Stock Price and Exchange Rate Interactions: A Cointegration and Granger Causality analysis for India

ABSTRACT

The paper analyzes the short-run and long-run relationships between stock prices and exchange rates in India using cointegration and Granger causality tests. We employed both bivariate and multivariate models using variables like domestic stock price index (BSE SENSEX), exchange rate (rupee-dollar exchange rate), Money Supply (M2), and foreign stock price index (S&P 500). Our cointegration studies suggest that there is no long run relationship between stock prices and exchange rates in both bivariate and multivariate settings. Whereas our Granger causality analysis suggests that there is unidirectional causality between stock prices and exchange rates in India in the Granger sense and it flows from stock prices to exchange rates. These findings indicate that the government should contain strong short-run policy measures to control stock price fluctuations to maintain exchange rate stability in the economy.

INTRODUCTION

After liberal reforms of the 1990s, we can observe the increasing global integration of the Indian economy over the years. This coupled with a move towards market based exchange rate determination (flexible exchange rate regime) in 1993, increased the exposure of exchange rate risk in the Indian economy. The Indian rupee depreciated significantly over the years in terms of rupee-dollar exchange rates. These resulted in increased attention towards the examination of stock price and exchange rate relationships in recent years. If there exists such a causal relationship, and it runs from exchange rate to the stock prices, then policies to stabilize exchange rates can be used to control the fluctuations in the stock markets. On the other hand, if such a relationship runs from stock market to exchange rates, then measures can be taken to control stock prices to minimize the exchange rate risks.

There are quite a number of empirical studies in recent years which explored the relationship between exchange rates and stock prices. However, the findings from these studies are not uniform. Some studies showed unidirectional causality from stock prices to exchange rates (Ibrahim 2000, Farooq et al. 2004). Some others found unidirectional causality from exchange rates to stock prices (Kabir et al. 2014, W. N. W. Azman-Saini et al. 2003). Few people found bidirectional causality between these variables (W. N. W. Azman-Saini et al. 2003, Muhammad et al. 2002). However, many studies found that no long-run relationship exists between stock prices and exchange rates (Dar et al. 2014, Farooq et al. 2004, Ibrahim 2000, Muhammad et al. 2002).

Recently, Kabir et al. (2014) examined the relationship between macroeconomic variables, domestic stock prices and foreign stock prices in the Malaysian economy. According to them, there exists a statistically significant relationship between these variables with exchange rate being the most significant variable. Dar et al. (2014) did the wavelet analysis on relationship between stock prices and exchange rate in the Indian economy. This study found that there is a positive relationship between stock returns and exchange rate, they found that causality and its direction is different at different time scales.

The existing studies suggest that the relationship between stock prices and exchange rates is not uniform. It depends on different temporal and geographical settings. The objective of our study is to extend the existing literature to India and examine the relationship between stock prices and exchange rates in the case of India. In our study, we employed more recent data: monthly data from 2000 to 2023 for all the variables. We used the Vector error correction model (VECM) to examine the long run relationship using Johansen cointegration test, and we used Vector Autoregression (VAR) and Granger Causality to examine the causal relationships. We used both bivariate models using the BSE SENSEX index and Rupee-Dollar exchange and multivariate models by adding variables like M2, and S&P 500 index.

In the next section we explain the theoretical framework behind the relationship between stock prices and exchange rates, and other variables. The data and its stationarity properties will be explored in section 3, section 4 presents the models and discusses our results, and the last section will conclude the study.

THEORETICAL FRAMEWORK

There are mainly two approaches to understand the relationship between stock prices and exchange rates: 1) Flow-Oriented approach 2) Stock-Oriented approach. The flow-oriented approach states that the relationship flows from exchange rates to stock prices. The appreciation or depreciation of the currency affects the competitiveness of the domestic firms and it will affect the stock prices of the firms. The appreciation of the domestic currency makes exports costlier and imports cheaper so that it will negatively affect the international competition of domestic firms. On the other hand, the depreciation of the domestic currency will make imports more expensive and exports cheaper, so it enhances competitiveness. It follows that depreciation affects stock prices positively, whereas appreciation affects negatively. So, according to this approach, the causality runs from exchange rates to stock prices.

The Stock-Oriented approach suggests that the relationship flows from stock prices to exchange rates. According to this approach, stock prices affect the exchange rate through capital flows. The increase in domestic stock prices lead to capital inflows which in turn lead to appreciation of the domestic currency. On the other hand, decrease in stock prices leads to capital outflows and the depreciation of domestic currency.

There are two major theoretical arguments on the effect of money supply on the exchange rate. One comes from the Mundell-Fleming Model and the other comes from the Monetary approach to balance of payments. Both explained, even though with different assumptions and mechanisms, monetary expansion (increase in the money supply) leads to rise in exchange rates and monetary contraction (decrease in the money supply) leads to fall in the exchange rates. And finally, in the integrated world markets, it is clear that the movements of stock prices in one country affects stock prices in the others. So, we used the S & P 500, an American stock index, to examine the effects of changes in foreign stock prices on the domestic ones.

These theoretical foundations suggest to us the different directions of causal relationships between stock prices and exchange rates. The available empirical evidence also confirms these differences in causal relations. So, this area is open to more and more empirical research to explore the relationships in different temporal and geographical settings. Our analysis focuses on India, and the time span ranges from 2000 to 2023. We used Cointegration and Granger causality tests to examine the relationships.

DATA AND ITS STATIONARITY PROPERTIES

As said before, we employ cointegration and Granger causality tests to analyze the interactions between exchange rates and stock prices. To study the relationship, the paper uses a bivariate framework and multivariate framework. The latter extends the analysis of the bivariate framework to include Money Supply Measure (M2) and foreign stock price index (S&P 500). Monthly data of the variables are used, which covers a period from January 2000 to September 2023. Beginning-of-the-month data of BSE SENSEX Index, Rupee Dollar spot exchange rate, M2 and S&P 500 are used in these models. The data for exchange rate is collected from the website of Federal Reserve Economic Data (FRED) of the Federal Reserve Bank of St.Louis (https://fred.stlouisfed.org/). S&P 500 was retrieved from datahub (https://datahub.io/), BSE SENSEX data was retrieved from BSE India website (https://www.bseindia.com/index.html) and M2 data was retrieved from CEIC (https://insights.ceicdata.com/).

Prior to the analysis, we examine the stationarity of the data using Dickey-Fuller(DF) tests and Phillips Perron(PP) tests. Table 1 and table 2 show the test statistics of DF and PP tests respectively. In both the Tables column (a) shows the test statistics for the log-levels of the series, while column (b) shows the test statistics for their first-order differences. Both the unit root tests reveal the same result: from column (a) the null hypothesis of unit root cannot be rejected in all the cases whereas null hypothesis of unit root is rejected in all cases in column (b). The results of these statistical tests suggest that the variables are integrated of order one, or I(1).

Table 1
Dickey-Fuller test for unit roots

Variables	**a) DF test statistic of log transformation of the variables.**	**b) DF test statistic of first log differences of the variables.**
BSE	-0.263	-15.952***
ER	0.340	-12.465***
M2	-0.937	-15.516***
SP	-0.541	-23.360***

*, **, *** indicates significance at 10%, 5%, 1% respectively.

Table 2
Phillips-Perron test for unit roots

Variables	**a.) PP z(t) test statistic of log transformation of the variables.**	**b.) PP z(t) test statistic of first log differences of the variables.**
BSE	-0.345	-16.008***
ER	0.017	-12.354***
M2	-1.048	-15.781***
SP	0.148	-24.275***

*, **, *** indicates significance at 10%, 5%, 1% respectively.

Both VECM and VAR require all the variables in the data to be non-stationary at levels and stationary at their respective first differences. The above analysis confirms that all variables are non-stationary at levels and are I(1). So, we can employ VAR and VECM models for our further analysis.

METHODOLOGY AND RESULTS

Cointegration Analysis

Having established that variables are I(1) in the previous section, we can now move for cointegration analysis. A set of variables are said to be cointegrated if they are individually non-stationary at levels and are I(1), and their linear combination is stationary. If the variables are cointegrated, then there exists a long-run relationship between them, and any deviation between them will be corrected to long-run equilibrium relationship. The cointegration between variables can be tested using two different approaches, one is due to Engle and Granger (1987) and the other is due to Johansen (1988). The Engle and Granger approach is a two step procedure, in step one we run normal OLS regression on the relevant variables and obtain residuals, and in the second step, we conduct unit root test for the residuals. If the residuals turn out to be stationary, then according to Engel and Granger, the variables are cointegrated.

The Johansen (1988) procedure of cointegration takes variables into the VAR model framework and estimates the maximum likelihood estimates. Based on the estimates, two statistics will be taken: 1) Trace statistics, 2) Maximum EigenValue Statistics. These statistics test for the presence of n cointegrating vectors. The trace statistic tests the null hypothesis of presence of at most n cointegrating vectors against the alternative hypothesis of n or more than n cointegrating vectors. On the other hand, the Maximum Eigenvalue statistic tests the null hypothesis of presence of n cointegrating vectors against the alternative hypothesis of n+1 cointegrating vectors. In this study we employed the Johansen approach to cointegration and took the variables in the VECM framework. If there exists at least one cointegrating vector then we reject the proposition that there is no causation. The presence of cointegration suggests that there exists a short-run and long-run relationship between the variables.

The results for Johansen cointegration tests for bivariate and multivariate models are presented in the table 3 and table 4 below. Table 3 presents the results for bivariate model and table 4 presents the results for multivariate model. The optimal lag length for the model is taken using Akaike information criterion (AIC). And the cointegration is tested using trace statistics. The table 3 suggests that there is no cointegration vector between stock prices and exchange rates. The null hypothesis of 0 cointegrating vectors is failed to reject even at 10% significance level. So, we added more variables like M2 and S & P500 to correct the omitted variables bias problem. Even after addition of these variables, we failed to reject the null hypothesis of 0 cointegrating vectors, the results are given in table 4.

Table 3
Cointegration test for the Bivariate Model

Number of observations = 283
Number of lags = 2

Maximum Rank	Params	Log Likelihood	Eigenvalue	Trace Statistic	Critical Value (5%)
0	6	1190.4095	.	5.0723*	15.41
1	9	1192.6203	0.01550	0.6507	3.76
2	10	1192.9457	0.00230		

* Selected Rank

Table 4
Cointegration test for the Multivariate Model

Number of observations = 283
Number of lags = 3

Maximum Rank	Params	Log Likelihood	Eigenvalue	Trace Statistic	Critical Value (5%)
0	36	2194.2962	.	42.2244*	47.21
1	43	2205.6167	0.07715	19.5833	29.68
2	48	2212.0087	0.04432	6.7993	15.41
3	51	2215.339	0.02334	0.1387	3.76
4	52	2215.4084	0.00049		

* Selected Rank

In sum, our results suggest that there is no cointegrating relationship between stock prices and exchange rates in both bivariate and multivariate cases. In the next section we present the results for Granger causality tests.

Causality Tests

After investigating the long-run relationship and finding no cointegrating relationship in the previous section, in this section we came to investigate the short-term relationships using Granger Causality tests. The causality in the Granger sense is different from conventional causality in the sense that granger causality investigates the lead-lag structures of the variables. According to Granger, if the lagged values (previous period values) of one variable statistically significantly gives the information about the present values of the other variable, then the variable which temporally comes first in the relationship is said to be granger causes the other variable. If we consider two variables x and y, x is said to be Granger causes y if the occurrence of x precedes the occurrence of y. So, we can test four kinds of causal relationships between x and y in Granger sense: 1) Unidirectional causality from x to y, 2) Unidirectional causality from y to x, 3) Bidirectional causality between x and y, and 4) No causality between x and y. Here, we employed the VAR framework to investigate the Granger causality. The VAR framework is specifically designed for systems of interrelated variables. The VAR model assumes each variable in the system is explained by its own lagged values and the lagged values of other variables in the system. We used VAR framework instead of normal OLS and F-Test kind of Granger causality tests because we assumed the existence of interdependent relationships among the variables. Our VAR model specification can be described as follows:

$$Y_t = C + A_i Y_{t-p} + u_t$$

$$Y_t = [BSE, ER, M2, SP]^t$$

Where Y_t is a transpose of [BSE, ER, M2, SP] vector at time t, c is a column vector of intercept terms, A_i (i = 1,2,...,p) is a coefficient matrices for the i-th lag of the VAR variables, and u_t is a column vector of residuals. BSE represents BSE SENSEX index, ER represents rupee-dollar exchange rate, M2 represents money supply and SP represents S & P 500 index.

Table 5 and Table 6 show the results of Granger causality tests in the Bivariate and the Multivariate models. First we look into the causality test results of the Bivariate model. Looking at the 1st and 2nd rows in Table 5, we cannot reject the null hypothesis of no causation from exchange rates to the stock prices. By contrast, looking at the 3rd and 4th rows in Table 5, we can reject the null hypothesis of no causation from stock prices to exchange rates. Therefore, we can conclude that there is unidirectional causality from stock prices to exchange rates in the Bivariate case.

Table 5
Bivariate Granger Causality Wald Tests

Equation	Excluded	chi2	df	Prob > chi2
BSE	lnExchangeRate	2.9127	2	0.233
BSE	All	2.9127	2	0.233
ExchangeRate	lnBSE	18.099	2	0.000
ExchangeRate	All	18.099	2	0.000

The causality is significant at 5% level if ‘Prob > chi2’ is less than or equal to 0.05.

Now we can look into the Granger causality tests in the multivariate case. Looking at the 1st row, it can be concluded that none of the individual variables Granger cause BSE. However, when all the variables are considered jointly, there exists significant Granger causality from excluded variables to BSE, suggesting that their combined impact is statistically significant. The results for exchange rates are seen in row 2. When examining the excluded variables separately and also as a combination, the exchange rate results show a strong Granger causality from BSE, M2, and S&P 500 to exchange rates. In the case of M2, we didn’t find any statistically significant Granger causality from other variables to M2 both individually and also jointly. Finally, in the case of SP, M2 doesn’t individually Granger causes M2, whereas all other variables Granger causes SP individually. M2 combined with other variables Granger causes SP.

Table 6
Multivariate Granger Causality Tests

Equation	Excluded	chi2	df	Prob > chi2
lnBSE	lnExchangeRate	1.3436	3	0.719
lnBSE	lnM2	6.272	3	0.099
lnBSE	lnSP	6.6122	3	0.085
lnBSE	ALL	21.017	9	0.013
lnExchangeRate	lnBSE	21.975	3	0.000
lnExchangeRate	lnM2	12.686	3	0.005
lnExchangeRate	lnSP	8.675	3	0.034
lnExchangeRate	ALL	39.082	9	0.000
lnM2	lnBSE	3.8355	3	0.280
lnM2	lnExchangeRate	4.2094	3	0.240
lnM2	lnSP	1.2825	3	0.733
lnM2	ALL	8.0877	9	0.525
lnSP	lnBSE	32.823	3	0.000
lnSP	lnExchangeRate	7.9455	3	0.047
lnSP	lnM2	6.8539	3	0.077
lnSP	ALL	76.637	9	0.000

The causality is significant at 5% level if ‘Prob > chi2’ is less than or equal to 0.05.

The multivariate Granger causality results are in agreement with the bivariate result. Both in multivariate and bivariate cases, the causality only runs from stock prices to exchange rates but not vice-versa. The money supply being the independent variable not influenced by any other variable in the system. Whereas, as predicted by both Mundell-Fleming model and Monetary approach, the M2 is Granger causing exchange rate and the result is statistically significant.

SUMMING UP

The study employed cointegration and Granger causality tests to examine the relationship between stock prices and exchange rates in both bivariate and multivariable frameworks. We took the BSE SENSEX index as a proxy to stock prices, Rupee-dollar exchange rate for exchange rate, M2 for money supply and S & P 500 index for foreign stock index. After establishing the variables are non-stationary at levels, we tested for the stationarity of variables at differences. We found that all the variables are stationary at their first differences and I(1), so we moved to cointegration analysis.

Our cointegration analysis in the VECM framework by employing the Johansen methodology suggests that no long-run relationship exists between stock prices and exchange rates in both bivariate and multivariate frameworks in India. Later, we examined the short run relationship between stock prices and exchange rates using the VAR model specification and Granger causality tests. Our results suggest that there exists unidirectional causality in the Granger sense from stock prices to exchange rates for our data in India. These results are in agreement with the stock-oriented approach to relationship between stock price and exchange rates. Additionally, we find a statistically significant short run relationship between M2 and exchange rate, the direction of relationship moves from M2 to exchange rate. This is in confirmation with macroeconomic frameworks like the Mundell-Fleming model and Monetary approach to Balance of Payments.

Our results suggest that controlling fluctuations in stock markets is important to control exchange rate fluctuations in the short run. The money supply is also an important determinant to the exchange rate. So, the government should take measures to control fluctuations in stock prices to safeguard the economy from exchange rate risks in the short-run in India.

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