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Causal Nexus between Stock Price, Demand for Money, Interest Rate, Foreign Institutional Investment, and Exchange Rates in India: A Post Subprime Crisis Analysis

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This paper makes an attempt to empirically examine the causal nexus between stock price, demand for money, interest rates, foreign institutional investment and exchange rates in India in the post subprime mortgage crisis period. The study employed Granger causality test, Vector Auto Regression and Johansen Maximum Likelihood procedure to examine the short run and long run dynamic interaction among the above mentioned variables for the period January 1993 to May 2009. The major findings of the study are: stock return affects exchange rate return, net foreign institutional investment and growth of demand for money. Growth of demand for money, in turn, affects interest rate. Interest rate is more affected by exchange rate return. Foreign institutional investment also affects interest rate. The co-integration test confirms that there does not exist any long run equilibrium relationship between stock return and exchange rate return.

Keywords: *Flow oriented approach, stock oriented approach, asset return, Vector Auto Regression*

Introduction

In the post liberalization era, there has been substantial rethinking about how the economy should efficiently manage and integrate the financial sector to achieve the core objective of financial stability. The institutional reforms such as emergence of new capital markets, introduction of unified exchange rate system, openness of investment in equity and debt sectors by non resident Indians and foreign institutional investors, current account convertibility and financial innovations in international traded financial products and recent global financial crisis made a strong pitch for examining the interlinkages between the stock price, demand for money, interest rate, foreign investment and exchange rates.

However, the high level of investment, both Indian and foreign, in the Indian equity markets together with the liberalized capital flows have resulted in the stock price and exchange rate becoming increasingly interdependent but at the same point of time it has increased the cost of downside

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risk in a low income country like India. To keep that in mind, the basic objective of any economy policy such as price stability has to be ensured while formulating policies for the overall development of the financial markets. From the monetary or economic policy point of view, developed financial markets are critical for effective transmission of monetary policy shocks to the rest of the economy. Transmission of monetary policy is impossible without efficient price discovery particularly with respect of interest rates and exchange rates. Deep and liquid financial markets significantly contribute to efficient price discovery in various segments of financial markets. Strong interlinkages and well-integrated financial markets improve efficacy of policy impulses by enabling quick transmission of changes in the central bank's short-term policy rate to the entire spectrum of market rates, both short and long-term, in the money, the credit and the bond markets (Mohan, 2007). However, various benefits emanating from the functioning of the financial markets depend critically upon the resilience of various segments of the market to withstand shocks and the strength of the risk management systems in place. In view of the critical role played by the financial markets in financing the growing needs of various sectors of the economy, it is important that financial markets are developed further and well integrated. In addition to that, excessive fluctuations and volatility in financial markets can mask the underlying value and give rise to confusing signals, thereby hindering efficient price discovery. Furthermore, deregulation, liberalization, and globalization of financial markets pose several risks to financial stability. Financial markets are often governed by herd behavior and contagion and excessive competition among financial institutions can also lead to a race to the bottom. It is in this context, the interlinkages between stock prices, demand for money, interest rates and exchange rates assumed important for practitioners and policy makers. For policy makers, these prices would act as feedback on the effects of policy measures. For market players and practitioners, knowledge of dynamic linkages would enable them to predict the behavior of one market on the basis of the information from the other.

The theoretical literature appears to accept the existence of an interrelationship between stock price, demand for money, interest rate, foreign investment and exchange rates, but different models posit different kinds of relationship. There is no consensus on the nature of the relationship, with some claiming a positive relationship and some a negative. The interaction is also seen to be medicated through different variables in the different models. Equally important to the sign of the relationship is the direction of change. Is it movements in stock price that lead to exchange rate changes through demand for money, interest rates, foreign investments, or the other way round? The importance of the answer is self evident. In particular, for policy makers, knowledge of this would suggest whether they should carry out changes in the exchange rate to effect a change in the domestic stock market, or the other way around. The theoretical literature, however, does not provide a clear answer to this question. This paper looks at the issue from an empirical perspective and attempts to provide some evidence on the interlinkages and causal nexus between stock price, demand for money, interest rates, foreign institutional investment and exchange rates in India.

The paper has been organized in five parts, including this introduction part. Part II provides a brief account of the theoretical aspects of interlinkages between the above said variables. Part III discusses the design of the empirical analysis, data and variable description. The major findings have been outlined in Part IV followed by the concluding observations in Part V.

Literature Review

The interrelationship between stock price, demand for money, interest rate, net foreign investment and exchange rates has been studied in numerous ways. Classical theorist (Flow Oriented models by Dornbusch and Fisher (1980)) postulates that the relationship leads exchange rates to stock prices where as portfolio balance models (Stock Oriented models by Branson and Frankel (1983)) of exchange rate determination suggests a negative relationship between stock prices and exchange rates.

Researchers have used four major techniques to study the inter-relationship between the stock prices, demand for money, interest rate, net foreign investment and exchange rates. The first approach is to use a simple time series regression model between the aforementioned variables to investigate the interrelationship. Studies like Aggarwala (1981), Sonnen and Hennigar (1988) establish the relation between exchange rate and stock prices. They have pointed out that a change in exchange rate could change the stock prices of multinational firms directly and those of domestic firms indirectly. In case of multinational firms, a change in exchange rate will change the value of that firm's foreign operation, which will be reflected in its balance sheet as a profit or loss. Consequently, it contributes current account imbalance. Once that profit or loss is announced, the firm's stock price will change. Further, a general downward movement of the stock market will motivate investors to seek better return elsewhere. This decreases the demand for money and pushes interest rate down, thus causing huge outflows of funds and hence depreciating the currency.

However, in case of domestic firms, devaluation could either raise or lower a firm's stock price depending upon whether a particular firm is an exporting firm or it is a heavy user of imported input. If it is involved in both the activities, the stock price could move in either direction. Consider the case of domestic firm, which is an exporting firm. This firm will directly benefit from devaluation due to increased demand for its output. Since higher sales usually result in higher profit, its stock price will increase, whereas in case of a user of imported inputs of domestic firm, devaluation will raise its costs and lower its profits. The news of decline in profits may depress the firm's stock price.

The second approach measures the foreign exchange exposure on the return of the stock. Jorion (1990) estimates currency sensitivities for the universe of five US multinationals over the period 1971-1987. He found that only 5% of total numbers of firms in his sample has a significant currency exposure. Diermeier and Solnik (2001) compared the stock factor of domestic firms with the stock factor of non-domestic firms. They find that the ratio of foreign sales has impact on the relation between the non-domestic stock market factor and the currency risk factor. The result is consistent with theoretical expectation. Foreign exchange rate has more impact on the net income of non-domestic firms as compared to domestic firms.

The third approach adopts a multifactor Arbitrage Pricing Theory (APT) type of model. Hsing and Loo (1996) use this approach to investigate whether there is any linkage between foreign exchange risk and common stock return for US, Canada, England and Japan. Their multi-factor APT model is specified as:

$$E(R)_{kt} = E(r)_k + \beta_{kw} E(r)_{wt} + \beta_{km} E(r)_{mt} + \beta_{ke} E(r)_{et} \quad (1)$$

APT model shows $E(R)_{kt}$, the expected return of a stock in country k, is a function of expected returns from assets invested ($E(r)_k$), expected returns from world market ($E(r)_{wt}$), expected returns from national market ($E(r)_{mt}$) and expected return from foreign exchange rate ($E(r)_{et}$). β_{kw}, β_{km}, and β_{ke} are the sensitivities of the expected asset's return to the expected returns of the world market, national market and foreign exchange rate respectively. Hsing and Loo (1996) set the restriction on the parameters in order to find whether there is significant effect on common stock returns from foreign exchange rate. *First*, Hsing and Loo used time-series ARIMA model to extract the white noises from the series of exchange rate movements to remove unanticipated shocks. They checked the lags from 1 to 24 to test autocorrelation for each exchange rate series. They observed no autocorrelations and partial autocorrelations during the period of the study. *Then*, the likelihood ratio test was carried out on each β. Their results show the β of world market and national markets are significant at 5% level while a few of the β_s of foreign exchange rate are also significant at the 5% level. Hsing and Loo's results indicate that foreign exchange rate plays an important role in investors' decisions. Their decisions, in turn, will affect the supply of funds invested in the stock market. Therefore the linkage between foreign exchange rate and stock market is empirically supported.

The fourth approach is to use Granger causality and co-integration tests to examine the interlinkages between stock and other macro economic variables including foreign exchange rate. Horobet et al. (2007) examine the dynamic link between stock prices and exchange rates in the small open eastern European country of Romania. They employed two variable co-integration and Granger causality tests on daily and monthly exchange rates and stock prices data over the period from 1999 to 2007. They found no co-integration for the whole sample period as well as the two sub-periods. From Granger causality test, they found uni-directional causality from stock market to exchange rates for the whole period and the second sub-period. However, they found bidirectional causation in the first sub-period. To examine the long run equilibrium relationship between the co-integrated variables, the authors used modified Granger causality tests that include error correction terms. The result of this modified Granger causality test shows that exchange rates lead the stock prices. They also find that stock market adjusts quite dramatically to changes in the exchange rates in a month.

At the outset, existing literature speaks about the microeconomic as well as macroeconomic theoretical foundations of the linkage between stock prices and macro economic variables including exchange rates (Abdalla and Murinde, 1997; and Kim, 2003). At the micro level, the linkage is conceptualized and modeled in the context of exchange rate exposure by firms with significant foreign trading activities.

At the macroeconomic level, the main line of enquiry relates to the relationship between aggregate stock prices and the floating value of the exchange rate. It is predicted that a negative relationship exists between the strength of the home currency and the aggregate stock price index, as given by:

$$Ds_t=\alpha+\beta DRS_t+cDi_t+\varepsilon t \qquad (2)$$

where Ds_t is the change in real exchange rate; DRS_t is the real stock return differential (domestic minus foreign); and Di_t is the change in interest rate differential.

The above specifications may be sensitive to the exchange rate regime in force. For example, economic theory suggests that, under a floating exchange rate regime, exchange rate appreciation

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reduces the competitiveness of export markets; it therefore has a negative effect on the domestic stock market. Conversely, for an import dominant country, exchange rate appreciation lowers input costs and generates a positive impact on the stock market. Thus, in a macro economic framework, the relationship between exchange rates and stock prices can be best captured by including other macro variables in the model. Following Smith (1992a), such a broad model is specified as follows:

$$E_{ug} = \alpha_0+\alpha_1E_{uj}-\alpha_2R_{gu}+\alpha_3R_{ju}+\alpha_4S_g+\alpha_5S_j+ \alpha_6S_u+\alpha_7A_g+\alpha_8A_j+\alpha_9A_u+\alpha_{10}(A_g-A_g^{g(D)}) -\alpha_{11}CCAS^g \quad (3)$$

$$E_{uj} = \beta_0+\beta_1E_{ug}+\beta_2R_{gu}+\beta_3R_{ju}+\beta_4S_g+\beta_5S_j+ \beta_6S_u+\beta_7A_g+\beta_8A_j+\beta_9A_u+\beta_{10}X_{xx}+ \beta_{11}(A_j-A_j^{j(D)})CCAS^j \quad (4)$$

where E_{ug} is the US-German exchange rate; $A_g^{g(D)}$ is the debt of the German Government; E_{uj} is the US-Japanese exchange rate; $CCAS^g$ is the German current account surplus; R_{gu} is the German-US interest rate differentials; R_{ju} is the Japanese-US interest rate differential; S_j, S_u, S_g are the Japanese, US and German equity values respectively; A_j ,A_u, A_g are the Japanese, US and German bond values respectively, and (A_j -$A_j^{j(D)}$) is the debt of Japanese government.

Empirical studies in this line based on the model in equations (3) and (4), have uncovered mixed results. On the other hand, it had been found that a significant positive relationship exists between equity prices and exchange rates (representative examples are Smith, 1992b; Solnik, 1987).

Solnik (1987) employing regression analysis on monthly and quarterly data for eight industrialized countries from 1973 to 1983 found that a negative relationship between real domestic stock returns and real exchange rate movements. However, for monthly data over 1979-83, he observed a weak but positive relation between the two variables.

Soenen and Hanniger (1988) employed monthly data on stock prices and effective exchange rates for the period 1980-1986. They discovered a strong negative relationship between the value of the US Dollar and the change in stock prices. However, when they analyzed the above relationship for a different period, they found a statistical significant negative impact of revaluation on stock prices.

Jorion (1990), found a moderate relationship between the rate of return in US multinational firms common stocks and the rate of change in a trade weighted value of US dollar over 1971 to 1987.

Gavin (1989) focused on the relationship between exchange rate and stock market of the small open economy. He found evidence of an interaction of output, profitability, stock prices and aggregate demand tends to dampen the exchange rate.

Ma and Kao (1990), using the monthly data from 1973 to 1983 on six major industrialized countries, found that domestic currency appreciation negatively affects the domestic stock price movements for an export dominant economy and positively affects an import dominant economy.

Smith (1992a) attempted to derive an estimable exchange rate equation by considering the portfolio balance model. The model considered values of equities, stocks of bonds and money as important determinants of exchange rates, which were then applied to the German Mark vis-à-vis US Dollar and Japanese Yen vis-à-vis US Dollar exchange rate by using a general model of optimal choice over risky assets. He has considered the study period spanning from January 1974 to March 1988. The study found that equity value has a significant influence on exchange rates but the stock of money and bond has little impact on exchange rates. These results imply not only that equities are an important additional factor to include in portfolio balance models of the exchange rate, but also suggest that the impact of equities is more important than the impact of government bonds and money.

Rittenberg (1993) employed the Granger causality tests to examine the relationship between exchange rate changes and stock price level changes in Turkey. Since causality tests are sensitive to lag selection, therefore he employed three different specific methods for optimal lag selection i.e., an arbitrarily selected, Hsiao method (1979), and the SMART or subset model auto regression method of Kunst and Martin (1989). In all cases, he found that causality runs from price level change to exchange rate changes but there is no feedback causality from exchange rate to price level changes.

Bartov and Bodnar (1994) concluded that contemporaneous changes in the dollar have little power in explaining abnormal stock returns. They also found a lagged change in the dollar is negatively associated with abnormal stock returns. The regression results showed that a lagged change in the dollar has explanatory power with respect to errors in analyst's forecasts of quarterly earnings.

Ajayi and Mougoue (1996) made an attempt to examine the intertemporal relation between stock indices and exchange rates for a sample of eight advanced countries during the period 1985:4 to 1991:6. Using co-integration and causality test on daily closing stock market indices and exchange rates, they found that (i) an increase in aggregate domestic stock price has a negative short run effect on domestic currency values; (ii) sustained increase in domestic stock prices will induce domestic currency appreciation in the long run; (iii) currency depreciation has negative short and long run effects on the stock market.

Ong and Izan (1999) employed Nonlinear Least Square method to examine the association between stock prices and exchange rates. They found that *U* share price returns fully reflect information conveyed by movements in both Japanese yen and the French franc after four weeks. Morley and Pentecost (2000) investigated the nature of the relationship between stock prices and spot exchange rates in G-7 countries by employing the co-integration test and co-dependence technique. The study considered the monthly observations spanning from January 1982 to January 1994. The study broadly concluded that stock prices and exchange rates do not exhibit common trends, but do exhibit common cycles.

Saadet (2003) examined empirically the relationship between stock prices and exchange rate by using the daily data from 1990 to 2002 of exchange rates and aggregate stock indices of Turkey. By employing Johansen's co-integration test and Granger causality test, this study found a long run stable relationship between stock indices and exchange rate. The study also concluded that causality relationship existed only from exchange rate to industry sector index.

Phylaktis and Ravazollo (2005) examined the long run and short run relationship between stock prices and exchange rates in Pacific basin countries. They employed co-integration and multivariate Granger causality tests to investigate this relationship for the period of 1980 to 1998. Their results found that a positive relationship existed in these markets. Hau and Rey (2006) developed an equilibrium model in which exchange rates, stock prices, and capital flows are jointly determined. They show that net equity flows into the foreign market are positively correlated with a foreign currency appreciation.

Bhattacharya et al. (2002) studied the nature of causal relation between stock market, exchange rate, foreign exchange reserves and value of trade balance in India from 1990:4 to 2001:3 by applying co-integration and long run Granger non causality test. The study suggested that there was no causal linkage between stock prices and these three variables under consideration.

Rahman et al. (2007) empirically studied the issues of possible Granger causality and interactive feedback relationships between exchange rate changes and stock market returns of India and Japan. They have employed the daily data from January 1998 through December 2005. The time series data are found stationary in levels by ADF (Augmented Dickey-Fuller) test for unit root. No discernible evidence of Granger causality is observed between the above variables for Japan. However, such relationship is discovered in case of India, although not quite substantial. Evidence of very short-run interactive feedback relationships exists in both countries. Japanese stock and foreign exchange markets depict no intra-market risk-transmissions. In case of India, stock market seems to transmit relatively more risk to foreign exchange market than vice versa.

Thorough review, as outlined above, vindicates that at the macroeconomic level, most of the empirical studies show a negative relationship between exchange rates and stock prices. However, some studies have uncovered a positive relationship, while most of the studies on European markets tend to show a bi-directional causality and are therefore inconclusive and the conclusions are mixed. Apart from this, a few studies undertaken in the context of India provides no consistent results. In view of the foregoing, it can be argued that at the micro as well as macro levels, there is no much theoretical and empirical consensus on the interrelationship between exchange rates and stock prices. With this background, this paper aims to examine a thorough analysis of any possible relationship between the stock prices, demand for money, interest rate, net foreign investment and exchange rates in the post subprime mortgage crisis.

Methodology

To examine the dynamic short term and long term interaction between stock price, demand for money, interest rate, net foreign institutional investment, and exchange rates, we have applied the standard Granger (1995) causality test, Johansen Maximum Likelihood procedure, and Vector Auto Regression (VAR) technique, due to three reasons: *firstly*, in case of VAR modeling, we do not have any prior information regarding the endogenity and exogenity of the variables. *Secondly*, VAR comes with a number of tools such as impulse response functions and variance decompositions, which is not there in Granger causality test. *Thirdly*, in the case of more than a two variables system, Granger causality may not be robust enough to capture the causality in the presence of VAR.

Variables and data description

A five-variable VAR system has been constructed. Variables considered in the model are:

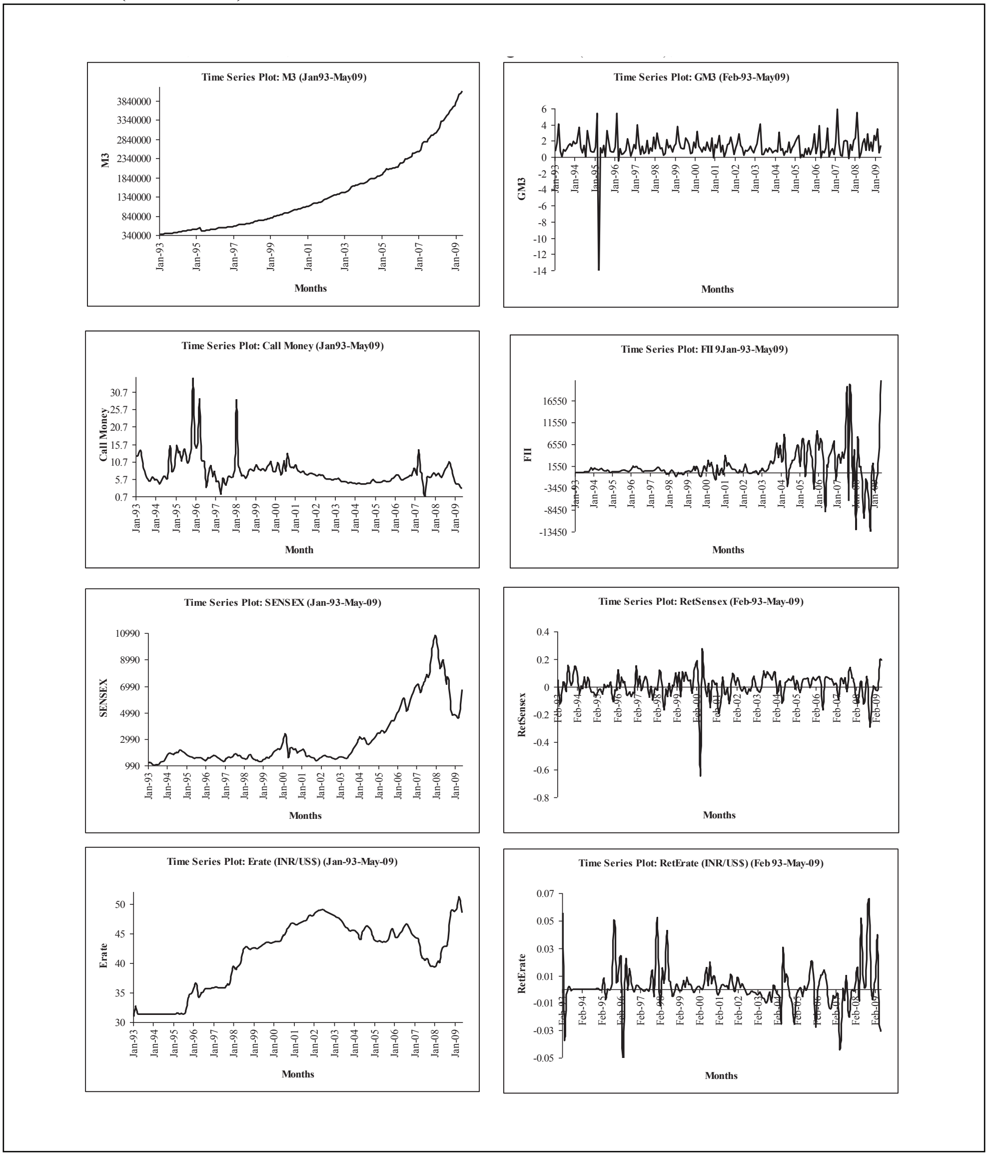
(i) BSE Sensitive index to represent the Indian Stock market.
(ii) Broad money supply (M_3) considered as proxy for demand for money.
(iii) Because there is no such data available to measure the demand for money in Indian context, call money rate is considered to represent the interest rate because call money rate is a market determined rate based on demand and supply of money in the money market and can represent the general market movements.

(iv) Net foreign institutional investment is considered to represent the foreign investment.

(v) To represent the exchange rate, the study considered the nominal bilateral exchange rate of Indian Rupee versus US Dollar (INR / USD).

The study is based on the monthly data covering the period from January 1993 to May 2009, forming around 197 observations. The data on BSE Sensitive (SENSEX) index are collected from BSE website and the data for exchange rates, demand for money (M_3), interest rate

Figure 1. Monthly movements M3, GM3, call money rate, net foreign institutional investment, BSE Sensex, RetSensex, nominal bilateral exchange rates (INR/US$), and RetErate



(Call Money), and net FII investment are collected from the Pacific Exchange Rate Data Base Services and the Handbook of Statistics on Indian Economy respectively.

The analysis is based on both the return of stock price (Ret Sensex) and exchange rate (Ret Erate). For return analysis the monthly closing price data are converted into continuously compounded rate of return R_t by taking the logarithmic first difference of the prices, i.e:

$$R_t = ln\ (P_t / P_{t-1}) * 100$$

It may be mentioned here that the rate of stock returns is defined as the dividend plus the percentage change in stock prices.

Similarly, the growth rate of demand for money is computed as:

$$GM_3 = log\ (M_3) – log\ (M_3\{1\})$$

Result and Discussion

The entire analysis is based on the monthly time series data. The data points are deseasonalised to remove the seasonal fluctuations by employing X-12 (census) method. Before presenting any time series econometric analysis of the data, it would be useful to observe the broad trends and behavior of the variables, which in turn will be helpful in interpreting the model results. For this purpose, time series plots are drawn for all the variables. Figure 1 plot the monthly movements of M_3, GM_3, call money rate, net foreign institutional investment, BSE Sensex, RetSensex, nominal bilateral exchange rates (INR/USD), and RetErate.

It is quite clear from the figures of RetSensex and RetErate that the returns exhibit pronounced clustering - a fact consistent with the observed empirical regularities regarding the asset returns as well as the exchange rate returns.

The summary statistics of all the considered variables are incorporated in the Table 1. The stock indices (BSE Sensex) and exchange rates (INR/USD) have very small positive rate of returns per month and the kurtosis coefficient, a measure of thickness of the tail of the distribution which is quite high. A Gaussian (normal) distribution has kurtosis equal to three and hence this implies that the assumption of Gaussianity cannot be made for the distribution of the concerned variables. This finding is further strengthened by Jarque-Bera test for normality which in our case yields very high values- much greater than for a normal distribution rejecting the null hypothesis of normality of return distributions at any conventional confidence level.

Taking into account of the non-stationary nature of the most of the time series data, Augmented Dickey Fuller (ADF) test and Phillips Perron (PP) test (both with trend and intercept and without trend and intercept) are conducted to check

Table 1. Summary statistics

	GM_3	Call	FII	RetErate	RetSensex
Mean	1.269	7.657	1358.187	0.002	0.008
Median	1.109	6.730	534.845	7.21E-05	0.012
Maximum	5.900	34.830	21114.760	0.065	0.256
Minimum	-15.307	0.730	-13461.390	-0.062	-0.638
Std. Dev.	1.619	4.067	4039.146	0.015	0.089
Skewness	-4.962	3.212	1.276	0.830	-2.040
Kurtosis	57.978	18.630	11.402	8.552	16.397
Jarque-Bera	25488.980	2332.425	629.754	274.330	1601.806
Probability	0.000	0.000	0.000	0.000	0.000
Sum	248.743	1500.910	266205.300	0.452	1.755
Sum Sq. Dev.	511.400	3226.691	3.18E+09	0.045	1.557
LB Q (2)	23.333	261.770	47.185	25.928	12.598
Probability	0.025	0.000	0.000	0.011	0.399
Observations	196	196	196	196	196

Note: L B Q is the Ljung –Box statistic

Table 2: Unit root test

Variables	Without Trend and Intercept		With Trend and Intercept	
	ADF	PP	ADF	PP
GM3	-6.01 (1)*	-10.73 (4)*	-10.90 (1)*	-16.08 (4)*
Call	-2.32(1)**	-2.47(4)**	-5.68(1)*	-7.78(4)*
FII	-5.52 (1)*	-9.30 (4)*	-6.65 (1)*	-10.47 (4)*
RetSensex	-9.83(1)*	-11.84 (4)*	-9.93(1)*	-11.88(4)*
RetNifty	-8.09(1)*	-10.34(4)*	-8.21(1)*	-10.40(4)*
RetErate	-8.85(1)*	-10.98(4)*	-9.08(1)*	-11.04(4)*

Note: The Critical Values for Unit Root Test at 1 %, 5 % and 10 % levels are -2.5762, -1.9414, and -1. 6165 (without Trend and Intercept) and -4.0081, -3.4339, and -3.1406 (with Trend and Intercept) respectively. The lag augmentation is on the basis of optimum lag length selection.
*denotes significance at 1% level, ** denotes significance at 5% level.

Table 3. Lag augmentation criterion test

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1966.188	NA	880.682	20.970	21.056	21.004
1	-1882.848	161.359	473.509*	20.349*	20.865*	20.558*
2	-1861.577	40.053	492.945	20.389	21.335	20.772
3	-1849.908	21.351	568.847	20.530	21.908	21.088
4	-1838.162	20.867	656.704	20.671	22.479	21.404
5	-1807.923	52.113	623.743	20.616	22.854	21.522
6	-1791.305	27.756	686.207	20.705	23.373	21.786
7	-1762.501	46.576*	664.776	20.664	23.763	21.920
8	-1750.019	19.518	768.383	20.798	24.327	22.227

Note: * indicates lag order selected by the criterion
LR : sequential modified LR test statistic (each test at 5% level)
FPE : Final prediction error
AIC : Akaike information criterion
SC : Schwarz information criterion
HQ : Hannan-Quinn information criterion

Table 4. Granger causality test

Null Hypothesis:	F-Statistic	Probability
Call does not Granger Cause GM3	0.601	0.439
GM3 does not Granger Cause Call	3.935**	0.048
FII does not Granger Cause GM3	0.343	0.558
GM3 does not Granger Cause FII	0.010	0.917
RetErate does not Granger Cause GM3	0.150	0.698
GM3 does not Granger Cause RetErate	1.317	0.252
RetSensex does not Granger Cause GM3	0.027	0.867
GM3 does not Granger Cause RetSensex	0.016	0.896
FII does not Granger Cause Call	0.536	0.464
Call does not Granger Cause FII	2.631	0.106
RetErate does not Granger Cause Call	30.979*	8.70E-08
Call does not Granger Cause RetErate	0.133	0.715
RetSensex does not Granger Cause Call	0.116	0.733
Call does not Granger Cause RetSensex	2.667	0.104
RetErate does not Granger Cause FII	5.529**	0.019
FII does not Granger Cause RetErate	7.322*	0.007
RetSensex does not Granger Cause FII	0.290	0.590
FII does not Granger Cause RetSensex	11.883*	0.000
RetSensex does not Granger Cause RetErate	0.929	0.336
RetErate does not Granger Cause RetSensex	6.171**	0.013

the stationarity property of the data as well as to check the order of integration. The results are reported in Table 2. The results show that null hypothesis of unit root is rejected for all the variables at their return level. Both Call Money rate (Call) and Net Foreign Institutional Investment (FII) are stationary at their level. Therefore, it can be concluded that all the variables except Call and FII are integrated of order 1, that is I(1). However, both Call and FII are integrated of order 0, i.e. I (0).

In order to examine the short run dynamic interaction between stock price, demand for money, interest rate, net foreign investment and exchange rates we have employed the Granger causality test. Granger causality test is sensitive to the lag-length used. Some previous researches employed five days lags because of five days trading in both stock and foreign exchange market whereas most of the studies employed Akaike's Information Criterion (AIC (1969, 1970)) and Final Prediction Error (FPE) criterion to search the optimum lag-length that produces the causality, though in the financial world, where information flow is never perfect, the time lag would be fairly short as investors react almost immediately to information in the market. We have employed six lag augmentation criterions such as Log Likelihood, Likelihood Ratio, Final Prediction Error (FPE), Akaike Information Criterion (AIC), Schwartz Information Criterion, and Hannan-Quinn Information Criterion (HQ) to search for optimum lag length in the present study. The test results of the optimum lag length are presented in the Table 3. The results of Granger causality tests are reported in Table 4. The results are summarized as follows: (a) there exists a unidirectional relationship between growth of demand for money (GM_3) and interest rate (Call); (b) there exists a unidirectional relationship between Return on nominal bilateral exchange rate (INR/USD, RetErate) and interest rate (Call); (c) there exists a bidirectional relationship between RetErate and net foreign investment (FII); (d) there exists a unidirectional relationship between FII and RetSensex; (e) there exists a unidirectional relationship between exchange rate return (RetErate) and stock return (RetSensex).

The indepth dynamic interaction is examined through the VAR methodology. According to VAR methodology, ordering of the variables is made by keeping the policy variables first and target variables at the bottom. We tried several orderings of the variables. Since varying the order did not systematically alter the results, we have reported the results for only one ordering which is as follows:

Ordering 1: {Ret Sensex, GM3, CALL, FII, Ret Erate}

The implication for such an ordering is that current innovations in RetSensex can affect the entire system contemporaneously but innovations in GM_3 cannot affect the current period RetSensex. Similarly, a shock in CALL cannot affect the current period Ret Sensex (Ret Nifty) and GM_3 but affects all the remaining variables in the system. Therefore, the variable Ret Erate have been placed at the end of the ordering with the presumption that current innovations in all the variables affect the current period returns whereas current innovations in RetErate can not affect the current period of any variables in the model, except itself.

The above ordering, to some extent is in conformity with macroeconomic logic. An increase in domestic stock prices lead individuals to demand more domestic assets. To buy more domestic assets, they require selling foreign assets as they are less attractive now. Therefore, it leads to increase in demand for money and increase the interest rate. Higher interest rate will attract more foreign investment into domestic country leading to an appreciation of local currency.

Estimation of VAR system

The VAR has been structured in the following manner:

$$M_t = K_m + \sum_{i=1}^{2} \alpha_{mi} M_{t-i} + \sum_{i=1}^{2} \beta_{mi} C_{t-i} + \sum_{i=1}^{2} \lambda_{mi} F_{t-i} + \sum_{i=1}^{2} \gamma_{mi} S_{t-i} + \sum_{i=1}^{2} \delta_{mi} E_{t-i} + e_{mt} \quad (5)$$

$$C_t = K_c + \sum_{i=1}^{2} \alpha_{ci} M_{t-i} + \sum_{i=1}^{2} \beta_{ci} C_{t-i} + \sum_{i=1}^{2} \lambda_{ci} F_{t-i} + \sum_{i=1}^{2} \gamma_{ci} S_{t-i} + \sum_{i=1}^{2} \delta_{ci} E_{t-i} + e_{ct} \quad (6)$$

$$F_t = K_c + \sum_{i=1}^{2}\alpha_{ci}M_{t-i} + \sum_{i=1}^{2}\beta_{ci}C_{t-i} + \sum_{i=1}^{2}\lambda_{ci}F_{t-i} + \sum_{i=1}^{2}\gamma_{ci}S_{t-i} + \sum_{i=1}^{2}\delta_{ci}E_{t-i} + e_{ct} \quad (7)$$

$$S_t = K_s + \sum_{i=1}^{2}\alpha_{si}M_{t-i} + \sum_{i=1}^{2}\beta_{si}C_{t-i} + \sum_{i=1}^{2}\lambda_{si}F_{t-i} + \sum_{i=1}^{2}\gamma_{si}S_{t-i} + \sum_{i=1}^{2}\delta_{si}E_{t-i} + e_{st} \quad (8)$$

$$E_t = K_e + \sum_{i=1}^{2}\alpha_{ei}M_{t-i} + \sum_{i=1}^{2}\beta_{ei}C_{t-i} + \sum_{i=1}^{2}\lambda_{ei}F_{t-i} + \sum_{i=1}^{2}\gamma_{ei}S_{t-i} + \sum_{i=1}^{2}\delta_{ei}E_{t-i} + e_{et} \quad (9)$$

where t is the time, M, C, F, S and E represent growth of demand for money, call money rate (a proxy for short term interest rate), net FIIs investment in Indian equity market, return on monthly averages of stock prices, return on exchange rates respectively. Here all the variables are expressed on log levels except M, C and F. The K_s, α_s, β_s, λ_s, γ_s and δ_s are coefficients that determine how the variables interacts and es are the error terms which capture the monthly unexplained or surprise movement in each variable.

The model as specified in ordering-1 is estimated with the above specified Equations from 5 to 9. The model has been estimated using VAR model- Eviews-6.0 package. The results are presented in Tables 5 and 7. The results are first analyzed in terms of impulse response and then variance decomposition.

Impulse response function

Impulse response function shows the possible dynamic response of all the variables in the system to shock or innovation in each variable. In this study, we have computed 24 period (two years) ahead impulse responses for the VAR system. Impulse responses of each variable are reported in Tables 5, where only five impulses are reported such as one month, four month, eight month, 12 month and 24 month ahead period horizon.

Table 5. Impulse response function

Due to Shock in	Steps	Responses to				
		RetSensex	GM_3	Call	FII	RetErate
RetSensex	1	0.086437	0.000000	0.000000	0.000000	0.000000
	4	0.001349	0.000715	-0.003175	0.003623	-0.003960
	8	0.000115	0.000092	-0.000457	0.000340	-0.000479
	12	0.000014	0.000012	-0.000061	0.000043	-0.000063
	24	0.000000	0.000000	-0.000000	0.000000	-0.000000
GM_3	1	-0.131129	1.620646	0.000000	0.000000	0.000000
	4	0.001669	0.003133	-0.020393	0.007268	-0.016800
	8	0.000558	0.000505	-0.002534	0.001707	-0.002564
	12	0.000078	0.000067	-0.000336	0.000237	-0.000345
	24	0.000000	0.000000	-0.000000	0.000000	-0.000000
Call	1	-0.156779	0.443814	2.961289	0.000000	0.000000
	4	-0.084263	-0.110374	0.577429	-0.291046	0.535537
	8	-0.016820	-0.014793	0.074038	-0.051065	0.075510
	12	-0.002307	-0.001972	0.009835	-0.006950	0.010113
	24	-0.000000	-0.000000	0.000023	-0.000016	0.000024
FII	1	1027.676	-123.6248	-202.8301	3728.071	0.000000
	4	66.45392	33.49795	-157.7598	178.7052	-194.5700
	8	5.676006	4.582038	-22.68153	16.83915	-23.72277
	12	0.719905	0.610661	-3.042536	2.164061	-3.135419
	24	0.001697	0.001446	-0.007210	0.005107	-0.007420
RetErate	1	-0.002861	-0.000087	-0.000855	-0.005075	0.012890
	4	-0.000223	-0.000031	0.000024	-0.000514	0.000275
	8	-0.000006	-0.000003	0.000015	-0.000016	0.000018
	12	-0.000000	-0.000000	0.000002	-0.000001	0.000002
	24	-0.000000	-0.000000	0.000000	-0.000000	0.000000

Impulse response functions of stock returns, growth of demand for money, interest rate, foreign institutional investment and exchange rate return due to shock in stock returns

Table 5 reveals that a one standard deviation shock in Retsensex (equal to 0.086437 units) has no contemporaneous effect on GM_3, Call, FII, and RetErate. In period 4, a one standard deviation increase in RetSensex (equal to 0.001349 units) gives contemporaneous increase in GM_3 and FII by 0.000715 units and 0.003623 units respectively but a contemporaneous fall in Call and RetErate by 0.003175 units and 0.003960 units respectively. In period 8, RetSensex is still 0.000115 units above its mean, while GM_3 and FII are 0.000092 units and 0.000340 units higher but decreases Call and RetErate by 0.000457 units and 0.000479 units contemporaneously. In period 12, a one standard deviation increase in RetSensex (equal to 0.000014 units), induces a contemporaneous increase in GM_3 and FII by 0.000012 units and 0.000043 units respectively, but decline in Call and RetErate by 0.000061 units and 0.000063 units respectively. In period 24, there has no contemporaneous effect on GM_3, Call, FII and RetErate due to shock in Retsensex. This finding is clear from the Figure 2, Panel-a, which shows that the normalized random one standard deviation shock to each variable in the VAR system produces fluctuating responses in stock returns up to seven-period ahead time frames. Thereafter, the responses decay towards zero.

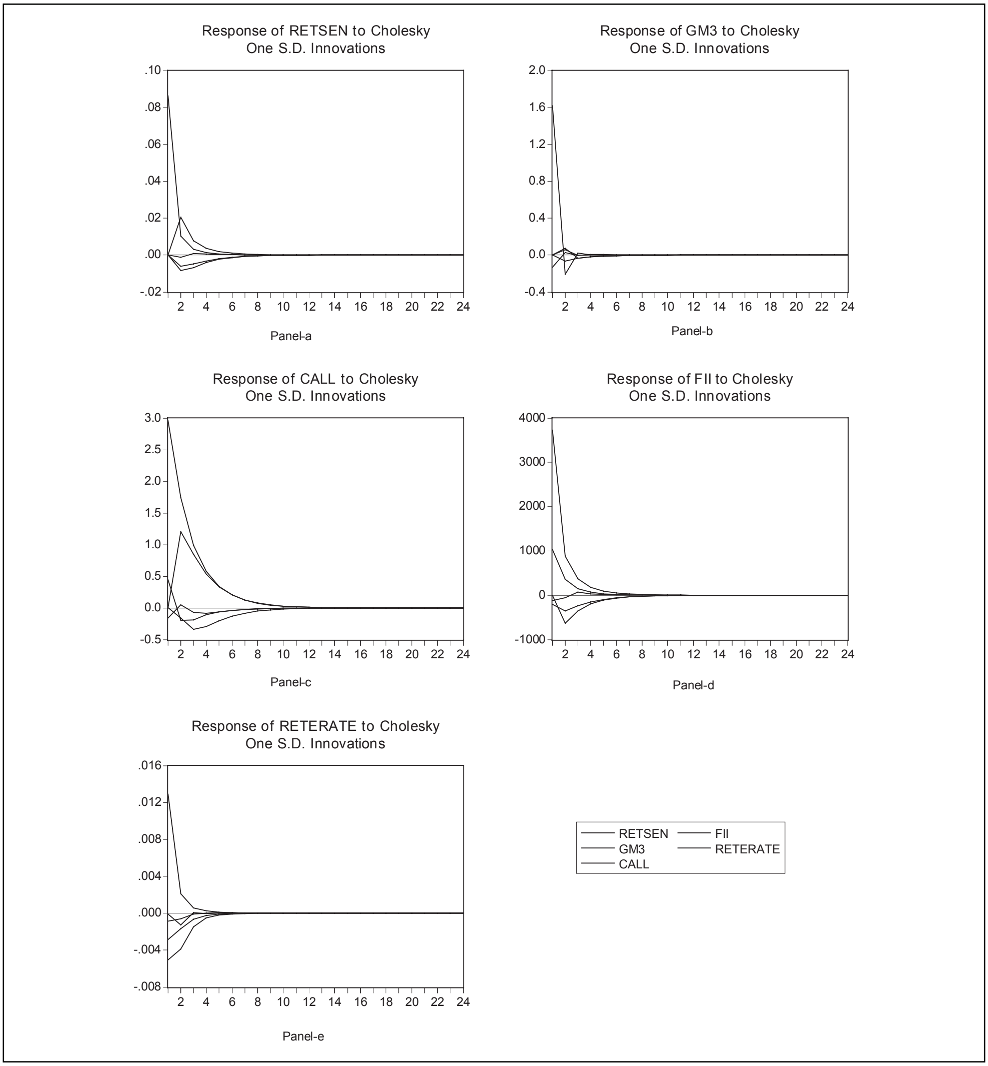
Impulse response functions of stock returns, growth of demand for money, interest rate, foreign institutional investment and exchange rate return due to shock in growth of demand for money

A one standard deviation increase in GM_3 (equal to 1.620646 units) induces no contemporaneous effect in Call, FII, and RetErate but decreases RetSensex by 0.131129 units in period 1. In period 4, a one standard deviation increase in GM_3 by 0.003133 unit increases RetSensex and FII by 0.001669 units and 0.007268 units respectively and decreases Call and RetErate by 0.020393 units and 0.016800 units respectively. Similarly, in period 8, a rise in GM3 by 0.000505 units gives rise in RetSensex and FII by 0.000558 units and 0.001707 units respectively but it has decreased Call and RetErate by 0.002534 units and 0.002564 units contemporaneously. In period 12, GM_3 still 0.000067 units above its mean, while RetSensex and FII are 0.000078 units and 0.000237 units higher respectively but it has decreased Call and RetErate by 0.000336 and 0.000345 units contemporaneously. The response of GM_3 due to one standard deviation shock in RetSensex, Call, FII and RetErate can be clearly shown in Figure 2, Panel-b. Panel-b shows that the responses of GM_3 due to shock in Call, FII, RetSensex and RetErate are fluctuating up to five-period ahead time frames. Thereafter, the responses decay towards zero.

Impulse response functions of stock returns, growth of demand for money, interest rate, foreign institutional investment and exchange rate return due to shock in interest rate

Again a one standard deviation increase in Call (equal to 2.961289 units) has no contemporaneous effect on FII and RetErate and increases GM3 by 0.443814 units. But it decreases RetSensex by 0.156779 units. In period 4, an increase in Call by 0.577429 units leads to increase in RetErate by 0.535537 units, while decrease in RetSensex, GM3, and FII by 0.084263, 0.110374 and 0.291046 units contemporaneously. In period 24 when Call increases by 0.009835 units above its

Figure 2. Impulse response function of RetSensex, GM3, Call, FII, and RetErate



mean, RetErate increases by 0.010113 units but RetSensex, GM3, and FII decreases by 0.002307, 0.001972, and 0.006950 units contemporaneously. The responses of Call due to one standard deviation shock in RetSensex, GM3, FII and RetErate are shown in Figure 2, Panel-c. From Panel-c, it can be concluded that there is no definite pattern of relationship between RetSensex, GM3, Call, FII and RetErate. The response of Call due to shock in RetSensex, GM3, Call, FII and RetErate are fluctuating up to 11 periods ahead time frame. Thereafter, the responses decay towards zero.

Impulse response functions of stock returns, growth of demand for money, interest rate, foreign institutional investment and exchange rate return due to shock in foreign institutional investment

In Table 5, a one standard deviation increase in FII (equal to 3728.071 units) has no contemporaneous effect on RetErate, but it has decreases GM_3 and Call by 123.6248 units and 202.8301 units and increases RetSensex by 1027.676 units in period 1. But in period 4, a one standard deviation positive innovation in the FII (equal to 178.7052 units) increase RetSensex and GM_3 by 66.45392 units and 33.49795 units respectively but decrease Call and RetErate by 157.7598 and 194.5700 units contemporaneously. In period 8, an increase in FII by 16.83915 units leads increase in RetSensex and GM_3 by 5.676006 units and 4.582038 units contemporaneously while a decrease in Call and RetErate by 22.68153 and 23.72277 units respectively. In period 12, when FII increases by 2.164061 units, RetSensex, GM_3 increase by 0.719905, and 0.610661 units respectively but Call and RetErate decreases by 3.042536 and 3.135419 units. Similarly in period 24, an increase in FII by 0.005107 units above its mean level leads to an increase in RetSensex and GM_3 by 0.001697 units and 0.001446 units contemporaneously but decreases Call and RetErate by 0.007210 and 0.007420 units. The responses of RetSensex, GM_3, Call, FII and RetErate to the shock in FII are shown in Figure 2, Panel-d. From panel-d, it is clearly shown that all the concerned variables are fluctuating up to seven periods time frame. Thereafter, the responses decay towards zero.

Impulse response functions of stock returns, growth of demand for money, interest rate, foreign institutional investment and exchange rate return due to shock in exchange rate return

Further, a one standard deviation increase in RetErate (equal to 0.012890 units) has decreased RetSensex, GM_3, Call and FII by 0.002861, 0.000087, 0.000855 and 0.005075 units contemporaneously in period 1. But in period 4, a one standard deviation positive innovation in RetErate (equal to 0.000275 units) increase Call by 0.000024 units but it decreases RetSensex, GM_3 and FII by 0.000223, 0.000031 and 0.000514 units and respectively. Similarly in period 12, an increase in RetErate by 0.000002 units has no contemporaneous effect on RetSensex and GM_3 but increases Call by 0.000002 units and decreases FII by 0.000001 units. The responses of RetSensex, GM_3, Call, FII and RetErate to the shock in RetErate are plotted in Figure 2, Panel-e. From Panel-e, it is clearly shown that all the concerned variables are fluctuating up to seven periods timeframe.

Variance decomposition

Variance decomposition is used to detect the causal relations among variables. It explains the extent at which a variable is explained by the shocks in all the variables in the system. The forecast error variance decomposition explains the proportion of the movements in a sequence due to its own shocks versus shocks to the other variables. The forecast error variance decomposition results are reported in Table 6.

Stock return and exchange rate return

In Table 6, at one step ahead horizon, 0% forecast error variance in return on BSE Sensex is explained by the shock in return on exchange rate, where as returns on BSE Sensex explain 4.07% forecast error variance in RetErate in the same period. In period 4, a shock in RetErate explains 1.62% of forecast error variance returns on BSE Sensex. However, in the same period, returns on BSE Sensex explain a substantial fraction i.e. 5.05% of forecast error variance in RetErate. Similarly, at 24 step ahead horizon, the innovation in RetSensex explain 5.05% of forecast error variance in RetErate whereas, the RetErate explains only 1.71% variance in RetSensex for the same period. From these findings, it can be surmised that the causality runs from RetSensex to RetErate, which, in turn, implies that the returns on BSE Sensex affects exchange rate return.

Stock return and net foreign investment

In Table 6, at eight-step ahead horizon, 6.02% of forecast error variance in RetSensex is explained by the shock in FII, where as RetSensex explain 7.14% forecast error variance in FII in the same period. Similarly, at 24 ahead period horizon, 6.02% forecast error variance in RetSensex is explained by FII, whereas RetSensex explains only 7.14% of forecast error variance in FII in the same period. These findings suggest that return on BSE Sensex affects FII.

Stock return and interest rates

Similarly, between RetSensex and Call in Table 6, at 24 step ahead horizon, 0.93% of forecast error variance in RetSensex is explained by the shock in Call, whereas RetSensex explains 0.27% of forecast error variance in Call. Thus from these findings, we fail to conclude if the causality runs from Call to RetSensex or RetSensex to Call.

Stock return and growth of demand for money

At 24 step ahead horizon 0.03% of forecast error variance in RetSensex is explained by the shock in GM_3 in Table 6. However, RetSensex explains 0.66% of forecast error variance in GM_3. This finding suggests that RetSensex affects GM_3.

Growth of demand for money and exchange rate return

In Table 6, at 24 step ahead horizon, between GM_3 and RetErate, 0.24% of

Table 6. Variance decomposition

Variables Explained	Steps	By Innovations in RetSensex (%)	GM_3 (%)	Call (%)	FII (%)	RetErate (%)
RetSensex	1	100.000	0.000	0.000	0.000	0.000
	4	91.503	0.030	0.863	5.981	1.620
	8	91.290	0.033	0.936	6.027	1.710
	12	91.287	0.033	0.938	6.027	1.712
	24	91.287	0.033	0.938	6.027	1.712
GM_3	1	0.650	99.349	0.000	0.000	0.000
	4	0.666	98.745	0.219	0.127	0.240
	8	0.666	98.728	0.227	0.129	0.247
	12	0.666	98.728	0.228	0.129	0.247
	24	0.666	98.728	0.228	0.129	0.247
Call	1	0.273	2.190	97.535	0.000	0.000
	4	0.243	1.768	81.333	1.389	15.265
	8	0.278	1.763	80.277	1.765	15.913
	12	0.279	1.763	80.257	1.773	15.925
	24	0.279	1.763	80.256	1.774	15.925
FII	1	7.035	0.101	0.274	92.588	0.000
	4	7.159	0.150	1.470	87.879	3.340
	8	7.147	0.153	1.557	87.696	3.444
	12	7.147	0.153	1.559	87.693	3.446
	24	7.147	0.153	1.559	87.693	3.446
RetErate	1	4.077	0.003	0.363	12.824	82.730
	4	5.055	0.700	0.492	18.993	74.758
	8	5.056	0.700	0.493	19.007	74.741
	12	5.056	0.700	0.493	19.007	74.741
	24	5.056	0.700	0.493	19.007	74.741

forecast error variance in GM_3 is explained by the shock in RetErate, whereas GM_3 explains only 0.70% of forecast error variance in RetErate. From this finding also, we fail to find any causal relationship between GM_3 and RetErate.

Growth of demand for money and net foreign investment

Similarly, between GM_3 and FII in Table 6, at 24 step ahead horizon, 0.12% of forecast error variance in GM_3 is explained by the shock in FII, whereas GM_3 explains 0.15% of forecast error variance in FII. From this finding also, we fail to find any causal relationship between GM_3 and FII.

Growth of demand for money and interest rate

At 24 step ahead horizon, 0.22% of forecast error variance in GM_3 is explained by the shock in Call, whereas GM_3 explains 1.76% of forecast error variance in Call. From this finding, it can be concluded that GM_3 affects Call.

Interest rate and exchange rate return

In between Call and RetErate in Table 6, at 24 step ahead horizon 15.92% of forecast error variance in Call is explained by shock in RetErate, whereas, Call explains only 0.49% of forecast error variance in RetErate. From this finding, it can be concluded that interest rate is more affected by exchange rate return.

Interest rate and net foreign investment

In Table 6, at 24 step ahead horizon, 1.77% of forecast error variance in Call is explained by the shock in FII whereas, Call explains only 1.55% of forecast error variance in FII. From this finding, it is surmised that FII affects Call.

Results from Johansen Maximum Likelihood Co-integration test

In order to confirm the long run equilibrium relationship between stock prices and exchange rates, we proceed to Johansen Maximum Likelihood co-integration test. The results are reported in Table 7.

In both the tables, the trace and λ max statistics confirmed that there is no long run equilibrium relationship between monthly closing stock prices and exchange rates.

Conclusion

This article empirically examined the causal nexus between stock return, growth of demand for money, interest rate, net foreign investment and exchange rate returns. The study found that that the stock return (BSE Sensex) affects exchange rate return, FII

Table 7. Johansen Maximum Likelihood test

Null Hypothesis	Alternative Hypothesis		Critical Values	
λ TRACE TESTS	λ TRACE TESTS	λ TRACE VALUES	5%	1%
r = 0	r > 0	4.817	15.41	20.04
r £	r > 1	0.234	3.76	6.65
r £	r > 2	-	-	-
λ MAX TESTS	λ MAX TESTS	λ MAX VALUES	5%	1%
r = 0	r = 1	4.582	14.07	18.63
r = 1	r = 2	0.234	3.76	6.65
r = 2	r = 3	-	-	-

and RetNifty affects Call. and GM3, GM3 also affects Call. Interest rate (Call) is more affected by exchange rate Return (RetErate), FII affects Call. However, we fail to find any significant causal relationship between Call and RetSensex, GM3 and RetErate and GM3 and FII. The co-integration test confirms that there does not exist any long run equilibrium relationship between stock return and exchange rate return.

The estimation results are strikingly similar in respect of portfolio balance approach in the sense that an exogenous increase in stock prices has a positive wealth effect. Demand for money increases and local or domestic interest rate goes up. This attracts foreign capital and appreciates the domestic currency. The appreciation hurts export competitiveness, reduces output, money demand and the interest rate gap. The appreciation continues so long as local interest rates exceed foreign interest rates. Therefore, in the final equilibrium, we have higher stock prices, an appreciation of the domestic currency and no effect on money demand and interest rates, and, the initial rise is neutralized by a secondary decline. The analysis holds good in an economy with partial capital mobility like India because the relevant foreign interest rate for India is r^*m where m is a premium reflecting partial capital mobility. In equilibrium, $r = r^* + m$.

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