977	-5.854252	-5.928636	-5.832000
Taiwan Returns					
Akaike Info Criterion	-5.365984	-5.169987	-6.278592	-6.349080	-6.263390
Schwarz Criterion	-5.665223	-5.329922	-6.223660	-6.266682	-6.180992
Hannan-Quinn Criterion	-6.265988	-6.298877	-6.256506	-6.315951	-6.230261
Singapore Returns					
Akaike Info Criterion	-5.265987	-5.187955	-6.265488	-6.216597	-6.459879
Schwarz Criterion	-5.126666	-5.125487	-6.236598	-6.215487	-6.195632
Hannan-Quinn Criterion	-6.248623	-6.298721	-6.359687	-6.326988	-6.423699

Source: Calculated from the Primary Analysis.

Discussion

The present study is an endeavour to find out the various fluctuations from the selected index from ten different countries like India, Germany, Hang Seng, South Korea, Jakarta, Nikkei, Shanghai, Singapore, Europe and Taiwan. The fluctuations were analysed with various econometric tools to check whether there is asymmetric presence in the data etc of ten countries. The result shows that there are both conditional variance and positive shock is observed in majority of the countries. We also see that there is negative leverage effect in countries like Taiwan, India, Singapore and South Korea. In terms of best fit model, the results show all the countries have best fit models. By using GARCH family we see that few countries portrayed more volatility compared to other countries. Further we see that the developed countries have showed more reaction towards good news and the bad news. The result also shows the presence of high fluctuations during the specific months and weeks.

Conclusion

This paper is part of a broader movement focusing on the volatility and its primary movements. Much recent work focuses on high-frequency data, and some of that work focuses on the high frequency relationships among returns, return volatilities and fundamentals. Here, in contrast, we focus on international indexes obtained by averaging over time. Hence this paper can be interpreted not only as advocating more exploration of the fundamental volatility, but also in particular as a call for more exploration of volatility at medium and high frequency dataset. In that regard we conclude by saying that more advanced analysis can be done using high frequency dataset and also volatile models can be identified. We may also take minute by minute data to see the fluctuations closely by using advanced econometric tools.

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