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VOLATILITY IN STOCK MARKETS: A COMPARISON OF DEVELOPED AND EMERGING MARKETS OF THE WORLD

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ABSTRACT

Volatility in markets is the growing area of crucial attention which is being analysed by many academicians over the world. The reason being that with the passage of time, the probability of deviation of the prices from the initial intrinsic value increases. In this research we have tried to model the volatility of two indices: MSCI emerging markets index and MSCI world index with the use of ARCH and GARCH models.

The volatility clustering and ARCH effect were seen and the models were constructed. Both the ARCH and GARCH terms were found to be significant in both the market indices.

It was found that in emerging markets, yesterday's volatility had greater influence in explaining today's volatility while in case of developed markets, both yesterday's volatility and information had immense influence in explaining today's volatility. The information is of immense use to the finance professionals and investors and can help them in taking correct portfolio decisions.

***Keywords**: ARCH, GARCH, volatility, developed markets, emerging markets, MSCI index.*

Introduction:

Volatility refers to the measure of risk due to the time change in price of any financial instrument. It is usually measured in terms of annualized returns. Any financial security whose price follows a random Gaussian distribution usually tends to increase as the time increases, the reason being that with the passage of time, the probability of deviation of the prices from the initial intrinsic value increases. We can measure the market risk of one security or of the entire portfolio with different financial assets. In daily routine, volatility can be used to measure the risks associated with changing interest rates, exchange rates, stock prices etc. Volatility has been defined as a measure of variability in prices of stocks by academicians. It is helpful in prediction of markets and selection of portfolios by assessment of risk associated. Investors also define volatility as upswings or downswings or rapid price movements within a short time.

The degree of unpredictable change in a certain variable over time is commonly referred to as volatility. Stock volatility is time varying and this displays patterns rendering the return distribution abnormal. Many time series models have been proposed to explain such features. The simplest of these historical models deals with the assumption that the past variance of variables (returns) can be predicted with considerable accuracy. The most popular model which defines volatility is the "Random walk model". This model says that the market has no memory and the change in prices of shares is independent of previous information. In such a situation the best estimate for today's volatility is the realized value of yesterday's volatility because the information that has got reflected once, remains.

The next thing of importance in this context is the volatility clustering. It refers to the large change in prices followed by large change in prices and small change in prices followed by small change in prices in either direction for prolonged periods. The existence of non constant variances and volatility clustering has finally helped in the estimation of volatility of the current day with the use of ARCH family modeling. Here the underlying theory is that, current volatility can be gauged by seeing the impact of preceding period's mean and variance.

Justified volatility can lead to efficient price discovery which can be helpful to investors due to its certainty feature. Change is volatility affects equilibrium prices while valuation of derivatives depends upon accuracy of volatility predictions. The risk management and investment decisions of the corporate treasurers, arbitrageurs, portfolio managers etc. are immensely affected by the changes in prices. They are therefore regular trend watchers of volatility to facilitate their decision making. Extreme volatility on the other hand is a dangerous signal as it ruins the smooth working of the financial system and has a negative impact on economic performance. Market makers increase their charges with increase in risk (with increased volatility). This situation also gives rise to arbitrage in time.

Thus it is really crucial to study the volatility of market and stocks so as to gain an insight into the real situation of the economy.

Literature Review:

A lot of researchers had made significant contributions to volatility modeling and to the studies of developed and developing markets. Their work was rigorously studied to get an in-depth knowledge of the concept and to find research gaps. A few of these important ones have been discussed in this part.

(Hassan & Malik, 2007) used daily returns of six U.S. sector indices (health, technology, finance, consumer, energy and industry) from 1 January 1992 to 6 June 2005 to estimate the mean and variance. They analysed the returns using trivariate GARCH and BEKK parameterization of multivariate GARCH model. Significant transmission of the shocks and volatility was reported among the various sectors and it was suggested that there was cross market hedging and the investors in different sectors shared common information.

(Bhar & Nikolova, 2009) studied the weekly closing equity price indices of the BRIC countries from January 1995 to October 2006. They used bivariate EGARCH model and reported that India had the highest level of regional and global integration among all the sample countries followed by Brazil, Russia and China in that order. A negative relationship came to light between China's regional volatility with world and India's regional volatility with Asia Pacific. Thus, the diversification opportunities for investors were suggested.

(Mukherjee & Mishra, 2010) examined thirteen Asian countries including India using the intraday equity prices from July 1997 to April 2008. They used GARCH (1,1) model, GARCH-M(1,1) model along with BHHH algorithm. There was indication of bidirectional intraday return spillover and volatility between India and many of the other Asian countries. It was found that there was significant flow of market information from Korea, Hong Kong, Thailand and Singapore to India. It was also seen that stock markets in India strongly influenced stock markets in Sri Lanka and Pakistan.

(Chong, 2011) analyzed the effect of subprime crisis on US stock market volatility and returns using daily data of S&P 100 index from May 2006 to December 2009. The study used unit root test, diagnostic statistics, ARMA and GARCH (1,1) for analysis. Volatility clustering was investigated and significant ARCH effect was seen in period after the crash of Lehman Brothers. A huge impact was reported on stock market volatility but not on stock returns.

Allen et al. (2013) studied the stock market of China along with its trading partners: Hong Kong, Japan, Australia, Singapore and U.S.A. ARMA, GARCH (1,1) and multivariate VARMA-GARCH models were used to analyze the daily data from August 1991 to November 2010. Volatility spillovers were reported from China to the rest five markets in pre-crisis periods and not in the crisis period.

Abidin et al. (2014) studied the stock markets of China, Japan, New Zealand, Australia and Hong Kong from 2004 to 2010 using AR-GARCH and AR-VAR models. Significant return spillovers and volatility spillovers were reported across these markets.

Adrangi et al. (2014) studied the markets of Brazil, Argentina and Mexico for a period of five years, i.e. from 2007 to 2012. They analysed the equity indices using VAR-GARCH and VAR-EGARCH models. Bidirectional leverage effects and volatility spillovers were reported.

Nishimura et al.(2015) examined the equity markets of Japan and China from 2003 to 2011. They used fractionally integrated GARCH model and revealed that Chinese markets affected other markets but were not significantly affected by them. Information was not found to be transmitted through volatility but through returns.

Park et al. (2015) studied U.S. and Japanese stock markets from 1990 to 2014 using symmetric and asymmetric GARCH models and GARCH-BEKK model. It was found that Japanese stock markets had leverage and clustering effects. There was shock transition between both the markets and volatility transmission took place from U.S. to Japanese markets.

Objectives of the study:

The current research had the under listed objectives:

- To estimate the volatility of the developed markets and emerging markets.
- To diagnose the existence of volatility clustering in residuals of both the market types.
- To test the residuals for presence of ARCH effect.
- To do volatility modeling of the two market types using ARCH and GARCH models.

Research Methodology:

This study used the market indices by Morgan Stanley Capital International (MSCI) at the world level, where MSCI emerging markets index represented the emerging markets in the world and MSCI world index represented the developed markets in the world. The daily closing prices in INR were taken from 2 January 2012 to 17 February 2017. Since our data represented prices, we calculated returns for making analysis easier. If P_t denoted the closing price of index on day t and P_{t-1} denoted the closing price of the same index on its previous working day, then the daily closing prices were converted into daily returns using the logarithmic difference of prices on two successive days:

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

- **Unit root tests**

Time series is a single realization of a stochastic process and such a series is said to be stationary if its mean, variance and auto-covariance (at different lags) are constant with time. Such a mean reverting series will have constant variance. This property of any time series is checked through unit root tests. Two types of unit root tests were used for current analysis, namely: Augmented Dickey Fuller test (ADF test) and Philips Perron test (PP test).

- **Autoregressive conditional heteroskedasticity model (ARCH)**

In ARCH model, we model the autocorrelation in volatility by allowing for the conditional variance of error term to depend on the immediate previous value of the squared error.

- **Generalised autoregressive conditional heteroskedasticity model (GARCH)**

In GARCH model, we allow the conditional variance to be dependent on previous own lags. Using the GARCH model we can interpret the current fitted variance as a weighted function of long term average information about volatility of previous period and fitted variance from the model of previous period.

Empirical Results and Discussion:

The table 1 highlights the descriptive statistics of both the market indices under study. It can be seen that returns generated are higher in case of developed markets when compared to emerging markets but the volatility is higher in emerging markets which is seen from its higher standard deviation. Both the indices show negative skewness highlighting the distributions to have a long tail towards the left. The Kurtosis value shows leptokurtic nature of the returns with fat tails. The null hypothesis of normal distribution is rejected as can be seen from the Jarque Bera test of normality.

Table 1: Descriptive Statistics

	RDM	**REM**
Mean	0.000513	0.000191
Standard deviation	0.007167	0.008196
Skewness	-0.219632	-0.123025
Kurtosis	5.971231	4.554547
Jarque-Bera	508.9442*	139.7529*

***significant at 1% level**

In the table 2 below the results of F-test and Levene test for the returns of emerging market index and the world index are shown. The null hypothesis for both the tests was that the variance of the two series do not have a significant difference. The results of both the tests unanimously reject this null hypothesis of equal variances.

Table 2: Equality of variance test

Method	**Degrees of freedom**	**Value**
F-test	(1353, 1353)	*1.307726 (0.0000)
Levene test	(1, 2706)	*24.27750 (0.0000)

***significant at 1% level**

Next the unit root tests were applied and the value was seen at intercept since the graphical analysis showed absence of trend in both the series. The ADF and PP test unanimously showed that the series of returns for both the indices were stationary. These results are depicted in table 3 below.

Table 3: Unit root test

MSCI Index	**ADF Test (intercept only)**	**PP Test (intercept only)**
Emerging markets index	-32.54049* (0.0000)	-32.38080* (0.0000)
World index	-34.14819* (0.0000)	-34.06013* (0.0000)

***significant at 1% level**

The least square regression was done for both the market indices. The equations for the same were:

$REM = \alpha + \beta * REM(-1) + \mathcal{E}_t$ ……………………………………………………(1.1)

$RDM = \alpha + \beta * RDM(-1) + \mathcal{E}_t$ ……………………………………………………(1.2)

Here,
REM = Daily returns calculated from MSCI emerging market index
REM(-1) = Yesterday's returns of emerging markets index
RDM =Daily returns calculated from MSCI world index representing developed markets
RDM(-1) = Yesterday's returns of world index

The table 4 shows the regression results for the two market indices. The results for emerging market index showed that the intercept was insignificant with a high p value while the slope was significant. This showed that a change of one unit in yesterday's return of emerging market index led to a change of 0.121 units in today's returns of the same index. The F statistic was significant and the null hypothesis stating that all the coefficients are zero was rejected for this equation (1.1).

The results for world market index showed that the intercept was insignificant and the slope term was significant for equation (1.2). Thus a unit change in yesterday's return of the world market index caused a change of 0.073 unit in today's return of world market index. The F statistic was significant and the null hypothesis stating that all the coefficients are zero was rejected for the equation (1.2).

Table 4: Regression results

	Emerging markets index		World index	
	REM = α + β * REM(-1) + ε_t		RDM = α + β * RDM(-1) + ε_t	
	C	REM(-1)	C	RDM(-1)
Coefficient	0.000167	0.120849	0.000475	0.073444
Standard error	0.000221	0.027017	0.000195	0.027133
t-statistic	0.752830 (0.4517)	*4.473052 (0.0000)	2.436323 (0.0150)	*2.706786 (0.0069)
R-squared	0.014594		0.005394	
Adj. R-squared	0.013864		0.004658	
F-statistic	*20.00819 (0.000008)		*7.326692 (0.006879)	
D-W statistic	1.996025		1.996399	

***significant at 1% level**

There are two conditions that must be satisfied in order to apply autoregressive conditional heteroskedasticity (ARCH) model. These conditions are listed below:

1) There should be presence of volatility clustering. Volatility clustering means that the periods of low volatility are followed by periods of low volatility and the periods of high volatility are followed by periods of high volatility.
2) The residual diagnostic test for presence of heteroskedasticity i.e. ARCH test should be rejected. The null hypothesis for this test is that there is no ARCH effect in regression equation.

The residuals of the regression models (1.1) and (1.2) were generated and plots were analysed as seen in figure 1 and figure 2. It was evident from both the plots that there was presence of prolonged periods of high volatility and low volatility in both MSCI emerging market returns series and MSCI world market return series. This thus satisfied the first condition (presence of conditional heteroskedasticity) for feasibile application of ARCH and GARCH models.

Figure 1: Residual of MSCI emerging markets index returns

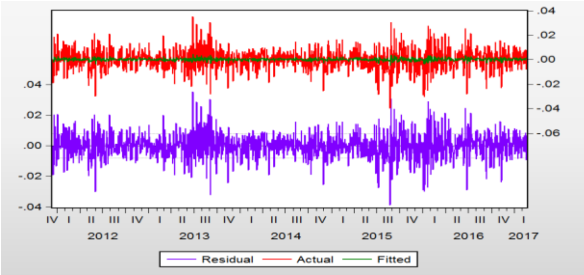
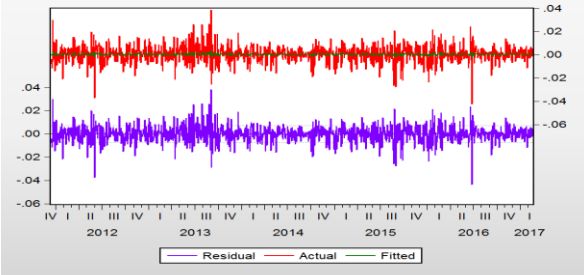


Figure 2: Residual of MSCI world markets index returns



The results for the ARCH test applied to the residuals of both the market indices are shown in table 5. The null hypothesis stating that there is no ARCH effect was rejected in both the cases. Thus the second condition for feasible application of ARCH/GARCH model was satisfied.

Table 5: Heteroskedasticity Test: ARCH

	Emerging markets index		World index	
	C	RESID^2(-1)	C	RESID^2(-1)
Coefficient	6.21E-05	0.061940	4.40E-05	0.138220
Standard error	3.88E-06	0.027162	3.40E-06	0.026956
t-statistic	*16.01153 (0.0000)	*4.280430 (0.0027)	*12.9556 4 (0.0000)	*5.127585 (0.0000)
R-squared	0.003837		0.019104	
Adj. R-squared	0.003099		0.018377	
F-statistic	*15.200361 (0.002738)		*26.29213 (0.000000)	
D-W statistic	2.008691		2.023839	

***significant at 1% level**

Since the two required conditions were satisfied, we next proceeded with the estimation of regression equation with the models of ARCH and GARCH. Table 6 shows the corresponding results for the ARCH and GARCH mean and variance equations. It was seen that the mean equation for both the indices was same as in equation (1.1) and (1.2).

The mean equation showed that the constant term was insignificant in case of both the indices while the slope coefficient of yesterday's return was significant in both the cases. The variance equations could be written as:

For emerging markets index

σ_t^2 = C3 + C4*e^2_{t-1} +C5*σ^2_{t-1} + C6*RDM ……………………………………………(1.3).

For world index

σ_t^2 = C3 + C4*e^2_{t-1} +C5*σ^2_{t-1} + C6*REM ……………………………………………(1.4)

where

C3, C4, C5, C6 are constants

σ_t^2 = variance of residual term

e^2_{t-1} = it is the ARCH term. Also called the previous day's squared residual. It is the previous day's information about return volatility.

σ^2_{t-1} = it is the GARCH term. Also known as the previous day's residual variance.

For our estimation of volatility, we have used normal Gaussian distribution. Under this we found that the ARCH was significant which meant that the previous day's return information (that is e^2_{t-1}) could influence today's return volatility. The GARCH was also found to be significant under this distribution. It meant that previous day's return volatility σ^2_{t-1} could influence today's return volatility. Thus we can say that the return volatility was influenced by own shocks.

For emerging market index, the return volatility was found to be influenced by both ARCH and GARCH (the corresponding terms were significant) and had a value of 0.055 and 0.925 respectively. For the emerging market index, the return of the world index was taken as external regressor and its coefficient was found to have a significant value of -0.000393 which implied that the external shock had a very little negative effect on the variance of the residual of emerging market index.

For world market index, the return volatility was found to be influenced by both ARCH and GARCH (the corresponding terms were significant) and had a value of 0.09698 and 0.850 respectively. For the world market index, the return of emerging market index was taken as external regressor and its coefficient was found to have a significant value of -0.000354 which implied that the external shock had a very little negative effect on the variance of the residual of world index.

Summary and Conclusion:

In the above study a comparison of stock market volatility in emerging and developed markets was done. Volatility has become an importantly growing area of concern because the more the volatility, the more is the probability of the stock price being away from its intrinsic value. In order to do this study, we took MSCI world index and MSCI emerging markets index as proxies for the developed and the developing economies respectively. The Augmented Dickey Fuller test and the Philips Perron test of stationarity showed that the daily return series of the two indices were stationary. There was visible volatility clustering and presence of ARCH effect in the regression that we ran. So we applied ARCH and GARCH models to tap the volatility. Both the ARCH and GARCH terms were found to be significant in both the market indices. It was found that in emerging markets, yesterday's volatility had greater influence in explaining today's volatility while in case of developed markets, both yesterday's volatility and information had immense influence in explaining today's volatility.

Recommendations for future Researchers:

The current study compared the market indices of developed and developing economies. Future studies can aim to study the economies of different set of countries like BRICS nations, G-8 nations, commonwealth nations, SAARC nations etc. This will help in exploring the investment opportunities and hotspots and also help in boosting the GDP of different nations by tapping those opportunities. It will also help the investors to realize good returns.

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Table 6: ARCH and GARCH process with normal error distribution

	Emerging markets index			World index		
Mean eq.						
Coefficient	**Variable**	**Value of coefficient**	**Std. error**	**Variable**	**Value of coefficient**	**Std. error**
C1	**Constant**	0.000332 (0.0907)	0.000196	**Constant**	0.000706 (0.1055)	0.000168
C2	**REM(-1)**	*0.127239 (0.0000)	0.029876	**RDM(-1)**	*0.048817 (0.0000)	0.030160
Var. eq.						
C3	**Constant**	*1.43E-06 (0.0006)	4.14E-07	**Constant**	*2.76E-06 (0.0000)	5.07E-07
C4	e^2_{t-1}	*0.055281 (0.0000)	0.008750	e^2_{t-1}	*0.096980 (0.0000)	0.012304
C5	σ^2_{t-1}	*0.925385 (0.0000)	0.012108	σ^2_{t-1}	*0.850084 (0.0000)	0.018820
C6	**RDM**	*-0.000393 (0.0000)	8.88E-05	**REM**	*-0.000354 (0.0000)	7.25E-05
	R-squared	0.014142		**R-squared**	0.003861	
	Adj. R-squared	0.013412		**Adj. R-squared**	0.003124	
	D-W statistic	2.007774		**D-W statistic**	1.946364	

***significant at 1% level**

On comparing the models for both the emerging markets and the developed markets, it was seen that yesterday's information had less effect as compared to yesterday's volatility in case of emerging markets. While both yesterday's information and volatility had very drastic effect in case of developed markets.

We once again applied the ARCH test of heteroskedasticity to the residuals of ARCH model of both the emerging markets and world indices.

Table 7: Heteroskedasticity test: ARCH

	Emerging markets index		World index	
	C	**WGT_RESID^2 (-1)**	**C**	**WGT_RESID^2 (-1)**
Coefficient	1.026772	-0.027042	1.023499	-0.020747
Standard error	0.053984	0.027210	0.060303	0.027211
t-statistic	*19.01975 (0.0000)	-0.993850 (0.3205)	*16.97261 (0.0000)	-0.762440 (0.4459)
R-squared	0.000731		0.000430	
Adj. R-squared	-0.000009		-0.000310	
F-statistic	0.987738		0.581315	
D-W statistic	1.997706		2.000589	

***significant at 1% level.**

The table 7 shows the results for the heteroskedasticity test for the residuals of ARCH model. Here it was seen that the null hypothesis stating that there is no ARCH effect was accepted at 1% level of significance. Thus we could say that there was no ARCH effect now in the models.

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