Asymmetrical Impact Of S&P 500 & Exchange Rate On Sensex : A NARDL Analysis

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Abstract

Using Nonlinear Autoregressive Distributed Lag NARDL (model), this study investigates asymmetrical effects of S&P 500 and the USDINR exchange rate on the Sensex. The advantage of NARDL framework is that it presents the simplest technique for modelling short and long-run asymmetries simultaneously. Present study is based on secondary data and our data set includes monthly average data on S&P 500, Sensex, and USDINR exchange from January 1, 2009, through October 31, 2022. The results of the Bounds co-integration test show that the underlying variables are co-integrated over the long term. The estimates from NARDL framework show that the daily movements in the S&P 500 Index and exchange rate tend to have a perceptible impact on the behavior and movements of the Sensex. Further, the results also suggest that negative movements tend to have greater impacts than do positive movements in exchange rate and S&P 500 levels, and that long-term multiplier impacts take about 5 months to take effect.

Keywords: S&P 500, NARDL, Asymmetry, Bounds Test, Co-integration

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1. Introduction

Due to increased international capital inflows and increased engagement from domestic institutional investors, the Indian equities market has experienced extraordinary expansion over the past three to four decades. Market participants are now demanding more appropriate benchmarks due to the rising depth and breadth of market. Over time, the importance of Indian stock market in the context of Indian economic growth is well known. Financial factors indicate the health of any economy, and this can determine the fortune for a go investment avenue. Many economists and researchers have demonstrated that the capital market is critical in fostering capital formation and sustaining economic growth. The fundamental changes in the structure of macroeconomic factors and the relative policies make the stock markets in the emerging countries like India very sensitive various shocks.

Further, as a result of globalisation, there are ever more connections between stock markets around the world. The speed of global integration, or the strengthening of international economic ties between nations, is high and is likely to continue to do so in the years to come.

Presently, it is standard practise for governments to modify their policies to fit the global order, which includes internationalising trade and finance, increasing interdependence among nations, and other factors. As a result of the internationalisation process, nations have a larger stock of foreign inputs into production, attracting more foreign capital, technology, and tech specialists. There are worries about the stock market's exposure to risk in a country like India where it is undergoing significant change as a result of liberalisation measures. In an increasingly globally integrated environment, it is important to understand how much S&P 500 movements of USA can affect the Indian stock market. As a result, an analysis of the types of long-term dependencies or co-movements with USA would not only give an idea of the potential gains from portfolio diversification to be reaped from the Indian market, but it might also give some indication of the asymmetrical relationships between India's Sensex and S&P 500 stock price movements of USA. With this background, this study investigates the asymmetrical effects of the S&P 500 movements and the USDINR exchange rate on the Sensex.

2. Literature Review

The world's top and sixth largest economies are the United States and India respectively. According to figures from the commerce ministry, bilateral trade between the United States and India was $119.42 billion in 2021-2022, up from 480.50 billion in 2020-2021. This meant that USA was India's largest trading partner. As a result, quite normal to assume that external shocks in either of the nation will have an impact on the other. The method for assessing these shocks is determined by the economic or financial time series employed.

Black (1976) investigated exchange rate behavior and inferred that asymmetry exists and this may increase transaction costs, thus reducing the gains to international trade. His study also found out that diversification of risk, by investing in USA, United Kingdom and the European country's equity markets is not much effective during periods of external shocks. If any firm is heavily leveraged, fall in its price increases equity return volatility.

Mork (1989) concluded that increase in oil price had a far greater impact on USA's GDP than compared to decreasing oil prices. Kumar et al. (2009) found presence of asymmetric impact of oil-shocks on industrial growth. Oil-shocks have a negative impact on industrial production. Furthermore they concluded that increase in oil prices have a twofold negative impact on the economy but decreasing prices have one fold positive and one fold negative impact.

Taylor and Tonks (1989) implemented co-integration techniques to analyze links amongst markets in Germany, USA, Netherlands and Japan. There was no significant increase of short run stock market gains for these markets post 1979 and long run gains from diversification were absent. Kasa (1992) presented evidence regarding common stochastic trends in markets of USA, Japan, England, Germany and Canada. The results concluded that there indeed is a one common trend that is moving the equity markets of these nations. The common trend was most pronounced in Japan and least pronounced in Canada.

Allen and McAleer (2020) applied NARDL model to check asymmetrical relationship between WTI Oil Prices and Dow Jones Index. The results indicated that negative movements in oil prices have more pronounced impact on DJIA than positive movements. Allen and McAleer (2021) further extended their scope of research and applied NARDL framework for testing asymmetry in S&P 500 and FTSE index. The results indicated that downward movements in S&P 500 were more pronounced than upward movements, and therefore downward movements in S&P 500 affected FTSE index more, than compared to upward movements.

Fiaz et al. (2021) found that exchange rate has an asymmetrical impact on agricultural production in Pakistan. This was done with the help of NARDL model. In such a situation, the researcher suggested that the government should provide aid to the agriculture sector, as as to boost its competitiveness.

3. Methodology

Shin et al. (2014), considering a long run regression which is asymmetrical, formulated the following:

$$\boldsymbol{Y_t = \alpha^+ X_t^+ + \alpha^- X_t^- + e_t} \quad (1)$$

Here, Y_t denotes the dependent variable, X_t, a (k x 1) set of independent variables and α^+ and α^- are the long run parameters of the model. e_t is the Gaussian white noise error term.
Here, the independent variables X_t, takes the following form:

$$X_t = X_0 + X_t^+ + X_t^- \quad (2)$$

X_t^+ and X_t^- are the partial sum decompositions of positive and negative shocks in X_t.

Schoderet (2001) proposed the partial sum process as :

$$X_t^+ = \sum_{i=1}^{t} \Delta X_t^+ = \sum_{i=1}^{t} \max(\Delta X_i, 0) \quad (3)$$
$$X_t^- = \sum_{i=1}^{t} \Delta X_t^- = \sum_{i=1}^{t} \min(\Delta X_i, 0) \quad (4)$$

Here, X_t is the first difference of variable X. Note that in equation (3) and (4), the threshold limit is 0, which is a description of the positive and negative changes in the independent variables. In reality, financial time series data rarely follow a normal distribution. So, equation (3) and (4), have some serious limitations on financial time series data and therefore, the empirical results would not be statistically significant. 2819

This limitation can be solved if we change the threshold limit from 0, to the mean of the underlying variables in the model (Shin, Yu & Greenwood-Nimmo, 2014).
After making the necessary modifications, we can re-write equation (3) and (4) as :

$$X_t^+ = \sum_{i=1}^{t} \Delta X_t^+ = \sum_{i=1}^{t} \max(\Delta X_i, \bar{X}) \quad (5)$$
$$X_t^- = \sum_{i=1}^{t} \Delta X_t^- = \sum_{i=1}^{t} \min(\Delta X_i, \bar{X}) \quad (6)$$

4. Results

4.1 Augmented Dickey-Fuller (ADF) Test

Stationarity of underlying variable plays a key role in time series analysis. Here we have used Augmented Dickey Fuller (ADF) Test. Critical Values for ADF Test has been borrowed from MacKinnon (1996), with which the null hypothesis has been tested. Appropriate lag length has been selected using Akaike Information Criterion. For testing stationarity, we have estimated three models, namely, i) Constant only, ii) Constant and trend, iii) No constant and trend.

The results of ADF test at levels and first difference are summarized in Table 1 and Table 2 respectively. The results show that interest variables are non-stationary at level while they become stationary after first difference. Thus, our interest variables are integrated of order I(1). Since none of the variables is of order I(2), the ARDL cointegration approach's crucial assumption is fulfilled. Therefore, ARDL appears to be the most appropriate estimation procedure for the present study

Table 1 : Augmented Dickey Fuller Test at level and first difference

	Augmented Dickey Fuller Test – Level			
		LOG S	LOG SP	LOG ER
With constant only	t-statistic	-1.789476	-1.489182	-0.402637
	p-value	0.3847	0.5368	0.9047
With constant and trend	t-statistic	-4.539749	-2.870528	-2.679591
	p-value	0.0018	0.1749	0.2465
Without constant and trend	t-statistic	3.090591	3.050992	1.789488
	p-value	0.9995	0.9994	0.9823

	Augmented Dickey Fuller Test – First Difference			
		Δ LOG S	Δ LOG SP	Δ LOG ER
With constant only	t-statistic	-9.88080	-11.50190	-10.11258
	p-value	0.0000	0.0000	0.0000
With constant and trend	t-statistic	-9.824870	-11.58669	-10.09619
	p-value	0.0000	0.0000	0.0000
Without constant and trend	t-statistic	-9.378641	-10.88217	-9.881165
	p-value	0.0000	0.0000	0.0000

Notes: H0: The series has a unit root.
*, ** and *** indicate significance at 1%, 5% and 10% level respectively.
Critical values for ADF test are -3.57, -2.92 and -2.59 at 1%, 5% and 10% respectively (MacKinnon, 1996).
Appropriate lag length was chosen by Schwarz Information Criterion (SIC).

4.2 Results of Bounds Test

After confirming that the variables under investigation are integrated to order I(1), we could use the ARDL Bounds testing approach to determine whether or not the variables of interest are connected over the long term. Table 3 demonstrates that the computed F-statistic value (5.394343) is greater than the upper bound values of 4.37. Therefore, we reject the null hypothesis (H_0) that there is no long-run relationship among our interest variables. Instead, we accept our alternative hypothesis and conclude that S&P 500, exchange rate and Sensex are cointegrated over the long-run.

Table 3: Results of Bounds Test

F – Bounds Test; Null Hypothesis : No levels relationship				
Test Statistic	Value	Signif.	I(0)	I(1)
Asymptotic: n=1000				
F-statistic	5.394343	10%	2.2	3.09
		5%	2.56	3.49
k	4	2.5%	2.88	3.87
		1%	3.29	4.37
Finite Sample : n = 80				
Actual Sample Size	153	10%	2.303	3.22
		5%	2.688	3.698
		1%	3.602	4.787

4.3 Long Run Estimates (Asymmetrical Relationship)

The next stage is to estimate the short-run and long-run NARDL models after determining the long-term connection between the variables. Table 4 reports the long-run asymmetric relationship between S&P 500, exchange rate and Sensex. The results show that the negative changes in S&P500 have more pronounced effect on Sensex than positive movements in S&P500. Similarly, negative shocks in Exchange rate have stronger effects on Sensex, than positive shocks.

Table 4: Long Run Equations

Long Run Levels Equation				
Variable	Coefficient	Std. Error	t-Statistic	Prob
LOG S^+	1.791191	0.218709	8.189855	0.0000
LOG S^-	2.050244	0.352953	5.808825	0.0000
LOG ER^+	-0.141541	0.271736	-0.520877	0.6034
LOG ER^-	0.937098	0.730243	1.283269	0.2020
C	9.358407	0.73799	126.8095	0.0000

4.4 Short Run Equations

Table 5 reports the long-run asymmetric relationship between S&P 500, exchange rate and Sensex. Short run estimates also indicate the presence of asymmetrical effects. The results show that the negative changes in S&P500 have more pronounced effect on Sensex than positive movements in S&P500. Similarly, negative shocks in Exchange rate have stronger effects on Sensex, than positive shocks.

Table 5: Short Run Equations

Short Run Equations				
Variable	Coefficient	Std. Error	t-Statistic	Prob
Δ LOG $S_{(-1)}$	0.319270	0.073269	4.357519	0.0000***
Δ LOG SP^{+}	0.199710	0.131465	1.519109	0.1315
Δ LOG SP^{-}	0.830930	0.88468	9.392437	0.0000***
Δ LOG ER^{+}	-0.954425	0.185544	-5.143920	0.0000***
Δ LOG ER^{-}	-0.935071	0.266636	-3.506918	0.0006***
$CointEq_{(-1)}$*	-0.214708	0.036952	-5.810435	0.0000***
R-Squared			0.743853	
Adjusted R-Squared			0.678229	
Durbin – Watson Stat			1.926530	
Akaike Info. Criterion			-4.517562	
Schwarz Criterion			-3.883745	
Hannan – Quinn Criter.			-4.260095	

4.4 Residual diagnostics and stability tests

The reliability of empirical results depend on the stability of the underlying model and therefore, checking for the same is essential. The results of the diagnostics tests are exhibited in Table 5. From LM test (F_{BP}) it is evident that there is no problem of serial correlation in the residuals. Jarque-Bera test of Normality χ^2NOR confirms that the residuals follow a normal distribution. Breusch-Pagan-Godfrey Test (F_{BPG}) affirms that the residuals are constant. From Ramsey RESET Test, it can be concluded that there is no model misspecification.

Table 5 : Residual Diagnostics

Test Statistic	Serial Correlation (F_{BP})	Heteroscedasticity (F_{BPG})	Model Specification (F_{RESET})	Normality (χ^2NOR)
LM Test	1.022201 (0.4323)			
Breusch-Pagan-Godfrey heteroscedasticty test		1.041293 (0.4218)		

Ramsey RESET test			0.114381 (0.9091)	
Jarque-Bera normality test				0.170710 (0.918186)

Note: The figures in the parentheses () are the associated p-values.

Stability of the NARDL model can be measured by CUSUM and CUSUMQ tests for residuals, as proposed by Brown, Durbin & Evans (1975). For both CUSUM and CUSUMQ tests, as given in Figure 1 and Figure 2, the test statistic lies well within the 5% significance level bands. From this, it can be inferred that for both the tests, the test statistic is stable and that there is no structural stability. Stability of the test statistic further implies that the parameters estimated by NARDL framework are structurally stable.

Figure 1 : CUSUM Test Statistic

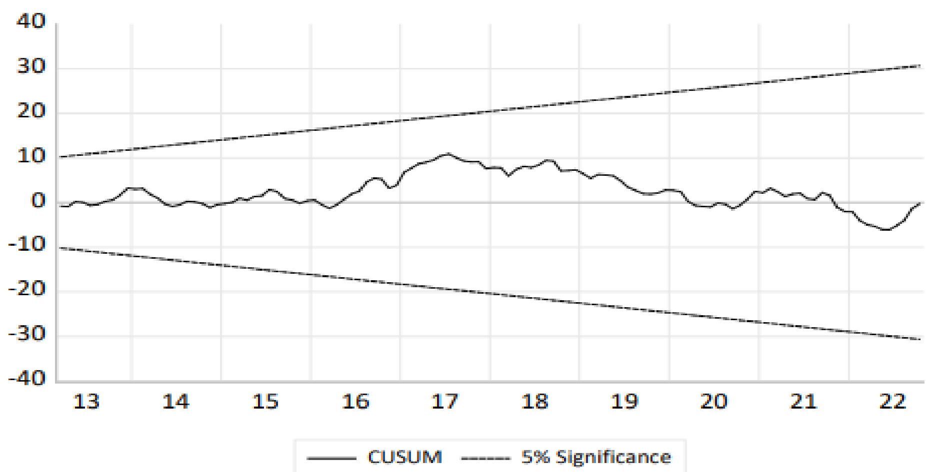
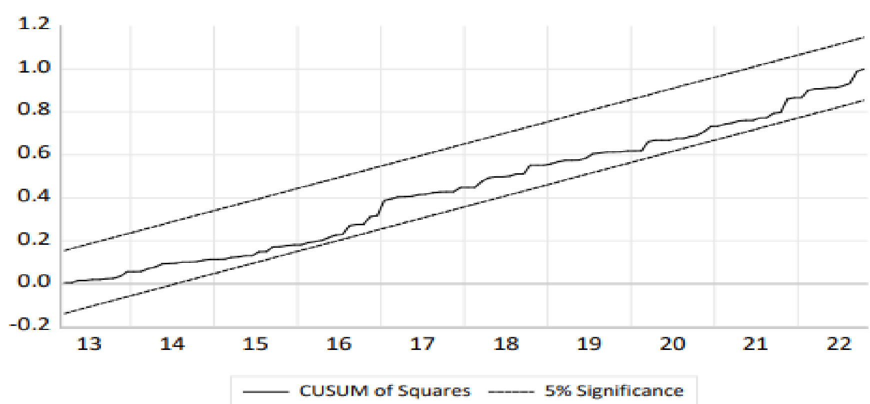


Figure 2 : CUSUM Q Test Statistic



5. Conclusion

From NARDL Model, we can conclude that S&P500 and Exchange asymmetrically affects Sensex. In long run, negative shocks in S&P500 and exchange rate have stronger effect on Sensex, than positive shock in the above mentioned variables do. In short run, negative shocks in S&P 500 has stronger effects on Sensex, but positive shocks in exchange rate has stronger effect on Sensex, than negative shocks do. F-Bounds test strongly indicates that there, does exist long run co-integrations amongst the variables, even at 1% significance level. Short run dis-equilibriums take about 5 months to correct themselves. CUSUM and CUSUMQ tests too conclude that the test statistic is well within the 5& significance band and thus our estimated model is stable and robust.

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