Relationship Between Exchange Rate and Stock Prices in India – An Empirical Analysis

By

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Abstract: The dynamic linkage between exchange rate and stock prices has been subjected to extensive research for over a decade and attracted considerable attention from researchers worldwide during the Asian crisis of 1997-98. The issue is also important from the viewpoint of recent large cross-boarder movement of funds. In India the issue is also gaining importance in the liberalization era. With this background, the present study examines the causal relationship between returns in stock market and forex market in India. Using daily data from March 1993 to December 2002, we found that causal link is generally absent though in recent years there has been strong causal influence from stock market return to forex market return. The results, however, are tentative and we need further in-depth research to identify the causes and consequences of the findings.

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The views expressed in the paper are those of the authors’ and not necessarily of the organizations they belong to.
Introduction

The Asian crisis of 1997-98 has made a strong pitch for dynamic linkage between stock prices and exchange rates. During the crisis period, the world has noticed that the emerging markets collapsed due to substantial depreciation of exchange rates (in terms of US$) as well as dramatic fall in the stock prices. This has become important again from the view point of large cross border movement of funds due to portfolio investment and not due to actual trade flows, though trade flows have some impact on stock prices of the companies whose main sources of revenue comes from foreign exchange.

In retrospect of the literature, a number of hypotheses also support the existence of a causal relation between stock prices and exchange rates. For instance, ‘goods market approaches’ (Dornbusch and Fischer, 1980) suggest that changes in exchange rates affect the competitiveness of a firm as fluctuations in exchange rate affects the value of the earnings and cost of its funds as many companies borrow in foreign currencies to fund their operations and hence its stock price. A depreciation of the local currency makes exporting goods attractive and leads to an increase in foreign demand and hence revenue for the firm and its value would appreciate and hence the stock prices. On the other hand, an appreciation of the local currency decreases profits for an exporting firm because it leads to a decrease in foreign demand of its products. However, the sensitivity of the value of an importing firm to exchange rate changes is just the opposite to that of an exporting firm. In addition, variations in exchange rates affect a firm's transaction exposure. That is, exchange rate movements also affect the value of a firm’s future payables (or receivables) denominated in foreign currency. Therefore, on a macro basis, the impact of exchange rate fluctuations on stock market seems to depend on both the importance of a country’s international trades in its economy and the degree of the trade imbalance.

An alternative explanation for the relation between exchange rates and stock prices can be provided through ‘portfolio balance approaches’ that stress the role of capital account transaction. Like all commodities, exchange rates are determined by market mechanism, i.e., the demand and supply condition. A blooming stock market would attract capital flows from foreign investors, which may cause an increase in the demand for a country’s currency. The reverse would happen in case of falling stock prices where the investors would try to sell their stocks to avoid further losses and would convert their money into foreign currency to move out of the country. There would be demand for foreign currency in exchange of local currency and it would lead depreciation of local currency. As a result, rising (declining) stock prices would lead to an appreciation (depreciation) in exchange rates. Moreover, foreign investment in domestic equities
could increase over time due to benefits of international diversification that foreign investors would gain. Furthermore, movements in stock prices may influence exchange rates and money demand because investors’ wealth and liquidity demand could depend on the performance of the stock market.

Although theories suggest causal relations between stock prices and exchange rates, existing evidence on a micro level provides mixed results. Jorion (1990, 1991), Bodnar and Gentry (1993), and Bartov and Bodnar (1994) all fail to find a significant relation between simultaneous dollar movements and stock returns for U.S. firms. He and Ng (1998) find that only about 25 percent of their sample of 171 Japanese multinationals has significant exchange rate exposure on stock returns. Griffin and Stulz’s (2001) empirical results show that weekly exchange rate shocks have a negligible impact on the value of industry indexes across the world. However, Chamberlain, Howe, and Popper (1997) find that the U.S. banking stock returns are very sensitive to exchange rate movements, but not for Japanese banking firms. While such findings are different from those reported in prior research, Chamberlain et al. attributed the contrast to the use of daily data in their study instead of monthly data as used in most prior studies.

On a macro level, the empirical research documents relatively stronger relationship between stock price and exchange rate. Ma and Kao (1990) find that a currency appreciation negatively affects the domestic stock market for an export-dominant country and positively affects the domestic stock market for an import-dominant country, which seems to be consistent with the goods market theory. Ajayi and Mougoue (1996), using daily data for eight countries, show significant interactions between foreign exchange and stock markets, while Abdalla and Murinde (1997) document that a country’s monthly exchange rates tends to lead its stock prices but not the other way around. Pan, Fok & Lui (1999) used daily market data to study the causal relationship between stock prices and exchange rates and found that the exchange rates Granger-cause stock prices with less significant causal relations from stock prices to exchange rate. They also find that the causal relationship have been stronger after the Asian crisis.

In the context of Indian economy, however, study in the similar direction is not available, though the issue is gaining importance in recent years. Like other Asian emerging economies, Indian equity market has continued to grow and has seen the relaxation of foreign investment restrictions primarily through country deregulation. During the 1990s, India has initiated the financial sector reforms by way of adopting international practices in its financial market. Parallel to this, the issuance of American Depository Receipts (ADR’s) or General Depository Receipts (GDR’s) has
facilitated the trade of foreign securities on the NYSE, NASDAQ or on non-American exchanges. Over the years, Indian Rupee is slowly moving towards full convertibility, which has also had an impact in the Indian capital market as international investors have invested about US $15 billion in Indian capital market. The two-way fungibility of ADRs/GDRs allowed by RBI has also possibly enhanced the linkages between the stock and foreign exchange markets in India. In this background, this study aims at examining the dynamic linkages between foreign exchange of Indian Rupee and stock market price index in India. The rest of the paper has been arranged as follows: The Section 2 gives the methodological issues and Section 3 talks about the data and empirical results. Finally Section 4 concludes.

2. Methodological Issues

The dynamic linkage may simply be examined using the concept of Granger’s (1969) causality. Formally, a time series $X_t$ Granger-causes another time series $Y_t$ if series $Y_t$ can be predicted better by using past values of $(X_t, Y_t)$ than by using only the historical values of $Y_t$. In other words, $X_t$ fails to Granger-cause $Y_t$ if for all $m > 0$ the conditional probability distribution of $Y_{t+m}$ given $(Y_t, Y_{t-1}, ...)$ is the same as the conditional probability distribution of $Y_{t+m}$ given both $(Y_t, Y_{t-1}, ...)$ and $(X_t, X_{t-1}, ...)$. That is, $X_t$ does not Granger-cause $Y_t$ if

$$\Pr(Y_{t+m} | \Psi_t) = \Pr(Y_{t+m} | \Omega_t)$$

where $\Pr(*)$ denotes conditional probability, $\Psi_t$ is the information set at time $t$ on past values of $Y_t$, and $\Omega_t$ is the information set containing values of both $X_t$ and $Y_t$ up to time point $t$.

Testing causal relations between two stationary series $X_t$ and $Y_t$ can be based on the following bivariate autoregression (Granger, 1969)

$$Y_t = \alpha_0 + \sum_{k=1}^{p} a_k Y_{t-k} + \sum_{k=1}^{p} \beta_k X_{t-k} + u_t$$

(2)

$$X_t = \varphi_0 + \sum_{k=1}^{p} \varphi_k Y_{t-k} + \sum_{k=1}^{p} \Phi_k X_{t-k} + v_t$$

(3)

where $p$ is a suitably chosen positive integer; $\alpha_k$ ’s and $\beta_k$ ’s, $k = 0,1, \ldots, p$ are constants; and $u_t$ and $v_t$ usual disturbance terms with zero means and finite variances. The null hypothesis that $X_t$ does not Granger-cause $Y_t$ is rejected if the $\beta_k$ ’s, $k > 0$ in equation (2) are jointly significantly different from zero using a standard joint test (e.g., an $F$ test). Similarly, $Y_t$ Granger-causes $X_t$ if
the $\phi_k$’s, k>0 coefficients in equation (3) are jointly different from zero. A bi-directional causality (or feedback) relation exists if both $\beta_k$’s and $\phi_k$’s, k>0 are jointly different from zero.

It may be mentioned that the above test is applicable to stationary series. In reality, however, underlying series may be non-stationary. In such cases, one has to transformed the original series into stationary series and causality tests would be performed based on transformed-stationary series. A special class of non-stationary process is the I(1) process (i.e. the process possessing a unit root). An I(1) process may be transformed to a stationary one by taking first order differencing. Thus, while dealing with two I(1) process for causality, equations (2) and (3) must be expressed in terms of differenced-series. However, if underlying I(1) processes are cointegrated, the specifications so obtained must be modified by inserting the lagged-value of the cointegration relation (i.e. error-correction term) as an additional explanatory variable. In other words, equations (2) and (3) should be modified as

$$\Delta Y_t = \alpha_0 + \sum_{k=1}^p \alpha_k \Delta Y_{t-k} + \sum_{k=1}^p \beta_k \Delta X_{t-k} + \delta ECT_{t-1} + u_t \quad (4)$$
$$\Delta X_t = \phi_0 + \sum_{k=1}^q \phi_k \Delta Y_{t-k} + \sum_{k=1}^q \phi_k \Delta X_{t-k} + \eta ECT_{t-1} + v_{t} \quad (5)$$

where $\Delta$ is the difference operator and $ECT_{t-1}$ represents an error correction term derived from the long-run cointegrating relationship between the I(1) processes $X_t$ and $Y_t$. This term can be estimated by using the residual from a cointegrating regression.

3. Data and Empirical Results

The data used in this empirical study are daily stock market index and exchange rate (expressed in Indian Rupee per U.S. dollar) for India. We use daily data for the period March 1993 to December 2002. We have chosen the stock index S&P CNX NIFTY of National Stock Exchange (NSE), an index constructed with impact cost consideration, is one of the most robust indices available for Indian stock market. We denote the chosen stock price index and exchange rate by NF and ER, respectively. For the period from March 1993 to November 1995, we have used the simulated S&P CNX NIFTY values calculated by NSE. From March 1993, India introduced unified exchange rate system and started the process of exchange rate determination by market forces, though there has been some sort of intervention by the central bank depending upon situations. However, as well known, exchange rate decontrol has been a time consuming process and in 1994 India adopted the current account convertibility. Keeping pace with the liberalization
process in financial sector, exchange rate liberalization has also been done in phases and hence it
would be interesting to break the period into various time buckets to see how the causal
relationship has behaved over various time buckets. Again, there has also been substantial
regulatory changes taking place in capital market and over a period of time, many international
best practices have been implemented in a phased manner. However, there have been concerns
about the regulations on foreign investors’ ownership of stocks issued by domestic firms. Though
it is a major issue that guides the flow of funds into various markets, for India it has been a time
consuming affair and even today we have sectoral limits for foreign ownership.

3.1 Preliminary analysis

The Granger causality test requires that all data series involved are stationary; otherwise the
inference from the F-statistic might be spurious because the test statistics will have nonstandard
distributions. Accordingly, we first employ the Augmented Dickey-Fuller (ADF) unit root tests to
check for stationarity for the exchange rate and stock market index using the optimal lags as per
smallest Schwarz Criterion. Following the literature, all data series have been transformed to
natural logarithms. The equation used for conducting ADF test has the following general structure

\[ X_t = \alpha + \beta t + \rho X_{t-1} + \sum_{i=1}^{k} \delta_i \Delta X_{t-i} + \epsilon_t \]  

(6)

In equation (6), if (i) \( \beta = 0 \) and \( |\rho| < 1 \), the series \( X_t \) is stationary; (ii) \( \beta = 0 \) and \( \rho = 1 \) then the series is an I(1) process; (iii) \( \beta \neq 0 \) and \( |\rho| < 1 \) then the series is trend-stationary (i.e. stationary around a
deterministic linear time trend). Our empirical results of ADF tests for entire data period are
shown in Table 1. These results indicate that there is a unit root in all the logarithmic series (i.e.
log(ER) and log(NF) series) and thus these log-level series can be described as I(1) processes,
indicating that their first-order differences (denoted by \( \Delta \log(ER) \) and \( \Delta \log(NF) \), respectively)
are stationary. Plot of \( \Delta \log(ER) \) and \( \Delta \log(NF) \) also appear to be oscillating around a constant
value (Figure 1). Further, application of ADF tests on \( \Delta \log(ER) \) and \( \Delta \log(NF) \) also confirms
the stationarity of underlying series (Table 1).

<table>
<thead>
<tr>
<th>Table 1: Results of ADF Tests for Unit Root</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
</tr>
<tr>
<td>Log(ER)</td>
</tr>
<tr>
<td>Log(NF)</td>
</tr>
<tr>
<td>ΔLog(ER)</td>
</tr>
<tr>
<td>ΔLog(NF)</td>
</tr>
</tbody>
</table>

¹‘#’ Optimal p is selected based on minimum Schwarz Information Criterion.

²‘$’ Critical Values of ADF test statistics for 1%, 5% and 10% level of significance are
-3.9676, -3.4144 and -3.1290, respectively.

‘*’ Significant at 1% level.
We now employ Johansen's (1991) maximum likelihood method to examine whether or not the logarithms of exchange rate and stock price index for the country are cointegrated. The Table-2 reports the relevant results. As can be seen in the table, there is no cointegration vector between the underlying series. Consequently, an error correction term need not be included in the Granger causality test equations.

### Table 2: Multivariate Cointegration Test Between log(RE) and log(NF)

<table>
<thead>
<tr>
<th>Period</th>
<th>Eigen Values (Descending Order)</th>
<th>Hull Hypothesis</th>
<th>Trace Statistic</th>
<th>Critical Values (Trace) at 5% at 1%</th>
</tr>
</thead>
<tbody>
<tr>
<td>March 93 - 2002</td>
<td>0.004463 r=0 10.26026       15.41 20.04</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.000208 r=&lt;1 0.455485       3.76 6.65</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*'r' indicates number of cointegrating relationship. 
*'*' For a null hypothesis regarding r, Trace Statistics is derived as

\[
Trace = -T \sum_{i=1}^{2} \log(1 - \lambda_i)
\]

where T is number of observations and \( \lambda_i \) is the r-th Eigen-value in ascending order.

### 3.2 Linear Granger Causality Test Results

The test results of Granger-causality between exchange rates and stock prices are given in Table-3. A lag orders of one, two, three, four and five (i.e., \( n = 1, 2, 3, 4 \) and 5) are used in equations 4 and 5 without any error-correction term. We experimented with a maximum lag of 5-day from the consideration that there are 5 trading days in a week and we hope that 5 days
period would be adequate to get effects of one market to another under the assumption of substantial informational efficiency.

### Table 3: Pairwise Granger Causality Tests Between $\Delta \log(ER)$ and $\Delta \log(NF)$

<table>
<thead>
<tr>
<th>Period</th>
<th>Null Hypothesis</th>
<th>F-Values</th>
<th>P-Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>March 1993 - 2002</td>
<td>$\Delta \log(NF) \not\rightarrow \Delta \log(ER)$</td>
<td>1.70417</td>
<td>0.13027</td>
</tr>
<tr>
<td></td>
<td>$\Delta \log(ER) \not\rightarrow \Delta \log(NF)$</td>
<td>1.61944</td>
<td>0.15802</td>
</tr>
<tr>
<td>1993</td>
<td>$\Delta \log(NF) \not\rightarrow \Delta \log(ER)$</td>
<td>2.50716</td>
<td>0.03256</td>
</tr>
<tr>
<td></td>
<td>$\Delta \log(ER) \not\rightarrow \Delta \log(NF)$</td>
<td>3.27622</td>
<td>0.27574</td>
</tr>
<tr>
<td>1994</td>
<td>$\Delta \log(NF) \not\rightarrow \Delta \log(ER)$</td>
<td>0.97559</td>
<td>0.43387</td>
</tr>
<tr>
<td></td>
<td>$\Delta \log(ER) \not\rightarrow \Delta \log(NF)$</td>
<td>1.32136</td>
<td>0.25659</td>
</tr>
<tr>
<td>1995</td>
<td>$\Delta \log(NF) \not\rightarrow \Delta \log(ER)$</td>
<td>2.50716</td>
<td>0.03256</td>
</tr>
<tr>
<td></td>
<td>$\Delta \log(ER) \not\rightarrow \Delta \log(NF)$</td>
<td>3.27622</td>
<td>0.27574</td>
</tr>
<tr>
<td>1996</td>
<td>$\Delta \log(NF) \not\rightarrow \Delta \log(ER)$</td>
<td>0.50659</td>
<td>0.7711</td>
</tr>
<tr>
<td></td>
<td>$\Delta \log(ER) \not\rightarrow \Delta \log(NF)$</td>
<td>1.21477</td>
<td>0.30337</td>
</tr>
<tr>
<td>1997</td>
<td>$\Delta \log(NF) \not\rightarrow \Delta \log(ER)$</td>
<td>1.98707</td>
<td>0.08185</td>
</tr>
<tr>
<td></td>
<td>$\Delta \log(ER) \not\rightarrow \Delta \log(NF)$</td>
<td>0.99769</td>
<td>0.42016</td>
</tr>
<tr>
<td>1998</td>
<td>$\Delta \log(NF) \not\rightarrow \Delta \log(ER)$</td>
<td>1.19896</td>
<td>0.31076</td>
</tr>
<tr>
<td></td>
<td>$\Delta \log(ER) \not\rightarrow \Delta \log(NF)$</td>
<td>0.53617</td>
<td>0.74875</td>
</tr>
<tr>
<td>1999</td>
<td>$\Delta \log(NF) \not\rightarrow \Delta \log(ER)$</td>
<td>1.21313</td>
<td>0.30403</td>
</tr>
<tr>
<td></td>
<td>$\Delta \log(ER) \not\rightarrow \Delta \log(NF)$</td>
<td>0.33378</td>
<td>0.89215</td>
</tr>
<tr>
<td>2000</td>
<td>$\Delta \log(NF) \not\rightarrow \Delta \log(ER)$</td>
<td>0.5305</td>
<td>0.7532</td>
</tr>
<tr>
<td></td>
<td>$\Delta \log(ER) \not\rightarrow \Delta \log(NF)$</td>
<td>0.71373</td>
<td>0.58416</td>
</tr>
<tr>
<td>2001</td>
<td>$\Delta \log(NF) \not\rightarrow \Delta \log(ER)$</td>
<td>2.59108</td>
<td>0.02671</td>
</tr>
<tr>
<td></td>
<td>$\Delta \log(ER) \not\rightarrow \Delta \log(NF)$</td>
<td>1.18445</td>
<td>0.110358</td>
</tr>
<tr>
<td>2002</td>
<td>$\Delta \log(NF) \not\rightarrow \Delta \log(ER)$</td>
<td>3.07255</td>
<td>0.01054</td>
</tr>
<tr>
<td></td>
<td>$\Delta \log(ER) \not\rightarrow \Delta \log(NF)$</td>
<td>2.04028</td>
<td>0.07403</td>
</tr>
</tbody>
</table>

# The symbol $\not\rightarrow$ implies ‘does not Granger Cause’. Thus $X \not\rightarrow Y$ means variable $X$ does not Granger cause $Y$.

$F$-Values are derived using lag $p = 5$ in related regression equations (in our exercise equations 4 and 5 without error-correction terms).

## Significant at 5% level.

For the full sample period, the reported $F$-values as well as p-values suggest that these two markets did not have any causal relationship. If we go into individual years to see if the liberalization in both the markets have brought them together or not, then also we do not see any significant causal relationship between exchange rate and stock price movements except for the years 1993, 2001 and 2002, during when unidirectional causal influence from stock index return to return in forex market is detected (as corresponding F-statistics are significant at 5 % level of significance). Very mild causal influence in reverse direction is also found in some years (1997, 2002).
4. Conclusions

In this study, we examine the dynamic linkages between the foreign exchange and stock markets for India. While the literature suggests the existence of significant interactions between the two markets, our empirical results show that generally returns in these two markets are not interrelated, though in recent years, the return in stock market had causal influence on return in exchange rate with possibility of mild influence in reverse direction. These results have opened up some interesting issues regarding the exchange rate and stock price causal relationship. In India, though stock market investment does not constitute a very significant portion of total household savings compared to other form of financial assets, it may have a significant impact on exchange rate movement as FII investment has played a dominant role. The results, however, are tentative and there is a need to undertake an in-depth research to address the issue.

References


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