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# Forecasting the foreign exchange rates in India – an application of emaco model

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## ABSTRACT

Foreign exchange rate is considered as one of the key economic indicator influencing economy health of a country. The movement in FER affects the foreign direct investment, foreign institutional investment, gold price, export and import (balance of payment), forex reserve, commodity prices, corporate performance, stock market, financial institutions trading in currency market, etc. Movements in exchange rates thus have important implications on business cycle, capital flows and are therefore crucial to understanding financial developments and changes in economic policy. The deteriorating foreign exchange rate in India was responsible for increase in fiscal deficit, gold prices, petrol & diesel prices in India. Timely forecasts of foreign exchange rates can therefore provide valuable information to decision makers, investors, policy makers, corporate and traders. Little literature is available about the possibility of accurately predicting foreign exchange rates. This has encouraged the researchers to take up the present study. Exponential Moving Average Crossover Model (EMACO) to forecast the foreign exchange rate in India. Three currencies have been selected for the purpose of study and study period was from 1970 to 2012 (43 years). The study concluded that the EMACO Model helps in forecasting the foreign exchange rate more accurately than their corresponding techniques. The comparison of outcome of forecasting and real-time foreign exchange rate signifies that it is possible to predict the foreign exchange more accurately by adopting Exponential Moving Average Crossover Model.

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## Introduction

Forecasting exchange rate is quite important not only for the corporate entities having their business spread across globe or corporate entities planning to raise funds from international markets but also for the domestic firms, because a change in foreign exchange rate can change the business and competition scenario for the firms. The movement in FER also affects the foreign institutional investment, gold price, export and import (balance of payment), forex reserve, commodity prices, stock market, financial institutions trading in currency market, etc. Forecasting exchange rate is an important input in various corporate decisions like invoicing, pricing decision, borrowing decision, exchange rate risk management, Forecasting foreign exchange rate is also important input for FII investment decision, investors in cash and derivatives market, policy makers and researchers. Exchange rates can be forecasted in two broad ways; using a fundamental analysis and technical analysis tools. Empirical studies used some of them very frequently especially fundamental approach. Little literature is available on application of technical analysis tools such as Box-Jenkins Methodology, Vector autoregressive and Bayesian Vector Autoregressive Models, Neural Network Forecasting Model. But no literature is available in India on application of Exponential Moving Average Crossover Model. This has motivated the researchers to take up the present study.

## Objectives of Study

This paper is an attempt to forecast the exchange rate of Indian rupee (INR) in terms of three different currencies: USD, GBP and JPY. Paper tries to make long horizon forecasts based on Exponential Moving Average Crossover Model. A survey of

literature shows a continuous debate is going on whether exchange rate follows a random walk or it can be modeled, there is also debate whether one should use econometric model, mathematical model, statistical models to forecast exchange rate.

## Operational Definitions

**Foreign Exchange Rate:** The rate at which one currency will be exchanged for another.

**Forecasting:** Predating future movement of foreign exchange rate by using historical FER

**Moving Average Cross Over:** Moving average crossover is a technical analysis tool wherein faster Moving Average curve (i.e. a shorter period Moving Average) crosses either above the slower Moving Average curve (i.e. a longer period Moving Average) or below the slower Moving Average curves (i.e. Shorter Period Moving Average).

## Abbreviation

FER: Foreign Exchange Rate, MACO: Moving Average Crossover, FII: Foreign Institutional Investment, USD: US dollar, GBP: British Pound, JPY: Japanese Yen, PDEMAER: Previous Day Exponential Moving Average Exchange Rate, EMAER: Exponential Moving Average Exchange Rate

## Literature Review

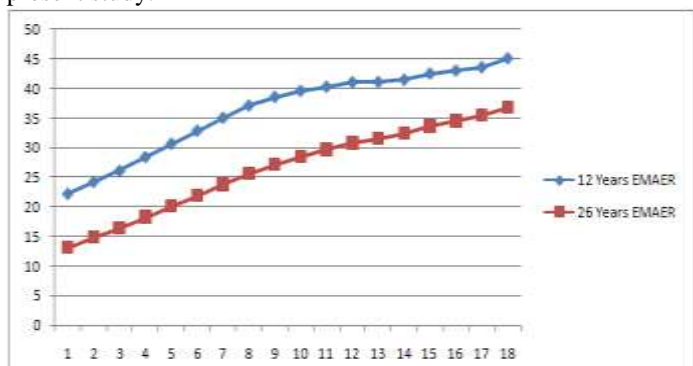
Pami Dua and Rajiv Ranjan had conducted a study on "Modeling and Forecasting the Indian Re/Us Dollar Exchange Rate". The authors had developed Vector Autoregressive and Bayesian Vector Autoregressive Models to forecast the Indian Rupee/US dollar exchange rate. The study finds that the monetary model generally outperforms the naïve model. It also finds that forecast accuracy can be improved by extending the

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monetary model to include forward premium, volatility of capital inflows and order flow. Information on intervention by the central bank also helps to improve forecasts at the longer end. The study also reports that the Bayesian vector autoregressive models generally outperform their corresponding VAR variants. Mahesh Kumar Tambi in his paper "Forecasting Exchange Rate- A Uni-variate out of sample Approach (Box-Jenkins Methodology)" tried to build univariate model to forecast exchange rate of Indian Rupee in terms of different currencies like SDR, USD, GBP, Euro and JPY. He used Box-Jenkins Methodology of building ARIMA model. Result of the research shows that ARIMA models provides a better forecasting of exchange rates than simple auto-regressive models or moving average models. Imad A. Moosa had critically evaluated Market-based forecasting of exchange rates. He is of the view that this methodology is flawed because it is based on two hypotheses that are not supported by empirical evidence: the simple random walk hypothesis and the unbiased efficiency hypothesis. No literature is available in India on application of Exponential Moving Average Crossover (EMACO) Model to predict the future movement of foreign exchange rates of various currencies in comparison with Indian currency. This has motivated the researcher to take up the present study.



**Chart -1: moving average crossover of exchange rate (Indian rupee v/s USD)**

### Research Plan

Technical analysis tool i.e. Exponential Moving Average Crossover Model is developed to forecast exchange rate of Indian Rupee in terms of different currencies like USD, GBP and JPY. Sample data was taken from April 1970 to March 2012. All the data were used to build the model. The period of study was deemed a long time enough to observe consistent trends in the variables. The period was also relevant because it incorporated the periods when Indian foreign exchange market has seen mixed performances. During this period foreign exchange rate performed both poorly as well as excellently on account of booming IT sector and recession and maximum exposure to severe external shock (i.e. global economic meltdown). All the data were collected from Reserve Bank of India database. The collected data were presented in the form of tables and charts.

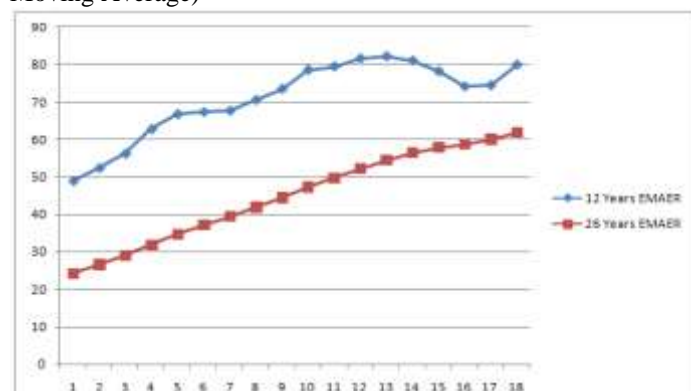
### Data Unit

| Currency | Units |
|----------|-------|
| USD      | 1     |
| GBP      | 1     |
| JPY      | 100   |

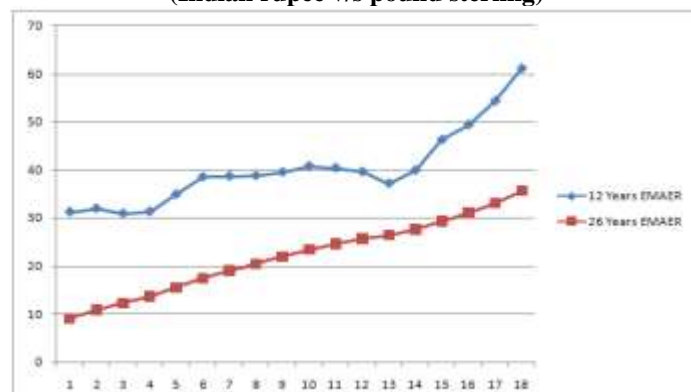
### EMACO Model

The following statistical tools were used to develop Moving Average Crossover (MACO) Model. It was done in four stages, namely:

- Determination of Moving Average Period
  - Calculation of smoothing factor
- Smoothing Factor =  $2 / (1+N)$
- Calculation of Exponential Moving Average Exchange Rate
- EMAER = (Spot Exchange Rate – PDEMAER) \* SF + PDEMAER
- EMAER: Exponential Moving Average Exchange Rate  
SF: Smoothing Factor  
PDEMAER: Previous Day Exponential Moving Average Exchange Rate
- Exponential Moving Average Crossover
- MACO = SMAC – LMAC
- EMACO: Exponential Moving Average Crossover  
SMAC: Slower Moving Average curve (i.e. Longer Period Moving Average)  
LMAC: Longer Moving Average Curve (i.e. Shorter Period Moving Average)



**Chart -2: Moving average crossover of exchange rate (Indian rupee v/s pound sterling)**



**Chart 3. Moving average crossover of exchange rate (Indian rupee v/s japanese yen)**

### Experimental Results

The data used in this study is the foreign exchange rate of four different currencies against Indian Rupee from 1970 to 2012 made available by the Reserve Bank of India and website of <http://www.x-rates.com>. We considered exchange rate of US dollar, British Pound and Japanese Yen data for evaluating the model.

The table 1, 2 and 3 depict that both shorter duration Moving Average curve as well as longer duration Exponential Moving Average Curve of exchange rate were moving in upward direction which had generated a bullish signal. Further, the shorter duration Exponential Moving Average Curve of exchange rate never intersected with longer duration Exponential Moving Average Curve and it was moving above longer duration Exponential Moving Average Curve.

## Appendices

Table 1. 12 Years And 25 Years Exponential Moving Average Exchange Rate Of Indian Rupee V/S USD

| Year | Rupee Per Unit of USD | 12 Years PDEMAER | 12 Years EMAER | 26 Years PDEMAER | 26 Years EMAER | Year | Rupee Per Unit of USD | 12 Years PDEMAE R | 12 Years EMAER | 26 Years PDEMAE R | 26 Years EMAER |
|------|-----------------------|------------------|----------------|------------------|----------------|------|-----------------------|-------------------|----------------|-------------------|----------------|
| 1970 | 7.5668                |                  |                |                  |                | 1992 | 25.9206               | 14.218201         | 16.01803       |                   |                |
| 1971 | 7.5244                |                  |                |                  |                | 1993 | 31.4439               | 16.01803          | 18.39053       |                   |                |
| 1972 | 7.5563                |                  |                |                  |                | 1994 | 31.3742               | 18.390529         | 20.38742       |                   |                |
| 1973 | 7.6742                |                  |                |                  |                | 1995 | 32.4198               | 20.387417         | 22.238         |                   | 13.183804      |
| 1974 | 8.0375                |                  |                |                  |                | 1996 | 35.4280               | 22.237998         | 24.26662       | 13.1838           | 14.832099      |
| 1975 | 8.4058                |                  |                |                  |                | 1997 | 36.3195               | 24.26662          | 26.12035       | 14.8321           | 16.424315      |
| 1976 | 9.0017                |                  |                |                  |                | 1998 | 41.2665               | 26.120353         | 28.44983       | 16.42432          | 18.265121      |
| 1977 | 8.7625                |                  |                |                  |                | 1999 | 43.0552               | 28.44983          | 30.69614       | 18.26512          | 20.102066      |
| 1978 | 8.2133                |                  |                |                  |                | 2000 | 44.9401               | 30.696136         | 32.88686       | 20.10207          | 21.942564      |
| 1979 | 8.1467                |                  |                |                  |                | 2001 | 47.1857               | 32.886858         | 35.08602       | 21.94256          | 23.813081      |
| 1980 | 7.8800                |                  |                |                  |                | 2002 | 48.5993               | 35.08602          | 37.16436       | 23.81308          | 25.649739      |
| 1981 | 8.6926                |                  | 8.121817       |                  |                | 2003 | 46.5818               | 37.164362         | 38.61276       | 25.64974          | 27.200805      |
| 1982 | 9.4924                | 8.1218167        | 8.332612       |                  |                | 2004 | 45.3165               | 38.612764         | 39.6438        | 27.20081          | 28.543178      |
| 1983 | 10.1379               | 8.3326124        | 8.610266       |                  |                | 2005 | 44.1000               | 39.643799         | 40.32916       | 28.54318          | 29.695939      |
| 1984 | 11.3683               | 8.6102656        | 9.034451       |                  |                | 2006 | 45.3070               | 40.329163         | 41.09475       | 29.69594          | 30.852718      |
| 1985 | 12.3640               | 9.0344513        | 9.546536       |                  |                | 2007 | 41.3485               | 41.094754         | 41.13378       | 30.85272          | 31.630456      |
| 1986 | 12.6053               | 9.5465359        | 10.01697       |                  |                | 2008 | 43.5049               | 41.13378          | 41.49846       | 31.63046          | 32.510352      |
| 1987 | 12.9552               | 10.016974        | 10.46887       |                  |                | 2009 | 48.4049               | 41.498458         | 42.56067       | 32.51035          | 33.688138      |
| 1988 | 13.9147               | 10.468873        | 10.99884       |                  |                | 2010 | 45.7262               | 42.560669         | 43.04753       | 33.68814          | 34.580158      |
| 1989 | 16.2238               | 10.998841        | 11.80244       |                  |                | 2011 | 46.6723               | 43.047528         | 43.60502       | 34.58016          | 35.476186      |
| 1990 | 17.4992               | 11.80244         | 12.6786        |                  |                | 2012 | 53.4368               | 43.605018         | 45.11715       | 35.47619          | 36.807068      |

Table 2: Moving Average Crossover Of Exchange Rate (Indian rupee V/S USD)

| Period | 12 Years EMAER | 26 Years EMAER | MACO   |
|--------|----------------|----------------|--------|
| 1      | 22.24          | 13.18          | -9.06  |
| 2      | 24.27          | 14.83          | -9.44  |
| 3      | 26.12          | 16.42          | -9.7   |
| 4      | 28.45          | 18.27          | -10.18 |
| 5      | 30.7           | 20.1           | -10.6  |
| 6      | 32.89          | 21.94          | -10.95 |
| 7      | 35.09          | 23.81          | -11.28 |
| 8      | 37.16          | 25.65          | -11.51 |
| 9      | 38.61          | 27.2           | -11.41 |
| 10     | 39.64          | 28.54          | -11.1  |
| 11     | 40.33          | 29.7           | -10.63 |
| 12     | 41.09          | 30.85          | -10.24 |
| 13     | 41.13          | 31.63          | -9.5   |
| 14     | 41.5           | 32.51          | -8.99  |
| 15     | 42.56          | 33.69          | -8.87  |
| 16     | 43.05          | 34.58          | -8.47  |
| 17     | 43.61          | 35.48          | -8.13  |
| 18     | 45.12          | 36.81          | -8.31  |

**Table 3: 12 years and 25 years exponential moving average exchange rate of Indian rupee v/s pound sterling**

| Year | Rupee Per Unit of Pound Sterling | 12 Years PDEMAER | 12 Years EMAER | 26 Years PDEMAER | 26 Years EMAER | Year | Rupee Per Unit of Pound Sterling | 12 Years PDEMAER | 12 Years EMAER | 26 Years PDEMAER | 26 Years EMAER |
|------|----------------------------------|------------------|----------------|------------------|----------------|------|----------------------------------|------------------|----------------|------------------|----------------|
| 1970 | 18.0000                          |                  |                |                  |                | 1992 | 45.7104                          | 34.5395          | 40.5494        |                  |                |
| 1971 | 18.0000                          |                  |                |                  |                | 1993 | 47.2160                          | 40.5494          | 44.1361        |                  |                |
| 1972 | 18.8850                          |                  |                |                  |                | 1994 | 48.0482                          | 44.1361          | 46.2408        |                  |                |
| 1973 | 18.8000                          |                  |                |                  |                | 1995 | 51.1662                          | 46.2408          | 48.8907        |                  | 24.197         |
| 1974 | 18.8000                          |                  |                |                  |                | 1996 | 55.3422                          | 48.8907          | 52.3616        | 24.197           | 26.5048        |
| 1975 | 18.6125                          |                  |                |                  |                | 1997 | 59.5346                          | 52.3616          | 56.2207        | 26.5048          | 28.9523        |
| 1976 | 16.2542                          |                  |                |                  |                | 1998 | 68.3525                          | 56.2207          | 62.7476        | 28.9523          | 31.8719        |
| 1977 | 15.2917                          |                  |                |                  |                | 1999 | 69.6700                          | 62.7476          | 66.4718        | 31.8719          | 34.6727        |
| 1978 | 15.7633                          |                  |                |                  |                | 2000 | 68.0760                          | 66.4718          | 67.3349        | 34.6727          | 37.1479        |
| 1979 | 17.2783                          |                  |                |                  |                | 2001 | 67.9826                          | 67.3349          | 67.6834        | 37.1479          | 39.4328        |
| 1980 | 18.3242                          |                  |                |                  |                | 2002 | 73.0028                          | 67.6834          | 70.5452        | 39.4328          | 41.9203        |
| 1981 | 17.5423                          |                  | 17.6293        |                  |                | 2003 | 76.0974                          | 70.5452          | 73.5323        | 41.9203          | 44.4528        |
| 1982 | 16.5954                          | 17.6293          | 17.0731        |                  |                | 2004 | 82.9983                          | 73.5323          | 78.625         | 44.4528          | 47.309         |
| 1983 | 15.3653                          | 17.0731          | 16.1543        |                  |                | 2005 | 80.2530                          | 78.625           | 79.5009        | 47.309           | 49.7502        |
| 1984 | 15.1469                          | 16.1543          | 15.6123        |                  |                | 2006 | 83.5115                          | 79.5009          | 81.6586        | 49.7502          | 52.2519        |
| 1985 | 15.9904                          | 15.6123          | 15.8157        |                  |                | 2007 | 82.7218                          | 81.6586          | 82.2306        | 52.2519          | 54.5097        |
| 1986 | 18.4924                          | 15.8157          | 17.2558        |                  |                | 2008 | 80.1362                          | 82.2306          | 81.1038        | 54.5097          | 56.4086        |
| 1987 | 21.2366                          | 17.2558          | 19.3975        |                  |                | 2009 | 75.7282                          | 81.1038          | 78.2117        | 56.4086          | 57.8402        |
| 1988 | 24.7729                          | 19.3975          | 22.2894        |                  |                | 2010 | 70.6912                          | 78.2117          | 74.1657        | 57.8402          | 58.7925        |
| 1989 | 26.5515                          | 22.2894          | 24.5824        |                  |                | 2011 | 74.7736                          | 74.1657          | 74.4927        | 58.7925          | 59.9767        |
| 1990 | 31.2835                          | 24.5824          | 28.1876        |                  |                | 2012 | 84.6955                          | 74.4927          | 79.9818        | 59.9767          | 61.8083        |
| 1991 | 39.9941                          | 28.1876          | 34.5395        |                  |                |      |                                  |                  |                |                  |                |

**Table 4: moving average crossover of exchange rate (Indian rupee v/s pound sterling)**

| Period | 12 Years EMAER | 26 Years EMAER | MACO   |
|--------|----------------|----------------|--------|
| 1      | 48.89          | 24.2           | -24.69 |
| 2      | 52.36          | 26.5           | -25.86 |
| 3      | 56.22          | 28.95          | -27.27 |
| 4      | 62.75          | 31.87          | -30.88 |
| 5      | 66.75          | 34.67          | -32.08 |
| 6      | 67.33          | 37.15          | -30.18 |
| 7      | 67.68          | 39.43          | -28.25 |
| 8      | 70.55          | 41.92          | -28.63 |
| 9      | 73.53          | 44.45          | -29.08 |
| 10     | 78.63          | 47.31          | -31.32 |
| 11     | 79.5           | 49.75          | -29.75 |
| 12     | 81.66          | 52.25          | -29.41 |
| 13     | 82.23          | 54.51          | -27.72 |
| 14     | 81.1           | 56.41          | -24.69 |
| 15     | 78.21          | 57.84          | -20.37 |
| 16     | 74.17          | 58.79          | -15.38 |
| 17     | 74.49          | 59.98          | -14.51 |
| 18     | 79.98          | 61.81          | -18.17 |

**Table 5: 12 years and 25 years exponential moving average exchange rate of Indian rupee v/s Japanese yen**

| Year | Rupee Per Unit of Japanese Yen | 12 Years PDEMAER | 12 Years EMAER | 26 Years PDEMAER | 26 Years EMAER | Year | Rupee Per Unit of Japanese Yen | 12 Years PDEMAER | 12 Years EMAER | 26 Years PDEMAER | 26 Years EMAER |
|------|--------------------------------|------------------|----------------|------------------|----------------|------|--------------------------------|------------------|----------------|------------------|----------------|
| 1970 | 2.1578                         |                  |                |                  |                | 1992 | 20.4800                        | 14.405           | 17.673         |                  |                |
| 1971 | 2.4819                         |                  |                |                  |                | 1993 | 28.3600                        | 17.673           | 23.423         |                  |                |
| 1972 | 2.7811                         |                  |                |                  |                | 1994 | 30.7370                        | 23.423           | 27.358         |                  |                |
| 1973 | 3.0000                         |                  |                |                  |                | 1995 | 34.6113                        | 27.358           | 31.26          |                  | 9.1819         |
| 1974 | 3.0000                         |                  |                |                  |                | 1996 | 32.5971                        | 31.26            | 31.979         | 9.1819           | 10.917         |
| 1975 | 3.0000                         |                  |                |                  |                | 1997 | 30.0495                        | 31.979           | 30.941         | 10.917           | 12.335         |
| 1976 | 3.0000                         |                  |                |                  |                | 1998 | 31.6680                        | 30.941           | 31.332         | 12.335           | 13.767         |
| 1977 | 3.1700                         |                  |                |                  |                | 1999 | 37.9983                        | 31.332           | 34.919         | 13.767           | 15.563         |
| 1978 | 3.9200                         |                  |                |                  |                | 2000 | 41.7258                        | 34.919           | 38.581         | 15.563           | 17.501         |
| 1979 | 3.9200                         |                  |                |                  |                | 2001 | 38.8674                        | 38.581           | 38.735         | 17.501           | 19.085         |
| 1980 | 3.8300                         |                  |                |                  |                | 2002 | 38.8722                        | 38.735           | 38.809         | 19.085           | 20.551         |
| 1981 | 3.9600                         |                  | 3.1851         |                  |                | 2003 | 40.2047                        | 38.809           | 39.56          | 20.551           | 22.007         |
| 1982 | 3.8200                         | 3.1851           | 3.5267         |                  |                | 2004 | 41.8941                        | 39.56            | 40.816         | 22.007           | 23.481         |
| 1983 | 4.2600                         | 3.5267           | 3.9212         |                  |                | 2005 | 40.1020                        | 40.816           | 40.432         | 23.481           | 24.713         |
| 1984 | 4.7900                         | 3.9212           | 4.3886         |                  |                | 2006 | 38.9752                        | 40.432           | 39.648         | 24.713           | 25.769         |
| 1985 | 5.2200                         | 4.3886           | 4.8359         |                  |                | 2007 | 35.1348                        | 39.648           | 37.22          | 25.769           | 26.463         |
| 1986 | 7.5400                         | 4.8359           | 6.2907         |                  |                | 2008 | 42.3079                        | 37.22            | 39.957         | 26.463           | 27.637         |
| 1987 | 8.9800                         | 6.2907           | 7.7375         |                  |                | 2009 | 51.8119                        | 39.957           | 46.335         | 27.637           | 29.429         |
| 1988 | 10.8700                        | 7.7375           | 9.4228         |                  |                | 2010 | 52.1669                        | 46.335           | 49.473         | 29.429           | 31.114         |
| 1989 | 11.7600                        | 9.4228           | 10.68          |                  |                | 2011 | 58.6244                        | 49.473           | 54.396         | 31.114           | 33.152         |
| 1990 | 12.1600                        | 10.68            | 11.476         |                  |                | 2012 | 67.0289                        | 54.396           | 61.193         | 33.152           | 35.662         |
| 1991 | 16.9200                        | 11.476           | 14.405         |                  |                |      |                                |                  |                |                  |                |

**Table -6: moving average crossover of exchange rate (Indian rupee v/s jaanese yen)**

| Period | 12 Years EMAER | 26 Years EMAER | MACO   |
|--------|----------------|----------------|--------|
| 1      | 31.26          | 9.18           | -22.08 |
| 2      | 31.98          | 10.92          | -21.06 |
| 3      | 30.94          | 12.33          | -18.61 |
| 4      | 31.33          | 13.77          | -17.56 |
| 5      | 34.92          | 15.56          | -19.36 |
| 6      | 38.58          | 17.5           | -21.08 |
| 7      | 38.74          | 19.09          | -19.65 |
| 8      | 38.81          | 20.55          | -18.26 |
| 9      | 39.56          | 22.01          | -17.55 |
| 10     | 40.82          | 23.48          | -17.34 |
| 11     | 40.43          | 24.71          | -15.72 |
| 12     | 39.65          | 25.77          | -13.88 |
| 13     | 37.22          | 26.46          | -10.76 |
| 14     | 39.96          | 27.64          | -12.32 |
| 15     | 46.34          | 29.43          | -16.91 |
| 16     | 49.47          | 31.11          | -18.36 |
| 17     | 54.4           | 33.15          | -21.25 |
| 18     | 61.19          | 35.66          | -25.53 |

This also indicates that the exchange rate will move in upward direction in the future.

#### Real-time Exchange Rate

|                        | USD   | GBP   | Yen   |
|------------------------|-------|-------|-------|
| 2013                   | 54.36 | 85.88 | 65.73 |
| 2014<br>( Half Yearly) | 58.97 | 91.07 | 59.68 |

The real-time exchange rate of Indian rupee v/s US dollar was moving in upward direction as per the prediction made by EMACO model during 2012-13. Pound was also moving in upward direction as per the prediction made by EMACO model during 2012-13 and 2013-14. However, Japanese yen was moving against the prediction during 2012-13 as well as in the first half of 2013-14.

#### Conclusion

It can be concluded from above discussion that there is 67 percent chance of predicting future movement of exchange rate by applying EMACO Model. In other words, the EMACO Model can be used as forecasting model to forecast future movement in exchange rate accurately.

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