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Study of Association between Volatility Index and Nifty using VECM

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ABSTRACT

Volatility in capital markets is the measure degree of variability of stock return from their expected return. The volatility in the capital market is the basis for price discovery in the financial asset. The volatility index (VIX) is the measurement index of the volatility of the capital market. It is the fear index of the capital market. The concept is first coined in 1993 in Chicago Board Options Exchange (CBOE). In India, such an index was introduced in 2008 by NSE. India VIX calculates the expected market volatility over the coming thirty days on Nifty Options. It Market index is the performance metric of the Indian capital market. This index is designed to reflect the overall market sentiments. An index is an important parameter to measure the performance of the economy as a whole. While the market index measures the direction of the market and is calculated by the price movements of the underlying stocks, the Volatility Index measures the volatility of the market and is calculated using the order book of the underlying index's options. In this study, we examine the association between India VIX and Nifty Index returns by using Johanson's co-integration, Vector Error Correction Model (VECM), and Granger causality Tools. The data for this study covers closing data of VIX value and Nifty closing value from January 2014 to December 2019 and has a total of 1474 daily observations. The result confirms that there are co-integrating relationships (long-run association) between VIX and Nifty. The Granger causality indicates Nifty does Granger Cause VIX but VIX does not granger Cause Nifty.

Keywords-- VIX, Data Stationarity, Johansen Cointegration Test, VECM

I. INTRODUCTION

Volatility is the measure of uncertainty about the variation in the return of the stock market, bond market, commodity market, and foreign exchange market. A higher volatility means a large variation in the return, whereas low volatility indicates fluctuation in the value of a security is not dramatically. Estimation of the volatility of a financial time series has gained large popularity among researchers and academicians and market players. Volatility can be of two types. Unconditional volatility-which is the single measure of the volatility of asset return over time and other, is conditional volatility which is varying over time and depends on own past volatility (Autoregressive) and upon past asset returns (conditional). The volatility in the capital market is the basis for the determination of price in the financial asset, like option pricing. In this context Volatility index (VIX) is the measurement index of the volatility of a capital market. It is the fear index of the capital market. The concept is first coined in 1993 in Chicago Board Options Exchange (CBOE). In India, such an index was introduced in 2008 by the National Stock Exchange. India VIX captures the expected market volatility over the next thirty days based on the implied volatility in the used in Nifty Options. The market index, Nifty is the performance metric of the Indian capital market. This index is designed to reflect the overall market sentiments. An index is an important parameter to measure the performance of the economy as a whole. While the market index measures the direction of the market and is calculated by the price movements of the underlying stocks, the Volatility Index measures the volatility of the market and is calculated using the underlying Index's options. Volatility is the indicator of expected risk in the capital market. Market return decreases when the volatility increases as investors are reluctant to invest in the risky market, leads to a fall in the demand of share as well as price (as demand in the stock market is less). However, return increases when volatility decreases as investors are willing to invest in the capital market, which leads to an increase in demand as well as price. Thus the correlation between the capital market return and volatility is negative. Most of the researches on volatility modelling are based on the past fluctuation in market return. Hence it has less future prediction capability. In this context, VIX is based on the future Nifty option price of the next 30 days. It is the Index of the market expectation of volatility over a short-term period and indicates the implied volatility as well as an implied risk of the stock market. Since the volatility index looks into the future and is derived from the option prices, it may offer important clues to the investors by observing the sentiments of the options investors to buy and sell in the market. This paper will investigate the association between VIX and Nifty and their short-term causality and dynamics using VAR Framework.

II. LITERATURE STUDY

Floros (2008) modelled the volatility applying daily data from two Middle East stock indices viz., the Egyptian CMA index and the Israeli TASE-100 index, and used GARCH, EGARCH, and TGARCH. The study found that the coefficient of the EGARCH model showed a negative and significant value for both the indices, indicating the existence of the leverage effect.

Ahmed and Aal (2011) studied Egyptian stock market return volatility and his study showed that EGARCH is the best fit model among the other models for measuring volatility.

Karmakar (2005) estimated the volatility model to study the feature of Indian stock market volatility.. The study also capture the presence of leverage effect in the Indian stock market volatility and the study showed that the GARCH (1,1) model provided reasonably good forecasts of market volatility. Whereas, in another study, he (Karmakar2007) found that the conditional variance was asymmetric during the study period and the EGARCH-M was found to be an adequate model that reveals a positive relationship between risk and return.

Goudarzi and Ramanarayanan (2010) examined the volatility of the Indian stock market using the BSE 500 stock index as the proxy for ten years. ARCH and GARCH models were estimated and the best model was selected using the model selection criterion viz., Akaike information criterion (AIC) and Schwarz Information Criterion (SIC). The study found that GARCH (1,1) was the most appropriate model for explaining volatility clustering.

Goudarzi and Ramanarayanan (2011) in their study, investigated the volatility of the BSE 500 stock index and modelled two non-linear asymmetric models viz., EGARCH (1,1) and TGARCH (1,1) and found that TGARCH(1,1) model was found to be the best-preferred model as per Akaike Information Criterion (AIC) and Schwarz Information Criterion (SIC).

Mittal, Arora, and Goyal (2012) examined the behaviour of Indian stock price and investigated to test whether volatility is asymmetric using daily returns from 2000 to 2010. The study reported that GARCH and PGARCH models were found to be best-fitted models to capture symmetric and asymmetric effects respectively.

Mall, S.Mishra P.K Mishra B.B Pradhan (2014) in their study they examine the relationship by implementing Johanson's co-integration and Granger causality methods between India VIX and Nifty index returns. This study confirms cointegration between VIX and Nifty as well as in the long run VIX will cause Nifty movement whereas in the short run reverse is true.

Based on the above literature review we can conclude that in India very little work has been conducted to study the co-integration between VIX and Stock return under the VECM framework.

III. OBJECTIVES OF THE STUDY

1. To study the existence of unit root (Stationarity) in the Nifty data and VIX data using ADF (Augmented Dickey-Fuller) and PP (Phillips-Perron) Test.
2. To study the long-term association between Nifty and VIX using Johansen Co-integration Test.
3. To study the cause-effect relationship between the two variables using Granger Causality Test.
4. To study the long-term and short-term causality and dynamics among these variables Using VAR Framework.

IV. RESEARCH METHODOLOGY

Sample: The data for this study covers the closing value of the Volatility Index (VIX) and Market Index (Nifty).
Sample Period: The sample covers daily data from January 2014 to December 2019 and has a total of 1474 daily observations.
Data Source: The entire data has been collected from the NSE (National Stock Exchange) Website.
Research Tools: Various statistical tools ADF (Augmented Dickey-Fuller) and PP (Phillips-Perron) Test and Jarque-Bera statistic were utilised to study the stationarity. For the long-term relationship between the indices, we can use Engle-Garner Cointegration Test or Johansen Co-integration Test. However, we use here the Johansen Co-integration Test. Now to study the interrelationship in the variation among the variable we can use Vector Auto-Regressive (VAR) model or Vector Error Correction Model (VECM). If the variables are non-stationary at the level form and cointegrated we can use restricted VAR but if data are not cointegrated then we should use unrestricted VAR. The entire null hypothesizes are tested using appropriate test statistics at a 5% level of significance.
Research Software: The entire econometrics analysis has been done using E-views 8 Econometrics package.

V. RESEARCH FINDINGS

We have used the Augmented Dickey-Fuller Test to check whether the time series data are stationary at the level form and stationary at the first difference. For that purpose, we can form the following hypothesizes.
Null Hypothesis: VIX return (growth) and Nifty return (growth) data are not stationary.
Alternative Hypothesis: The above time series is stationary.

If the p-value is less than 5%, we will reject the hypothesis, and if the p-value more than 5% we accept the null hypothesis.

Table 1: Augmented Dickey-Fuller test statistic and Phillips-Perron test statistic

		Return Nifty		**Return VIX**	
		t-Statistic	**Prob.***	**t-Statistic**	**Prob.***
Augmented Dickey-Fuller test statistic		-35.631904	0.00	-30.60226	0.00
Test critical values:	1% level	-3.4345728		-3.434579	
	5% level	-2.8632921		-2.863295	
	10% level	-2.5677513		-2.567753	
		Adj. t-Stat	**Prob.***	**Adj. t-Stat**	**Prob.***
Phillips-Perron test statistic		-35.534196	0.00	-38.42132	0.00
Test critical values:	1% level	-3.4345728		-3.434576	
	5% level	-2.8632921		-2.863293	
				-2.567752	

The results of the test are given in table 1. The result indicates that all the daily index data are not stationary at the level form but stationary at first difference i.e. I (1). This result indicates that we can move on with the two tests of cointegration. The stationarity is further confirmed by the Phillips-Perron test. The tabulated values of these series are much higher than critical values at 1%, 5%, and 10% levels of significance. Hence we reject the null hypothesis that these series have no unit root and conclude that data of the time series for the entire study period is non-stationary at the level form but stationary at the 1st level difference.

The next step is to examine whether there exists a long-run equilibrium relationship among variables. This is called Co-integration analysis which is very significant to avoid the risk of spurious regression. The co-integration analysis is important because if the Co-integration relationship is identified, the model should include residuals from the vectors (lagged one period) in the dynamic VECM system. In this stage, Johansen's Co-integration test is used to identify a co-integrating relationship between the variables. The Johansen method applies the maximum likelihood procedure to determine the presence of co-integrated vectors in non-stationary time series.

Null Hypothesis: No cointegration among the time series data.

Alternative hypothesis: there is cointegration among the variables.

The test statistics used for this purpose are Trace Statistic and Max-Eigen Statistic and they are tested at a 5% level of significance. The decision rule is the same as above. If the p-value is less than 0.05 we will reject the hypothesis and if the p-value more than 0.05 we accept the null hypothesis.

Table 2: Johansen's Co-integration test

Trend assumption: Linear deterministic trend				
Series: NIFTY VIX				
Lags interval (in first differences): 1 to 3				
Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		**Trace**	**0.05**	
No. of CE(s)	**Eigenvalue**	**Statistic**	**Critical Value**	**Prob.****
None *	0.015450155	24.26460306	15.49471288	0.00186611
At most 1	0.000901755	1.328884964	3.841465501	0.249002854
Trace test indicates 1 cointegrating equation(s) at the 0.05 level				
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized		**Max-Eigen**	**0.05**	

No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.015450155	22.93571809	14.26460015	0.001690988
At most 1	0.000901755	1.328884964	3.841465501	0.249002854
Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				

The result of the Johansen Cointegration Test indicates that VIX and Nifty have a long-term association at level form as both the Trace and the Max-Eigen statistics is significant at 5%. If the variables are cointegrated or have long-run relationships or associations then we can use restricted VAR i.e. VECM (vector error correction model) to study short-term dynamics and causality. The existence of Co-integration implies the existence of Granger causality at least in one direction. To study the short-run causality between the VIX and the Nifty a standard Granger causality test has been performed based on F statistics. The result is given in table 3.

Table 3: Granger Causality

Pair-wise Granger Causality Tests			
Null Hypothesis:	**F-Statistic**	**Prob.**	**Decision**
NIFTY does not Granger Cause RVIX	5.2039	0.0055	Reject
RVIX does not Granger Cause NIFTY	1.492	0.2252	Accept

The result in Table 3 indicates VIX does not Granger cause of Nifty. However, Nifty Granger causes the VIX index in the short run. Here variables (VIX and Nifty) are non-stationary (at level form) and stationary at 1st level difference. Hence, we can use the vector error correction model (VECM). The VECM is the restricted VAR designed for use with non-stationary series that are co-integrated. The VECM has co-integrating relations built into specification so that it restricts the long-run behaviour of endogenous variables to converge to their co-integrating relationship while allowing for short-run adjustment dynamics. The co-integrating term is known as the error correction term since the deviation from long-run equilibrium is corrected gradually through a series of short-run dynamic adjustments. In VECM, the value of variables is expressed as a linear function of past or lagged values of that variable and all other variables included in the model. Here the result is presented in table -4 below:

Test 4: Vector Error Correction Estimates

Error Correction:	D(RVIX)	Prob.	Decision	D(NIFTY)	Prob.	Decision
CointEq1 –C1	***-0.03214***	***0.00***	***Sig.***	***0.87005***	***0.140681***	***No Sig.***
D(VIX(-1))-C2	0.062	0.04	Sig	-2.45815	0.317402	No Sig.
D(VIX(-2)) –C3	-0.11694	0.00	Sig.	0.272667	0.911058	No Sig.
D(NIFTY(-1))-C4	0.001059	0.00	Sig	0.061943	0.037836	Sig
D(NIFTY(-2))-C5	-0.00041	0.05	Sig.	-0.00579	0.846153	No Sig.
C	-0.00621	0.80	No Sig.	3.817607	0.059778	No Sig.
R-squared	0.034661			0.00737		
Akaike AIC	-2.703894			11.54415		

The coefficient of the co-integrated equation of D(VIX) is negative and significant at a 5% level. Hence, there is long-term causality running from Nifty and VIX. However, The coefficient of the co-integrated equation of D (NIFTY) is positive and not significant. Hence, there is no long-term causality running from VIX to Nifty. We also state that there is short-term casualty running from Nifty and VIX and Short-run dynamics in

the variable D(VIX) as the coefficient C2, C3, C4, and C5 are significant statistically in the case of the first equation. However, there is no short-term causality running from VIX to Nifty and short-run dynamics in variable D(Nifty) as most of the variables are statistically insignificant. The negative value of the Akaike Information Criterion indicates the appropriateness of the VAR system in the first equation. To examine the possible presence of autocorrelation in our model, we have conducted the Autocorrelation LM test which shows the absence of serial correlation in the VAR model that we have estimated.

VI. CONCLUSION

Augmented Dickey-Fuller Test indicated that VIX and Nifty are non-stationary at the level form but stationary at first difference. Co-integrating relationships between the variables are confirmed through the Johansen test of cointegration**.** The Trace statistic and Max-eigenvalue statistic suggest the presence of a cointegrating vector. The Granger causality test also indicates that Nifty does granger causes VIX. The VECM shows that the long-run and short-run casualty running from Nifty to VIX but no such causality running from VIX to Nifty. This study is useful for understanding the behaviour of India VIX and helps for hedging and risk management for the financial institution and the investors. Further, this study will help policymakers in the design of appropriate derivative instruments based on India VIX for hedging and risk management. The paper is, however, not devoid of limitations. First, the data used in the study is restricted to the last six years which can be extended from 2008; second, we are using the closing value of Nifty and VIX, however, we can use the average value of opening, closing, a high and low value of these variables of particular trading days; third we have used here Johansen Co-integration Test to study the Long-run relationship. However, we can use Engle-Garner Co-integration Test. Subject to these limitations the study reveals that long term association between VIX and Nifty and there exist long and short-term casualty running from Nifty to VIX.

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