Dynamic Relation Between Exchange Rate and Stock Prices – A Case for India

Golaka C. Nath[*] and G. P. Samanta[**]

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 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

---

[*] Manager, NSE

[**] Assistant Adviser, Reserve Bank of India. The views expressed and the approach suggested are of the authors and not necessarily of the organizations to which they belong.

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 strengthened 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: 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, 1988) causality. Formally, a time series X_t Granger-causes another time series Y_t if series Y_t can be predicted with better accuracy by using past values of X_t rather than by not doing so, other information being identical. In other words, variable X_t fails to Granger-cause Y_t if

$$\Pr(Y_{t+m} \mid \Psi_t) = \Pr(Y_{t+m} \mid \Omega_t) \tag{1}$$

where $Pr(\bullet)$ denotes conditional probability, ψ_t is the set of all information available at time t and Ω_t is the information set obtained by excluding all information on X_t from ψ_t.

Testing causal relations between two stationary series X_t and Y_t (in bivariate case) can be based on the following two equations

$$Y_t = a_0 + \sum_{k=1}^{p} a_k Y_{t-k} + \sum_{k=1}^{p} b_k X_{t-k} + u_t \tag{2}$$

$$X_t = j_0 + \sum_{k=1}^{p} j_k Y_{t-k} + \sum_{k=1}^{p} \Phi_k X_{t-k} + v_t \tag{3}$$

where p is a suitably chosen positive integer; a_k's and $ß_k$'s, k = 0,1, ...,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 not accepted if the β_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 f_k's, $k>0$ coefficients in equation (3) 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 transform 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 (Engle and Granger, 1987). In other words, equations (2) and (3) should be modified as

$$\Delta Y_t = a_0 + \sum_{k=1}^{p} a_k \Delta Y_{t-k} + \sum_{k=1}^{p} b_k \Delta X_{t-k} + d \, \text{ECT}_{t-1} + u_t \qquad (4)$$

$$\Delta X_t = f_0 + \sum_{k=1}^{p} f_k \Delta Y_{t-k} + \sum_{k=1}^{p} \Phi_k \Delta X_{t-k} + h \, ECT_{t-1} + v_t \qquad (5)$$

where Δ 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. Clearly, if X_t and Y_t are I(1) but not cointegrated, the term ECT_{t-1} would be absent from equations (4) and (5).

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 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 (Dickey and Fuller, 1979, 1981) to check for stationarity for the exchange rate and stock market. Following the literature, all data series have been transformed to natural logarithms. The equation used for conducting ADF test has the following general structure

$$X_t = a + b \, t + r \, X_{t-1} + \sum_{k=1}^{p} d_k \Delta X_{t-k} + e_t \qquad (6)$$

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). In Table 1, we present results of ADF tests for entire data period. Estimated coefficients of time trend in equation (6) for different variables were statistically insignificant and are not reported here. Empirical 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 ΔLog(ER) and ΔLog(NF), respectively) are stationary. Plot of ΔLog(ER) and ΔLog(NF) also appear to be oscillating around a constant value (Figure 1). Further, application of ADF tests on ΔLog(ER) and ΔLog(NF) also confirms the stationarity of underlying series (Table 1).

Table 1: Results of ADF Tests for Unit Root

Variable	Optimal p[#]	Test Statistics[$]
Log(ER)	5	-2.151
Log(NF)	1	-2.726
ΔLog(ER)	5	-17.895[*]
ΔLog(NF)	1	-45.545[*]

'#' Optimal p is selected based on minimum Schwarz Information Criterion.
'$' 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.

Figure 1: Returns in Exchange Rate and Nifty Index
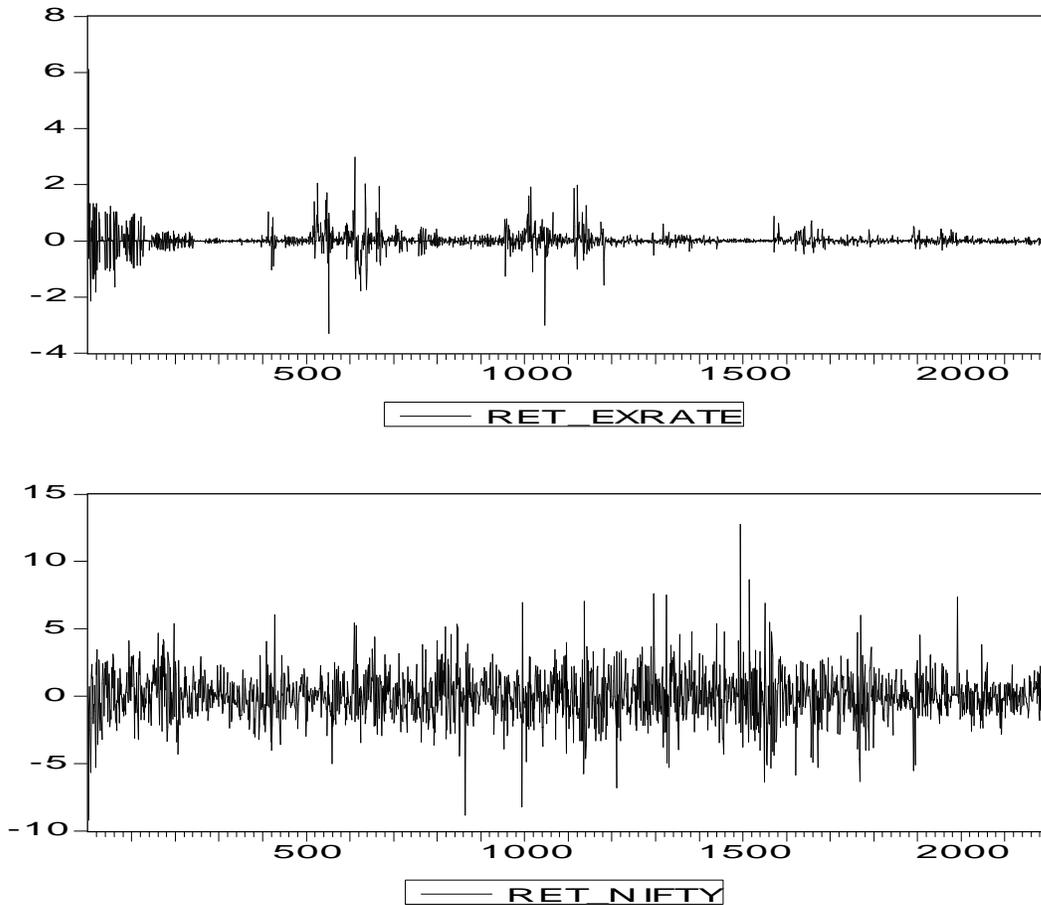
We now employ Johansen's (1991) maximum likelihood method to examine whether or not the logarithms of exchange rate and stock price index for the country are cointegrated. The Table-2 reports the relevant results. As can be seen in the table, there is no cointegration vector between the underlying series. 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)

Period	Eigen Values (Descending Order)	Hull Hypothesis#	Trace Statistic*	Critical Values (Trace)	
				at 5%	at 1 %
	0.004463	r=0	10.26026	15.41	20.04
March 93 - 2002	0.000208	r=<1	0.455485	3.76	6.65

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

$$Trace = -T \sum_{i=r+1}^{2} \log(1 - \lambda_t)$$

where T is number of observations and λ_r 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. We experimented with a lag of 5-days 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 DLog(ER) and DLog(NF)

Period	Null Hypothesis[#]	F-Values[$]	P-Values
March 1993 - 2002	ΔLog(NF) $\neq$> ΔLog(ER)	1.70417	0.13027
	ΔLog(ER) $\neq$> ΔLog(NF)	0.51041	0.7686
1993	ΔLog(NF) $\neq$> ΔLog(ER)	2.50716	0.03256[*]
	ΔLog(ER) $\neq$> ΔLog(NF)	1.61944	0.15802
1994	ΔLog(NF) $\neq$> ΔLog(ER)	1.16323	0.32878
	ΔLog(ER) $\neq$> ΔLog(NF)	1.27622	0.27574
1995	ΔLog(NF) $\neq$> ΔLog(ER)	0.97559	0.43387
	ΔLog(ER) $\neq$> ΔLog(NF)	1.32136	0.25659
1996	ΔLog(NF) $\neq$> ΔLog(ER)	0.50659	0.7711
	ΔLog(ER) $\neq$> ΔLog(NF)	1.21477	0.30337
1997	ΔLog(NF) $\neq$> ΔLog(ER)	1.98707	0.08185
	ΔLog(ER) $\neq$> ΔLog(NF)	0.99769	0.42016
1998	ΔLog(NF) $\neq$> ΔLog(ER)	1.19896	0.31076
	ΔLog(ER) $\neq$> ΔLog(NF)	0.53617	0.74875
1999	ΔLog(NF) $\neq$> ΔLog(ER)	1.21313	0.30403
	ΔLog(ER) $\neq$> ΔLog(NF)	0.33378	0.89215
2000	ΔLog(NF) $\neq$> ΔLog(ER)	0.5305	0.7532
	ΔLog(ER) $\neq$> ΔLog(NF)	0.75373	0.58416
2001	ΔLog(NF) $\neq$> ΔLog(ER)	2.59108	0.02671[*]
	ΔLog(ER) $\neq$> ΔLog(NF)	1.85445	0.10358
2002	ΔLog(NF) $\neq$> ΔLog(ER)	3.07255	0.01054[*]
	ΔLog(ER) $\neq$> ΔLog(NF)	2.04028	0.07403

'#' The symbol $\neq$> implies 'does not Granger Cause'. Thus X $\neq$> 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 inter-related, 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

Abdalla, I. S. A. and V. Murinde, 1997, "Exchange Rate and Stock Price Interactions in Emerging Financial Markets: Evidence on India, Korea, Pakistan, and Philippines," Applied Financial Economics 7, 25-35.

Ajayi, R. A. and M. Mougoue, 1996, "On the Dynamic Relation between Stock Prices and Exchange Rates," Journal of Financial Research 19, 193-207.

Bartov, E. and G. M. Bodnar, 1994, "Firm Valuation, Earnings Expectations, and the Exchange-Rate Exposure Effect," Journal of Finance 49, 1755-1785.

Bekaert, G. and C. R. Harvey, 2000, "Foreign Speculators and the Emerging Equity Markets," Journal of Finance 55, 565-613.

Bodnar, G. M. and W. M. Gentry, 1993, "Exchange Rate Exposure and Industry Characteristics: Evidence from Canada, Japan, and the USA," Journal of International Money and Finance 12, 29-45.

Chamberlain, S., J. S. Howe, and H. Popper, 1997, "The Exchange Rate Exposure of U. S. and Japanese Banking Institutions," Journal of Banking and Finance 21, 871-892.

Dickey, D. A. and W. A. Fuller (1979): Distribution for the estimators for auto-regressive time series with unit root, *Journal of American Statistical Association*, Vol. 74, pp. 427-31.

Dickey, D. A. and W. A. Fuller (1981): Likelihood ratio statistics for auto-regressive time series with unit root, *Econometrica*, Vol. 89, No. 4, July, pp. 1057-72.

Dornbusch, R. and S. Fischer, 1980, "Exchange Rates and Current Account," American Economic Review 70, 960-971.

Engle, R. F. and C. W. J. Granger, 1987, "Co-integration and Error Correction: Representation, Estimation, and Testing," Econometrica 55, 251-276.

Granger, C. W. J., 1969, "Investigating Causal Relations by Econometrics Models and Cross Spectral Methods," Econometrica 37, 424-438.

Granger, C. W. J., 1988, "Some Recent Developments in A Concept of Causality," Journal of Econometrics 39, 199-211.

Griffin, J. M. and R. M. Stulz, 2001, "International Competition and Exchange Rate Shocks: A Cross-Country Industry analysis of Stock Returns," Review of Financial Studies 14, 215-241.

He, J. and L. K. Ng, 1998, "The Foreign Exchange Exposure of Japanese Multinational Corporations," Journal of Finance 53, 733-753.

Johansen, S., 1991, "Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models," Econometrica 58, 165-188.

Jorion, P., 1990, "The Exchange Rate Exposure of U.S. Multinationals," Journal of Business 63, 331-345.

Jorion, P., 1991, "The Pricing of Exchange Rate Risk in the Stock Market," Journal of Financial and Quantitative Analysis 26, 363-376.

Ma, C. K. and G. W. Kao, 1990, "On Exchange Rate Changes and Stock Price Reactions," Journal of Business Finance & Accounting 17, 441-449.

Pan, Fok & Lui (1999): Dynamic Linkages Between Exchange Rates and Stock Prices: Evidence from Pacific Rim Countries, Shippensburg University Working Papers