# Integration and Efficiency of Stock and Foreign Exchange Markets in India

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***Abstract***

*This article attempts to examine the integration and efficiency of Indian stock and foreign exchange markets. The study employed Time series ordinary least square regression, Unit Root test, Grangers causality test, Vector Auto Regression techniques on monthly data of stock return and exchange rate return for the period spanning from February 1995 to March 2005.The major finding of this study are as follows. Both the stock indices return (Rsensex and Rnifty) are near normal whereas exchange rate return is not normal and more peak. The stock return and exchange rate return are positively related. The policy implication of this above result of the positive relation between stock return and exchange rate return for the foreign investors in India should be further studied. From the Granger's causality test, it is found that there is no causality for the return series of stock indices and exchange rate except return Nifty and return exchange rate. Weak form of market efficiency hypothesis is also corroborated for stock and foreign exchange markets.*

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**Keywords:** Weak form of market efficiency, stock return, exchange rate return, Buy-Hold strategy, Convex trading strategy, Granger's causality test, Vector Auto Regression

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## 1.0 Introduction

Global investors choose to diversify their funds across the financial markets to reduce the portfolio risk on the assumption that the returns in various financial markets may not be highly correlated. Another related issue is how far the return in one market will enable to predict the return in the other financial market. From the informational efficiency criteria, any past information even if that information may be pertaining to the return in one financial market, it should not enable to predict the future changes in the return in the other financial market. But at the same time, from the rational expectation point of view, all the informations including the returns from any other financial markets should be factored into the return of the financial markets. For example, how far the return in the stock market influences the return in the foreign exchange market and vice versa. In order to study the aforementioned research problems, we have used the time series techniques *viz,* unit root test, OLS regression, Granger's causality and Vector Auto Regression techniques. Our data points are based on the monthly data of stock price and exchange rate, where the sample period spanning from February 1995 to March 2005, forming around 121 observations. Against this background, the present study empirically examined the integration and efficiency of stock and foreign exchange markets in India. One basic issue which has been confronting the practitioners in financial industry is about the probability distribution of the returns in financial markets because it has investing and trading implications .In this context, we have investigated the normality of the return distribution of the respective financial markets. In section 2.0, we discuss the theoretical interlink ages between stock and foreign exchange markets in India. Section 3.0 and 4.0 presents the empirical literature and empirical methodology respectively. Section 5.0 presents the variables description and nature of the data points. Section 6.0 reports the empirical results followed by the conclusion in Section 7.0.

## 2.0 Interlink ages between stock and Foreign Exchange Markets in India: Theoretical Underpinnings

The linkages between stock market performance and exchange rate behavior has long been debated in the economic literature. The arguments for the linkage have been made at both micro and macro economic levels. At the macroeconomic level, the discussion has

been centered around the relationship between aggregate stock price and floating value of exchange rates. This link is seen by models that focus on the current account (Flow Oriented Models, e.g. Dornbusch & Fisher, 1980) as well as those that focus on the asset market (Stock Oriented Models, e.g. Branson & Frankel, 1983), though in different ways. "Flow Oriented" models [Dornbusch & Fisher (1980)] of exchange rate determination focus on the current account or the trade balance. This model posits that currency movements affect international competitiveness and balance of trade positions, and, consequently, the real output of the country, which in turn affects the current and future expected cash flows of firms and their stock prices. The detailed logical deduction of this relationship is like this. Changes in exchange rates affect the competitiveness of a firm as fluctuations in exchange rates affect the value of the earnings and cost of its funds because many companies borrow in foreign currencies to fund their operations and hence its stock prices. But this will affect in either way depending upon whether that firm is an exporting unit or a heavy user of imported inputs. In the case of an exporting firm, a depreciation of the local currency makes exporting goods more attractive and this leads to an increase in foreign demand for export of goods and services. As a result, the revenue of the firm and its value will increase which will in turn increase stock prices. On the other hand, an appreciation of local currency decreases profits of an exporting firm because of decrease in foreign demand of its products. Hence the stock price will decrease. This is exactly opposite to the case of an importing firm as exchange rate changes.

"Stock Oriented" models [Branson & Frankel (1983)] of exchange rates or portfolio balance approach gives emphasis on capital account as the major determinant of exchange rate dynamics. The essence of the portfolio balance model is based on the notion that agents should allocate their entire wealth among domestic and foreign assets including currencies in their portfolio. Hence, exchange rate plays the role of balancing the demand for and supply of assets. Now the logical deduction of negative effects of stock prices on exchange rates is as follows: An increase in domestic stock prices leads individuals to demand more domestic assets. To buy more domestic assets, they need to

sell foreign assets as these are now relatively less attractive. As a result of which, there is an appreciation of local currency due to more demand for domestic assets.

Studies like Aggarwala (1981), Sonnen and Hennigar (1988) establish the relation between exchange rates and stock prices. They have pointed out that a change in exchange rates could change the stock prices of multinational firms directly and those of domestic firms indirectly. In the case of multinational firms, a change in the exchange rate will change the value of that firm's foreign operation, which will be reflected in its balance sheet as profit or loss. Consequently, it contributes current account imbalance. Once the 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 returns 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 the case of domestic firms, devaluation could either raise or lower a firm's stock price depending upon whether that particular firm is an exporting firm or it is a heavy user of imported input. If it is involved in both the activities, then the stock price could move in either direction. Consider the case of an exporting domestic 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 the 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.

Bahmani , Oskooe and Sohrabian (1992) offered an alternative explanation for the effect of stock price on exchange rate. The argument is as follows: Consider the resulting increase in the real balance which will result in an increase in interest rate. Thus domestic assets are more attractive, and, as a result, individual investors or firms will adjust their domestic and foreign portfolio by demanding more domestic assets. The portfolio adjustments of firms and individuals will lead to an appreciation of the domestic currency because they require domestic currency for transaction.

Further, integration of the US stock market with the Pacific basin country's markets and world markets, which led to the requirement of establishing the relationship between stock prices and exchange rates. Thus, an increase in international stock market causes the local stock market to rise, which in turn increases wealth as well as raises interest rates. Higher interest rate will attract foreign capital and lead to an increase in the real exchange rate.

**3.0 Empirical Literature:**

Some of the early studies like Aggawal (1981), Soenen and Hennigar (1988) simply consider the correlation between the two variables. Aggarwal, using monthly U.S. stock price data and the effective exchange rate for the period 1974 to 1978, explored the relationship between the changes in the dollar exchange rates and changes in indices of stock prices. He found a significant positive correlation, and finds that the relationship is stronger in the short run than in the long run. However Soenen and Hennigar, employing monthly data on the same variables, for the period 1980 to 1986, found a strong negative relationship.

Solnik (1987) employing OLS regression analysis on monthly and quarterly data from 1973 to 1983 for eight industrialized countries found 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 Aggarwal (1989) found mixed results among industrial countries. Ma and Kao (1990) tried to attribute these differences to the nature of the countries. They used the asset pricing model on the monthly data from January 1993 to December 1983 on six major industrialized countries and found that domestic currency appreciation negatively affects the domestic stock price movements for an export dominant economy and positively affects an import dominant economy.

Jorion (1998) attempted to analyze and compare the empirical distribution of returns in the U.S. stock market and in the foreign exchange market by using the maximum

likelihood estimation procedure and ARCH model in daily data of exchange rates and stock returns spanning from June 1973 to December 1985. The study found that exchange rates display significant jump components, which are more manifest than in the stock market. The statistical analysis of the study for the foreign exchange market and stock market suggests that there are important differences in the structure of these markets.

Jorion (1990) examined the exposure of U.S. multinationals to foreign currency risk, by employing the time series regression on the rate of return in the U.S. multinational firms' common stocks and the rate of change in a trade weighted value of the U.S. dollar over the period 1971 to 1987. The study found significant cross sectional differences in the relationship between the value of U.S. multinationals and the exchange rate. Given these results, the study focused on the determinants of exchange rate exposure. The co movement between stock returns and the value of the dollar is found to be positively related to the percentage of foreign operations of U.S. multinationals.

Smith, C.E. (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 the US dollar and the Japanese Yen vis-à-vis the 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 be included in the 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.

Bodnar and Gentry (1993) employed the market model of Capital Asset Pricing (CAPM) model and categorized the industries into traded and non traded goods industries covering the USA, Canada and Japan. to examined the relation between changes in exchange rate and industry values. The study had considered the data period from January 1979 to

December 1988 for the USA and Canada and from September 1983 to December 1988 for Japan. The model was estimated using the SURE method for the US, Canada and OLS for Japan. The results of the study indicated that for the three countries, 20-35 percent of industries had significant foreign exchange exposure and particularly with more exposure in the case of Canada and Japan. Except for the US, non-traded goods industries indicated a gain with appreciation of local currency. Industry export and import ratios were associated with negative and positive exposures respectively. For the US and Japan, foreign dominated assets showed a significant negative exposure to exchange rate changes. Overall, the study found insignificant contemporaneous effect.

There have also been several studies that have used cointegration and Granger causality to study the direction of movement between stock prices and exchange rates. Taylor, M. P. *et al.* (1988) was one of the early studies using this. They studied the impact of the abolition of the UK exchange control on the degree of integration of the UK and overseas stock markets such as West Germany, Netherlands, Japan and US employing the Granger causality and Engel Granger Cointegration test over the two sub-periods spanning from April 1973 to September 1979 and October 1979 to June 1986 respectively. The study concluded that, there was no significant increase in the correlation of stock market returns as a result of the abolition of exchange control. Cointegration test confirmed that the UK and foreign (non-US) stock market indices were cointegrated in post-1979 period but not before that.

Oskooe, B.M. and Sohrabian, A. (1992) tried to test the causality as well as cointegration between stock price and effective exchange rate using monthly observations over the period July 1973 to December 1988 for a total of 186 observations from the U.S. economy. They found that there was a bi-directional causality between stock prices and the effective exchange rate of the dollar at least in the short run. The co-integration analysis revealed that there was no long run relationship between two variables.

Libly Rittenberg (1993) employed the Granger causality test to examine the relationship between exchange rate changes and stock price level changes in Turkey. Since causality tests are sensitive to lag selection, 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.

Ajayi, A. and Mougoue (1996) examined the intertemporal relation between stock indices and exchange rates for a sample of eight advanced countries during the period 1985:4 to 1991:6. By employing the co-integration and causality tests on daily closing stock market indices and exchange rates, the study 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 and (iii) currency depreciation has negative short-run and long-run effects on the stock market.

Qiao, Yu (1997) employed daily stock price indices and spot exchange rates obtained from the financial markets of Hong Kong, Tokyo and Singapore over the period from January 3 1983 to June 15 1994 to examine the possible interaction between these financial variables. Based on Granger causality test, he found that the changes in stock prices are caused by changes in exchange rates in Tokyo and Hong Kong markets. However, no such causation was found for the Singapore market. On the reverse causality from stock prices to exchange rates, his results show such causation for only Tokyo market. Therefore for Tokyo market there is a bi-directional causal relationship between stock returns and changes in exchange rates. The study also uses Vector Autoregression model to analyse a long run stable relationship between stock prices and exchange rates in the above Asian financial markets. His results found a strong long run stable relationship between stock prices and exchange rates on levels for all three markets.

Johnson and Soenen (1998) analysed the stock price reactions of 11 Pacific Basin stock markets to exchange rate changes with respect to the US dollar and Japanese Yen for the period January 1985 to June 1995. The study found that a significantly strong positive

relationship is indicated with the Yen while weak and mixed results are reported with regard to the US dollar.

Ong, L.L. and Izan H.Y (1999) employed Nonlinear Least Square method to examine the association between stock prices and exchange rates. They found that the US share price returns fully reflect information conveyed by movements in both Japanese Yen and the French Franc after four weeks. However, this result suggests a very weak relationship between the US equity market and exchange rates. They concluded that depreciation in a country's currency would cause its share market returns to rise, while an appreciation would have the opposite effect.

Studying the long-run and short-run dynamics between stock prices and exchange rates on six Pacific Basin countries such as Hong Kong, Indonesia, Malaysia, Singapore, Thailand and the Philippines over the period 1980 to 1998 through employing co-integration and multivariate Granger causality tests, Katephylaktis and Fahiala Ravazzolo (2000) concluded: (i) there is no long run relationship between the real exchange rate and the local stock market in each of the Pacific Basin countries during the decade of the 1980's or 1990's except Hong Kong; (ii) for all the countries the real exchange rate and the US stock prices are positively related to domestic stock prices for the period of the 1990s; (iii) foreign exchange restrictions have not been found to be an important determinant of the link between the domestic stock and foreign exchange markets on the one hand and between the domestic capital and world capital markets on the other.

Morley, *et al* (2000) investigated the empirical nature of the relationship between stock prices and exchange rates for G-7 countries since the relaxation and abolition of exchange controls in the early 1980s from the period 1982:1 to 1994:1. By employing the co-integration and co-dependence method [developed by Engel and Kozicki (1993), Engel and Vahid (1993))] the study found that stock markets and exchange rates are linked through a common cyclical pattern rather than a common trend.

Ibrahim (2000) investigated the interactions between stock prices and exchange rates in Malaysia, using bi-variate and multivariate co-integration and the Granger causality test. The study took multiple variables such as stock prices, three exchange rate measures, *viz,* the real effective exchange rate, the nominal effective exchange rate and RM/US$, money supply, and reserves during the period 1979:1 to 1996:6. The results from bi-variate models indicated that there was no long-run relationship between the stock market and any of the exchange rates; however, there was some evidence of co-integration when the models were extended to include money supply and reserves. This finding indicates that in the short run, a concerted stance on monetary policy, exchange rate and reserve policy is vital for stock market stability, and, also indicates there is informational inefficiency in the Malaysian stock market. Multivariate test showed: (i) there was unidirectional causality from stock market to exchange rate; (ii) both the exchange rates and the stock indices were Granger caused by the money supply and reserves; (iii) there was bi directional causality between variables only in the case of nominal effective exchange rate.

Amare and Mohsin (2000) examined the long-run association between stock prices and exchange rates for Japan, Hong Kong, Taiwan, Singapore, Thailand, Malaysia, Korea, Indonesia and Philippines. The study considered monthly data spanning from January 1980 to June 1998 and employed cointegration technique. The long-run relationship between stock prices and exchange rates was found only for Singapore and Philippines. They attributed this lack of cointegration between the said variables to the bias created by the "omission of important variables". When interest rate variable was included in their cointegrating equation, they found cointegration between stock prices, exchange rates and interest rate for six of the nine countries.

Granger, C.W.J. *et al* (2000) applying co-integration and Granger causality test and structural break test on daily data of exchange rate and stock prices in Hong Kong, Indonesia, Japan, South Korea, Malaysia, the Philippines, Singapore, Thailand and Taiwan for the period 1986 to 1998 suggested: (i) there exists very little interaction between currency and stock markets except for Singapore for the period January 3, 1986 to November 30, 1987; (ii) there is no definitive pattern of interaction between the two

markets, however, changes in exchange rates lead to stock prices in the case of Singapore and vice versa in the case of Taiwan and Hong Kong during the period December1, 1987 to May 31, 1997; (iii) In the case of South Korea, changes in the exchange rate Granger causes stock prices where as the reverse direction such as changes in stock prices Granger causes exchange rates is found in Hong Kong and the Philippines. The rest of the countries such as Malaysia, Singapore, Thailand and Taiwan are characterized by feedback interactions in which change in exchange rate can take the lead and vice versa from the period June 1, 1997 to June 16, 1998.

Bruce Morley and Eric Pentecost (2000) investigated the nature of the relationship between stock prices and spot exchange rates on G-7 countries by employing the cointegration test and codependence technique. The study considered the monthly observations spanning from January 1982 to January 1994, and broadly concluded that stock prices and exchange rates do not exhibit common trends, but do exhibit common cycles.

Bala Ramasamy and Matthew Yeung (2001) studied the hit and run behaviour in the interaction between stock prices and exchange rates of nine countries, namely Hong Kong, Indonesia, Japan, South Korea, Malaysia, the Philippines Singapore, Thailand and Taiwan affected by the Asian flu. The study considered the quarterly data spanning from January 1, 1997 to December 31, 2000, forming around 1,040 samples for each country. By employing the Granger causality test, the study concluded that stock prices Granger caused movements in the exchange rate in the case of all the countries except Hong Kong, where bidirectional-causality was seen. However, different results were obtained when they (Bala Ramasamy and Matthew C.H.Yeung, 2002) followed with an examination of the links between the foreign exchange and stock markets on six countries in the East Asia region, namely Indonesia, South Korea, Malaysia, Thailand, the Philippines and Singapore. The study considered the period from January 2, 1995 to August 6, 2001, forming around 1,720 observations. By employing the cointegration test and Granger causality test, the study concluded that there are inconsistent results in tests

for bivariate causality between stock prices and exchange rates. This finding suggested that the stock and foreign exchange markets in the region may still be unstable.

Hatemi, J. A. and Irandoust, M. (2002) examined a new Granger non-causality testing procedure developed by Toda and Yamamoto (1995) to contribute to the debate on exchange rates and stock prices in Sweden. The study also examined the possible causal relation between these variables in a Vector Auto Regression model. The results of the study found that Granger causality is unidirectional running from stock prices to effective exchange rates. The results also revealed that an increase in Swedish stock prices is associated with an appreciation of the Swedish Krona.

Lean, H.H, Halim, M and Wong, W.K. (2003) employed the cointegration and bivariate causality tests to explore the relationship between exchange rates and stock prices prevalent in the pre-Asian crisis, during Asian crisis and during 9/11-terrorist attack in the US periods on the seven Asian countries such as Hong Kong, Indonesia, Singapore, Malaysia, Korea, Philippines and Thailand badly hit by the Asian financial crisis. The study also included Japan for the control purpose. The empirical results of the study found that during the period before 1997 Asian financial crisis, all the countries except the Philippines and Malaysia experienced no evidence of Granger causality and no specific cointegration relationship between the exchange rates and stock prices. Causality, but not cointegration, between the capital and financial markets appears to become strong during the Asian financial crisis period and all the countries showed evidence of causality between the two markets. The study also found a surprising result that after the 9/11-terrorist attack, the causality relationship between the two markets turns back to normal as in the pre Asian crisis period, when in all the countries except Korea are found no linkages between exchange rates and stock prices. In addition, the study found that after the 9/11-terrorist attack, there is less cointegration relationship between exchange rates and stock prices. Based on these findings, the study broadly concluded: (i) Asian financial crisis has bigger and more direct impact on the causality relationships between stock prices and currency exchanges in Asian markets and the 9/11-terrorist attack in the USA basically has no impact on the causality relationship

between the two markets; and (ii) the financial and capital markets become more mature and more efficient after the crisis.

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

Stavarek Daniel (2004) investigated the nature of the causal relationship between stock prices and effective exchange rates in the four old EU member countries (Asia, France, Germany and the UK), four new EU member countries (Czech Republic, Hungary, Poland and Slovakia) and in the USA. Both the short term and long term causalities between these variables were explored using the monthly data. The study employed cointegration analysis, vector error correction modeling and standard Granger causality test to examine whether stock prices and exchange rates were related to each other or not and what kind of causality direction exists between them. The results of the study found much stronger causality in countries with developed capital and foreign exchange markets (old EU member countries and the USA) than in the new comers. The evidence also suggested more powerful long-run as well as short-run causal relations during the period 1993-2003 than during 1970-1992. Causalities seem to be predominantly unidirectional with the direction running from stock prices to exchange rates.

Victor Murinde and Sunil Poshakwale (2004) investigated the price interactions between the two main components of European emerging financial markets, *viz.* the foreign exchange market and the stock market before and after the adoption of the Euro by most European Union (EU) economies. The study employed Granger (1969) causality test to analyse daily observations on the stock price index and nominal exchange rate for Hungary, Czech Republic and Poland from January 2, 1995 to December 31, 1998, for the pre-Euro period and January 1, 1999 to December 31, 2003 for the Euro period. The study found that for the pre-Euro period, mutually reinforcing interactions existed

between exchange rates and stock prices in the Czech Republic and Poland but no interaction seem to exist for Hungary. During the Euro period, exchange rates unidirectionally Granger cause stock prices in all the three sample economies. The study also concluded that a higher positive correlation existed among the stock and the foreign exchange markets in Hungary, Czech and Poland during the Euro period and pre Euro period respectively.

There have also been a few studies of the interaction between stock prices and exchange rates in the Indian context. Perhaps the earliest is Abdalla *et al* (1997). They studied the interactions between exchange rates and stock prices in the case of India, Korea, Pakistan and the Philippines by applying bi-variate vector autoregressive models on monthly observations of stock price index and the real effective exchange rate over 1985:1 to 1994:7. The study found unidirectional causality from exchange rate to stock prices in all the countries except the Philippines. This finding suggests policy implication that the respective governments should be cautious in their implementation of exchange rate policies since these policies have ramifications in their stock markets.

Pethe and Karnik (2000) investigated the interrelationships between stock prices and macro economic variables such as exchange rate of rupee vis-à-vis dollar, prime lending rate, narrow money supply, broad money supply and index of industrial production on the monthly data spanning from April 1992 to December 1997. By employing unit root test, cointegration and error correction models, the study found there was no long run stable relationship between stock prices, exchange rates, prime lending rate, narrow money supply, broad money supply and index of industrial production.

Karmarkar *et al* (2001) by employing the coefficient determination and regression analysis on weekly closing values of exchange rate (RM/US$) and five composite as well as five sectoral indices of stock market over the period 2000 concluded that the depreciation of the rupee with respect to dollar leads to an appreciation of stock prices and vice versa.

However, when 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, they found that there was no causal linkage between stock prices and the three variables under consideration.

Muhammad, N. (2002) examined the long-run and short-run association between stock prices and exchange rates for four south Asian countries, namely Pakistan, India, Bangladesh and Srilanka for the period January 1994 to December 2000. The study employed monthly data and applied cointegration, error correction modeling approach and standard Granger causality tests. The major findings of the study are as follows. There is no long run equilibrium relationship between stock prices and exchange rates for Pakistan and India. In the case of Bangladesh, there is a long-run relationship between the variables considered for the study. The results for Srilanka showed a long-run relationship for lag one and two but for higher lag order; the study did not find any cointegration between stock price and exchange rate. However, the Engel and Granger test found a cointegrating relationship to stock prices and exchange rates for Srilanka. Granger causality test confirmed that there seemed to be no short run association between stock prices and exchange rates either in the case of Pakistan and India. The error correction model confirmed that there is bi-directional long-run causality in the case of Srilanka; however, there is no short-run causation in either direction for Bangladesh and Srilanka.

In order to examine the dynamic linkages between the foreign exchange and stock markets for India, Nath and Samanta (2003) employed the Granger causality test on daily data during the period March 1993 to December 2002. The empirical finding of the study suggests that these two markets did not have any causal relationship. When the study extended its analysis to see if liberalization in both the markets has brought them together or not then also the study did not find any significant causal relationship between exchange rate and stock price movements except for the years 1993, 2001 and 2002.

Mishra, A. K (2004) examined whether stock market and foreign exchange markets are related to each other or not in the context of India. The study employed Granger's causality test and Vector Auto Regression technique on monthly stock return, exchange rate, interest rate and demand for money for the period April 1992 to March 2002. The major findings of the study are (a) there exists a unidirectional causality between the exchange rate and interest rate and between the exchange rate return and demand for money; (b) there is no Granger's causality between the exchange rate return and stock return. Through Vector Auto Regression modeling, the study confirmed that though stock return, exchange rate return, the demand for money, and interest rate are related to each other but it lacks any consistent relationship. The forecast error variance decomposition further evidences that (a) the exchange rate return affects the demand for money, (b) the interest rate causes exchange rate return change (c) the exchange rate return affects the stock return, (d) the demand for money affects stock return, (e) the interest rate affects the stock return, and (f) the demand for money affects the interest rate.

**4.0 Methodology:**

The discussion in the preceding section reveals that there is neither theoretical nor empirical consensus on any definite pattern or consistent relationship between the stock and foreign exchange markets. Similarly, no conclusive generalization can be made about the causal nexus between these two markets. However, this is a question of vital importance to policy makers as well as investors, in so far as information from one market can be used to predict the behavior of the other market. If stock and foreign exchange markets are related and causation runs from stock market to foreign exchange market, then authorities can focus on domestic economic policies to stabilize the stock market. On the other hand, if causation runs from foreign exchange market to stock market, then the crises in the stock market can be prevented by controlling exchange rates.

In the very first step the study employed the ordinary least square time series regression analysis to examine the behavior of stock return and exchange rate return. The linear regression analysis is defined as the following two regression equations.

$$S_t = \alpha + \beta E_t + \varepsilon_t \qquad (1)$$

$$E_t = \alpha_1 + \beta_1 S_t + \varepsilon_{1t} \qquad (2)$$

Where both $\alpha$ and $\alpha_1$ in equation 1 and 2 represents the intercept, $\beta$ and $\beta_1$ represents the coefficients for exchange rate return and stock price return respectively where, $S_t$ and $E_t$ are stock price return and exchange rate return at time period t and $\varepsilon_t$ and $\varepsilon_{1t}$ are the white noise error terms in both the equations.

In order to examine the dynamic interactions of stock and foreign exchange markets in India, various sophisticated time series econometric techniques are employed. Although there are many approaches to modeling causality or short-term interactions in temporal systems, we first apply the prototype model developed by Granger (1969) not only because it is the simplest and most straight forward but also the existence of causal ordering in Granger's sense points to a law of causation and implies predictability and erogeneity (Abdalla, *et al* (1997)). However, the non-stationary nature of most times series data and the need for avoiding the problem of spurious or nonsense regression calls for the examination of their stationarity property. The study employed Augment Dickey Fuller Test and Phillips Perron test to remove the unit root problems among the variables both at without trend and intercept and with trend and intercept level respectively.

Granger's causality [proposed by Granger (1969) and popularized by Sims (1972)] may be defined as the forecasting relationship between two variables. In short, Granger causality test states that if S & E are two time series variables and, if past values of a variable S significantly contribute to forecast the value of the other variable E, then S is said to be Granger causing E and vice versa. The test involves the following two regression equations:

$$S_t = \gamma_0 + \sum_{i=1}^{n} \alpha_i E_{t-i} + \sum_{j=1}^{n} \beta_j S_{t-j} + u_{1t} \qquad (3)$$

$$E_t = \gamma_1 + \sum_{i=1}^{m} \lambda_i E_{t-i} + \sum_{j=1}^{m} \delta_j S_{t-j} + u_{2t} \qquad (4)$$

where $S_t$ and $E_t$ are the stock price and exchange rate to be tested, and $u_{1t}$ and $u_{2t}$ are mutually uncorrelated white noise errors, and t denotes the time period. Equation 3 postulates that current S is related to past values of S as well as of past E. Similarly, Equation 4 postulates that E is related to past values of E as well as related to past values of S. Three possible conclusions can be adduced from such analysis, *viz,* unidirectional causality, bi-directional causality and that they are independent of each other.

1. Unidirectional causality from E to S is indicated if the estimated coefficients on the lagged E in Equation 3 are statistically different from zero as a group (i.e., $\sum_{i=1}^{n} \alpha_i \neq 0$) and the set of estimated coefficients on the lagged S in Equation 4 is not statistically different from zero (i.e., $\sum_{j=1}^{m} \delta_j = 0$).
2. Unidirectional causality from S to E exists if the set of lagged E coefficients in Equation 3 is not statistically different from zero (i.e., $\sum_{i=1}^{n} \alpha_i = 0$) and the set of the lagged S coefficients in Equation 4 is statistically different from zero (i.e., $\sum_{j=1}^{m} \delta_j \neq 0$).

3. Feedback or bilateral causality is suggested when the sets of E and S coefficients are statistically and significantly different from zero in both regressions.

4. Finally, independence is suggested when the sets of E and S coefficients are not statistically significant in both the regressions.

There are two important steps involved with the Granger's causality test. First, stationary data is required for Equations 3 and 4. Second, in addition to the need for testing the stationary property of the data, the Granger methodology is somewhat sensitive to the lag length used in Equations 3 and 4. It is better to use more rather than fewer lag length since the theory is couched in terms of the relevant past information. The chosen lag

length must be matched with the actual lag length. If it is lesser than actual lag length, the omission of relevant lags can cause bias and if it is more than the relevant lag length causes the equation to be insufficient. To deal with this problem, Hsiao (1981) has developed a systematic autoregressive method for choosing appropriate lag length. Therefore, the appropriate lag length is one where Akaike's Final Prediction Error (FPE) is lowest. Akaike's information criteria (AIC), or Schwarz Criterion (SC) or Likelihood Ratio (LR) criterion or Hannan-Quinn information criterion (HQ) is also useful for choosing the lag length.

To further confirm the impulse response between stock price and exchange rate and to predict the behavior among them in coming future, the study extends the analysis towards Vector Auto Regression modeling (VAR). VAR system consists a set of regression equation in which all the variables are considered to be endogenous. In VAR methodology, each endogenous variable is explained by its lagged or past values and the lagged values of all other endogenous variables included in the model. In general, there are no exogenous variables in the model. Thus, by avoiding the imposition of a priori restriction on the model the VAR adds significantly to the flexibility of the model. A VAR in the standard form represented as:

$$S_t = a_{10} + a_{11}S_{t-1} + a_{12}E_{t-1} + e_{1t} \qquad (5)$$

$$E_t = a_{20} + a_{21}S_{t-1} + a_{22}E_{t-1} + e_{2t} \qquad (6)$$

Where, $S_t$ is the stock price at the time period t, $E_t$ is the exchange rate at the time period t, $a_{io}$ is element i of the vector $A_o$, $a_{ij}$ is the element in row i and column j of the matrix $A_1$ and $e_{it}$ as the element i of the vector $e_t$ and it represents in the above equation as $e_{1t}$ and $e_{2t}$ respectively are white noise error term and both have zero mean and constant variances and are individually serially uncorrelated.

Now we discuss about various steps, which are involved in VAR estimation. To start with VAR estimation procedure requires the selection of variables to be included in the system. The variables included in the VAR are selected according to the relevant economic model. The next step is to verify the stationarity of the variables. Regarding the

issue of whether the variables in VAR need to be stationary Sims (1980) and Doan (1992) recommend against differencing even if the variables containing a unit root[1]. Here in this paper, Augmented Dickey- Fuller (ADF) and Phillips Peron (PP) tests are used to carry out unit root test.

The next step is to select the appropriate lag length. The lag length of each of the variables in the system is to be fixed. For this we use Likelihood Ratio (LR) test. After setting the lag length, now we are in a position to estimate the model. But it may be noted that the coefficients obtained from the estimation of VAR model can't be interpreted directly. To overcome this problem, Litterman (1979) had suggested the use of Innovation Accounting Techniques, which consists of both Impulse response functions (IRFS) and Variance Decompositions (VDS). Impulse response function is being used to trace out the dynamic interaction among variables. It shows how the dynamic response of all the variables in the system to a shock or innovation in each variable. For computing the IRFS, it is essential that the variables in the system are ordered and that a moving average process represents the system. Variance decomposition is used to detect the causal relations among the 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 verses shocks to the other variables.

**5.0 Variable Description and Data Points:**

To examine the dynamic interrelationship between stock and forex markets in India, the study considered two variables such as stock price return and exchange rate(INR/USD) return. To represent the Indian stock market, the present study considered two liquidity indices here such as Sensex and S & P CNX Nifty and to represent the Foreign exchange market, we have taken into consideration the nominal bilateral exchange rate of Indian Rupee versus US $. The stock return and exchange return is defined as flowingly.

[1] They argue that the goal of a VAR analysis is to determine the inter-relationship among the variables, not to determine the parameter estimates. The main argument against differentiating is that it 'throws away' information concerning the co movements in the data such as the possibility of co integrating relationships.

$RS_t = \ln (S_t) - \ln (S_{t-1})$

$RE_t = \ln (E_t) - \ln (E_{t-1})$

Where, $RS_t$ and $RE_t$ represents the stock price return and exchange rate return and $S_t$ and $S_{t-1}$ are the stock prices of time period t and t-1 and $E_t$ and $E_{t-1}$ are the exchange rate of time period t and t-1 respectively.

The present study considered the monthly data of stock price and exchange rate, where the sample period spanning from February 1995 to March 2005, forming around 121 observations. The data for stock prices are collected from the respective web pages of BSE and NSE and the data on nominal bilateral exchange rate (INR/USD) are collected from the Handbook of Statistics on Indian Economy (2004-05).

**6.0 Estimated Equation and Result Interpretation:**

At the outset, before undertaking any time series econometric analysis of the data, it would be useful to see the broad trends and behavior of the variables, which may help in interpreting the model results latter. For this purpose, time series plots are drawn for all the variables. Figures 3 to 8 plot the monthly movement of stock indices and the exchange rates and the rates of return on their respective indices and exchange rate over the sample period. As can be expected, the monthly data on most of the variables exhibit trends (both stochastic and deterministic) and considerable volatility, which varied over time. It is also quite clear from these figures 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.

In the next step, we have computed the descriptive statistics of the stock return and exchange rate return. The summary statistics are presented in the Table 1. It can be seen from the table that both stock indices return (Rsensex and Rnifty) are near normal. However, exchange rate return is not normal and more peak than in normal distributions. This supports the general observation that foreign exchange markets return is not normal distribution, but the stock market returns are near normal. The practical implication for the trading and investing community in the financial markets is that the return is near

normal distribution as we have observed in the case of both stock indices (Rsensex, Rnifty), the investing and trading strategy can be to buy and hold for a long span of time and there will be some certain profit out of the foregoing strategy. But if the return distribution is not normal as we have observed in the case of foreign exchange market in India, this strategy of 'buy and hold' for a long time may not necessarily yield any clear profit. Therefore, in foreign exchange market 'convex trading strategies' where the trader may buy in a market which is already appreciating and sell in a market which is depreciating. However, we are not at this stage able to go into the details of advising a profitable trading and investing strategy from the forgoing results, and in any case our results are relevant for further investigation and research.

To examine the stationarity property of all the variables used in our study, we have carried out the ADF and PP unit root test. All the tests have been conducted both with intercept alone and with intercept and time trend[2]. The null hypothesis is that there exists a unit root or the underlying process is non stationary. The results of unit root tests are given in Table 2. The optimum lag length in the case of ADF and PP tests is chosen on the basis of AIC and FPE criterion. From the table, we can see that the null hypothesis is rejected i.e. all the variables are stationary at their return (Rsensex, Rerate, Rnifty) level. However, the null hypothesis can not be rejected i.e. all the variables are non stationary at their level (Sensex, Erate, Nifty). Therefore, the OLS regression can be run with the data and variables at the return level without the fear of yielding spurious parameters.

In order to see the degree of association between the stock return and exchange rate return the correlation matrix is constructed. The results are reported in Tables 5 and 6 respectively. From the Table 5, it can be concluded return on Sensex and return on exchange rate are negatively correlated (r = -0.219) where as from Table 6 the same conclusion can be derived that both return Nifty and return exchange rate are also negatively correlated ( r = -0.211).

To examine the dependence (both at degree and direction) between the stock return and exchange rate return, the regression equations are estimated by the method of ordinary least squares (OLS), which method is justified earlier as they are found to be stationary

[2] Eviews 4.0 package was used for the unit root tests.

variables. The adequacy of the equations in explaining stock return and exchange return behavior are judged by the appropriateness of the signs and magnitudes of the regression coefficients, statistical criteria such as the coefficient of multiple determination ($R^2$), DW statistic, for auto correlation among residuals, 'T' values of the regression coefficients and the standard error of estimate (SEE), which are presented in Table 3 and 4 respectively. From the table, it is inferred that the coefficient of all the explanatory variables preserve expected sign. In Table 3, a one percent depreciation of return erate (INR/US$) will lead to 1.09 percent decrease in stock return (Rsensex). Like wise a one percent increase in stock return (Rsensex) will lead to the appreciation in exchange rate return by 0.04 percent. In Table 4, one percent depreciation in exchange rate leads to a 1.03 percent decrease in stock return (Rnifty). Similarly a one percent increase in stock return (Rnifty) leads to appreciate the exchange rate return (INR/USD) by 0.04 percent. This shows that both stock return and exchange rate return are positively related to each other.

The stock return and exchange rate return are positively related. The policy implication of this aforementioned results of the positive relation between stock return and exchange rate return appears to be not to a very good news for the foreign investors in India because ideally, for the portfolio diversification, the stock return and local currency return should be negatively correlated because when they convert to the base currency, if the local currency is depreciated together with the reduced stock return, it adds to the loss rather than reducing the loss to their portfolio. However, this aspect has to be further studied because the return of the stock market in India may be negatively correlated to the stock market return abroad which would be relevant to the foreign institutional investors. We have not examined that issue in the context of the correlation between stock and forex markets in India. Needless to mention, for international diversification of the portfolios, the correlations with the stock markets elsewhere have also to be further reexamined. Moreover, when the return in the stock market goes down, and the stock prices go down, there will be an obvious substitution effect from domestic currency denominated assets to foreign assets, and therefore, the domestic currency value goes down, and the return in the foreign exchange markets from that perspective also goes

down. Thus our results of the positive correlation between stock markets and foreign exchange markets can easily be explained in terms of a positive demand for domestic currency when the domestic stock prices increase, and the opposite action when domestic stock prices decrease and the demand for domestic currency falls. In the aforesaid perspective, the causality is from domestic stock prices to domestic currency. The export firms may not be that dominant to influence the causality from a depreciated domestic currency to a strong stock price movement in the Indian context.

As we mentioned in the last section, between any pair of variables there is possibility of unidirectional causality or bidirectional causality or none. This can also be the case between two pairs of variables used in our empirical analysis. These are stock return (both Rsensex and Rnifty) and exchange rate return (Rerate). There are arguments in the literature to support more than one type of relationship. We therefore would like to examine examine the direction of causality between these two pairs of variables before formulating models to analyze the interrelationship between them. As our variables in return form are already found in stationary, we can directly proceed with Granger causality. In this case, we can explain the causality through changes in one variable causing the changes in another variable which would be find out through Granger causality. The first step for the Granger causality test is to found out the appropriate lag length for each pair of variables. For this purpose, we used the vector auto regression (VAR) lag order selection method available in Eviews 4.0 package. This technique uses six criteria, namely log likelihood value (LogL), sequential modified likelihood ratio (LR) test statistic, Akaike final prediction error (FPE), Akaike information criterion (AIC), Schwarz information criterion (SC) and Hannan-Quinn information criterion (HQ), for choosing the optimal lag length. These lag specification criteria results are reported in Tables 7 and 8 respectively. In practice, it may not be possible that all the criteria will suggest one lag length as optimal. One may have to be content with a lag length supported by 2-3 criteria only. In this study, the optimum lag length has been found out to be 2 and 1 for return Sensex and return erate and return Nifty and return erate respectively, based on two criteria, AIC and FPE.

Finally, the result of Granger causality test is reported in Tables 9 and 10. From both the table it may be concluded that the null hypothesis that there is no Granger causality between the pairs can not be rejected only in the case of return Nifty and return exchange rate at 5 percent level of confidence. However, in case of other variables the null hypothesis is strongly rejected. From table 9, it is clear that the past values of return Sensex do not Granger cause the current values of return on exchange rate. Similarly the past values of return on exchange rate do not Granger cause the present values of return on Sensex. From aforementioned results, it is clear that all past values about the respective markets (both stock and forex) do not influence the current values of the return in both stock (BSE Sensex) and foreign exchange markets. As the past values of the different markets are already factored and incorporated in the returns of Sensex and exchange rates. This shows that there is informational efficiency in the markets of Sensex and foreign exchange rates. These results should be contrasted with the regression results reported in Table 3. In Table 3, the current values of return on Sensex and return on exchange rate are influenced the current rates of return on Sensex and exchange rates. These further shows that return Sensex and return exchange rate market are perfectly integrated with each other.

From Table 2, we can see that the variables are non stationary either at their level and log level form, and in difference form, they are stationary. This supports the random walk models of weak form of efficiency for respective markets. This is consistent with our results reported earlier that the return Sensex and return foreign exchange markets are information ally efficient and integrated with each other.

In Table 10, the past values of the changes in exchange rate return do not Granger cause the changes on return on Nifty. However, the past values of return Nifty do Granger cause the current values of return in foreign exchange market at 3 percent significance level. From this, it is surmised that the stock market (Nifty) is more efficient from information criteria than the foreign exchange (INR/USD) market. But from weak form of market efficiency point of view, both Nifty and foreign exchange markets follow the random walk pattern. Both at their level and log level forms, they are non stationary and at their differenced form they are stationary.

The result of dynamic interaction between stock return and exchange rate return is extracted by employing Vector Auto Regression technique. The result of forecast error variance at 24 step ahead horizon is reported in Table 11 and 12 respectively. The impulse response between stock return and exchange rate return is plotted in Graph 1and 2 respectively.

**Returns on Stock prices (BSE Sensex, NSE Nifty) and Return on Exchange rate (INR/US$)**

In Table 11, a shock in return on erate explains only 3.41 percent of forecast error variance in return on Sensex, whereas return on Sensex explains a substantial portion i.e. 9.01 percent of forecast error variance in return in exchange rate from $6^{th}$ step ahead horizon onwards. From this finding, it can be surmised that the causality runs from return on Foreign exchange rates to return on Sensex as, at least, 9 percent of the Return on Sensex is explained by the Return on Foreign exchange rates. However, in Table 12, return on Nifty explains 3.82 percent of forecast error variance in return on exchange rate whereas marginally higher i.e. 4.10 percent of variance in return on Nifty is explained by return on exchange rate from 5-step ahead horizon. Thus we fail to conclude if the causality runs from Return on Nifty to return on exchange rate or vice versa.

From Graph 1, a one standard deviation shock in return on Sensex exchange rate initially appreciates up to second month and again it appreciates and converges after fifth month. Whereas, a one standard deviation shock in return on foreign exchange rate return on Sensex initially increase up to second month and decreases up to fourth month and after that it converges to the initial value. In Graph 2 a one standard deviation shock in return on foreign exchange rate increases the return on Nifty up to fifth month and then converges.

**7.0 Conclusions:**

Both the stock indices returns are near normal, whereas exchange rate return is non normal and more peak. The practical implication for the trading and investing community in the financial markets is that the return is near normal distribution as we have observed

in the case of both stock indices (Rsensex, Rnifty), the investing and trading strategy can be to buy and hold for a long span of time and there will be some certain profit out of the foregoing strategy. But if the return distribution is not normal as we have observed in the case of foreign exchange market in India, this strategy of 'buy and hold' for a long time may not necessarily yield any clear profit. Therefore, in foreign exchange market 'convex trading strategies' where the trader may buy in a market which is already appreciating and sell in a market which is depreciating. However, we are not at this stage able to go into the details of advising a profitable trading and investing strategy from the forgoing results, and in any case our results are relevant for further investigation and research.

The stock return and exchange rate return are positively related. The policy implication of this aforementioned results of the positive relation between stock return and exchange rate return appears to be not to a very good news for the foreign investors in India because ideally, for the portfolio diversification, the stock return and local currency return should be negatively correlated because when they convert to the base currency, if the local currency is depreciated together with the reduced stock return, it adds to the loss rather than reducing the loss to their portfolio. However, this aspect has to be further studied because the return of the stock market in India may be negatively correlated to the stock market return abroad which would be relevant to the foreign institutional investors. We have not examined that issue in the context of the correlation between stock and forex markets in India. Needless to mention, for international diversification of the portfolios, the correlations with the stock markets elsewhere have also to be further reexamined. Moreover, when the return in the stock market goes down, and the stock prices go down , there will be an obvious substitution effect from domestic currency denominated assets to foreign assets, and therefore, the domestic currency value goes down, and the return in the foreign exchange markets from that perspective also goes down . Thus our results of the positive correlation between stock markets and foreign exchange markets can easily be explained. explained in terms of a positive demand for domestic currency when the domestic stock prices increase, and the opposite action when domestic stock prices decrease and the demand for domestic currency falls.. In the aforesaid perspective, the causality is from domestic stock prices to domestic currency.

The export firms may not be that dominant to influence the causality from a depreciated domestic currency to a strong stock price movement in the Indian context

From the Granger's causality test for return data, it is found that there is no causality for all the return series of stock and exchange rate except return Nifty and return exchange rate. There is a unidirectional causality between return Nifty and return exchange rate and the causality is running from return Nifty to return exchange rate. We would like to interpret the causality results as a test of weak form of efficiency from an informational criteria as all past informations from the other market are incorporated through the rational expectations by the investors in the respective current markets. Therefore, the past informations from the other market will not be able to predict the return in the current market. We may note that that the simple OLS regressions result show that the stock market influences the forex market and vice versa. But all informations from the other markets are factored into the returns of the respective current markets. From impulse response functions, it can be seen that a one standard deviation shock in the return of any market produces the effect on the other market for a few months and then converges. Therefore, the impulse response function also corroborates our conclusion that both the markets are efficient from the stand point of the weak form of market efficiency.

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**Table: 1**

**Descriptive Statistics**

| Variables | Sample | Mean | SD | SK | KURTOSIS | JB |
|---|---|---|---|---|---|---|
| **Rsensex** | 1995:02-2005:03 | 0.0049 | 0.0645 | -0.1754 | 2.7482 | 0.9477 (0.622) |
| **Rerate** | 1995:02-2005:03 | 0.0027 | 0.0130 | 0.2503 | 10.8169 | 311.8904 (0.000) |
| **Rnifty** | 1995:02-2005:03 | 0.0053 | 0.0639 | -0.1298 | 2.5925 | 1.1865 (0.552) |

Note: SD is the standard deviation
SK is skew ness
JB is Jarqua-Bera statistics
Figures in parentheses represent the significance level

**Table: 2**
**Unit Root Test**

| Variables | ADF | | | PP | | |
|---|---|---|---|---|---|---|
| | **None** | **Intercept** | **Trend & Intercept** | **None** | **Intercept** | **Trend & Intercept** |
| **Sensex** | 0.85(4) | -0.76(4) | -1.40(4) | 0.72(4) | -0.69(4) | -1.49(4) |
| **Erate (INR/US$)** | 1.26(4) | -2.44(4) | -0.21(4) | 1.49(4) | -2.29(4) | 0.00(4) |
| **Nifty** | 0.91(4) | -0.62(4) | -1.61(4) | 0.83(4) | -0.48(4) | -1.64(4) |
| **Rsensex** | -4.66(4) | -4.73(4) | -4.80(4) | **-**9.34(4) | -9.35(4) | -9.38(4) |
| **Rerate** | -4.10(4) | -4.48(4) | -5.54(4) | -8.37(4) | -8.58(4) | -9.03(4) |
| **Rnifty** | -4.74(4) | -4.82(4) | -4.90(4) | -9.28(4) | -9.30(4) | -9.33(4) |
| **Lsensex** | 0.87(4) | -1.22(4) | -1.75(4) | 0.69(4) | -1.16(4) | -1.84(4) |
| **Lnifty** | 0.93(4) | -1.06(4) | -2.00(4) | 0.76(4) | 0.98(4) | -2.08(4) |
| **Lerate** | 1.76(2) | -2.53(2) | -0.26(2) | 1.81(2) | -2.51(2) | -0.30(2) |

Note: The critical values for ADF test at 1%, 5% and 10% are -2.5833,-1.9427 and -1.6171 respectively. The critical values for PP test at 1%, 5% and 10% are -4.0361,-3.4472 and -3.1484 respectively.
'L' stands for logarithmic transformation.
Figures in parentheses represent the optimum lag length.

**Table-3**
**Regression Result: Rerate and Rsensex**

| Dependent Variable | Independent variable | coefficient | Std.error | t-stat | $R^2$ | DW |
|---|---|---|---|---|---|---|
| **Rsensex** | **Rerate** | -1.090008 | 0.441454 | -2.469133 (0.01) | 0.0483 | 1.788 |
| | **Constant** | 0.007908 | 0.005847 | 1.352524 (0.17) | | |
| **Rerate** | **Rsensex** | -0.044356 | 0.017964 | -2.469133 (0.01) | 0.0483 | 1.641 |
| | **Constant** | 0.002934 | 0.001158 | 2.533895 (0.01) | | |

**Table-4**
**Regression Result: Rerate and Rnifty**

| Dependent Variable | Independent variable | coefficient | Std.error | t-stat | $R^2$ | DW |
|---|---|---|---|---|---|---|
| **Rnifty** | **Rerate** | -1.037698 | 0.438157 | -2.368325 (0.01) | 0.044 | 1.769 |
| | **Constant** | 0.008175 | 0.005803 | 1.408598 (0.16) | | |
| **Rerate** | **Rnifty** | -0.043032 | 0.018170 | -2.368 (0.01) | 0.044 | 1.63 |
| | **Constant** | 0.002945 | 0.001161 | 2.537 (0.01) | | |

**Table-5**
**Correlation Matrix: Rerate and Rsensex**

| | Rsensex | Rerate |
|---|---|---|
| **Rsensex** | 1 | |
| **Rerate** | -0.219884 | 1 |

**Table-6**
**Correlation Matrix: Rerate and Rnifty**

| | Rnifty | Rerate |
|---|---|---|
| **Rnifty** | 1 | |
| **Rerate** | -0.211315 | 1 |

**Table-7**
**Lag length Criterion-Rsensex and Rerate**

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| 0 | 488.4959 | NA | 6.74E-07 | -8.535015 | -8.487012* | -8.515533 |
| 1 | 495.3135 | 13.27646* | 6.41E-07 | -8.584448 | -8.440437 | -8.526002* |
| 2 | 499.3941 | 7.803217 | 6.40E-07* | -8.585861* | -8.345844 | -8.488452 |
| 3 | 502.8137 | 6.419324 | 6.47E-07 | -8.575680 | -8.239655 | -8.439306 |
| 4 | 503.9859 | 2.159257 | 6.80E-07 | -8.526068 | -8.094037 | -8.350731 |
| 5 | 504.3209 | 0.605338 | 7.26E-07 | -8.461770 | -7.933732 | -8.247469 |
| 6 | 505.2952 | 1.726325 | 7.66E-07 | -8.408687 | -7.784642 | -8.155422 |
| 7 | 507.4211 | 3.692468 | 7.92E-07 | -8.375809 | -7.655757 | -8.083580 |
| 8 | 507.9501 | 0.900223 | 8.43E-07 | -8.314914 | -7.498855 | -7.983722 |

* 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-8**
**Lag length Criterion-Rnifty and Rerate**

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| 0 | 489.5143 | NA | 6.62E-07 | -8.552883 | -8.504879* | -8.533401 |
| 1 | 496.6011 | 13.80049* | 6.27E-07* | -8.607036* | -8.463026 | -8.548590* |
| 2 | 499.9866 | 6.474153 | 6.34E-07 | -8.596257 | -8.356239 | -8.498847 |
| 3 | 503.4231 | 6.450972 | 6.40E-07 | -8.586371 | -8.250346 | -8.449997 |
| 4 | 504.4638 | 1.917097 | 6.74E-07 | -8.534453 | -8.102422 | -8.359116 |
| 5 | 504.6430 | 0.323829 | 7.21E-07 | -8.467422 | -7.939384 | -8.253121 |
| 6 | 505.4334 | 1.400378 | 7.64E-07 | -8.411112 | -7.787066 | -8.157847 |
| 7 | 507.7238 | 3.978168 | 7.88E-07 | -8.381120 | -7.661067 | -8.088891 |
| 8 | 508.5430 | 1.394086 | 8.34E-07 | -8.325316 | -7.509257 | -7.994124 |
| * 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-9
## Granger's Causality Test: Rsensex and Rerate

| Null Hypothesis: | Obs | F-Statistic | Probability |
|---|---|---|---|
| Rsensex does not Granger Cause Rerate | 120 | 2.12748 | 0.12380 |
| Rerate does not Granger Cause Rsensex | | 2.08794 | 0.12862 |

## Table-10
## Granger's Causality Test: Rnifty and Rerate

| Null Hypothesis: | Obs | F-Statistic | Probability |
|---|---|---|---|
| Rerate does not Granger Cause Rnifty | 121 | 0.58640 | 0.44534 |
| Rnifty does not Granger Cause Rerate | | 4.84728 | 0.02963 |

## Table-11
## Variance Decomposition: Rerate and Rsensex

**Variance Decomposition of Rerate:**

| Period | Rerate | Rsensex |
|---|---|---|
| 1 | 100.0000 | 0.000000 |
| 2 | 96.86167 | 3.138328 |
| 3 | 96.60386 | 3.396139 |
| 4 | 96.58852 | 3.411484 |
| 5 | 96.58452 | 3.415482 |
| 6 | 96.58229 | 3.417710 |
| 7 | 96.58180 | 3.418200 |
| 8 | 96.58172 | 3.418280 |
| 9 | 96.58170 | 3.418297 |
| 10 | 96.58170 | 3.418302 |
| 11 | 96.58170 | 3.418303 |
| 12 | 96.58170 | 3.418303 |
| 13 | 96.58170 | 3.418303 |
| 14 | 96.58170 | 3.418303 |
| 15 | 96.58170 | 3.418303 |
| 16 | 96.58170 | 3.418303 |
| 17 | 96.58170 | 3.418303 |
| 18 | 96.58170 | 3.418303 |
| 19 | 96.58170 | 3.418303 |
| 20 | 96.58170 | 3.418303 |
| 21 | 96.58170 | 3.418303 |
| 22 | 96.58170 | 3.418303 |
| 23 | 96.58170 | 3.418303 |
| 24 | 96.58170 | 3.418303 |

**Variance Decomposition of Rsensex:**

| Period | Rerate | Rsensex |
|---|---|---|
| 1 | 4.444223 | 95.55578 |
| 2 | 4.538094 | 95.46191 |
| 3 | 8.497276 | 91.50272 |
| 4 | 8.961667 | 91.03833 |
| 5 | 8.998258 | 91.00174 |
| 6 | 9.007553 | 90.99245 |
| 7 | 9.011356 | 90.98864 |
| 8 | 9.012205 | 90.98779 |
| 9 | 9.012356 | 90.98764 |
| 10 | 9.012389 | 90.98761 |
| 11 | 9.012398 | 90.98760 |
| 12 | 9.012400 | 90.98760 |
| 13 | 9.012400 | 90.98760 |
| 14 | 9.012400 | 90.98760 |
| 15 | 9.012400 | 90.98760 |
| 16 | 9.012400 | 90.98760 |
| 17 | 9.012400 | 90.98760 |
| 18 | 9.012400 | 90.98760 |
| 19 | 9.012400 | 90.98760 |
| 20 | 9.012400 | 90.98760 |
| 21 | 9.012400 | 90.98760 |
| 22 | 9.012400 | 90.98760 |
| 23 | 9.012400 | 90.98760 |
| 24 | 9.012400 | 90.98760 |

Cholesky Ordering: Rerate, Rsensex

## Table-12
## Variance Decomposition: Rerate and Rnifty

**Variance Decomposition of Rerate**:

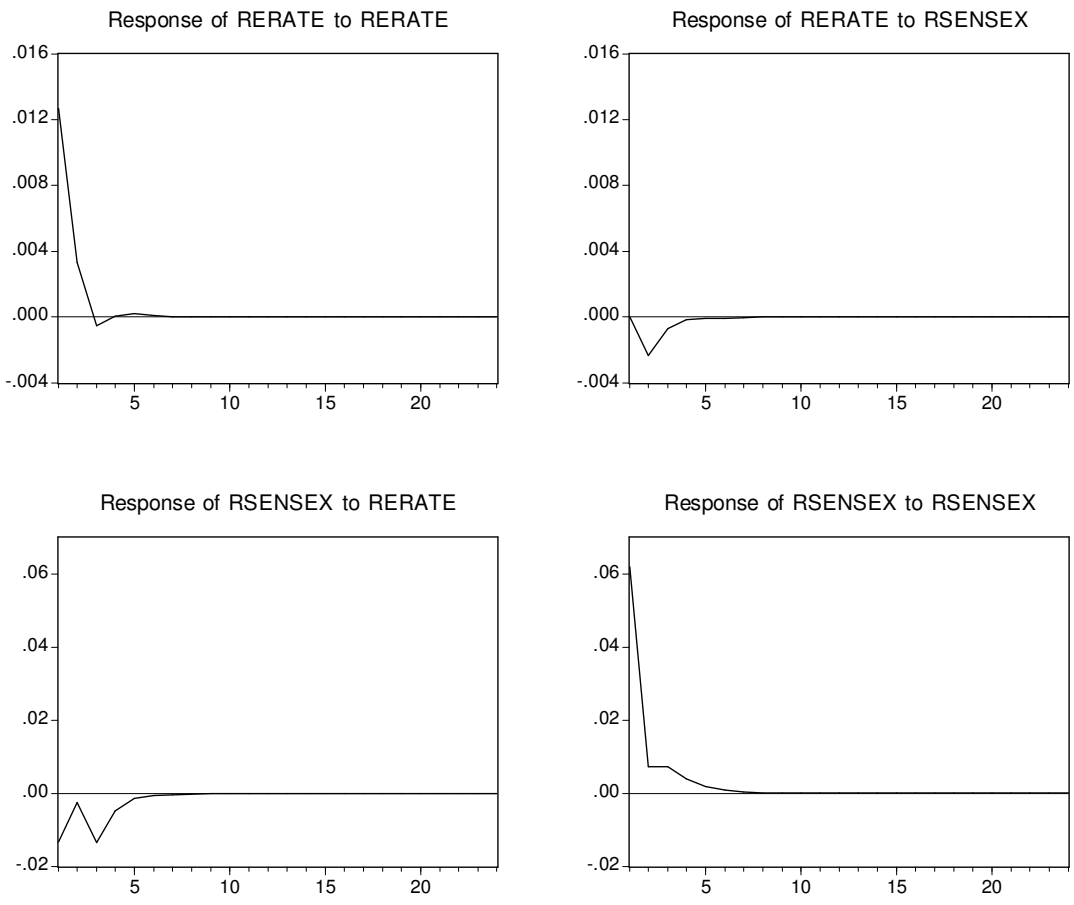
| Period | Rerate | Rnifty |
|---|---|---|
| 1 | 100.0000 | 0.000000 |
| 2 | 96.34074 | 3.659259 |
| 3 | 95.93667 | 4.063326 |
| 4 | 95.90033 | 4.099671 |
| 5 | 95.89718 | 4.102815 |
| 6 | 95.89691 | 4.103085 |
| 7 | 95.89689 | 4.103108 |
| 8 | 95.89689 | 4.103110 |
| 9 | 95.89689 | 4.103111 |
| 10 | 95.89689 | 4.103111 |
| 11 | 95.89689 | 4.103111 |
| 12 | 95.89689 | 4.103111 |
| 13 | 95.89689 | 4.103111 |
| 14 | 95.89689 | 4.103111 |
| 15 | 95.89689 | 4.103111 |
| 16 | 95.89689 | 4.103111 |
| 17 | 95.89689 | 4.103111 |
| 18 | 95.89689 | 4.103111 |
| 19 | 95.89689 | 4.103111 |
| 20 | 95.89689 | 4.103111 |
| 21 | 95.89689 | 4.103111 |
| 22 | 95.89689 | 4.103111 |
| 23 | 95.89689 | 4.103111 |
| 24 | 95.89689 | 4.103111 |

**Variance Decomposition of Rnifty:**

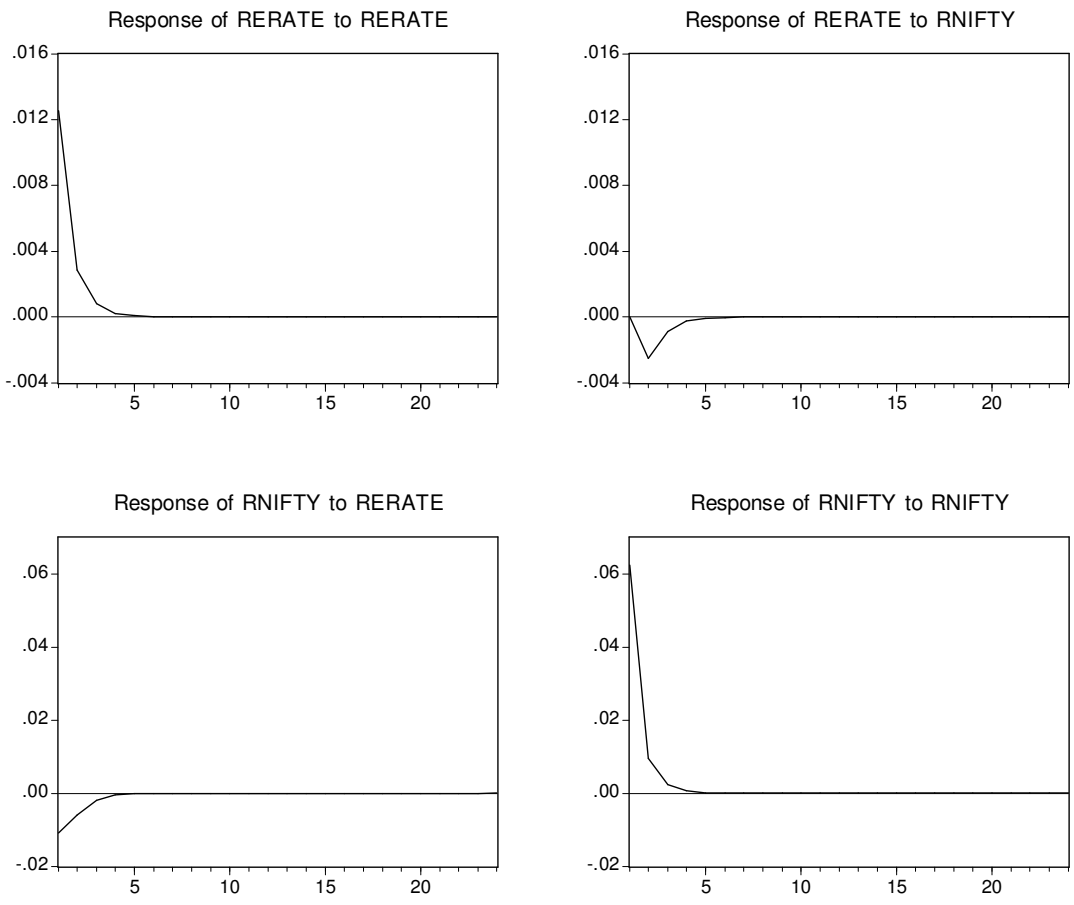
| Period | Rerate | Rnifty |
|---|---|---|
| 1 | 2.960023 | 97.03998 |
| 2 | 3.740657 | 96.25934 |
| 3 | 3.820138 | 96.17986 |
| 4 | 3.827168 | 96.17283 |
| 5 | 3.827775 | 96.17223 |
| 6 | 3.827827 | 96.17217 |
| 7 | 3.827831 | 96.17217 |
| 8 | 3.827831 | 96.17217 |
| 9 | 3.827831 | 96.17217 |
| 10 | 3.827831 | 96.17217 |
| 11 | 3.827831 | 96.17217 |
| 12 | 3.827831 | 96.17217 |
| 13 | 3.827831 | 96.17217 |
| 14 | 3.827831 | 96.17217 |
| 15 | 3.827831 | 96.17217 |
| 16 | 3.827831 | 96.17217 |
| 17 | 3.827831 | 96.17217 |
| 18 | 3.827831 | 96.17217 |
| 19 | 3.827831 | 96.17217 |
| 20 | 3.827831 | 96.17217 |
| 21 | 3.827831 | 96.17217 |
| 22 | 3.827831 | 96.17217 |
| 23 | 3.827831 | 96.17217 |
| 24 | 3.827831 | 96.17217 |

Cholesky Ordering: Rerate, Rnifty

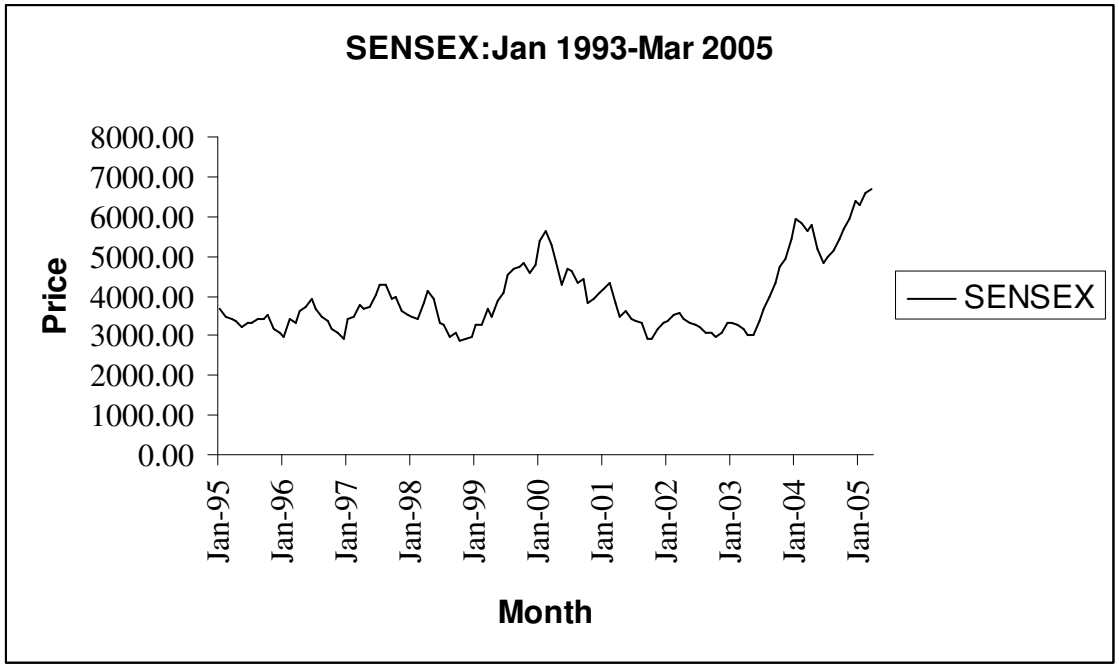
**Graph: 1**
**Impulse Response Function: Rerate and Rsensex**



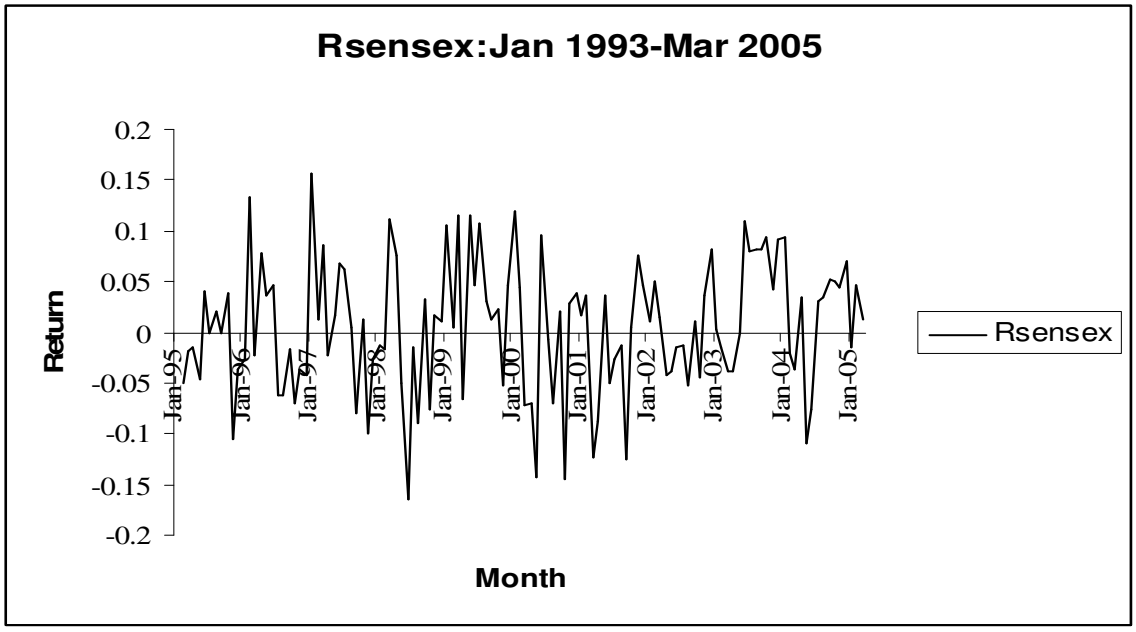
**Graph: 2**
**Impulse Response Function: Rerate and Rnifty**



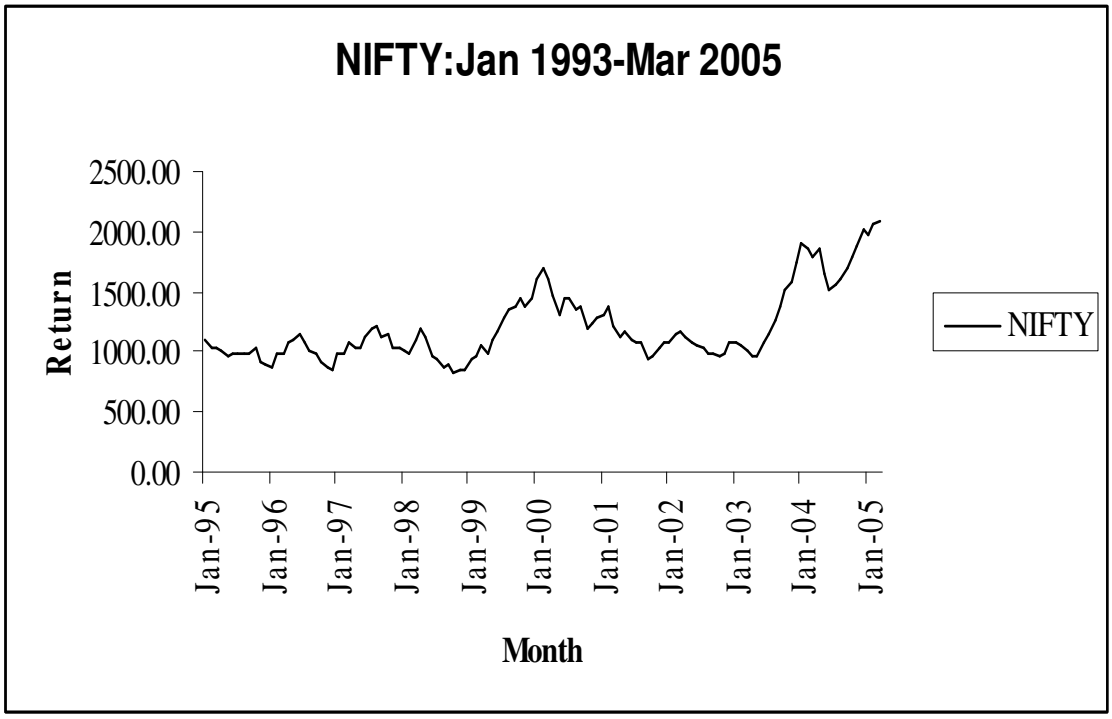
**Graph: 3**



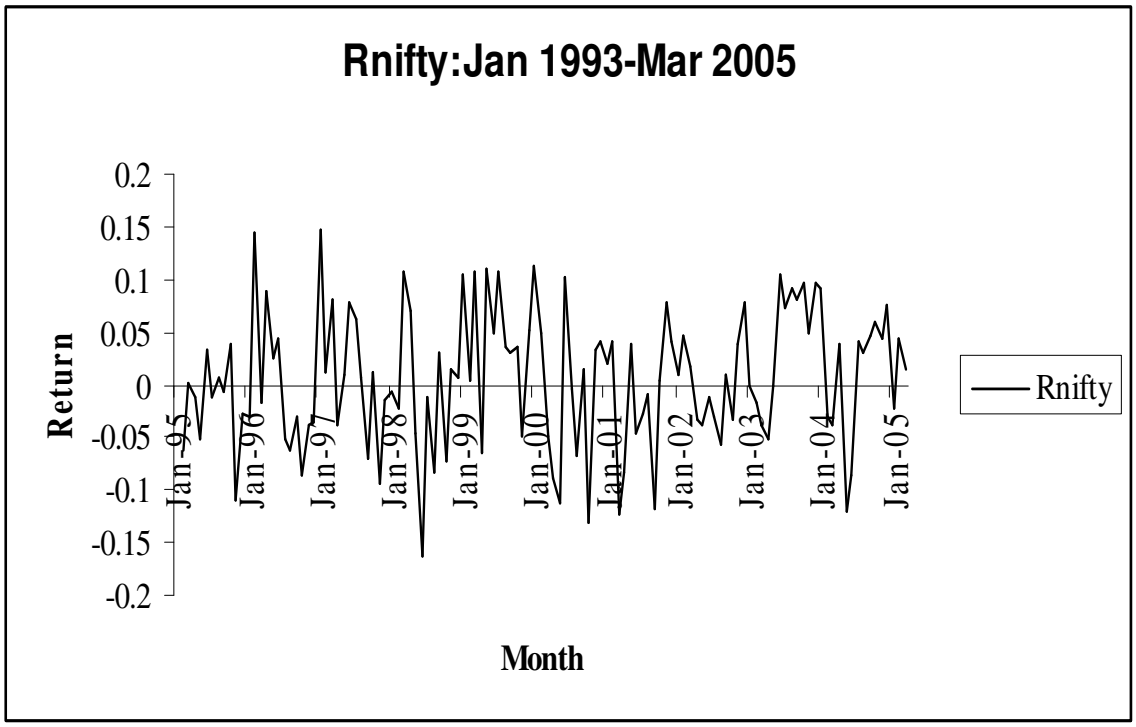

**Graph-4**



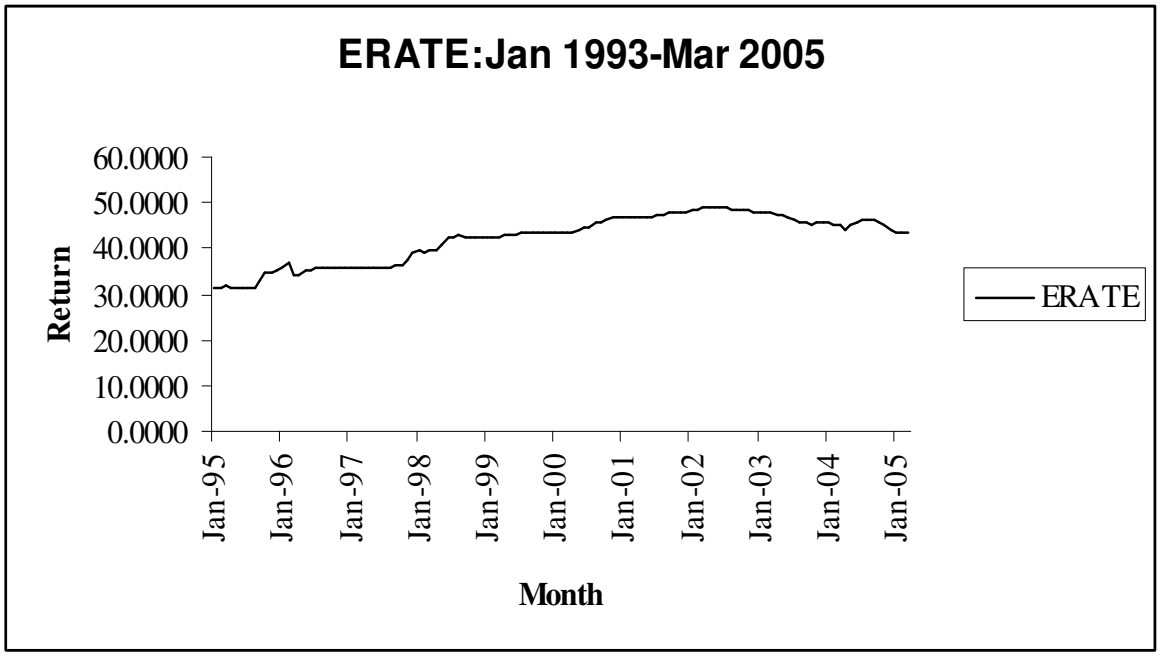
**Graph-5**




**Graph -6**



**Graph-7**




**Graph-8**