Modeling Volatility of Indian Stock Market Evidence from BEKK Model

***Dr.Xavier Mahimairaj**
****A.Amali Vinupriyadharshini**

Assistant Professor, P.G & Research Department of Commerce, Loyola College, Chennai -34
Research Scholar, P.G & Research Department of Commerce, Loyola College, Chennai -34

Abstract: This paper uses BEKK (Baba, Engle, Kraft and Kroner) multivariate GARCH model to tape the volatility of Indian stock market. This paper uses Sensex, BSE Midcap, BSE Smallcap indices from Bombay stock exchange and Nifty50, NSE Midcap, NSE Smallcap indices from National stock exchange. It is a multivariate analysis and brings out the constant volatility of each index, cross volatility among the indices, and within volatility of each index. This paper helps to understand the complete volatility structure of Indian stock market.

Keywords: Volatility, GARCH, Constant volatility.

Introduction:

In the words of John train, "for the investor who knows what he is doing, volatility creates opportunity" A volatile market is a successful market, always active and creates a lot of opportunity for its investors. To understand a market, one needs to understand its volatility. By volatility, we mean the fluctuation of stocks' value or return or market condition. The Economic times defines volatility as "a rate at which the price of a security increases or decreases for a given set of returns. Volatility is measured by calculating the standard deviation of the annualized returns over a given period of time. It shows the range to which the price of a security may increase or decrease" Indian stock market is one of the most followed stock markets in the world. Volatility in Indian stock market is very predominant and this paper tries to measure the volatility of two major stock markets of India, the Bombay Stock Exchange (BSE) and National Stock Exchange (NSE). These stock markets have a number of indices and this study picks up Sensex, BSE Midcap, BSE Smallcap, Nifty50, NSE Midcap and NSE Smallcap for a multi-variate volatility analysis. It tries to model the volatility of these indices using BEKK multi-variate GARCH model.

Review of Literature

(Karthika & Kathikeyan, 2016) Various conditional heteroskedasticity models were modeled and compared to study the volatility of Nifty 50 index for a period of one year from Jan'15 to Dec'15. The objective of the study was to estimate the volatility of Nifty 50 index using GARCH models. The study finds the presence of Asymmetry in stock returns. The study finds GARCH(1,1) model to fit the best in capturing the symmetrical volatility and E-GARCH and T-GARCH models captures asymmetric volatility efficiently.

(Banumathy & Azhagaiah, 2015) This paper studies the volatility pattern in Indian stock market with special reference to Nifty. Asymmetric and symmetric models were used to estimate the volatility pattern, leverage effects etc. To find out the appropriate GARCH model that fits best in the stock market data. The data was taken from Centre for Monitoring Indian Economy (CMIE) Prowess database. The daily closing prices of Nifty was taken for a period of 10 years from Jan 2003 to Dec 2012. The study reveals that volatility is highly persistent and GARCH (1, 1) model has been found to be the best fit model among the symmetric models. TGARCH (1, 1) was found to be the best fit model among the asymmetric models. The study concludes that an increased risk does not increase the returns because the co-efficient of the selected variables were insignificant.

(Adhikary & Saha, 2015) This paper tries to estimate the volatility of S&P CNX Nifty using Heteroskedasticity models for the period from July 1990 to Sep 2013. Daily closing prices of NSE were taken with 5595 observations. GARCH (1,1), GARCH M(1,1) were fit to the market data. The analysis showed evidences of conditional volatility, volatility clustering, time-varying volatility, existence of risk-premiums and high persistence of volatility. There is a postive correlation between volatility and expected stock returns. The study reveals that volatility is not explained by fundamental economic factors. Actions of noise trders influence the price volatility, fads and bubbles were seen in the data due to irrational behaviour of the investors and speculators.

(Pandikumar & Muthukumar, 2014) The main objective of this paper is to estimate and analyse the historical volatility of NSE. CNX Bank, S&P CNX Nifty, S&P CNX Defy, CNX Nifty Junior and Nifty

Midcap 50 Indices were taken for analysis. The period covered for data is 2006 to 2012 except for Nifty Midcap 50, as the data is from Oct 2007 to Sep 2012 due to non-availability of Open, High and Low prices. The analysis uses different estimators like Close-to-close estimator, Parkinson Garman Klass, Rogers, Satchell-Yoon and Yang Zhang estimator. In CNX Bank Index, the historical volatility was very high. All the indices showed the presence of volatility cone. They reverted back to mean. This study proved that there is no significant difference in the historical volatility before and after 2008 among the various indices, and the recession did not have any impact on the historical volatility. The study also tested and found that there is a significant difference in historical volatility after the Reserve Bank of India's credit policy announcement at 5% level of significance. The study proves that historical volatility is the best indicator to measure the pulse of an index. It states that historical volatility could predict the index's direction for the next one year. This study finds the CNX Bank index to have the highest historical volatility and S&P CNX Nifty index has the lowest. This paper suggests investing in S&P CNX Nifty index as the risk is very low.

(Meena, Jain, & Mathur, 2013) This paper studies the market volatility in India through BSE Sensex for a period of 11 years from 2001-2011. Monthly stock return data is collected and used for analysis. This paper investigates the presence of volatility in Indian stock market by using inter-day and intra-day volatility methods. The objective was to gauge the degree of volatility present in the stock market which would lead investors to demand a high risk premium. Parkinson's model was used to tap the high-low volatility. After the analysis, the study reveals that there is a strong persistence of volatility and in 2008 the close-to-close volatility is higher than the open-to-open inter day volatility. Also the volatility showed the presence of asymmetry and a strong relationship between volatility and market performance.

(Sandhya, Naik, & Anuradha, 2012) This paper tries to study the volatility of Indian stock market. It takes into consideration 5 indices of NSE namely Nifty, S&P CNX 500, Nifty Junior, CNX Midcap, and CNX Defty. The period of study is between 2005 and 2011. Volatility has a positive or negative impact on the market. Volatility may affect many factors like monetary policy, inflation, central budget announcements, company's internal policy changes etc., This study mainly attempts to gauge the degree of volatility of NSE. Volatility was very high during 2007-2009. It started to give a negative trend during 2008 due to American mortgage crisis. This proved the spill-over effect. The study says that the market performed well in all the years except 2008 and 2011. In 2009, the market was bullish. During 2007 and 2009, there was high volatility and was able to survive because of efficient market conditions and favourable investments in India. The study suggests that investors should carefully analyse the systematic and unsystematic risk, equip themselves with economic conditions of the country and trade according to the market trends.

(Bekaert & Wu, 2000) This article studies the Asymmetric volatility at the firm and market level and validates leverage effects and volatility feedback. It states that stock return and volatility are negatively correlated. The study rejected the pure leverage model of Christie(1982) as it can be used only for univariate analysis but used BEKK frame work as it is very useful for multi-variate analysis. The paper concludes that volatility feedback is very strong in Asymmetries at the firm level, and the conditional betas does not show significant asymmetries.

Objectives:

1. To measure the volatility of Sensex, BSE Midcap, BSE Smallcap, Nifty50, NSE Midcap and NSE Smallcap individually.
2. To meaure the cross volatility of all the above mentioned indices.
3. To meausre the within volatility of all indices mentioned above.

Scope of the study:

This study covers a period from 2011 to 2016, of BSE and NSE market. The indices measured are Sensex, BSE Midcap, BSE Smallcap, nifty, NSE Midcap and NSE Smallcap. The data is collected from the official website of the exchanges. Understanding a market's volatility will help in creating a number of opportunities, and huge profits. This study will be useful for the current and potential investors of the Indian stock market. An investor who is a risk taker, may prefer to invest in a market which is highly volatile, while a risk averse investor may prefer passive market where the volatility is mild. Since this study also measures cross volatility, it will help to understand the impact of other indices in the market and also give a hint to the investor on when and where to invest.

Methodology:

Daily trading data of Sensex, BSE Midcap, BSE Smallcap, Nifty50, NSE Midcap, NSE Smallcap were taken from BSE and NSE websites for the period between Jan2011 to Dec 2016. To find the volatility the BEKK model is used. The model with best convergence will be used in the analysis, as such all possible BEKK specifications will be utilised (various combination of AR and MA). Since the research is utilising multivariate volatility model, OX matrix software is used.

Limitations:

The analysis measures only the volatility and cross volatility of BSE and NSE and its selected indices. It fails to measure the spillover effects between the indices and between the markets. It doesn't try to find a correlation between BSE and NSE. It only measures cross volatility, as such this a gap and room for further research.

Analysis and Interpretation:

Conditional mean

Variable	Co-efficient	Standard error	t-value	Probability
Sensex	4.27527	0.00154	2776	0.0000
BSE Midcap	3.853361	0.0013951	2762	0.0000
BSE Smallcap	3.824037	0.0012642	3025	0.0000
Nifty	3.757305	0.0015512	2422	0.0000
NSE Midcap	3.290859	0.001748	1883	0.0000
NSE Smallcap	3.355151	0.0018984	1767	0.0000

Sensex has a mean co-efficient of 4.27527 with standard error of 0.00154 and probability of 0.000. The mean value of BSE Midcap is 3.853361 with standard error of 0.0013951 and probability of 0.000. BSE Smallcap has a co-efficient of 3.824037 with standard error of 0.0012642 and probability of 0.000. Nifty has a mean co-efficient of 3.757305 with standard error of 0.0015512 and probability of 0.000, while NSE Midcap has a co-efficient of 3.290859 with standard error of 0.001748 and probability of 0.000. NSE Smallcap has a co-efficient of 3.355151 with standard error of 0.0018984 and probability of 0.000.

Conditional variance

Conditional variance consists of three matrices namely C matrix which gives out constant volatility or own volatility, B matrix which gives out the cross volatility and A matrix which gives out within volatility.

C Matrix

Variables	Sensex	BSE Midcap	BSE Smallcap	Nifty	NSE Midcap	NSE Smallcap
Sensex	0.004375 [0.00014998] (0.00000)	0.003475 [0.00021925] (0.0000)	0.00355 [0.00017720] (0.0000)	0.004404 [0.00015184] (0.0000)	0.004527 [0.00025384] (0.0000)	0.004717 [0.00024213] (0.0000)
BSE Midcap		0.003021 [0.00015728] (0.0000)	0.002198 [0.00011992] (0.0000)	0.000102 [0.0023355] (0.0000)	0.002995 [0.00021798] (0.0000)	0.002625 [0.00019592] (0.0000)
BSE Smallcap			0.001207 [0.0036392] (0.0000)	0.000154 [0.0017933] (0.000)	0.001038 [0.00018625] (0.0000)	0.001516 [0.00014514] (0.0000)
Nifty				0.000384 [0.0078688] (0.0000)	-0.00007 [0.0082293] (0.3972)	0.000213 [0.0080915] (0.0085)
NSE Midcap					0.001661 [0.00010523] (0.0000)	0.000407 [0.00016436] (0.0134)
NSE Smallcap						0.001895 [0.0064535] (0.0000)

C Matrix denotes Constant volatility or own volatility. It's the own volatility of that particular index. The constant co-efficient of Sensex is 0.004375 with standard error at 0.00014998 and probability of 0 which indicate that it is statistically significant in determining the volatility of Sensex. The constant co-efficient of BSE Midcap is at 0.003021 with standard error of 0.00015728 with probability 0 states that it is statistically significant in determining the volatility of BSE Midcap. The constant co-efficient of BSE Smallcap is 0.001207 with standard error of 0.0036392 and probability of 0 confirms that it is statistically significant in determining the volatility of BSE Smallcap. The constant co-efficient of Nifty is 0.000384 with standard error of 0.0078688 and probability 0 states that it is significant in determining the volatility of Nifty. The constant co-efficient of NSE Midcap is 0.001661 with standard error of 0.00010523 and probability of 0 states that it is statistically significant in determining the volatility of NSE Midcap. The constant co-efficient of NSE Smallcap is 0.001895 with standard error of 0.0064535 and probability 0 states that it is statistically significant in determining the volatility of NSE Smallcap. Therefore it can be concluded that average volatility is statistically significant in determining the volatility of the market.

B Matrix

Variables	Sensex	BSE Midcap	BSE Smallcap	Nifty	NSE Midcap	NSE Smallcap
Sensex	0.095300 [0.10003] (0.3409)					
BSE Midcap		0.101654 [0.097720] (0.2984)				
BSE Smallcap			0.097470 [0.099187] (0.3259)			
Nifty				0.095752 [0.099983] (0.3384)		
NSE Midcap					0.1062652 [0.096417] (0.2706)	
NSE Smallcap						0.102669 [0.097355] (0.2918)

This matrix is a Diagonal matrix which helps to find the cross volatility of the market. The cross volatility of Sensex is 0.095300 with standard error of 0.10003 with probability of 34.09% which states that volatility of other two indices of BSE is statistically insignificant in determining volatility of Sensex. The cross volatility of BSE Midcap is 0.101654 with standard error of 0.097720 and probability of 29.84% which states that volatility of other two indices of BSE is statistically insignificant in determining volatility of BSE Midcap. The cross volatility of BSE Smallcap is 0.097470 with standard error of 0.099187 with probability of 32.59% proves to be statistically insignificant in determining the cross volatility of BSE Smallcap and other indices of BSE. The cross volatility of Nifty is 0.095752 with standard error of 0.099983 and probability of 33.84% states that it is statistically insignificant in determining the cross volatility of Nifty and other indices in the NSE market. The cross volatility of NSE Midcap is 0.1062652 with standard error of 0.096417 and probability of 27.06% is statistically insignificant in determining the cross volatility of NSE Midcap and other indices in the market. The cross volatility of NSE Smallcap is 0.102669 with standard error of 0.097355 and probability of 29.18% which confirms that it is statistically insignificant in determining the cross volatility of NSE Smallcap and other indices of NSE. Cross volatility is absent in all the indices and in both the markets.

A Matrix

Variables	Sensex	BSE Midcap	BSE Smallcap	Nifty	NSE Midcap	NSE Smallcap
Sensex	0.991141 [0.0065362] (0.0000)					
BSE Midcap		0.992333 [0.0068591] (0.0000)				
BSE Smallcap			0.992869 [.0066125] (0.0000)			
Nifty				0.991168 [0.0065790] (0.0000)		
NSE Midcap					0.990952 [0.0071586] (0.0000)	
NSE Smallcap						0.990657 [0.0068571] (0.0000)

A matrix determines within volatility. Within volatility refers to the influence of minute volatilities of volatility of any particular index. It refers to the small details that create a significant impact on the volatility of the index. The within volatility of Sensex is 0.991141 with standard error of 0.0065362 and probability of 0 and is statistically significant in determining the volatility of Sensex. The within volatility of BSE Midcap is 0.992333 with standard error of 0.0068591 and probability 0 states that it is statistically significant in determining the volatility of BSE Midcap. The within volatility of BSE Smallcap is 0.992869 with standard error of 0.0066125 and probability 0 states that it is statistically significant in determining the volatility of BSE Smallcap. The within volatility of Nifty is 0.991168 with standard error of 0.0065790 and probability 0 is said to be statistically significant in determining the volatility of Nifty. The within volatility of NSE Midcap is 0.990952 and standard error of 0.0071586 with probability 0 is statistically significant in determining the volatility of NSE Midcap. The within volatility of NSE Smallcap is 0.990657 and standard error of 0.0068571 with probability 0 is statistically significant in determining the volatility of NSE Smallcap. All the co-efficient are close to 1 which indicates persistent volatility and long memory of information in the market.

In order to satisfy the a priori estimation condition we check for the normality of the residuals.

Hosking's multivariate Portmanteau statistics is used to test the normality of residuals. It is done on standardized residuals and squared standardized residuals.

Hosking's Multivariate Portmanteau Statistics on Standardized Residuals

Lag	Co-efficient	Probability
5	4926.76	[0.0000000]
10	9292.06	[0.0000000]
20	17384.7	[0.0000000]
50	37351.9	[0.0000000]

In the above table, to find whether the residuals are multivariate normal, Hosking's multivariate portmanteau statistics is used on standardized residuals. In lag 5, the co-efficient is 4926.76 with probability 0, which states that the residuals are normally distributed. In lag 10, the co-efficient is 9292.06 with probability 0, in lag 20, the co-efficient is 17384.7 with probability 0 and in lag 50 the co-efficient is 37351.9 with probability 0 states that the residuals are multivariate normal. As such we can estimate the model using upto lag 50.

Hosking's Multivariate Portmanteau Statistics on Squared Standardized Residuals

Lag	Co-efficient	Probability
5	563.21	[0.0000000]
10	900.394	[0.0000000]
20	1375.41	[0.0000000]
50	2469.91	[0.0000000]

Another procedure is applied to test on the normality of the multivariate. Hosking's multivariate Portmanteau statistics on squared standardized residual is used. In lag 5, the co-efficient is 563.21 with probability 0 states that the residuals are multivariate normal. In 10, the co-efficient is 900.394 with probability 0 states that the residuals are multivariate normal. In lag 20, the co-efficient is 1375.41 with probability 0 and lag 50; the co-efficient is 2469.91 with probability 0 states that the residuals are multivariate normal. The lag selection criteria follows Akaike -51.944607, Shibata -51.945937, Schwarz -51.805484 and Hannan-Quinn at -51.892756.

Summary of Findings and suggestions:

1. BEKK framework suits best for Indian stock market resulting in efficient measurement of volatility for Sensex, BSE Midcap, BSE Smallcap, Nifty, NSE Midcap, and NSE Smallcap. The volatility of the indices plays a significant role in determining the volatility of the market as a whole.
2. The probability of constant mean states that the average volatility is statistically significant in determining the volatility of the market.
3. Sensex has the highest volatility followed by Nifty and then followed by BSE Midcap. The least volatile index is BSE Smallcap. Investors can decide on their suitable markets based on the volatility and their risk choice. Risk takers can partake in active and high volatile markets, while risk averse investors can choose less volatile market.
4. The volatility of one index does not affect the volatility of the other indices. Each index has its own individuality. There is no cross volatility in all the indices, as the probability indicates that the cross volatility is statistically insignificant in determining the volatility of other indices. The co-efficient of diagonal matrix reveals that the cross volatility is very less among the indices as the values are not even close to 1.
5. Within volatility reveals that even tiniest detail of market information will have a significant influence on its volatility. Everyday's ups and down and even meager changes will have a considerable influence on its overall volatility. The probability of 'Within volatility' indicates that it is statistically significant in determining the volatility of the index. All the co-efficients are close to 1 which indicates that the volatility is persistent and the market enjoys long memory of information.

Conclusion:

This paper has measured volatility, cross volatility and within volatility of Sensex, BSE Midcap, BSE Smallcap, Nifty, NSE Midcap and NSE Smallcap. Volatility is the pulse of any market. Higher the volatility, higher is the opportunity, while slow and passive markets may bring out standard returns. Indian stock market have persistent volatility, and have long memory of information that influences the volatility in the long run. Even the tiniest detail is remembered and influences the stock return to a great extent. Therefore this paper suggests Indian stock market is a place to reap rich fruits with diverse opportunities, as the volatility is high yet persistent and long term memory prevails in the market.

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