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REVIEW OF LITERATURE

NEED/IMPORTANCE OF THE STUDY

STATEMENT OF THE PROBLEM

OBJECTIVES

HYPOTHESES

RESEARCH METHODOLOGY

RESULTS & DISCUSSION

FINDINGS

RECOMMENDATIONS/SUGGESTIONS

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- Sharma T., Kwatra, G. (2008) Effectiveness of Social Advertising: A Study of Selected Campaigns, Corporate Social Responsibility, Edited by David Crowther & Nicholas Capaldi, Ashgate Research Companion to Corporate Social Responsibility, Chapter 15, pp 287-303.

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CONFERENCE PAPERS

- Garg, Sambhav (2011): "Business Ethics" Paper presented at the Annual International Conference for the All India Management Association, New Delhi, India, 19–22 June.

UNPUBLISHED DISSERTATIONS AND THESES

- Kumar S. (2011): "Customer Value: A Comparative Study of Rural and Urban Customers," Thesis, Kurukshetra University, Kurukshetra.

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- Garg, Bhavet (2011): Towards a New Natural Gas Policy, Political Weekly, Viewed on January 01, 2012 http://epw.in/user/viewabstract.jsp

TESTING EFFICIENT MARKET HYPOTHESIS IN THE FOREIGN EXCHANGE MARKET

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ABSTRACT

Exchange rate is the most important price in an economy. It has wide ranging impact on almost everything in the economy. Thus trying to understanding its movements becomes very critical. In the current study, we have focussed solely on USDINR exchange rate as the exchange rate with respect to other countries is derived from the USDINR and the exchange rate of the other country with the USD. We have examined whether it is possible to predict the movement of the exchange rate in the short run and the long run. We found that the exchange rate follows a random walk in the short run. This means that the current exchange rate will incorporate all the previous exchange rates. It is not possible to predict the future exchange rates on a daily basis and any analysis of the past exchange rates will not help in making a prediction about the future rate. Thus in the short run, the foreign exchange market is weak form efficient. But in the long run, it is possible to predict the exchange rate as the variation in the exchange rate is governed by fundamentals. We have created a model for the monthly and quarterly variation of the exchange rate with other explanatory variables such as net FDI and FII flows, Sensex Index and DXY Currency Index.

JEL CODE
F31 (Foreign Exchange)

KEYWORDS
Exchange Rate, Market Efficiency, USDINR.

INTRODUCTION

Whenever any person residing in one country wants to enter into any transaction with another person residing in another country, he will require the currency of the foreign country. He cannot enter into the transaction using his domestic country's currency. Transactions between people living in various parts of the world are being conducted through the exchange rates existing between the 2 countries. Exchange rates determine the price at which these transactions occur. An exchange rate is the rate at which any country's currency can be exchanged to buy the currency of another country. It describes the price of a currency in terms of another.

Exchange Rate can be considered to be the most important price in any economy as it affects all other prices. It affects trade balances, capital flows, growth rates, profits, share prices, inflation rates, interest rates and even the relative sizes of economies. It even has an impact on the unemployment prevailing in a country. Exchange rate' movements can have a significant impact on a company's returns. Multinational companies may see significant shifts in their profitability, as exchange rates may make locally held currency more valuable. Even local companies can be affected, as changing FX rates may substantially alter their material costs, or affect their ability to sell their goods in foreign countries at competitive prices. Thus exchange rate plays a big role in the competitiveness as well as the profitability of companies. If the exchange rate appreciates, it makes a country's imports uncompetitive. It will make imports cheaper and thus the domestic goods will be substituted by the cheaper foreign goods. This will have a big hit on the productivity of the export concentrated companies, leading to job cuts and unemployment. This will have a detrimental impact on the growth of the country, thus hampering its progress as well as its welfare.

Generally the quoted price in the foreign exchange market is the Nominal Exchange Rate. It is the rate between the countries is the one country's currency expressed in terms of another country's currency without taking into account inflation. Real Exchange Rate is the inflation adjusted nominal exchange rate. In India the exchange rate with respect to any other country apart from USA is taken through the USDINR exchange rate and the corresponding country's exchange rate with the US Dollar. Hence we are focussing only on the USDINR exchange rate in this study. A nominal effective exchange rate is the exchange rate of the domestic currency vis-à-vis other currencies weighted by their share in either the country's international trade or payments. It is the unadjusted weighted average value of a country's currency relative to all major currencies being traded within an index or pool of currencies. Real effective exchange rates take account of price level differences between trading partners. Movements in real effective exchange rates provide an indication of the evolution of a country's aggregate external price competitiveness. It is the weighted average of a country's currency relative to an index or basket of other major currencies adjusted for the effects of inflation. The weights for both of them are determined by comparing the relative trade balances, in terms of one country's currency, with each other country within the index.

Foreign Exchange markets are the markets where currencies of various countries are traded at the existing exchange rates. Any person or an institution can buy or sell currencies in the foreign exchange markets. Foreign exchange markets serve companies and individuals that purchase or sell foreign goods and services denominated in foreign currencies. Foreign currencies are also needed to purchase foreign physical assets as well as foreign securities.

There are 2 kinds of markets or exchange rates:

- Spot Exchange Rates: It refers to the exchange rate prevailing today. It is the rate at which one currency can be bought with another country's currency today. It is generally delivered immediately.
- Forward Exchange Rates: It is the exchange rate for an exchange to be done in the future. It refers to the exchange rate that is quoted and decided today, but delivered on a future specific date. This is to avoid the impact of the fluctuations in the exchange rates and minimise any potential losses that might occur by the exchange rate either declining or increasing on the future date as the case maybe. Forward rates are quoted for various future dates like 30 days, 60 days, 90 days or one year.

FACTORS AFFECTING EXCHANGE RATES

Exchange rates are influenced by various factors. These factors can be classified based on their impact on the exchange rate with respect to time. Thus we can broadly classify the factors into:

1. Long Run Determinants
2. Short Run Determinants

LONG RUN DETERMINANTS

There are 4 major factors that affect the exchange rate in the long run. They are relative price levels, tariffs and quotas, preferences for domestic versus foreign goods and productivity. The underlying logic is that anything that increases the demand for domestic goods relative to foreign goods tends to appreciate the domestic currency because domestic goods will continue to sell even when the value of the domestic currency is higher. Similarly, anything that increases the demand for the foreign goods relative to the domestic goods tends to depreciate the domestic currency because domestic goods will continue to sell only if the value of the domestic currency is lower.

RELATIVE PRICE LEVELS

In the long run, a rise in the country's price level (price of the goods) relative to the foreign price level causes its currency to depreciate and a fall in the country's price level causes its currency to appreciate. This is in line with the Theory of Purchasing Power Parity which states that exchange rates between any 2 currencies will adjust to reflect changes in the price level of the 2 countries. It is simply an application of the law of one price to national price levels rather than to individual prices. Law of One Price states that if 2 countries produce an identical good, and transportation costs and trade barriers are very low, the price of the good should be the same throughout the whole world no matter which country produces it. Thus any rise in the price of the domestic goods relative to the price of the foreign goods will depreciate the domestic currency where as any decrease in the price of the domestic goods relative to the price of the foreign goods will appreciate the domestic currency.

TRADE BARRIERS

Increasing trade barriers cause a country's currency to appreciate in the long run. Any restriction on the foreign goods in the form of quotas or tariffs tends to increase the demand for the domestic goods thus causing the domestic currency to appreciate.

PREFERENCES FOR DOMESTIC VERSUS FOREIGN GOODS

Increased demand for a country's exports causes its currency to appreciate in the long run as there is a greater demand for the domestic currency as the domestic currency is required to buy the country's exports, whereas increased demand for imports causes the domestic currency to depreciate as it results in the domestic currency being exchanged for foreign currencies leading to depreciation of the domestic currency.

PRODUCTIVITY

In the long run, as a country becomes more productive relative to other countries, its currency appreciates. Increased productivity of the domestic country relative to the foreign country allows it to produce goods at lower costs and thus resulting in an increased demand for its goods relative to the foreign goods. Consequently the domestic currency appreciates.

Apart from the above 4 factors there are other factors as well that affect the exchange rate in the long run. They have been discussed briefly below.

DIFFERENTIALS IN INFLATION

Generally, a country with consistently lower inflation rate exhibits an appreciating currency as its purchasing power increases relative to other currencies. Countries with higher inflation see the value of their currency depreciating relative to its trading partners.

CURRENT ACCOUNT BALANCE

Current Account is the difference between a country's total exports of goods, services and transfers, and its total imports of them. It consists of all payments between the countries. Whenever a country has current account deficit, the country would be requiring more foreign currency to carry out the trade. This will drive down the value of the country's currency thus depreciating it. Similarly if a country has a current account surplus, the country's currency would increase in value and consequently appreciates it.

TERMS OF TRADE

Terms of trade works similar to the current account balance. If a country's exports rise by a greater amount than its imports, the value of the country's currency increase leading to the domestic currency appreciating with its trading partners. The reverse happens when the country's imports rise by a greater amount than its exports.

POLITICAL STABILITY AND ECONOMIC PERFORMANCE

Investors generally invest in country's which has a stable and strong economic performance. With the increase in foreign investments in such stable countries, their currency will appreciate.

SHORT RUN DETERMINANTS

The behaviour of the foreign exchange rate is very unpredictable in the short run. Trying to forecast the future exchange rate is very tough. They key to understand the short run behaviour of exchange rate is to recognise that an exchange rate is the price of domestic bank deposits in terms of foreign bank deposits. Few factors which affect the exchange rate in the short run are:

EXPECTED RETURNS ON DOMESTIC AND FOREIGN DEPOSITS

The most important factor affecting the demand for the domestic deposits when compared to foreign deposits is the expected returns of both of them relative to each other. While comparing the returns, it is imperative to take into consideration the expected appreciation or depreciation of the domestic and foreign currency as any investment in the foreign currency deposits requires conversion of domestic currency into foreign currency and then later while selling the foreign country deposit, converting the foreign currency back into the domestic currency. Let E_t be the current spot exchange rate while i_D be the domestic currency deposit interest rate and i_F the foreign currency deposit interest rate. Thus the return on the domestic deposits for a foreigner or a foreign deposit for an individual of the domestic country can be shown to be:

$R = i_D - i_F + (E_{t+1} - E_t) / E_t$

Thus an increase in the relative expected return of the domestic country deposits causes an increased demand for it, leading to an appreciation of the domestic currency compared to the foreign currency and vice versa.

MARKET EXPECTATIONS

Market expectations affect the spot exchange rate greatly. Similar to stock markets, foreign exchange markets react quickly to news regarding future change in the rates. Future expectations are many a time self-fulfilling. Whenever a large number of investors feel that the currency value is going to decrease subsequently, they start selling the currency. This leads to excess supply of the concerned currency leading to its value actually depreciating. Similarly, whenever investors feel that the currency value is going to increase in the future, they start buying it. This raised the demand for the currency, leading to its value appreciating.

ORDER FLOWS

Order flows refer to the aggregated, small securities that brokers send to dealers often in return for cash payments. There is evidence of a positive correlation between the spot exchange rate movements and the order flows in the inter dealer market and with movements in the customer order flows.

DIFFERENTIALS IN INTEREST RATES

Exchange Rates are greatly influenced by the difference in the interest rates existing in the two countries. By manipulating the interest rates, central banks exert influence over exchange rates. Higher interest rates offer lenders higher returns. This attracts investments from other countries and thus increases the demand for the domestic currency and hence appreciates it. Similarly, if interest rates are decreased, money starts flowing from the home country to other countries which offer higher interest rates. This decreases the value of the domestic currency and thus causes the domestic currency to depreciate. While analysing the effect of the interest rates on the exchange rates, we have to consider the factors causing the interest rates to increase. Fisher's equation says that:

$$Nominal\ Interest\ Rate = Real\ Interest\ Rate + Expected\ Inflation$$

Thus any increase in the nominal interest rate caused due to an increase in the real domestic interest rate causes the domestic currency to appreciate while any increase due to increase in the expected inflation causes the domestic currency to depreciate. Any decrease in the real interest rate causes the domestic currency to depreciate while any decrease in the expected inflation causes the domestic currency to appreciate.

EFFICIENT MARKET HYPOTHESIS

The main aim of the study is based on trying to find out whether we can predict the movement of the exchange rate in the short run. If we can predict the movement then, steps can be taken so that the exchange rate can be managed effectively. Generally, it is found that foreign exchange markets follow efficient market hypothesis. Hence it is very important to understand what is meant by efficient market hypothesis. Before we try to understand Efficient Market Hypothesis, it is essential to understand the Random Walk Hypothesis, from which Efficient Market Hypothesis evolved.

Random Walk Hypothesis came out in the early 1960s. It is a theory regarding the behaviour of the stock markets. It examines the effect of past or present movement of stock prices or even entire markets on future movements. It says that stocks take a random and unpredictable path and that the past and present movements cannot be used to determine what will be the prices in the future. The chance of a stock's price going up is the same as it going down. The theory holds that it is impossible to stay ahead of the circumstances without taking on a higher amount of risk. It stated that a long term 'buy and hold' strategy is the best and that individuals should not try to time the markets.

Efficient Market Hypothesis is a theory of investment developed by Fama in 1970, which says that the stock market is efficient. Fama defined an efficient market as one in which prices always fully reflect available information. Thus the stock price of a company has taken into consideration all relevant information about a company. It is impossible to outperform the market in the long run and the only way to make profits is by taking on considerable risk. In order to test the efficiency of the market, Fama in his study, defined tests for 3 different levels of market efficiency namely:

1. WEAK FORM

A market is said to have weak form efficiency, if the current prices reflect all information contained in the past price data. The information set which determines the price includes only the history of prices. It states that the return on the market is independent and past rates of return have no effect on future rates. Weak Efficiency thus rejects technical analysis, which is the study of the stock's performance based on past trends.

2. SEMI STRONG FORM

A market is said to exhibit semi strong efficiency, if current prices fully reflect all information known to all market participants, thus all readily available public information. It assumes that stocks adjust quickly to absorb new information and also incorporates the weak form hypothesis. Thus it rejects Fundamental Analysis, which looks at the business's prospects – its products offered financial health, business plans, and competitors as a means of determining its future stock performance. As the current prices already take into consideration all the present available public information, fundamental analysis will not help to beat the market.

3. STRONG FORM

A market is said to display strong form efficiency, if the current prices fully reflect all public and privileged information known to any market participant. Here privileged information refers to the private information which includes all knowledge available to a market maker, insider information available to corporate managers or information that investment managers spend time and money to compile for their own use.

If Efficient Market Hypothesis is a reasonable representation then markets will be in a continuous stochastic equilibrium, i.e. securities will always equal their fair or fundamental values and any change in the fundamental value will be reflected immediately in the market price. As such the only factor which could alter the fundamental value of a security would be new information. Without any additional information we would not expect there to be any change in the value of the security. However news by definition is unpredictable and random, otherwise it is not news. As such movements in the value of a security will also be unpredictable and random. News from one day to the next will affect the security's price in varying directions and by varying magnitudes.

Our major focus of the research is to try to test for the weak form efficiency of the efficient market hypothesis and analysis whether there is any prediction that can be made about the future exchange rates by examining the past exchange rates. We are solely focussing on the USDINR exchange rate in this research. We take the RBI reference rates for USDINR exchange rate. We also try to model the variation in the exchange rates by examining the role played by the Sensex movement, DXY currency index, Brent Oil Prices, FDI and FII flows as well as the Current Account Deficit of India. These variables have been selected as these are few of the major factors that affect the inflow and outflows of foreign currency in the country. Thus by taking these as the independent variables, we regress them over the USDINR exchange rate movements. We run various tests based on the availability of data. We check for the daily variations of the exchange rate as well as monthly and quarterly fluctuations. We try to analyse the significance of the various variables and the validity of the multiple linear regression model that we obtain.

REVIEW OF LITERATURE

Fama(1970) has examined various empirical works, which he has divided into the above 3 forms of efficiency. He found out that the weak form tests of the efficient model are the most voluminous and most of the results are strongly in support of it. Though he found statistically significant evidence for dependence in successive price changes or returns, some of this is consistent with the "fair game" model and the rest in not conclusive enough to declare the market as inefficient. He also found that the semi strong form tests have also supported the efficient market hypothesis. While testing for the strong form of efficiency, he found 2 deviations. First, Niederhoffer and Osborne point out that specialists on major security exchanges have monopolistic access to information on unexecuted limit orders and they use information to generate trading profits. Second, Scholes found that corporate insiders often have monopolistic access to information about their companies. He mentions that apart from these 2 deviations, there is no further evidence of deviation existing down any further in the investment community. Thus he concluded that evidence in support of the efficient market hypothesis was extensive and contradictory evidence very sparse. Then Fama (1991) ina sequel to his previous work, using event studies found that prices react quickly to new information. He also suggested that while private information afforded traders excess returns, such information was rarely obtained.

Various researchers have tested the efficient market hypothesis in the foreign exchange markets in various countries. Various tests have been conducted to check whether the foreign exchange markets are weak form and semi strong efficient. There have been less researches on the strong form efficiency. The general tests conducted to test for weak form efficiencies are Augmented Fuller Test (ADF), Philip Perron (PP) and Kwiatkowski Philips Schmidt Shin analysis. These tests examine for unit root test. The presence of a unit root test proves that the foreign exchange rate movement is a non-stationary variable and it follows a random walk. This proves that the market is weak form efficiency as the current exchange rates incorporate all the previous prices and it is not possible to predict the future exchange rates based on the past prices.

Noman and Ahmed (1998) tested the weak form efficiency for seven SAARC countries' foreign exchange markets for the period 1985 to 2005. They employed Variance Ratio Test of Lo and Mackinlay (1998) and Chow-Denning joint variance ratio test (1993). Their research could not reject the null hypothesis of random walk for all the seven currencies. Thus they concluded that the foreign exchange markets in South Asian region follow random walk process and are weak form efficient.

Al Khazali, Koumanakos conducted empirical testing of the Random Walk of Euro Exchange Rates in 10 Middle Eastern and North African currencies and found out that apart from Kuwaiti and Emirates currencies all other currencies. Ibrahim, Long, Ghani and Mohd. Salleh in their work test the weak form efficiency of the foreign exchange market in 30 Organisation for Economic Cooperation and Development (OECD) countries by applying ADF test, PP and Kwiatkowski Philips Schmidt Shin analysis to examine for the unit root. They found that the foreign exchange market was consistent with the weak form of the Efficient Market Hypothesis.

Cheung, Jen Je Su and Kim Choo examined the market efficiency hypothesis in Euro Foreign Exchange by testing for auto correlation in daily foreign exchange of 82 countries over the period of 1999-2010 and found that the majority of the Euro Foreign Exchange Markets are efficient. Guneratne Wickremasinghe tested weak and semi strong efficiency of the foreign exchange market in Sri Lanka using average monthly spot exchange rates for 6 bilateral foreign exchange rates

from January 1986 to November 2000. He found out that the markets are weak form efficient and inefficient in semi strong form. Moorthy (1995) using foreign exchange data found that markets react quickly and efficiently to news of changes in the economic data, US employment figures for example.

METHODOLOGY

In order to test for the weak form market efficiency, we take the daily reference rate published by Reserve Bank of India from April 2nd 2004 to March 30th 2012. In order to find out whether the exchange rate movement over the mentioned period follows a random walk or not, we run LOMAC Variance Ratio Test on the daily exchange rate. It checks for the randomness of the exchange rate variable.

Sensex Movement, DXY Currency Movement, Brent Crude Oil Price movement, net FDI and FII flows are considered as some of the critical variables that might have an influence on the exchange rate movement. These are some of the factors that affect the inflows and outflows of foreign currency in the country. Any fluctuations in these variables will lead to a change in the exchange rate. We try to analyse the impact of Sensex Movement, DXY Currency Index and Brent Crude Oil Prices on the exchange rate by collecting their values over the past one year from April 2011 to May 2012 from the Bloomberg database. We have also collected the RBI reference rate for the USDINR exchange rate over the same period from the RBI website. We check for the presence of unit root test in the above mentioned variables and then try to formulate a multiple linear regression model to explain their movements.

We also take the quarterly data of the Current Account Deficit, the net FDI and FII flows for the past 8 years from April – June 2004 to October – December 2011 and then check for the presence of unit root. We take the difference between the value of the exchange rate at the ending of the quarter and the beginning of the quarter as the value of the variable. Similarly, we take the values for the other variables as well. We then try to create a multiple linear regression model for these variables by taking the exchange rate as the dependent variable and the other variables as the independent variables.

We also take the monthly movements of the exchange rate, Sensex Movement, DXY Currency and Brent Oil Prices by taking the difference between the value of the exchange rate at the ending of the month and the beginning of the month. Again we try to create a multiple linear regression model the same way as we did it in the previous case.

We have used E-Views version 7 to run the above mentioned tests.

FINDINGS AND DISCUSSIONS

We have considered the daily reference rate published by RBI from 2nd April 2004 to 30th March 2012. The variance ratio test has been performed on a period of 5 days, 10 days, 15 days, 20 days, 25 days and 30 days.

The null and alternate hypothesis for the variance ratio tests are given below:

H_0: VR(k,1) = 1

H_1: VR(k,1) ≠ 1

As the alternate hypothesis has an inequality, we have a 2 tailed test. We consider the significance level to be 1%. The critical value for the given level of significance is 2.58. The test result has been shown below:

TABLE 1

	Daily Returns	5	10	15	20	25	30
SUM(RETURNSQ)	0.00808340	0.04317845	0.09210148	0.14757504	0.20684201	0.26544828	0.33009762
m		9655.05154639	19210.46391753	28666.62371134	38023.91752577	47282.73195876	56443.45360825
Variance	0.00000417	0.00000447	0.00000479	0.00000515	0.00000544	0.00000561	0.00000585
VR(k)		1.07274491	1.15003937	1.15112871	1.13462709	1.09053843	1.07509524
ø(k)		0.00247423	2.98608247	4.63298969	6.27130584	7.90103093	9.52216495
Test Statistics M1(k)		1.46245617	0.08682691	0.07021280	0.05375928	0.03221003	0.02433574
μ	0.00003542	0.06871763					

The calculated test Statistics $M_1(k)$ are 1.46, 0.087, 0.07, 0.054, 0.032, 0.024 which are lesser than the critical values of 2.58 for 1% significance level. Thus the null hypothesis that the daily exchange rate follows a random walk cannot be rejected. This proves that the foreign exchange market is weak form efficient.

We will also check for the presence of a unit root in the exchange rate. If a series features a unit root, they are better characterised as non-stationary processes that have no tendency to return to a long run deterministic path. The variance of the series is time dependent and goes to infinity as time approaches infinity, which results in serious problems for forecasting. They also suffer from permanent effects from random shocks. They also follow a random walk.

In our data analysis, we follow the following sequence:

1. Graphically check for the stationarity of the time series of the data.
2. Statistically check for the presence of unit root through the ADF test.
3. If the time series is not stationary we make it stationary by taking the first order difference or any other order difference that is required to make the time series stationary. This is done to eliminate the trend component of the time series.
4. Check for the correlation between the explained variable and the individual explanatory variables. We find out the particular lag of the variable which has more correlation with the explained variable.
5. Run a multiple linear regression over the explained variables and the particular lags of the explanatory variables to obtain a model. We check for the relevance of the model and the individual variables.
6. Check whether the model can be further improved by running multiple linear regression again by checking for multi collinearity.

In the beginning we consider the daily USDINR exchange rate through the reference rates issued by RBI. We also take the daily movements of the Sensex, DXY Currency and Brent Crude Oil Prices. These are the major variables that we feel have a greater influence on the variation of the exchange rate. There are other variables as well in our research that have a say in the fluctuation of the exchange rate, but the values of these variables are available on a daily basis. Hence we are considering only the daily exchange rate movement at this stage. Daily movement of the above variables are shown below:

FIG. 1

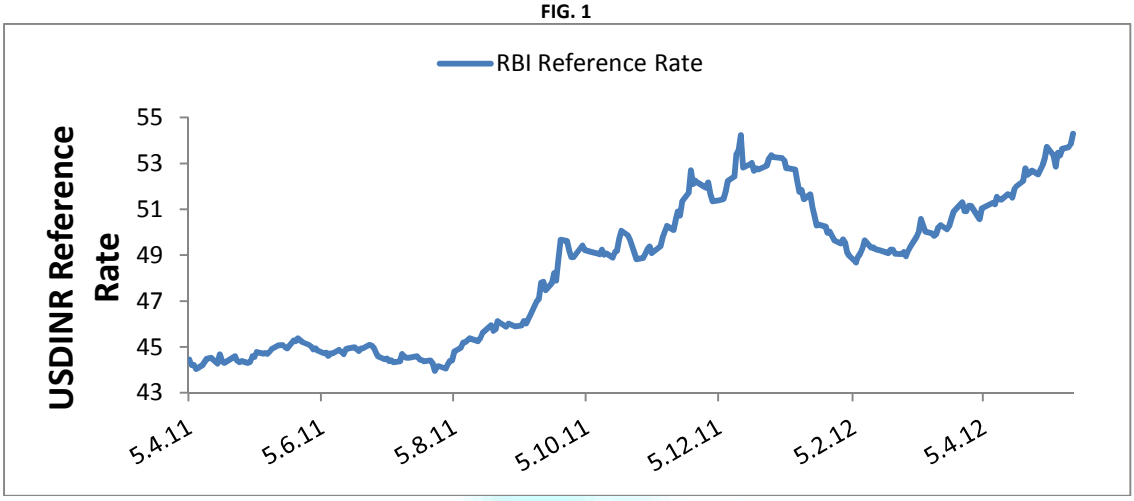


FIG. 2

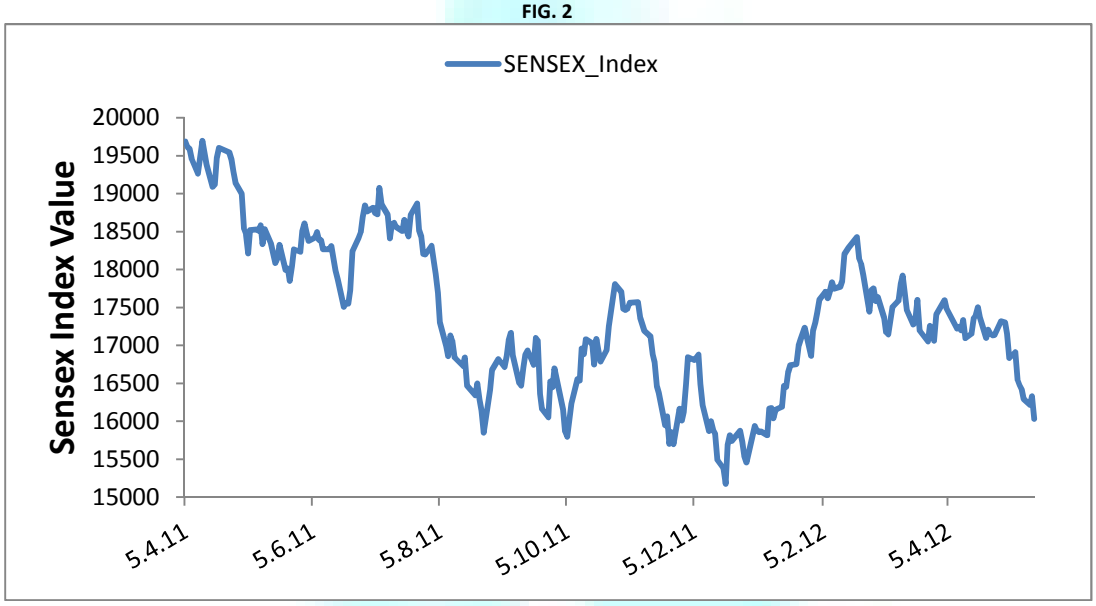


FIG. 3

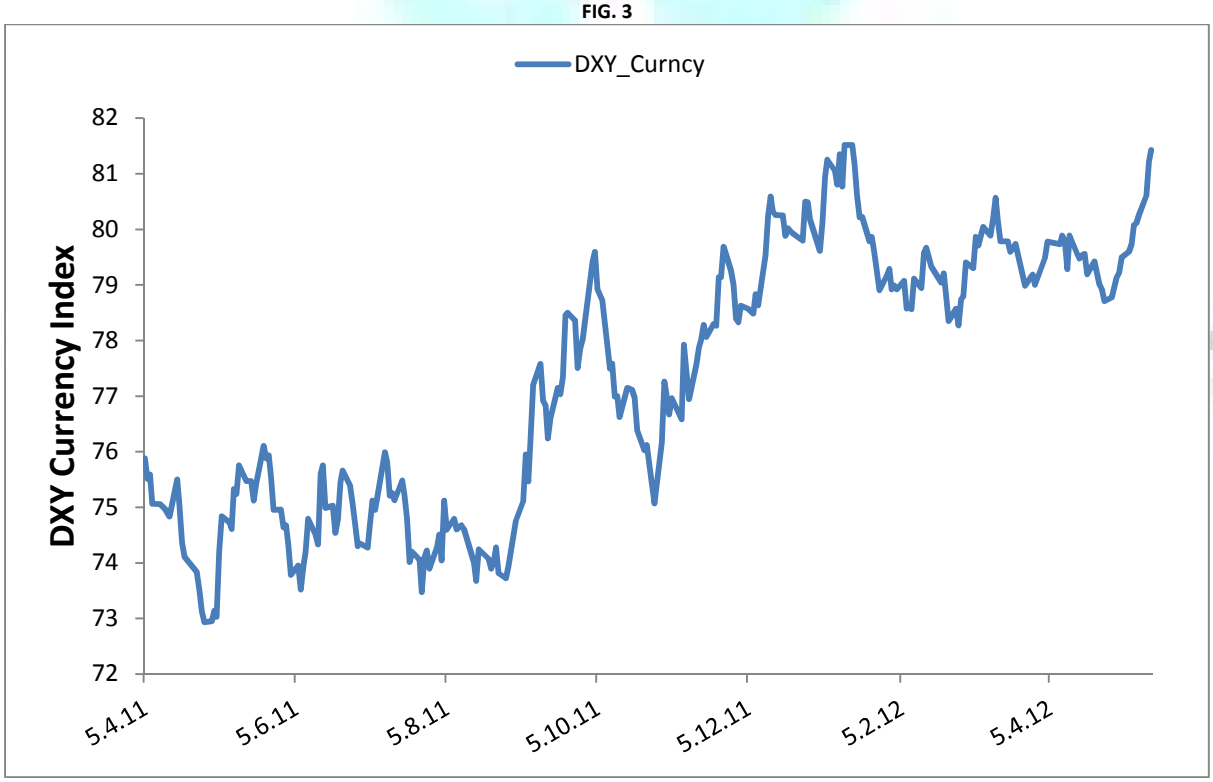
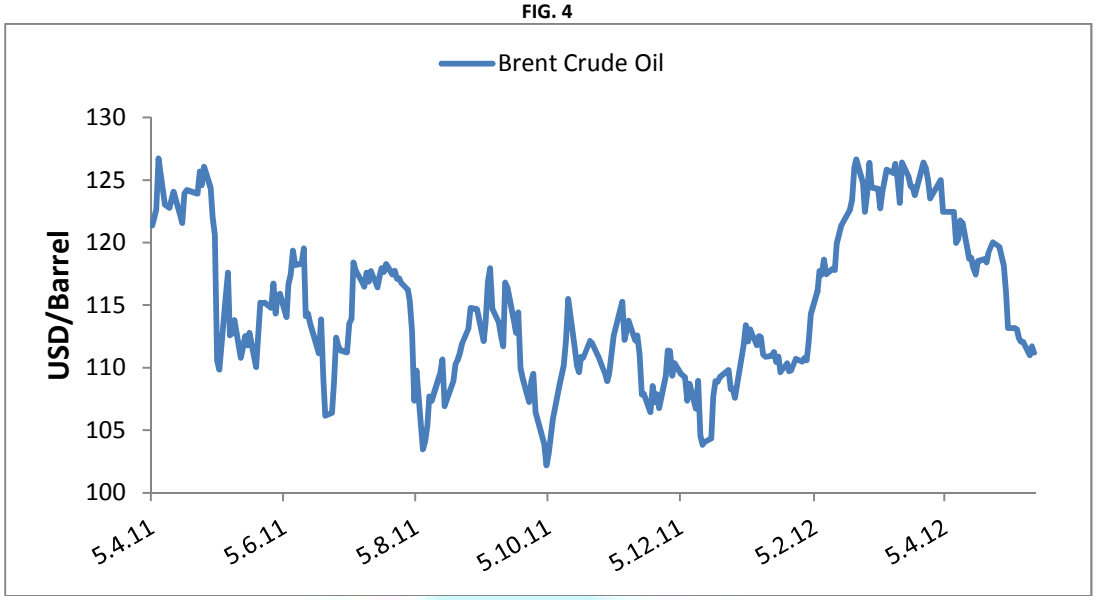


FIG. 4



When we analyse the movements of the above mentioned variables over the time period graphically, we can clearly make out that all the variables are non-stationary. A variable is said to be stationary if its mean and variance are constant over time and the value of covariance between the 2 time periods depends only on the distance or gap or lag between the two time periods and not the actual time at which covariance is computed. They cannot be bounded i.e. they do not have a constant upper bound or a lower bound. The bounds vary with time. The graphs are given below. From the graphs it is clearly visible that the variations in the variable over time cannot be bounded uniformly. The upper and lower bounds are changing as the time period varies. Thus we can conclude that the variables are non-stationary through the graphical analysis.

In the next step we have used the Augmented Dickey Fuller test to statistically check for the existence of unit root. ADF estimates an OLS model such as:

$Y_t = a + bt + uy_{t-1} + e_t$ in the form

$\Delta y_t = (u - 1)y_{t-1} + a + bt + e_t$

And then testing for u=1 (null hypothesis of unit root) using t test. Failing to reject the null is equivalent to failing to reject the existence of a unit root or stochastic trend in the time series. The null and alternate hypothesis of the ADF tests for exchange rate in particular is given below:

Null hypothesis H_0: Exchange rate movement is a non-stationary variable.

Alternate hypothesis H_1: Exchange rate movement is not a non-stationary variable i.e. stationary variable.

We ran the ADF test on the exchange rate movement over the past year and the results are given in the table 1 in the appendix. As shown in the table, the probability that the unit root is present in very high i.e. **0.9913**. This implies that the null hypothesis cannot be rejected. Thus we can deduce that the exchange rate movement is a non-stationary variable. This implies that the movement cannot be predicted and the movement follows a random walk. Thus the foreign exchange rate market with respect to USDINR is **weak form efficient**. We also run the ADF tests by taking exogenous variable as constant and constant linear trend. The results of the tests are given in tables 2 and 3 in the appendix. The probabilities in both the cases are **0.9464** and **0.8378** which are very high. As shown by the above tests, it is clear that the probability that the exchange rate variable has a unit root is very high in all 3 modes. Thus we cannot reject the null hypothesis that the exchange rate movement is non-stationary.

Similarly we check for the presence of unit root in the other variables as well. All of them have a high probability value as shown in the tables 4-6 in the appendix. This means that all of the variables have a unit root and are non-stationary.

In order to make the exchange rate movement stationary by eliminating the trend component in the time series, we take the first order difference and analyse it again using ADF test. First Order Difference is the difference between the value at a given time period and the value in the previous time period. The null hypothesis and the alternate hypothesis are mentioned below:

H_0: The first order difference of the exchange rate movement is a non-stationary variable

H_1: The first order difference of the exchange rate movement is not a non-stationary variable i.e. a stationary variable.

We performed the unit root tests on the first order difference of the exchange rate movement and the result has been shown in Table 7 in the appendix. From the table it is clearly visible that the probability that the probability that the variable has a unit root is 0. Thus we can reject the null hypothesis and accept the alternate hypothesis and infer that the first order difference of the exchange rate movement is a stationary variable. Similarly we also take the first difference of the daily Sensex Index, DXY Currency and Brent Crude Oil Prices. By taking the first difference of the variables, we find that all of them are stationary when we run the ADF tests on them. The results of the tests for all the 4 variables are given in the tables 8-10 in the appendix.

Ordinary least squares (OLS), when used to predict the future value of the explained variable, relies on the stochastic process being stationary. If OLS is being used to explain the explained variables in the time period over which the data is available, it will provide a good model even with non-stationary variables. But when we are predicting the future values, we cannot say with guarantee about how the variables will behave and whether they will behave as suggested by their trend or their values would be different. Hence when the stochastic process is non-stationary, the use of OLS can produce invalid estimates to estimate the future values. Granger and Newbold called such estimates 'spurious regression' results: high R2 values and high t-ratios yielding results with no economic meaning.

As all the above mentioned variable are non-stationary, running a multiple linear regression model to predict the future value of the exchange rate on these variables will result in a spurious regression. We also conduct a multiple linear regression analysis on the above mentioned variables taking the exchange rate as the dependent variable and Sensex Movement, DXY Currency Movement and Brent Oil Prices as the independent variables. We take the daily movement of all the above mentioned variables. The result of the analysis is given in Table 11 in the appendix. The significance value of all the 3 variables is very low. They are significant even at 1% significance level. Thus all the 3 variables are very important. The adjusted R^2 value is also very high indicating that the model explains majority of the variations in the exchange rate movement. But the Durbin Watson stat is very low; 0.22 to be exact, which is almost close to 0. Whenever the Durbin Watson test is close to 2, we can confidently say that auto correlation is absent among the variables. But in this test, the value is close to 0 indicating that auto correlation exists among the variables. When the correlation is calculated between a series and a lagged version of itself it is called autocorrelation. As in this case, even though the adjusted R^2 value is high, it is a spurious regression and we cannot model exchange rate linearly through these variables. Thus in order to make the variables stationary, we take the first order difference of all the variables. We get the first order difference by subtracting the current period value of the variable by the immediate previous period value.

$\Delta y = y_t - y_{t-1}$

We check for cross correlation of exchange rate and all the individual variables. Cross correlation is a standard method of estimating the degree to which two series are correlated. We use the cross correlograms to examine the cross correlation between the variables. In these tests, the correlation between the dependent variable, first order difference of daily exchange rate in this scenario, and the various lags of the dependent variable is examined. We consider it for

all the variables. The correlogram clearly shows the particular lag of the variable which has more correlation with the dependent variable. Whenever the correlation bar crosses the dotted boundaries, we say that the correlation between the dependent variable and the particular lag is the highest. In case there is more than one lag of the independent variable that has greater correlation, the earliest lag is taken as the independent variable value for the multiple linear regression model.

Based on the result of the cross correlogram shown in table 12 in the appendix, we take the level data i.e. no lags for First Order Difference of Sensex Index and the first lag for DXY Index and Brent Crude Oil Price as the explanatory variables for the regression. The results of the multi linear regression analysis are shown below:

TABLE 2

Dependent Variable: DREFRATE
Method: Least Squares
Sample (adjusted): 3 265
Included observations: 263 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.029034	0.015778	1.840101	**0.0669**
DSENSEX	-0.000330	7.26E-05	-4.543548	**0.0000**
DBRENT(-1)	-0.017176	0.009191	-1.868791	**0.0628**
DDXY(-1)	0.207157	0.040608	5.101312	**0.0000**
R-squared	0.231995	Mean dependent var		0.038365
Adjusted R-squared	**0.223099**	S.D. dependent var		0.289534
S.E. of regression	0.255201	Akaike info criterion		0.121559
Sum squared resid	16.86800	Schwarz criterion		0.175889
Log likelihood	-11.98505	Hannan-Quinn criter.		0.143393
F-statistic	26.07915	Durbin-Watson stat		**2.152126**
Prob (F-statistic)	**0.000000**			

The adjusted R^2 value of the model **0.223099** is low. All the variables are significant at 10% level of significance. The Durbin Watson stat is **2.152126** and the probability of the F-statistic **0**. But still the adjusted R^2 value of the model is low, indicating that the model is able to explain only a minor portion of the movement if the exchange rate. As much of the information is lost when we take the first order differences, the multiple linear regression model on the variables doesn't give us a model which can help in predicting the movement of the exchange rate. The model obtained above cannot be used to predict the future values of the exchange rate as very little of the exchange rate movement is captured by the model.

Next we try to formulate a multiple regression model for the quarterly value of the exchange rate and the explanatory variables, which are net FDI and FII flows, Sensex Index, DXY Index and Brent Crude Oil Prices. For getting the quarterly value of the exchange rate, we subtract the RBI reference rate at the ending of the quarter and at the beginning of the quarter. Similar to the exercise done in the previous stage, we take the total variation in the exchange rate for the quarter to better capture the movement of the exchange rate. Similarly we capture the movement in the Sensex, DXY Currency and Brent Oil Prices. We add the net FDI and FII inflows for the given months to get the quarterly data for these variables.

The graphs for the above mentioned variables are given below. From the graphs we can clearly make out that apart from net FDI flows, all other variables are stationary as they have a constant mean and variance. But net FDI flows don't look like it has a constant mean and variance. Their mean and variance varies based on the time period. Thus we have a combination of stationary and non-stationary values.

FIG. 5

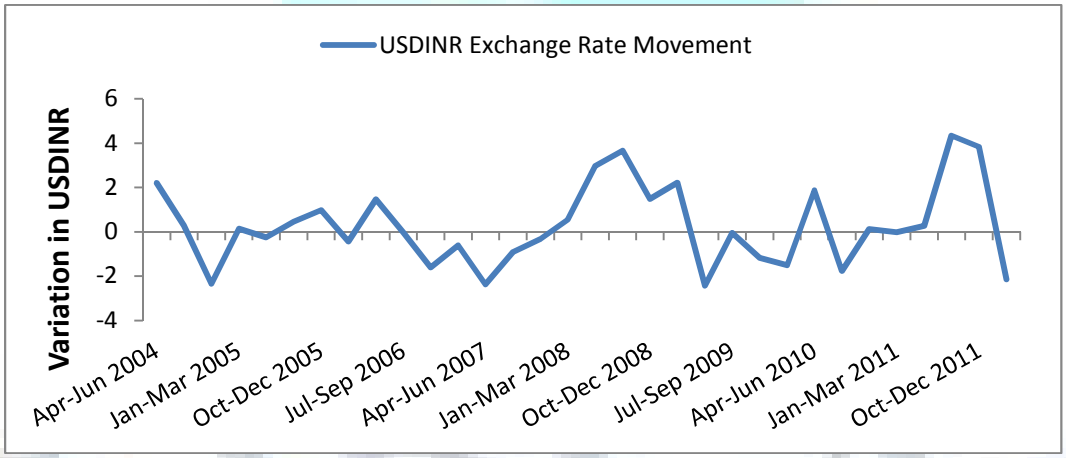


FIG. 6

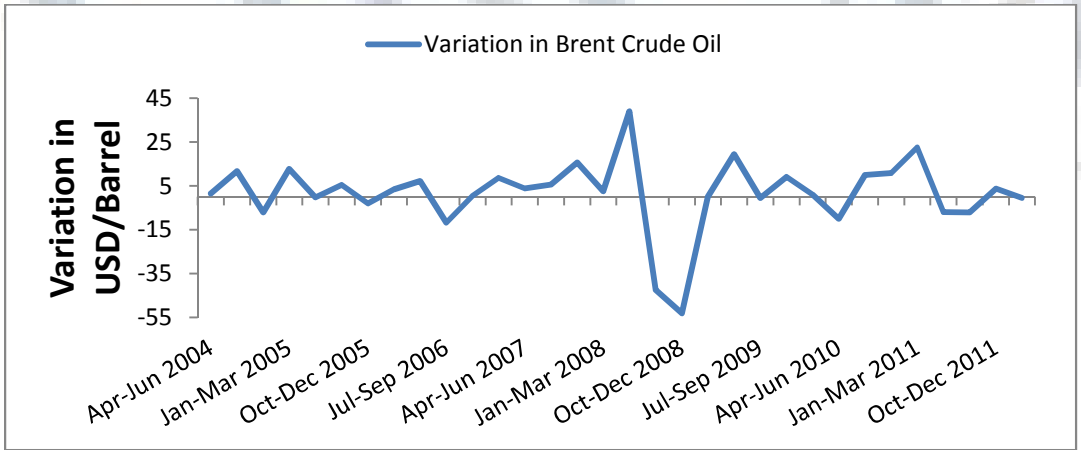


FIG. 7

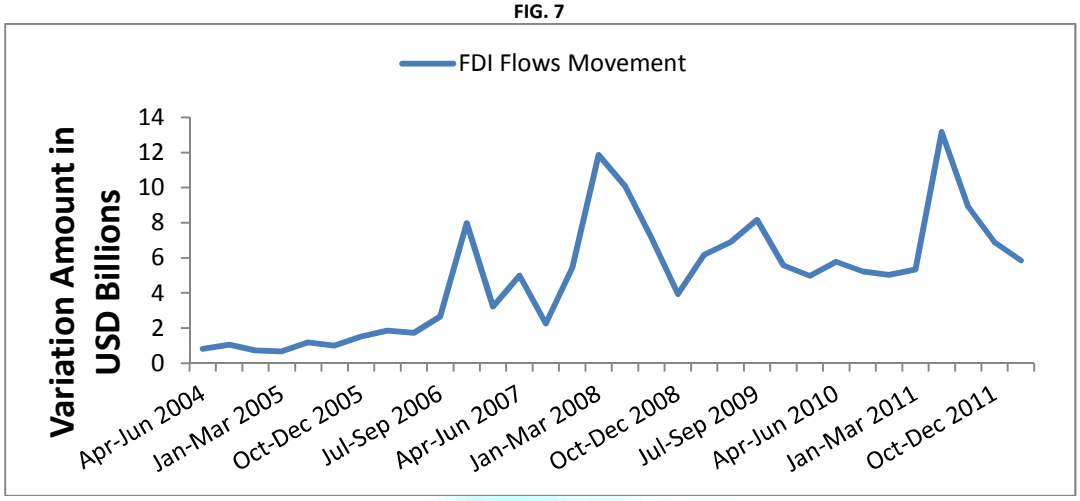


FIG. 8

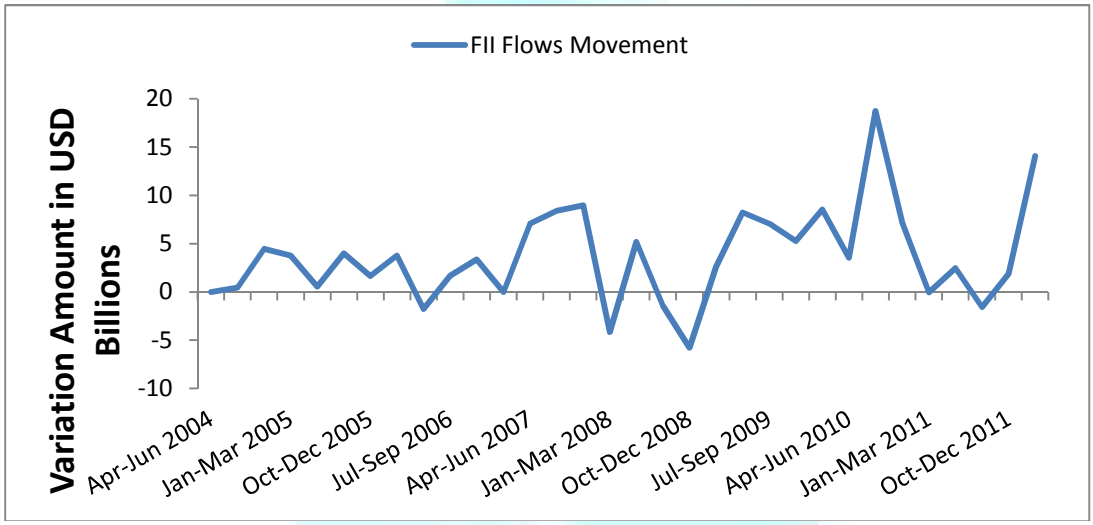


FIG. 9

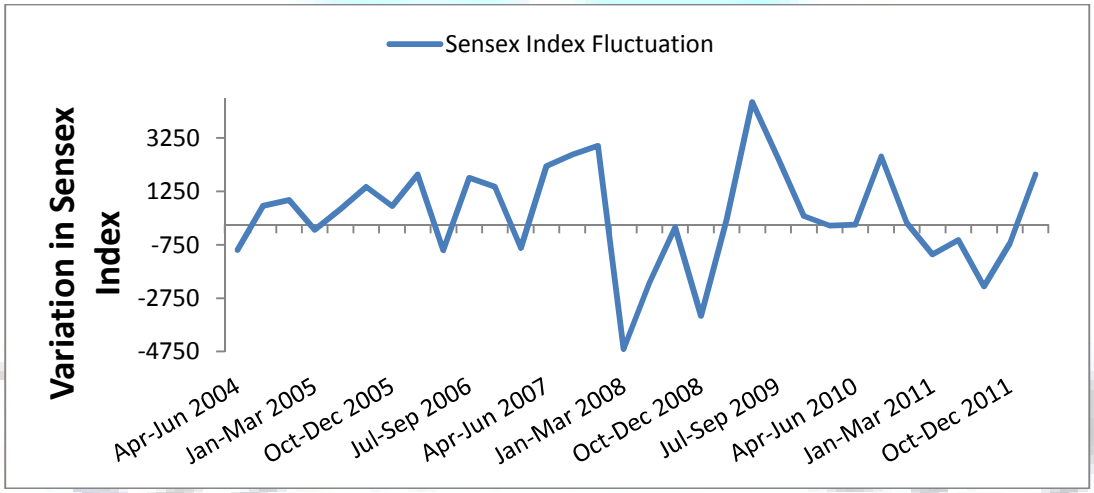
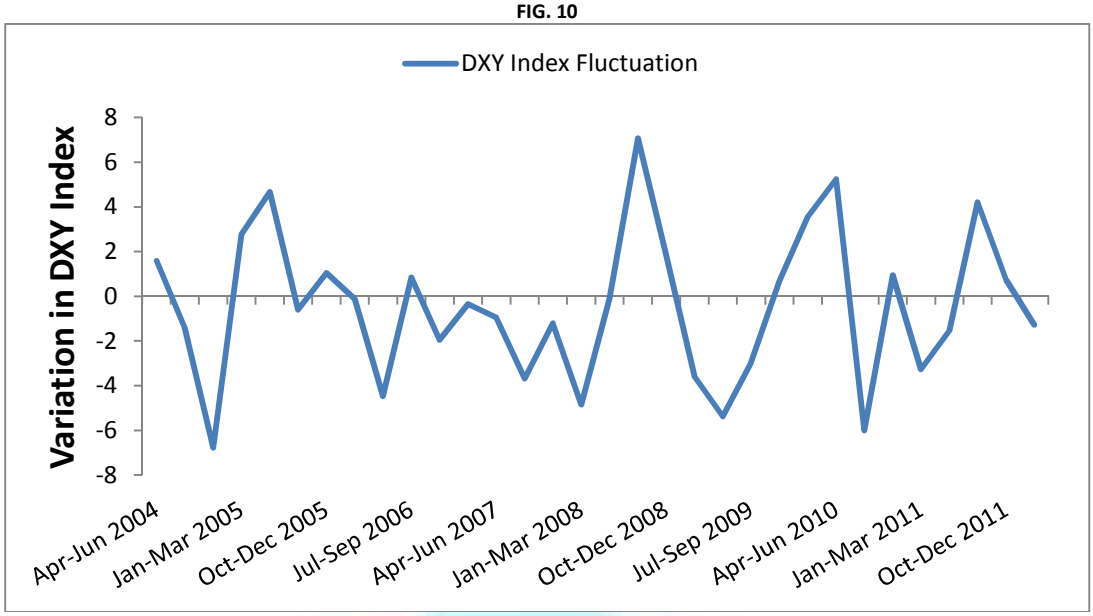


FIG. 10



We next run the ADF tests on the above mentioned variables to statistically check for the presence of unit root. The results of the ADF tests, shown in tables 14-19 in the appendix, prove what we could infer graphically: Sensex Index Variation, DXY Index Variation, exchange rate, FII flows and Brent Crude Oil Prices are all stationary variables as their probability values are high. Only FDI flows is non-stationary with the low probability value. The detailed results are given in tables in the appendix. We next take the first difference of the net FDI flows and then run ADF test on them. The results are given in table 20 in the appendix. From the tables it is clear that all the first order difference of FDI flows is stationary now as it has very low probability values thus proving that the first order differences of the variable is stationary.

We run cross correlation test between the exchange rate and the following variables: Sensex Index, DXY Currency Index, FII flows and Brent Crude Oil Prices as well as the first order differences of FDI flows. The correlogram is shown in table 21 in the appendix. From the table, it is clearly visible that the level data i.e. the data with no lag, of FII inflows, Sensex Index and the DXY index have the highest correlation with the dependent variable. Similarly it can be clearly observed that the third lag of the Brent Crude Oil Prices and the second lag of the FDI inflows have the highest correlation with the dependent variable. Taking these variables as the independent variables and the exchange rate movement as the dependent variable, we run the multiple linear regression. The result of the regression is included in table 22 of the appendix.

From the table, it is clear that none of the variables are significant even at 10% significance level. All of them have high probability values and the adjusted R^2 value is 0.49. Thus the model might be suffering from multi collinearity. Multi collinearity is said to exist in a multiple linear regression model when the variables are not individually significant but the adjusted R2 value of the model is significant. Thus in order to eliminate multi collinearity, we run multiple linear regression by eliminating the variables one by one till we get variables which are significant. The final model that we get is given below:

TABLE 3

Dependent Variable: REFRATE
Method: Least Squares
Sample (adjusted): 3/01/2005 3/01/2012
Included observations: 29 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.865227	0.329922	2.622521	**0.0147**
DFDI(-2)	0.168892	0.091182	1.852255	**0.0758**
FII	-0.171721	0.051218	-3.352757	**0.0025**
OIL(-3)	0.031334	0.015412	2.033125	**0.0528**
R-squared	0.509688	Mean dependent var		0.302097
Adjusted R-squared	0.450850	S.D. dependent var		1.839292
S.E. of regression	1.363001	Akaike info criterion		3.584696
Sum squared resid	46.44427	Schwarz criterion		3.773289
Log likelihood	-47.97810	Hannan-Quinn criter.		3.643761
F-statistic	8.662646	Durbin-Watson stat		**1.621818**
Prob(F-statistic)	**0.000410**			

All the 3 variables are significant at 10% significance level. The Adjusted R^2 value is close to **0.45**and the probability of the F-statistic is almost 0. The Durbin Watson stat is also near to **1.62** indicating auto correlation is absent among the residuals. But still its not very close to 2. Hence we further check for auto correlation through the correlogram shown in table 23. Here we check whether the bar for each residual has crossed the boundary in the Autocorrelation column. Thus we can safely say that auto correlation is absent from the model. We also check for heteroskedasticity in the model. That is done through a correlogram among the square of the residuals. This is shown in table 24 in the appendix. As in the previous case, it is clear that all the values are within the specified ranges. Thus it can be said that the model is free from heteroskedasticity. For a multiple linear regression model to be BLUE (Best Linear Unbiased Estimator), the model has to be free from multi collinearity, auto correlation and heteroskedasticity. The model that we obtained is free from all the above defects.

From the model, we can deduce that among the 5 variables which we considered in our analysis, only the quarterly FII flows, second lag of the first order difference of the FDI flows and the third lag of the variation in the Brent Crude Oil Prices have a significant impact on the quarterly variation in the exchange rate. The FII flows has a negative impact while the other 2 variables have a positive impact. This implies that any increase in the quarterly FII flows will decrease the USDINR exchange rate where as any increase in the annual FDI flows and annual Brent Crude Oil Prices will tend to increase the USDINR exchange rate.

We next proceed to analyse the monthly movement of the exchange rate, net FDI and FII flows, Sensex movement, DXY Currency Index and Brent Crude Oil Prices. For getting the quarterly value of the exchange rate, we subtract the RBI reference rate at the ending of the month and at the beginning of the month. If we just take the value of the exchange rate at the ending of the month, then it does not do justice to the exchange rate movement over the past month. The variation in the exchange rate also better explains the movement of the exchange rate over the month rather than taking an average of the exchange rate values over the past month. Hence we take the total variation in the exchange rate for the month to better capture the movement of the exchange rate. Similarly we

take the variation in the movement of the Sensex Index, DXY Currency Index and Brent Crude Oil Prices for every month from April 2004 to March 2012. We take the monthly FDI and FII flows available from the RBI website. The graphs of the variation of all the variables are given below. From the graphs it is clearly visible that apart from net FDI flows all other variables are stationary. All of them are mean reverting. We need to test the FDI flows statistically to check whether it is stationary or not.

FIG. 11

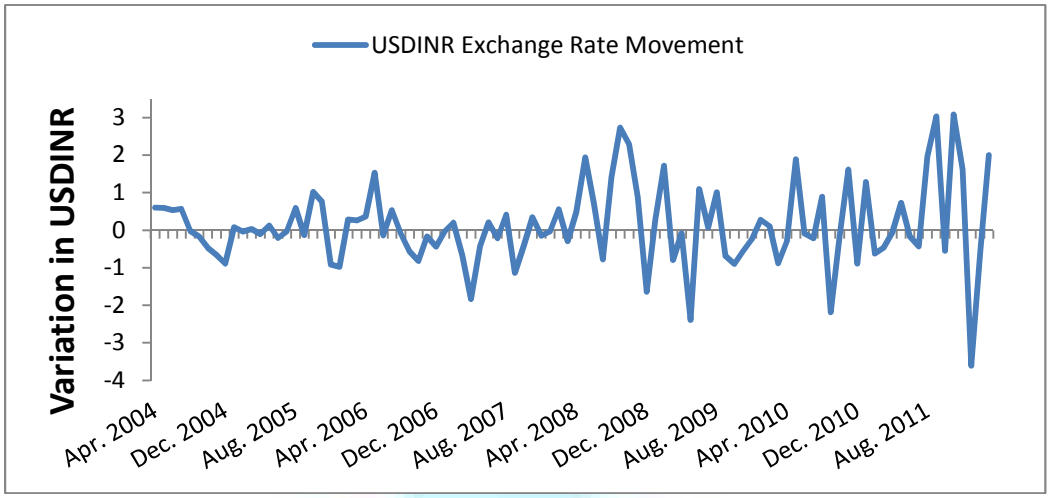


FIG. 12

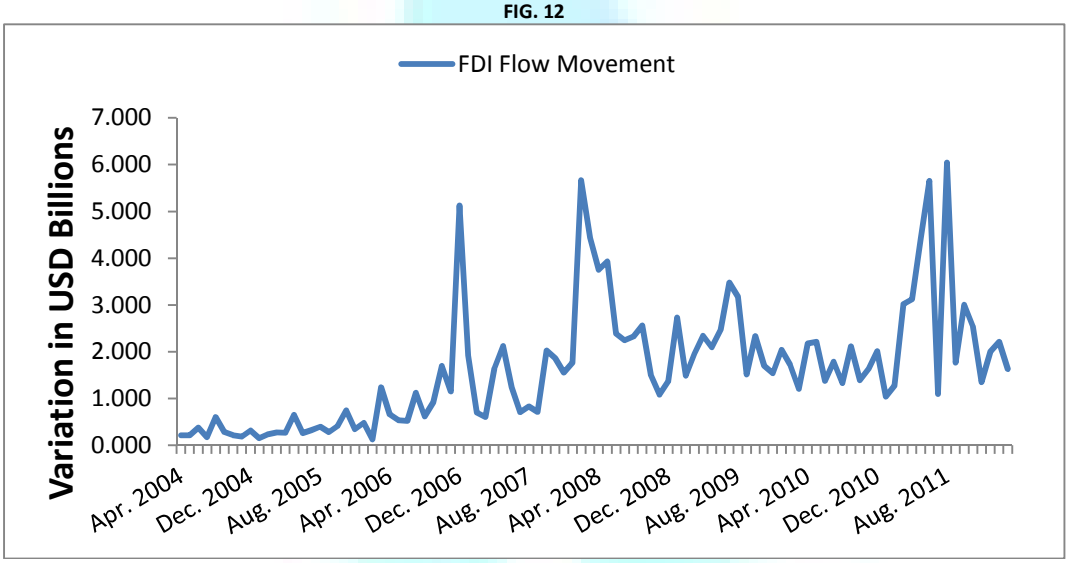


FIG. 13

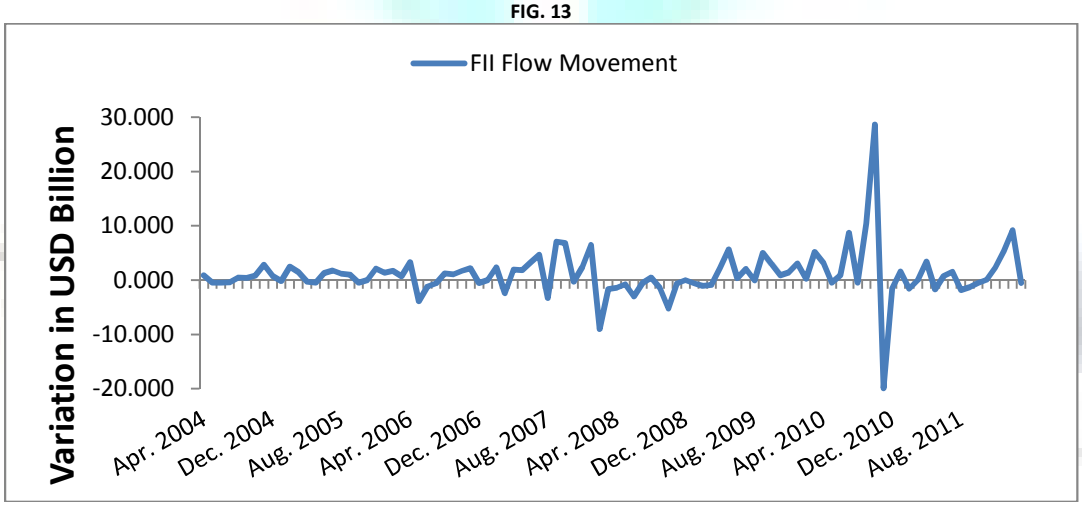


FIG. 14

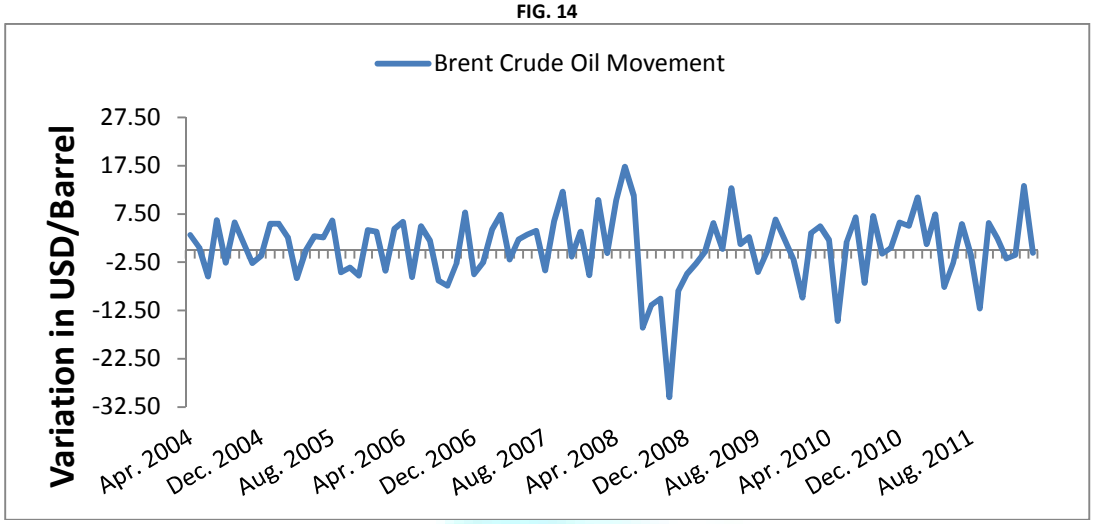


FIG. 15

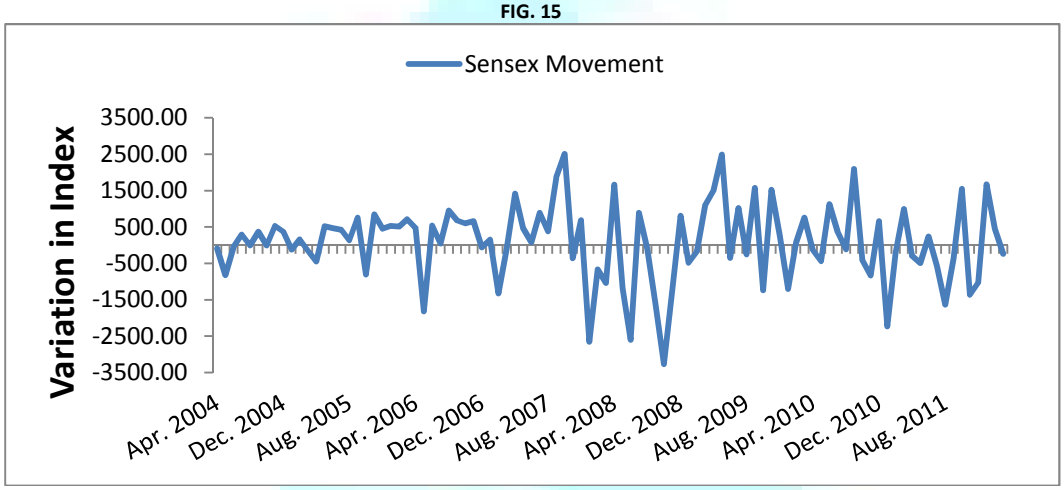
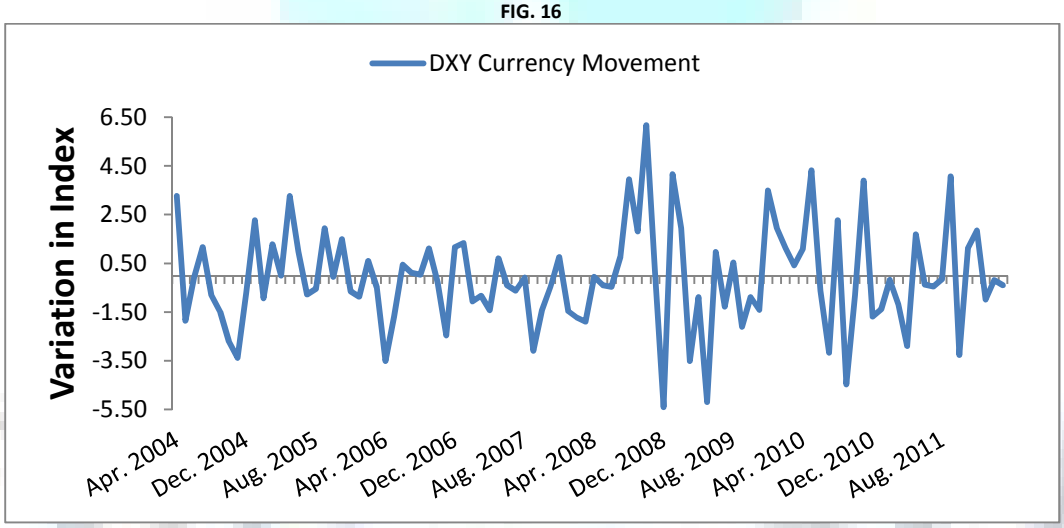


FIG. 16



The results of the ADF tests on the individual variables are given in tables 25-30 in the appendix. The probability values of all the ADF tests for all the variables are very low. Thus the null hypothesis that the series are non-stationary can be rejected and the alternate hypothesis that the series are stationary can be accepted. Next we examine the cross correlation between the individual variables and the exchange rate. The correlograms are shown in table 31 in the appendix. From the table it is clear that the level data of the monthly variation in the DXY Index, Sensex Index, Brent Crude Oil Prices and the net FII flow have the highest cross correlation with the monthly variation in the exchange rate. Similarly we also observe that the first lag of the net FDI flow has the highest cross correlation.

We next run a multiple linear regression model taking exchange rate as the dependent variable and the level data of the monthly variation in the DXY Index, Sensex Index, Brent Crude Oil Prices and the net FII flow as well as the first lag of the net FDI flow as the independent variables. The result is shown in table 32 in the appendix. Almost all the variables have low probability values indicating they are all significant. Only the Brent Crude Oil Price has a high probability value. The adjusted R^2 value of the model is pretty high. Thus the model might be suffering from multi collinearity problem. In order to eliminate it, we again run multiple linear regression on the above variables without considering the Brent Crude Oil Price monthly variation. The result of the test is shown below:

TABLE 4

Dependent Variable: REFRATE
Method: Least Squares
Sample (adjusted): 2004M05 2012M03
Included observations: 95 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.033124	0.125790	0.263326	**0.7929**
DXY	0.167442	0.041254	4.058824	**0.0001**
FDI(-1)	0.110642	0.059484	1.860009	**0.0662**
FII	-0.034732	0.017934	-1.936653	**0.0559**
SENSEX	-0.000465	7.95E-05	-5.842582	**0.0000**
R-squared	0.559730	Mean dependent var		0.112788
Adjusted R-squared	0.540162	S.D. dependent var		1.090171
S.E. of regression	0.739260	Akaike info criterion		2.284861
Sum squared resid	49.18543	Schwarz criterion		2.419275
Log likelihood	-103.5309	Hannan-Quinn criter.		2.339174
F-statistic	28.60497	Durbin-Watson stat		**1.669827**
Prob(F-statistic)	**0.000000**			

All the variables have low probability value indicating that all of the variables are significant. When we check for auto correlation through the correlogram, shown in table 33 in the appendix, we can see that all the values are within the specified limits. Thus we can say that the model is free from auto correlation. But when we check for heteroskedasticity, shown in table 34 in the appendix, we find that heteroskedasticity problem is present in the model as the value in the 2nd lag is exceeding the boundaries. Thus we need to eliminate this issue. We can do it by introducing moving average and Auto Regressive variables. This will help us in getting rid of it. The final model is given below:

TABLE 5

Dependent Variable: REFRATE
Method: Least Squares
Sample (adjusted): 2004M06 2012M03
Included observations: 94 after adjustments
Convergence achieved after 16 iterations
MA Backcast: 2003M10 2004M05

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.012180	0.070310	-0.173229	**0.8629**
DXY	0.195888	0.031557	6.207427	**0.0000**
FDI(-1)	0.114734	0.035489	3.232939	**0.0017**
FII	-0.040894	0.013943	-2.932938	**0.0043**
SENSEX	-0.000365	7.03E-05	-5.193051	**0.0000**
AR(1)	0.202393	0.109545	1.847586	0.0681
MA(2)	-0.576613	0.075529	-7.634291	0.0000
MA(8)	-0.364091	0.075023	-4.853078	0.0000
R-squared	0.658158	Mean dependent var		0.107712
Adjusted R-squared	0.630333	S.D. dependent var		1.094887
S.E. of regression	0.665694	Akaike info criterion		2.105291
Sum squared resid	38.11073	Schwarz criterion		2.321742
Log likelihood	-90.94868	Hannan-Quinn criter.		2.192721
F-statistic	23.65400	Durbin-Watson stat		**2.038130**
Prob(F-statistic)	**0.000000**			
Inverted AR Roots	.20			
Inverted MA Roots	.99	.67-.56i	.67+.56i	.00+.82i
	-.00-.82i	-.67-.56i	-.67+.56i	-.99

Even though the probability of the constant term is very high at 0.8638, we still retain the variable. In case we eliminate it, it means that the exchange rate variation would be 0 in case the other variation in the other variables are 0 for the quarter under consideration. This would be an incorrect assumption. There might some variables which we have not considered and they might have also influence the exchange rate variation as thus we cannot eliminate the constant term. Hence we retain the variable even though it doesn't have significance value. The R^2 value is much higher that the value obtained in the previous stage. The probability of the F-statistics which measures the goodness of fit test is 0 indicating that the model is a valid one. The Durbin Watson statistic is also very close to 2 thus confirming that the model doesn't suffer from auto correlation. The correlograms of both residuals and residual squares are shown in tables 36 and 37 respectively in the appendix. It is clearly visible that both the issues have been eliminated in the model.

FDI and DXY Currency Index have a positive impact on the exchange rate while FII and Sensex have a negative impact. Thus any decrease in the FII flow or the monthly Sensex Variation corresponding to the previous month or any increase in the DXY Currency Index and bimonthly FDI flows will increase the USDINR exchange rate leading to depreciation of the Indian Rupee.

CONCLUSION

It is clearly evident from that the daily exchange rate follows a random walk, proving that the foreign exchange markets are weak form efficient. Technical analysis won't be beneficial in this situation as the current price of the exchange rate incorporates all the previous period exchange rate. Thus we won't be able to predict the future prices through the past prices information. We also tried to model the daily exchange rate prices through the daily Sensex Index value, DXY Currency Index and Brent Crude Oil Prices. But all these variables are non-stationary. We get a spurious regression if we directly try to model these variables as multiple linear regression requires all the variables to be stationary in order to predict the future value of the dependent variable. When we took the first order difference of the variables, the multiple regression model obtained had a low adjusted R^2 value indicating the low explaining power of the model. A lot of information is lost when we take the first order difference of the variables. Thus we cannot model the daily exchange rate values linearly through these variables. We need to consider some extra variables or try a nonlinear model.

In the long run, when we try to model the quarterly variation in the exchange rate, we found that the multiple linear regression model obtained has significant explaining power. We found that FDI and the FII flows as well as the Brent Crude Oil Prices have a significant impact on the quarterly variation in the exchange rate. While the FII flows has a negative impact, the annual FDI flows and Brent Crude Oil Variation have a positive impact on the exchange rate. We also found that the monthly variation in the DXY Currency Index and bimonthly FDI flows have a positive impact on the exchange rate while FII and Sensex have a negative impact when we modelled the monthly variation in the exchange rate.

Hence the exchange rate variable can be modelled whenever we consider the monthly or quarterly variation. Thus its behaviour in the long run is based on fundamentals which can be analysed. But it is not possible to model it on a daily basis. This proves that the movement of the exchange rate variable in the short run is not based on any fundamentals. As it is a random variable, the daily exchange rate movement is random and cannot be predicted. Hence the authorities need to analyse how the random walk pattern of the exchange rate in the short run in mind has an impact on its intervention policy.

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