**Clustering and Forecasting Exchange Rates using Statistical Tools**

**Dr Tarika Singh\***

*Associate Professor, Prestige Institute of Management, Gwalior; Address: B25 Colour Valley Coatings India Ltd., Maharajpura Industrial Area, Pinto Park, Gwalior (M.P.) India. Contact no.9425342333.Email id:* [singh.tarika@gmail.com](mailto:singh.tarika@gmail.com)

**Dr Seema Mehta**

*Associate Professor, IIHMR, Jaipur*

**Ms. Gunjan Dwedi**

Alumnus, *Prestige Institute of Management, Gwalior*

**Abstract**

In this paper, researchers have tried to review the work on an exchange rate clustering and forecasting methodology based on the cluster analysis and time series forecasting. Ten exchange rates in comparison to Indian rupee were taken as the sample. The data of daily exchange rate has been taken from 1992 to 2014. Cluster analysis method was used for forming clusters of the different exchange rate. Time Series forecasting was used for predicting exchange rates. Cluster Analysis resulted in thirteen clusters. Forecasting exchanges rates showed that significant volatility in exchanges rates. Results have practical implications.

Keywords: Exchange rates, Forecasting, Clustering

**Section 1**

**1.1 Introduction**

Exchange Rate is the price of one country's currency expressed in another country's currency. In other words, the rate at which one currency can be exchanged for another. One of the goals of studying the behavior of exchange rates is to be able to forecast exchange rates. Exchange rate forecasts are necessary to evaluate the foreign denominated cash flows involved in international transactions. Thus, exchange rate forecasting is very important to evaluate the benefits and risks attached to the international business environment.

Here in the study Cluster Analysis Technique is used to forecast Exchange Rates. Cluster analysis is a major technique for classifying a ‘mountain’ of information into manageable meaningful piles. Cluster analysis divides data into clusters (subgroup) for the purposes of summarization or improved understanding. A forecast represents an expectation about a future value or values of a variable. There are two approaches to forecasting foreign exchange rates:

1. The Fundamental Approach
2. The Technical Approach

The fundamental approach is based on a wide range of data regarded as fundamental economic variables which are GNP, consumption, trade balance, inflation rates, interest rates, unemployment, productivity indexes, etc. While the technical approach (TA) focuses on a smaller subset of the available data. In general, it is based on price information. Technical analysis looks for the repetition of specific price patterns.

Volatility is a measure for variation of price of a financial instrument over time. Exchange rate volatility refers to the tendency for foreign currencies to appreciate or depreciate in value, thus affecting the profitability of foreign exchange trades. The risk of importing and exporting, unpredictable changes in exchange rates may reduce international trade. The exchange rate volatility may retard the flow of capital between countries.

Exchange rates are very difficult to forecast. The difficulty is to estimate the future value assets and liabilities denominated in foreign currency. There are periods where exchange rates are quite volatile, while during other periods exchange rates do not move very much.

**1.2 Literature Review**

Hondroyiannis (2005) examined the relationship between exchange-rate volatility and aggregate export volumes for 12 industrial economies based on a model that includes real export earnings of oil-producing economies as a determinant of industrial-country export volumes. This study showed that, there is no single instance in which volatility has a negative and significant impact on trade. Benigno and Benigno (2000) used a simple two-country general equilibrium model to evaluate monetary policy regimes. This study showed the behavior of the exchange rate, and other macroeconomic variables, depends crucially on the monetary regime chosen, though not necessarily on monetary shocks. Gupta, Chevalier and Sayekt (2000) examined the relationship between the interest rate, exchange rate and stock price in the Jakarta stock exchange for the period 1993 to 1997. They found sporadic unidirectional causality from closing stock prices to interest rates and vice versa and weak unidirectional causality from exchange rate to stock price. Although, their results did not establish any consistent causality relationships between any of the economic variables under study. Bhattarai and Armah (2005) examined the effects of exchange rates on the trade balance of Ghana. They first derived the real exchange rate as a function of preferences and technology of two trading economies and then applies small price taking economy assumption to the Ghanaian economy, for annual time series data from 1970-2000 to estimate trade balance as a function of the real exchange rate, domestic and foreign incomes. Their Co-integration analyses of both single equation models and VAR-Error correction models confirm a stable long-run relationship between both exports and imports and the real exchange rate. Their short-run elasticity’s of imports and exports indicate contractionary effects of devaluation in terms of the Marshall-Lerner-Robinson conditions though these elastisities add up to almost 1 in the long-run estimates. The overall conclusion drawn from their study is that for improved balance of trade in Ghana, coordination between the exchange rate and demand management policies should be strengthened and be based on the long-run fundamentals of the economy. Velasco (2000) examined exchange-rate Policies for Developing Countries during the 1997–1998 Asian crises, he concluded that adjustable or crawling pegs are extremely fragile in a world of volatile capital movements. They suggested that any exchange-rate regime, and especially one of flexible rates, requires complementary policies to increase its chances of success. Tenreyro (2006) examined the effect of nominal exchange rate variability on trade, from a broad sample of countries from 1970 to 1997; his estimates indicate that nominal exchange rate variability has no significant impact on trade flows. Alvarez-Diaz (2008) employed a composition of weekly data from January 1973 to July 2002, comprising a total of 1541 observations, to examine exchange rates of Japanese Yen and British Pound against the US Dollar; his results indicated the existence of a statistically significant short-term predictable structure in the exchange rates dynamic. Mark (1995) showed that the deviation of the log exchange rate from its fundamental value contains relevant information for forecasting long-horizon changes in log nominal exchange rates and the out of sample point predictions generally outperform the drift less random walk at the longer horizons.

The rest of the paper is organized as follows: last part of section 1, Section 1.3 discusses the objectives and section 2 discusses methodology of cluster analysis and forecasting. Section 3 presents the empirical results and its discussion thereof. Section 4 concludes with policy implications and conclusion.

**1.3 Objectives**

1. To forecast the exchange rates (Rupee Dollar, Rupee Sterling, Rupee Yen, Rupee Peso, Rupee Euro, Rupee Yuan, Rupee Rand, Rupee Birr,) by using cluster analysis technique and time series forecasting method.

2. To make clusters of the exchange rates using cluster analysis technique and further to forecast exchange rate.

3. To open new avenue for future study.

**2. Research Methodology**

The study was exploratory in nature and secondary data being used. The Population was all the exchange rates. Sampling frame was all the exchange rates in context with Indian Rupee. Individual Rupee-other nation’s currency was the sample element. Ten exchange rates in comparison to Indian rupee was the sample size. The data of daily exchange rate has been taken from 1992 to 2014. Non probability purposive sampling technique has been used. Secondary Data was collected from the website fxtop.com/historical-exchange rates.php‎

Cluster analysis method was used for forming clusters of the different exchange rate. Time Series forecasting was used for predicting exchange rates.

3. **Results and Discussions**

Cluster Analysis is a class of techniques used to classify cases into groups that are relatively homogeneous within themselves and heterogeneous between each other, on the basis of a defined set of variables. These groups are called clusters. Cluster analysis classifies a set of observations into two or more mutually exclusive unknown groups based on combinations of interval variables. The purpose of cluster analysis is to discover a system of organizing observations, usually people, into groups.

Hierarchical cluster analysis (HCA) is an exploratory tool designed to reveal natural groupings (or clusters) within a data set that would otherwise not be apparent. It is most useful when we want to cluster a small number (less than a few hundred) of objects. The objects in hierarchical cluster analysis can be cases or variables, depending on whether we want to classify cases or examine relationships between the variables.

**Table1**

| **Case Processing Summarya,b** | | | | | |
| --- | --- | --- | --- | --- | --- |
| Cases | | | | | |
| Valid | | Missing | | Total | |
| N | Percent | N | Percent | N | Percent |
| 8105 | 100.0 | 0 | .0 | 8105 | 100.0 |
| a. Squared Euclidean Distance used | | | | | |
| b. Ward Linkage | | | | | |

In Table1 a case summary is presented, i.e. valid, missing and total values. Hierarchical clustering using Ward Linkage, Ward’s Method is a minimum variance method that uses an ANOVA approach. The method tries to minimize the sum of squares of any two clusters that are formed at each step of the cluster analysis.

The results from the different stages of the hierarchical clustering in SPSS are summarized and displayed in Table 2 **Agglomeration Schedule**.

**Ward Linkage**

**Table 2**

|  | | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| Agglomeration Schedule | | | | | | |
| Stage | Cluster Combined | | Coefficients | Stage Cluster First Appears | | Next Stage |
| Cluster 1 | Cluster 2 | Cluster 1 | Cluster 2 |
| 1 | 8102 | 8103 | .000 | 0 | 0 | 2 |
| 2 | 8101 | 8102 | .000 | 0 | 1 | 4629 |
| 3 | 8095 | 8096 | .000 | 0 | 0 | 4 |
| 4 | 8094 | 8095 | .000 | 0 | 3 | 4381 |
| 5 | 8088 | 8089 | .000 | 0 | 0 | 6 |
| 6 | 8087 | 8088 | .000 | 0 | 5 | 4187 |
| 7 | 8081 | 8082 | .000 | 0 | 0 | 8 |
| 8 | 8080 | 8081 | .000 | 0 | 7 | 3222 |
| 9 | 8074 | 8075 | .000 | 0 | 0 | 10 |
| 10 | 8073 | 8074 | .000 | 0 | 9 | 3365 |

The columns **Cluster Combined** show the numbers of the clusters, which are combined at the different stages at the first stage the 8102 and the 8103 cluster are combined. The **Coefficients** column gives the mean distances for combining the clusters. Large coefficients (for divergence measures) or small coefficients (for similarity measures) indicate that a cluster is relatively heterogeneous and contains units which are considerably different from each other. **Stage Cluster First Appears** display the stages at which the respective clusters appeared for the first time, and in the **Next Stage** column can be found the stage at which the respective cluster will appear the next time it combines with another cluster, at the first stage, when the 8102 and the 8103 cluster are combined, a new cluster is formed and is assigned number 2

**Table 3**

**Re-formed Agglomeration**

|  |
| --- |
| **No. of Clusters Agglomeration Coefficients Change** |
| 2 81040.00 44694.375 36345.625  3 44694.375 27530.086 17164.289  4 27530.086 19459.750 8070.336  5 19459.750 14536.309 4923.441  6 14536.309 11443.268 3093.041  7 11443.268 9365.912 2077.356  8 9365.912 8175.896 1190.016  9 8175.896 7172.915 1002.981  10 7172.915 6190.372 982.543  11 6190.372 5466.576 723.796  12 5466.576 5016.419 450.157  13 5016.419 4568.729 447.69  14 4568.729 4174.749 393.98 |

The results start with Agglomeration schedule which provides a solution for every possible number of cluster cases under study (Year).

The column which should we focused for results is the column headed coefficients reading to bottom to the efforts, it shows that for one cluster the Agglomeration coefficient is 81040.00 and for second cluster 44694.375 and so on.

If we rewrite the coefficients as given in the above table, it will be easier to see the changes, enabling as to determine the number of clusters. In this case it is **13** clusters as succeeding clustering add very much less to distinguishing between cases.

We should return back to Hierarchical Clustering and request to SPSS to place cases into one of the **13** clusters.

The results of the cases are added in input sheet. From the results of Table 4 we can see – cases have been classified under **CLU13\_3**

**Table 4**

**Summarized Table for Clusters**

|  |  |
| --- | --- |
| **DATE** | **CLU13\_3** |
| 01.01.1992  14.09.1995  18.11.1997  26.06.1998  01.01.1999  24.07.2002  19.11.2003  13.05.2005  18.04.2006  24.04.2007  12.02.2008  11.09.2008  15.09.2008  22.10.2008  10.06.2009  06.10.2009  15.10.2009  19.02.2010  22.09.2011  12.10.2011  19.08.2013  10.03.2014 | 1  2  3  3  4  6  7  8  7  8  9  9  7  10  9  11  9  11  11  12  13  13 |

In the next step we calculate **One Way ANOVA** and find out thedifference between the variables for each cluster. The Grouping variables is a new cluster variable.

**Table 5**

**Test of Homogeneity Variance**

| **Test of Homogeneity of Variances** | | | | |
| --- | --- | --- | --- | --- |
|  | Levene Statistic | df1 | df2 | Sig. |
| USD | 337.496 | 11 | 8092 | .000 |
| GBP | 108.294 | 11 | 8092 | .000 |
| AUD | 276.995 | 11 | 8092 | .000 |
| JPY | 821.237 | 11 | 8092 | .000 |
| COP | 177.529 | 11 | 8092 | .000 |
| ESP | 325.941 | 11 | 8092 | .000 |
| CNY | 499.276 | 11 | 8092 | .000 |
| ZAR | 215.378 | 11 | 8092 | .000 |
| SGD | 280.106 | 11 | 8092 | .000 |
| ETB | 1104.431 | 11 | 8092 | .000 |

The Table 5 test for the null hypothesis of Homogeneity of Variance for different Exchange Rate Series. From the table we can see that for all the cases the significance level is **0%** which means Null Hypothesis is rejected. This implies that the variances are not homogeneous among series.

**Table 6**

| **ANOVA** | | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
|  | | Sum of Squares | df | Mean Square | F | Sig. |
| USD | Between Groups | 453652.980 | 12 | 37804.415 | 11135.670 | .000 |
| Within Groups | 27471.480 | 8092 | 3.395 |  |  |
| Total | 481124.460 | 8104 |  |  |  |
| GBP | Between Groups | 1409453.304 | 12 | 117454.442 | 18266.096 | .000 |
| Within Groups | 52033.085 | 8092 | 6.430 |  |  |
| Total | 1461486.389 | 8104 |  |  |  |
| AUD | Between Groups | 829240.087 | 12 | 69103.341 | 26054.869 | .000 |
| Within Groups | 21461.794 | 8092 | 2.652 |  |  |
| Total | 850701.881 | 8104 |  |  |  |
| JPY | Between Groups | 3207.888 | 12 | 267.324 | 3030.185 | .000 |
| Within Groups | 713.879 | 8092 | .088 |  |  |
| Total | 3921.767 | 8104 |  |  |  |
| COP | Between Groups | 884657.608 | 12 | 73721.467 | 11860.869 | .000 |
| Within Groups | 50295.986 | 8092 | 6.216 |  |  |
| Total | 934953.594 | 8104 |  |  |  |
| ESP | Between Groups | 2971.679 | 12 | 247.640 | 5973.977 | .000 |
| Within Groups | 335.439 | 8092 | .041 |  |  |
| Total | 3307.117 | 8104 |  |  |  |
| CNY | Between Groups | 15350.644 | 12 | 1279.220 | 5588.011 | .000 |
| Within Groups | 1852.439 | 8092 | .229 |  |  |
| Total | 17203.084 | 8104 |  |  |  |
| ZAR | Between Groups | 13049.485 | 12 | 1087.457 | 2799.935 | .000 |
| Within Groups | 3142.824 | 8092 | .388 |  |  |
| Total | 16192.310 | 8104 |  |  |  |
| SGD | Between Groups | 400713.314 | 12 | 33392.776 | 16970.919 | .000 |
| Within Groups | 15922.199 | 8092 | 1.968 |  |  |
| Total | 416635.513 | 8104 |  |  |  |
| ETB | Between Groups | 4013931.518 | 12 | 334494.293 | 569240.320 | .000 |
| Within Groups | 4754.983 | 8092 | .588 |  |  |
| Total | 4018686.500 | 8104 |  |  |  |

The Null Hypothesis tests for no difference in Means between and within the groups. From the above results we can see that the exchange series significantly differ with each other.

The Cluster Membership are significantly different and can be used as new grouping variables for other analysis. The significant difference between the variables (Exchange Rate Series) suggests the base in which the clusters differ or on which they are based. In this case Cluster1 is characterized by 1992-1995, 1995-1997, and so on (as shown in summarized table for clusters)

**Forecasting Model**

The Table 8 is a set of statistics like R-square, mean square error, mean absolute percentage error etc that describe how well the model fits the data. The acfs (autocorrelation function) and pacfs (partial autocorrelation function) are presented for the residuals. If the model is reasonable the residuals will look like white noise (independent zero mean random variables) which means that the acf and pacf are theoretically 0 at all non-zero lags. The sample estimates in your case indicate that the residuals do not have significant lagged acfs and pacfs. So that is good for the model.

The model parameter block show which AR and MA terms were fit, the value of their coefficients, the standard error of the estimate, the t statistic for the significance test and the p-values for the test of the null hypothesis that the coefficient is 0. The other covariates that we included in the model are also given with their parameter estimates and p-values. There is one AR term at lag 2 and moving average terms at lag 7, lag 9, and lag 17.

The approach for generating a forecast using averaging patterns is Auto Regressive Integrated Moving Average (ARIMA), which is also known as the Box-Jenkins Approach, has been developed for "univariate" time series. Univariate means a time series which consists of a sequence of single observations recorded at fixed time intervals. It predicts future values of a time series by a linear combination of its past values and a series of errors (also known as random shocksorinnovations)*.* The ARIMA command performs a maximum likelihood fit of the specified ARIMA model to the time series.

The series of Exchange Rates are calculated through ARIMA model. The results are summarized below.

Auto Regressive Integrated Moving Average (ARIMA) models describe the current behavior of variables in terms of linear relationships with their past values.

In the Table 7,

For the USD Model\_1 the AR is 0, I is 1 and MA is 18 which shows the model is best fit.

For the GBP Model\_2 the AR is 0, I is 1 and MA is 17 which shows the model is fit.

For the JPY Model\_4 the AR is 0, I is 1 and MA is 3 which shows the model is fit.

For the COP Model\_5 the AR is 0, I is 1 and MA is 3 which shows the model is fit.

For the CNY Model\_7 the AR is 0, I is 1 and MA is 1 which shows the model is fit.

For the ZAR Model\_8 the AR is 0, I is 1, and MA is 7 which shows the model is fit.

For the SGD Model\_9 the AR is 0, I is 1 and MA is 6 which shows the model is fit.

For the ETB Model\_10 the AR is 0, I is 1 and MA is 1 which shows the model is fit.

**Table 7**

|  |  |  |  |
| --- | --- | --- | --- |
| **Model Description** | | | |
|  | | | Model Type |
| Model ID | USD | Model\_1 | ARIMA(0,1,18) |
| GBP | Model\_2 | ARIMA(0,1,17) |
| AUD | Model\_3 | Simple |
| JPY | Model\_4 | ARIMA(0,1,3) |
| COP | Model\_5 | ARIMA(0,1,3) |
| ESP | Model\_6 | Simple |
| CNY | Model\_7 | ARIMA(0,1,1) |
| ZAR | Model\_8 | ARIMA(0,1,7) |
| SGD | Model\_9 | ARIMA(0,1,6) |
| ETB | Model\_10 | ARIMA(0,1,1) |

**Table 8**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Model Fit** | | | | | | |
| Fit Statistic | Mean | SE | Minimum | Maximum | Percentile | |
| 5 | 10 |
| Stationary R-squared | .091 | .156 | .005 | .434 | .005 | .005 |
| R-squared | .897 | .314 | .005 | .999 | .005 | .102 |
| RMSE | 2.398 | 6.965 | .020 | 22.218 | .020 | .021 |
| MAPE | .463 | .224 | .254 | 1.072 | .254 | .262 |
| MaxAPE | 28.537 | 36.887 | 9.444 | 114.364 | 9.444 | 9.451 |
| MAE | .117 | .104 | .012 | .302 | .012 | .012 |
| MaxAE | 204.430 | 630.895 | .354 | 1999.908 | .354 | .354 |
| Normalized BIC | -3.101 | 3.942 | -7.783 | 6.203 | -7.783 | -7.766 |

Stationary R-squared is a measure that compares the stationary part of the model to a simple mean model. This measure is preferable to ordinary R-squared when there is a trend or seasonal pattern. Here the value of Stationary R-squared is 9.1%

**R-squared** is a statistical measure of how close the data are to the fitted regression line. It is also known as the coefficient of determination. R-squared is the percentage of the response variable variation that is explained by a linear model. Here R-squared mean is 89.7 this means model is approximately 89% determined by the other variables.

RMSE (Root Mean Square Error) is the square root of mean square error. A measure of how much a dependent series varies from its model-predicted level, expressed in the same units as the dependent series. Here the value of RMSE is 2.398

MAPE (Mean Absolute Percentage Error) is a measure of how much a dependent series varies from its model-predicted level. It is independent of the units used and can therefore be used to compare series with different units. Here the value of MAPE is 46.3

MaxAPE (Maximum Absolute Percentage Error) is the largest forecasted error, expressed as a percentage. This measure is useful for imagining a worst-case scenario for your forecasts. Here the value of MaxAPE is 28.537

MAE (Mean Absolute Error) Measures how much the series varies from its model-predicted level. Here the value of MAE is 11.7%

MaxAE (Maximum Absolute Error) is the largest forecasted error, expressed in the same units as the dependent series. Like MaxAPE, it is useful for imagining the worst-case scenario for the forecasts. Maximum absolute error and maximum absolute percentage error may occur at different series points. Here the value of MaxAE is 204.430

Normalized BIC (Normalized Bayesian Information Criterion) is a general measure of the overall fit of a model that attempts to account for model complexity. It is a score based upon the mean square error and includes a penalty for the number of parameters in the model and the length of the series. The penalty removes the advantage of models with more parameters, making the statistic easy to compare across different models for the same series.

In output of SPSS we compute significations for the individual parameters in ARIMA model. From these values we can determine, if the parameters can be used in this model or not.

**Table 9**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Model Statistics** | | | | | | |
| Model | Number of Predictors | Model Fit statistics | Ljung-Box Q(18) | | | Number of Outliers |
| Stationary R-squared | Statistics | DF | Sig. |
| USD-Model\_1 | 0 | .045 | 22.796 | 14 | .064 | 0 |
| GBP-Model\_2 | 0 | .012 | 21.027 | 14 | .101 | 0 |
| AUD-Model\_3 | 0 | .005 | 62.599 | 17 | .000 | 0 |
| JPY-Model\_4 | 0 | .008 | 17.372 | 16 | .362 | 0 |
| COP-Model\_5 | 0 | .012 | 13.414 | 15 | .570 | 0 |
| ESP-Model\_6 | 0 | .008 | 50.267 | 17 | .000 | 0 |
| CNY-Model\_7 | 0 | .332 | 6.923 | 17 | .985 | 0 |
| ZAR-Model\_8 | 0 | .012 | 21.641 | 13 | .061 | 0 |
| SGD-Model\_9 | 0 | .043 | 16.518 | 14 | .283 | 0 |
| ETB-Model\_10 | 0 | .434 | 1.110 | 17 | 1.000 | 0 |

The **Ljung–Box test** (named for [Greta M. Ljung](http://en.wikipedia.org/w/index.php?title=Greta_M._Ljung&action=edit&redlink=1) and [George E. P. Box](http://en.wikipedia.org/wiki/George_E._P._Box)) is a type of [statistical test](http://en.wikipedia.org/wiki/Statistical_test) of whether any of a group of [autocorrelations](http://en.wikipedia.org/wiki/Autocorrelation) of a [time series](http://en.wikipedia.org/wiki/Time_series) are different from zero. Instead of testing [randomness](http://en.wikipedia.org/wiki/Randomness) at each distinct lag, it tests the "overall" randomness based on a number of lags, and is therefore a [portmanteau test](http://en.wikipedia.org/wiki/Portmanteau_test).

The Ljung–Box test can be defined as follows.

**H0:** The data are independently distributed (i.e. the correlations in the population from which the sample is taken are 0, so that any observed correlations in the data result from randomness of the sampling process).

**Ha:** The data are not independently distributed.

The Ljung–Box test is commonly used in [autoregressive integrated moving average](http://en.wikipedia.org/wiki/Autoregressive_integrated_moving_average) (ARIMA) modeling. It is applied to the [residuals](http://en.wikipedia.org/wiki/Errors_and_residuals_in_statistics) of a fitted ARIMA model, not the original series, and in such applications the hypothesis actually being tested is that the residuals from the ARIMA model have no autocorrelation. When testing the residuals of an estimated ARIMA model, the degrees of freedom need to be adjusted to reflect the parameter estimation. For example, for an ARIMA (p,0,q) model, the degrees of freedom should be set to m - p - q.

From the above table it can be seen that null hypothesis is rejected for model 3 and 6. For rest of the model the data was independently distributed.

**Table 10**

**Model Fit Statistics**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Fit Statistic | Percentile | | | | |
| 25 | 50 | 75 | 90 | 95 |
| Stationary R-squared | .008 | .012 | .117 | .424 | .434 |
| R-squared | .993 | .999 | .999 | .999 | .999 |
| RMSE | .047 | .232 | .388 | 20.040 | 22.218 |
| MAPE | .364 | .409 | .469 | 1.014 | 1.072 |
| MaxAPE | 9.565 | 10.289 | 36.863 | 110.721 | 114.364 |
| MAE | .023 | .104 | .202 | .298 | .302 |
| MaxAE | .842 | 3.027 | 12.165 | 1801.912 | 1999.908 |
| Normalized BIC | -6.240 | -2.922 | -1.897 | 5.418 | 6.203 |

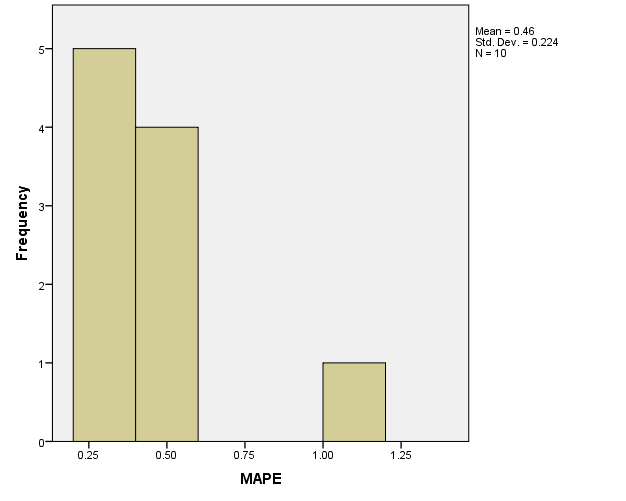
The Goodness of Fit of a [statistical model](http://en.wikipedia.org/wiki/Statistical_model) describes how well it fits a set of observations. Measures of goodness of fit typically summarize the discrepancy between observed values and the values expected under the model in question. Such measures can be used in [statistical hypothesis testing](http://en.wikipedia.org/wiki/Statistical_hypothesis_testing), e.g. to [test for normality](http://en.wikipedia.org/wiki/Normality_test) of [residuals](http://en.wikipedia.org/wiki/Errors_and_residuals_in_statistics), to test whether two samples are drawn from identical distributions or whether outcome frequencies follow a specified distribution.

Results for each model are labeled with the model identifier provided in the model description table. First, notice that the model contains ZERO predictors out of the five candidate predictors that we originally specified. So it appears that the Expert Modeler has identified ZERO independent variables that may prove useful for forecasting.

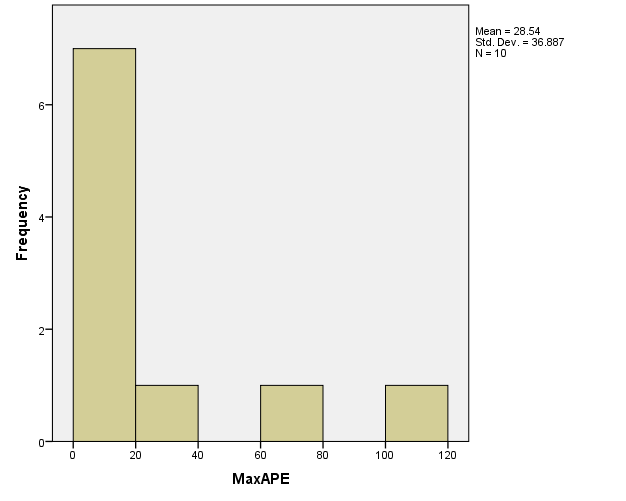
The Time Series Modeler procedure estimates exponential smoothing, univariate Autoregressive Integrated Moving Average (ARIMA), and multivariate ARIMA (or transfer function models) models for time series, and produces forecasts. The procedure includes an Expert Modeler that automatically identifies and estimates the best-fitting ARIMA or exponential smoothing model for one or more dependent variable series, thus eliminating the need to identify an appropriate model through trial and error.

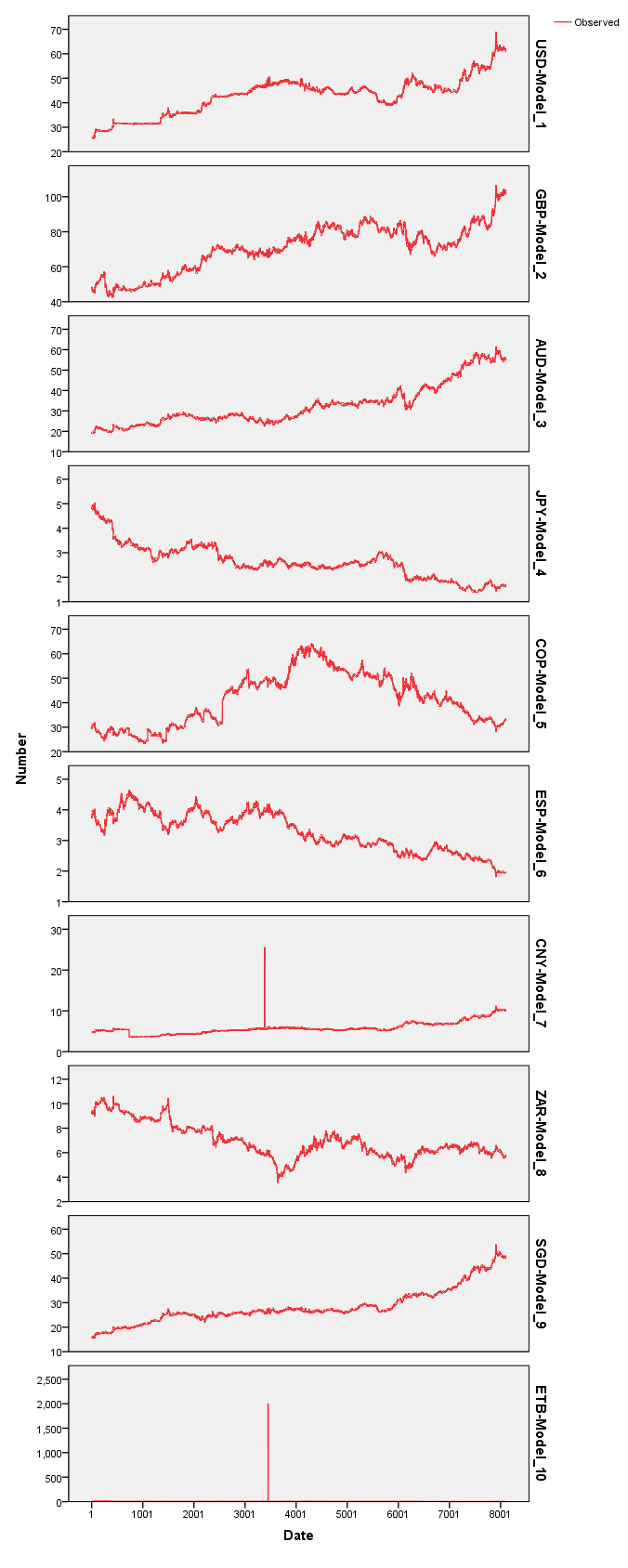
Although the Time Series Modeler offers a number of different goodness-of-fit statistics, we opted only for the stationary R-squared value. This statistic provides an estimate of the proportion of the total variation in the series that is explained by the model and is preferable to ordinary R-squared when there is a trend or seasonal pattern, as is the case here. Larger values of stationary R-squared (up to a maximum value of 1) indicate better fit. A value of 0.897 means, that the model does an excellent job of explaining the observed variation in the series. The Ljung-Box statistic, also known as the modified Box-Pierce statistic, provides an indication of whether the model is correctly specified. A significance value less than 0.05 implies that there is structure in the observed series which is not accounted for by the model. The value of 0.897 shown here is not significant, so we can be confident that the model is correctly specified. The Expert Modeler detected nine points that were considered to be outliers. Each of these points has been modeled appropriately, so there is no need for us to remove them from the series.

**Model Summary Chart**

This histogram displays the Mean Absolute Percentage Error (MAPE) across all models. It shows that all models display a mean uncertainty of roughly 1%.

This histogram displays the Maximum Absolute Percentage Error (MaxAPE) across all models and is useful for imagining a worst-case scenario for our forecasts. It shows that the largest percentage error for each model falls in the range of 1 to 5%.





In the above graph we can see that the graph of the observe data gives the general idea about the time series data, and the components of time series present. It shows significant peaks, in USD Model, GBP Model, AUD Model and SGD Model, Which presents the upward trend in the rates. For the JPY Model, ESP Model and ZAR Model the graph presents the downward trend in the rates and for the CNY Model and ETB Model there is no significant change in the rates.

**4. Implications**

The study is useful contribution for the analyst to evaluate the difference in exchange rates as the time passes on. It is also intended to be useful contribution for further research because it provides a base to predict the future exchange rates. This research is helpful for the companies and investors to find out the best option available in the foreign market. This research is helpful for the companies and investors to find out the different investment options in other countries and help them to increase their profitability.

**Conclusion**

According to, A Multivariate Analysis Approach to Forecasts Combination, Application to Foreign Exchange (FX) Markets, the foreign exchange market is highly competitive. Competitive settings, real-time econometrics and deregulated management frameworks will require an increasing number of forecast horizons, particularly in the globalised FX market. Forecasting is characterized by the availability of a large number of methods, Combining forecasts is generally regarded as an appropriate methodology for handling the present scenario, and the researchers found that multivariate analysis may be very useful in combining forecasts. However, much more research is required to evaluate the exciting possibilities offered by these methods in forecasting.

According to, Forecasting of Value at Risk (VAR) by Cluster Method in Chinese Stock Market, the study proposes a Cluster method to compare the Conventional method for estimating VAR in Chinese stock markets and the empirical results demonstrated that in terms of accuracy, the Cluster method is superior to any of the Conventional methods in estimating VAR.

Exchange Rate Forecasting is very important to evaluate the benefits and risks attached to the international business and for this purpose Cluster method is a superior method, as we find through the other research studies. Cluster analysis is most often used in cases in which it is unknown, prior to the analysis, the number of groups in the data or which observations belong to which groups.

The objective of this study was to make clusters of the exchange rates using cluster analysis technique and further to forecast exchange rate by using IBM SPSS 18. Under this study tools used were Hierarchical Clustering Ward Linkage and Time Series Forecasting.

Cluster analysis resulted in 13 clusters for the time frame 1992-2014 for which clusters included 1992-1995 the Cluster13 value is 1, 1995-1997 the Cluster13 value is 2, 1997-1999 the Cluster13 value is 3, 1999-2002 the Cluster13 value is 4, 2002-2003 the Cluster13 value is 6, 2003-2005 the Cluster13 value is 7, 2005-2006 the cluster13 value is 8, 2006-2007 the Cluster13 value is 7, 2007-2008 the Cluster13 value is 8,9,9,7, 2008-2009 the Cluster13 value is 10,9,11, 2009-2010 the Cluster13 value is 9,11, 2010-2011 the Cluster13 value is 11, 2011-2013 the Cluster13 value is 12 and for 2013-2014 the Cluster13 value is 13

The predicted exchange rates are also found through Time Series Forecasting and the input sheet of these predicted exchange rates are attached in Annexure. Graph shows significant peaks, in USD Model, GBP Model, AUD Model and SGD Model, Which presents the upward trend in the rates. For the JPY Model, ESP Model and ZAR Model the graph presents the downward trend in the rates and for the CNY Model and ETB Model there is no significant change in the rates.

**References**

1. Exchange Rate definition from <http://www.investopedia.com/terms/e/exchangerate.asp>
2. Cluster Analysis definition from <http://www.uk.sagepub.com/.../Chapter%2023%20%20Cluster%20Analysis.pdf>

Forecasting Foreign Exchange Rates Approaches from <http://www.bauer.uh.edu/rsusmel/7386/ln5.pdf>

1. http://books.google.co.in/books?isbn=8182054745

Exchange Rate Volatility definition from<http://www.wisegeek.com/what-is-exchange-rate-volatility.htm>

http://stats.stackexchange.com

Example of Exchange Rate Volatility from <http://share.pdfonline.com/ac955d4c2f8b4490af5c30f1cfc1c1ed/project%20report%20neethu.htm>

1. <http://www.wisegeek.com/what-is-exchange-rate-volatility.htm>

<http://home.deds.nl/~essentiae/exchange-rates-popular.pdf>

http://www.kansascityfed.org/publicat/ECONREV/.../1984/3q84hakk.pdf‎

http://home.deds.nl/~essentiae/exchange-rates-popular.pdf

1. Adam, C. and Cobham, D. (2008). Alternative exchange rate regimes for MENA countries: gravity model estimates of the trade effects. Mimeo http:// ideas.repec.org/p/hwe/certdp/0505.html‎
2. Adubi, A.A., and Okunmadewa, F. (1999). Price, exchange rate volatility and Nigeria’s

agricultural trade flows: A dynamic analysis. African Economic Research Consortium

(AERC) Research Paper 87

http://opendocs.ids.ac.uk/opendocs/bitstream/handle/.../2223/RP%2087.pdf

1. Aikaeli, J. (2007). Money and Inflation Dynamics: A Lag between Change in Money Supply and the Corresponding Inflation Response in Tanzania. Working Paper Series.

http://papers.ssrn.com/sol3/Jeljour\_results.cfm?nxtres...id...

1. Alaba, O. B. (2003). Exchange Rate Uncertainty and Foreign Direct Investment in Nigeria. A Paper Presented at the WIDER Conference on Sharing Global Prosperity, Helsinki, Finland, 6-7 September 2003.

http://www.econ.ucdavis.edu/faculty/knruss/ftentry.pdf

1. Alvarez-Diaz, M. (2008). A note on forecasting exchange rates using a cluster technique.

International Journal of Business Forecasting and Marketing Intelligence, Vol. 1, No. 1,

pp. 68–81.

http://ijbssnet.com/journals/Vol\_3\_No\_10\_Special\_Issue\_May.../15.pdf‎

1. Allayannis, G., Brown, G.W. and Klapper, L.F. (2001). Exchange Rate Risk Management: Evidence from East Asia. Darden Business School Working Paper No. 01-09 available online at

http*://* papers.ssrn.com

1. Avellaneda, M. and Zhu, Y. (1997a). An E-ARCH Model for the Term Structure of Implied Volatility of FX Options. Working Paper Series available online at http://www.ssrn.com
2. Bailliu, J. Lafrance, R., and Jean-François Perrault (2002). Does Exchange Rate Policy Matter for Growth? Bank of Canada Working Paper 2002-17

http:// ideas.repec.org/p/bca/bocawp/02-17.html

1. Balogun, E.D. (2007). Effects of exchange rate policy on bilateral export trade of WAMZ

countries. MPRA Paper No. 6234, Available Online at

<http://mpra.ub.unimuenchen> de/6234/

1. Benigno, G. and Benigno, P. (2000). Monetary Policy Rules and the Exchange Rate. available at [http*://*ssrn.com](http://ssrn.com)
2. Bhattarai, K.R. and Mark K. Armah, M.K. (2005). The Effects of Exchange Rate on the Trade Balance in Ghana: Evidence from Cointegration Analysis. Research Memorandum 52

http://www2.hull.ac.uk/hubs/pdf/memorandum52.pdf‎

1. Bitzenis, A. and Marangos, J. (2007). The monetary model of exchange rate determination: the case of Greece (1974–1994). International Journal of. Monetary Economics and Finance, Vol. 1, No. 1, pp. 57- 88

http://www.ssrn.com

1. Bleaney, M. and Fielding, D. (1999). Exchange Rate Regimes, Inflation and Output Volatility in Developing Countries. Centre for Research in Economic Development and International Trade (CREDIT) Research Paper 99/4

http://www.nottingham.ac.uk/credit/documents/papers/99-04.pdf‎

1. Bleaney, M. and Francisco, M. (2007). The Performance of Exchange Rate Regimes in

Developing Countries – Does the Classification Scheme Matter? Centre for Research in

Economic Development and International Trade (CREDIT) Research Paper, No. 07/04

http://www.ssrn.com

1. Bouakez, H., Kano, T. and Xu, J. (2007). Imperfect Information, Learning, and Exchange Rate Dynamics. Social Sciences and Humanities Research Council
2. Busse, M., Hefeker, C. and Koopmann, G. (2004). Between Two Poles: Matching Trade and Exchange Rate Regimes in Mercosur. Hamburg Institute of International Economics

(HWWA) Discussion Paper 301

1. Canetti, E. and Greene, J. (1991). Monetary growth and exchange rate depreciation as causes of inflation in African countries. Centre for Economic Research on Africa (CERAF)
2. Chen, Y., Rogoff, K. and Rossi, B. (2008). Can Exchange Rates Forecast Commodity Prices? University of Washington Working Paper available at http*://* faculty.washington.edu/yuchin/Papers/CR2.pdf
3. Cheng, K. C. (2007). A VAR Analysis of Kenya's Monetary Policy Transmission Mechanism: How Does the Central Bank's Repo Rate Affect the Economy? IMF Working Paper No. 06/300.
4. Chinn and Meese (1995) Research paper on Structural Exchange Rate Models available at http://people.ucsc.edu/~hutch/241B/...files/chinn-meese.pdf‎
5. Chukwuma, A. (2002). Real Exchange Rate Distortions and External Balance Position of

Nigeria: Issues and Policy Options. Paper submitted for publication to the Journal of

African Finance and Economic Development, Institute of African American Affairs, NewYork University.

1. Coricelli, F. and Jazbec, B. (2001). Real Exchange Rate Dynamics in Transition Economies. CEPR Discussion Paper No. 2869, Available online at

http://www.cepr.org/pubs/dps/DP2869.asp

1. Dufrenot, G.J. and Yehoue, E.B. (2005). Real Exchange Rate Misalignment: A Panel Co- integration and Common Factor Analysis. IMF Working Paper WP/05/164
2. Engle, R.F. (2000). Dynamic Conditional Correlation - A Simple Class of Multivariate GARCH Models. UCSD Economics Discussion Paper No. 2000-09 from A DCC-GARCH M http*://* www.ipe.ro/rjef/rjef1\_13/rjef1\_2013p136-148.pd
3. Esquivel, G. and Larraín, F.B. (2002). The Impact of G-3 Exchange Rate Volatility on Developing Countries. UNCTAD/GDS/MDPB/G24/16 G-24 Discussion Paper Series,

No. 16,

Goldberg & Knetter (1997) and Goldberg & Hellerstein (2008) from http:// [www.treasury.govt.nz/publications/research-policy/wp/2013/.../03.htm](http://www.treasury.govt.nz/publications/research-policy/wp/2013/.../03.htm)

1. Grauwe, P.D. (1988). The Long- Swings in Real Exchange Rates- Do they fit into Our Theories? BOJ Monetary and Economic Studies, Vol. 6, No. 1, May 1988.
2. Gupta, J. P., Chevalier, A. and Sayekt, F. (2000). The Causality between Interest Rate, Exchange Rate and Stock Price in Emerging Markets: The Case of the Jakarta Stock Exchange.EFMA 2000 Athens
3. Gylfason, T. (2002). The Real Exchange Rate Always Floats. Australian Economic Papers from http*://* citeseerx.ist.psu.edu.com
4. Jarmuzek, M., Orlowski, L. T. and Radziwill, A. (2004). Monetary Policy Transparency in the Inflation Targeting Countries: The Czech Republic, Hungary and Poland. Center for Social and Economic Research Studies and Analyses Working Paper No. 281.
5. Hooper, P. and Kohlhagen, S. W. (1976). The Effect of Exchange Rate Uncertainty on the Prices and Volume of International Trade. International Finance Discussion Papers, November 1976, No. 91 available at [http*://*ssrn.com](http://ssrn.com)
6. Kellard, N. and Sarantis, N. (2007). Can Exchange Rate Volatility Explain Persistence in the Forward Premium? School of Accounting, Finance and Management, Essex Finance

Centre, Discussion Paper No DP 07/06

1. Kidane, A. (1999). Real exchange rate price and agricultural supply response in Ethiopia: The case of perennial crops. African Economic Research Consortium (AERC) Research Paper 99
2. Kuijs, L. (1998). Determinants of Inflation, Exchange rate, and output in Nigeria. IMF Working Paper
3. Mauro, Sussman and Yafeh (2006) Research paper pdf available at http://www.norges-bank.no/.../SUSSMAN%20AND%20YAFEH%20Paper.pdf‎
4. Mark (1995) [Exchange Rates and Fundamentals: Evidence on Long Horizon](http://www3.nd.edu/~nmark/wrkpaper/Exchange%20Rates%20and%20Fundamentals.pdf) available at http*://* www3.nd.edu/~nmark/.../Exchange%20Rates%20and%20Fundamentals....
5. Nabli, M.K. (2002). Exchange Rate Regime and Competitiveness of Manufactured Exports: The Case of MENA Countries. Available online at [http*://*ssrn.com](http://ssrn.com)
6. Nkurunziza, J.D. (2002). Exchange rate policy and the parallel market for foreign currency in Burundi. AERC Research Paper 123
7. Nwafor, F.C. (2006). The Naira-Dollar Exchange Rate Determination: A Monetary. International Research Journal of Finance and Economics, ISSN 1450-2887 Issue 5, Euro Journals Publishing, Inc., Available at <http://www.eurojournals.com/finance.htm>
8. Hansen, P.R. and Lunde, A. (2004). A Forecast Comparison of Volatility Models: Does Anything Beat a GARCH (1, 1)? Brown Univ. Economics Working Paper No. 01-04 from Forecasting Volatility using High Frequency Data http*://*public.econ.duke.edu/.../VolatilityMeasures/.../hansen\_lunde\_forecasting.
9. Hondroyiannis, G., Swamy, P.A.V.B., Tavlas, G., Ulan, M. (2005). Some Further Evidence on Exchange-Rate Volatility and Exports. Bank of Greece Working Paper No. 28 October 2005
10. Prasad (2003) [Financial Globalization, Growth and Volatility in Developing Countries](http://www.nber.org/chapters/c0114.pdf) from http:// [www.nber.org/chapters/c0114.pdf](http://www.nber.org/chapters/c0114.pdf)
11. Ruiz, I.C. (2005). Empirical analysis on the real effects of inflation and exchange rate uncertainty: The case of Colombia. Ecos de Economía No. 20. Medellín, abril 2005, pp. 7

- 28 http*://* mpra.ub.uni-muenchen.de/48316/1/MPRA\_paper\_48316.pd

1. Rutasitara, L. (2004). Exchange rate regimes and inflation in Tanzania from AERC Research Paper 138 available at [http*://*ssrn.com](http://ssrn.com)
2. Tenreyro, S. (2006). On the Trade Impact of Nominal Exchange Rate Volatility. London School of Economics.
3. Velasco, A. (2000). Exchange -Rate Policies For Developing Countries: What Have We

Learned? What Do We Still Not Know? United Nations Conference on Trade and

Development UNCTAD/GDS/MDPB/G24/5, G-24 Discussion Paper Series

1. Wang, K. and Barrett, C.B. (2007). Estimating the Effects of Exchange Rate Volatility on Export Volumes. from Journal of Agricultural and Resource Economics http:// dyson.cornell.edu/.../Trade\_FXRiskFeb2007Revision%20CBBFinal.pdf‎
2. Weeks, J. (2008). The effectiveness of monetary Policy reconsidered. International Poverty Centre United Nations Development Programme, Technical Paper, available online at http://www.undp-povertycentre.org
3. Yeyati, E.L. and Sturzenegger, F. (1999). Classifying Exchange Rate Regimes: Deeds vs. Words. available online at http://www.utdt.edu/~fsturzen or http://www.utdt.edu/~ely