Comparing Forecasting Performance of Exchange Rate Models: Evidence from Emerging Asian Economies

Abstract:

This study has been conducted to compare the forecasting performance of exchange rate models on the Emerging Asian Economies. Forecasting models included in this study are namely; Purchasing Power Parity (PPP), Interest Rate Parity (IRP), Dornbush Frankel Sticky Price Monetary Model (DB), Auto Regressive Integrated Moving Average (ARIMA), Generalised Auto Regressive Conditional Heteroskedasticity (GARCH), Random Walk (RW) and Artificial Neural Network (ANN). Different predictive measures have also been used to test the forecasting performance of exchange rate models namely; Root Mean Square Error (RMSE), Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE), Median of Absolute Deviation (MAD) and Success Ratio (SR). A total of seven emerging Asian economies namely; Pakistan, china, India, Indonesia, Malaysia, Philippines and Turkey have been investigated to forecast their exchange rate. Frequency of data is daily, monthly and quarterly.It has been found that all the models included in this study have the capacity to forecast, but on the basis of RMSE,MAE and MAPE it is concluded that ARIMA model is better than its competitors. It is also found that non linear model (GARCH) also performed in a better way. Economic theory based models completey collapsed and did not forecast well. Comparatively ARIMA model perform well than its competitor models used in this study. It has been observed that no one model is better for all the countries and for all the currencies included in this study.

Introduction:

Exchange rate is the rate at which one currency is exchanged for another. It is commonly reported as direct quotation which means number of home currency units exchanged for one unit of foreign currency. In the past, exchange rate was only determined by the balance of payments in which only imports and exports were involved. However, with the passage of time the industrialized nations adopted the floating exchange rate system which was also pursued by other nations of the world. The floating exchange rate is influenced by a number of factors, such as inflation, interest rate, imports and exports, etc. Recent financial crises in the world have also increased the emphasis on the prediction of exchange rates.

Floating exchange rate system and immense trading volume of the foreign exchange market increase the importance of forecasting the exchange rate.Floating exchange rate system means that interaction of a large number of buyers and sellers in the foreign exchange market determines the price of currency. Our foreign exchange reserves can be decreased when our currency depreciates. These are the reasons why predicting exchange rate is important and crucial for the country, economy or businesses which are operating internationally. Multinational companies which need to transfer currency across different countries because of overseas operations, and all the firms which are concerned with the import and export, regardless of their size, may increase their overall performance and profitability by accurately forecasting exchange rates. Investors get the advantage because of better prediction of exchange rate. They are able to effectively hedge against potential risks while on the other hand they create new profit making opportunities.

Prediction of accurate exchange rate is not very simple because it is affected by a number of factors including economic, political and global activities. Keeping in mind all these factors, this study incorporates models which involve linear as well as the non-linear behavior of the exchange rate.Forecasting exchange rate has a great importance and is used at large scale, both for financial research as well as in market practice. This study is about the forecasting of exchange rate as well as the comparative forecasting capacity of exchange rate models. There are generally two types of exchange rate quotations, namely, direct quotation or price quotation and indirect quotation or quantity quotation. Direct quotation means number of home currency units exchanged for one unit of foreign currency. After the collapse of fixed exchange rate regime in 1973 major economies shifted their exchange rates from fixed exchange rate to floating exchange ratesand later on other nations also switched over to floating exchange rate. Bayoumi&Eichengreen (1998) said that there is general perception that the movements in exchange rates reduce the trade, for this reason the most of the European Nations met and they formed the European Union to overcome the adverse effect of floating exchange rate and to compete with the world currencies, especially the dollar.Floating exchange rate also encourages the central banks of the country to intervene in the currency market or foreign exchange market. To play its role this floating exchange rate is known as the managed floating exchange rate. It is influenced by a number of factors, e.g. inflation, interest rate, imports and exports etc.

Deboeck (1944) stated that financial time series data is non-stationary, deterministically chaotic and inherently noisy. The time series data having the noisy characteristics means that there is incomplete information produced by the markets from their past behavior. Non stationary time series data means that the distribution of data is changing with the passage of time. The third characteristics of the financial time series data which is deterministically chaotic, means that financial time series data behaves random in short term, and in long term it is deterministic. It is also observed in the recent years there aremore fluctuations in exchange rates than before. Such variationsare noticeable because the relative values of currencies have huge impact on the economic conditions of the countries. Recent financial crises in the world have also increased the emphasis for the prediction of exchange rates. Our foreign exchange reserves can be decreased or increased when our currency depreciates or appreciates. Analyzing exchange rates has strategic importance for everyone affected with this, especially for the merchants of export and import (Evans, 2005). For example, if home currency becomes weak then its cost will decrease due to economic cost and its demand will increase in overseas and vice versa. This is why predicting exchange rate is more important and crucial for the economies and businesses operating internationally. Floating exchange rate system and immense trading volume of the foreign exchange market increase the importance of forecasting exchange rate. Forecasting exchange rate better often leads to better economic decision.

According to Wang (2008) forecasting exchange rate with accuracy helps the merchants to make decisions better about exchange rate. Multinational companies that need to transfer funds across different countries due to overseas operations, and the firms involved in import, and export business regardless of their size, may increase the overall performance and their profitability by accurately forecasting exchange rates. Investors may get advantages because of better prediction of exchange rates. They will be able to effectively hedge against potential risk of exchange rate and on the other hand they will create new profit making opportunities. Keeping in mind all these factors, this study incorporates models which capture the linearity as well as non-linearity relationships between dependent and independent variables.

Although different models are used to forecast exchange rates but identification of an efficient model to forecast exchange rates in perspective of emerging Asian economies is still an issue. According to contingency theory which states that the context always matters, so the efficiency of model may be different with respect to different regions included in this study. The objectives of this study are to find out the model with best predicting performance of exchange rates for emerging Asian economies. In other words: To compare the forecasting power of the exchange rate models which are based on fundamental, technical and random walk based, also to compare the forecasting power of the linear and nonlinear models of exchange rate and to compare the forecasting power of exchange rate models included in this study.Exchange rate forecasting is an important issue because it affects everyone in real life, but it has greater importance for businesses which are operating domestically as well as under international environment. It is very difficult to survive in the international market without thorough study of the currency market and exchange rates. This study hasimplicationson both,micro as well as macro level or in other words at the firm level as well as at country level.

Literature Review:

Exchange rate forecasting is an elusive topic in international finance regardless of massive studies and lot of resources devoted for it. Studies have been empirically tested but they found different results, especially after 1971 when Bretton Woods's system of fixed exchange rate collapsed and floating exchange rate regime started. Consequently, there has been substantial concentration on the estimation of exchange rate among countries. Exchange rate forecasting models based on technical and economic fundamentals were unable to provide satisfactory outcomes. Mussa (1979) accomplished that spot exchange rate approximately monitored a random walk process and peak changes in exchange rates were unanticipated. The study on exchange rate forecasting without the discussion of the model paper on exchange rate forecasting by Meese and Rogoff (1983) could not be completed. The effect of their research work on exchange rate was surprising because they concluded that random walk model performed better than all theoretical exchange rate models. The model comprised of a drift less random walk process. This model remained a useful standard for which exchange rate models are measured. Root Mean Square Error (RMSE) was used to compare the forecasting performance of the exchange rate models.

Bowerman and O' Connell (1993) concluded the study that there was not a single forecasting model which yields better results for all situations. Gernshenfeld and Weigend (1993) said that there cannot be a universal model that will predict everything well for all problems; it means nonlinear model should be used for nonlinear behavior of data and linear model should be used for linear behavior of the data. According to Gorr (1994) ANN models are appropriate because these capture the nonlinearity behavior of the data. Kang (1991) concluded that ANN performed better than any other statistical model used in his study. Denton (1995) found in his study that under normal conditions and ideal situations the new model and other types of regression produced the same results. The sticky price model of Dornbusch (1976) and Frankel (1979) were quite recognized models in the literature of international finance. These could be construed as extended purchasing power parity (PPP) models.

Glick and Rogoff (1995), Krugman (1991) identified that there was a traditional demand and supply relationship with trade and exchange rate. Hann and Steurer (1996) conducted the study to forecast the exchange rate and they used monthly and weekly exchange rate data.In weekly exchange rate data they found lot of evidence available which showedANN model was much better than other models. In the case monthly data, both types of models produce the same results. Adya and Collopy (1998) conducted studies on 48 research papers and found that most of the time neural network model outperformed the time series model. Yao (2000) conducted study on the option prices and found ANN model was much better than traditional models. Maditinos and Chatzoglou studied the neural network and found that this model was better than the traditional models. Graham and Elena (2005) believed that up to a certain level deviations in income levels through different countries capture effective variation. Lillie, Laurence and Wing (2008), for exchange rate predictability, in general empirical results, suggested that the Purchasing Power Parity (PPP) model and sticky price monetary model (SP) were able to outperform the random walk (RW) model.

Kadilar and Simsek (2009) found in their study that ANN model had the best forecasting accuracy with respect to other traditional time series models, such as seasonal ARIMA models and GARCH family model. Pacelli (2009) conducted the study on the bank stock returns and used ANN model and found that this model performed better than other models. Azad and Mahsin (2011) studied the forecasting exchange rate and employed the time series techniques and nonlinear technique which is neural network and measured the performance of these models by MAE, MAPE and RMSE and found that new technique predicted more accurately than the traditional model. Pacelli, Bevilacqua and Azzollini (2011) studied the neural network and found that neural network can predict three days ahead exchange rate. Khashei and Bijari (2011) found that ANN performs better than the linear model. Philip, Taofiki and Bidemi (2011) worked on forecasting exchange rate and they used two models which are artificial neural network foreign exchange rate forecasting model (AFERFM) and hidden Markov foreign exchange rate forecasting model (HFERM). Perwej and Perwej (2012) studied on neural network and found that when there was large number of data available and long term prediction was required with greater accuracy, in such situations neural network was better than the traditional models.

Fishwick (1989) found in his study that ANN models did not predict well than linear regression models which were traditionally used for predicting. Brace et al. (1991) conducted study on the comparison of predictive power of artificial neutral network models and traditional models, and found that Artificial Neural Network (ANN) models were not good models as compared to the other traditional models which were based on Auto Regressive or random walk model. De Groot and Wurtz (1991) conducted research on analysis of models on the yearly data and found that ANN was not best model and it produced some less efficient results than other models which were statistically known as linear models or nonlinear models.

Some studies found that there was not much difference between Auto regressive and ANN models as they predicted same results. For example Tang et al. (1991) conducted study on the comparative performance of models and used monthly data for three businesses to find which model was consistent and produced efficient results.They found that there was no difference between ANN and ARIMA models when they tested on long time series data, but they found that ANN model did not predict better in small time series data.Caire et al. (1992) conducted study to know the daily consumption of electricity and found that there was no significant difference between ANN and ARIMA models. They only used these two models for predictions and found that in the short run ANN predicted more preciselythus better than ARIMA model. Tang and Fishwick (1993) also supported the results of Tang et al. and found that both types of models provided same results, i.e. ANN and ARIMA.They also found that ANN produced somewhat better results in increased forecasting horizon. Zhang, Patuwo and Hu studied the neural network and raised a number of questions and concluded that with the passage of time ANN technique could be more useful. Huang et.al (2004) supported use of both types of models i.e., linear as well as nonlinear.

According to Peters (1991) there are three schools of thought which forecast the exchange rate, one is the Fundamental approach, second is the Technical approach and third one is random walk which negates both the school of thought discussed above. This study used all three approaches to forecast the exchange rate. The detail of these schools of thoughts is given below.

Comparison among schools of thought

Fundamental, technical and random walk schools of thought have differences among themselves. Fundamental school of thought is based on macro and micro economics; it depends on financial reports which tell us that future values can be determined based on these fundamental variables. Whereas technical analysis depends on price charts and it analyzes the price patterns. According to this school of thought future value can be determined on the basis of price patterns and previous price trends. The third school of thought negates economic indicators as well as past price patterns.This school of thought is based on random walk hypothesis which tells that neither economic variables nor previous price patterns can predict the future.

Fundamental School of thought

This school of thought which is based on economic variables helps out to predict the exchange rate. According to Johnston and Scott (1997) variables that affect the exchange rate market are Productivity Index, Interest rates, Unemployment, trade balance, Gross National Product (GNP) and Consumption. A comparative performance of exchange rate model which incorporates Purchasing Power Parity (PPP) condition with interest rate differential found that interest rate differential has more importance in the long run to forecast the exchange rate.Bjorn land and Hungnes (2006). The working of fundamental based exchanged rate model comprises of calculation of economic data. The data is divided into two parts, one part is used to training and the other part is used for the validation. The fundamental models used in this study are Purchasing Power Parity, Interest Rate Parity and Dornbusch Frankel Sticky Price monetary model. Fundamental models are based on theory; these include number of macroeconomic variables, for example variables affecting determination of exchange rate are inflation rates, interest rates, GNP, unemployment, etc. The models which include macroeconomic variables are called multivariate models, because predicting exchange rate may depend upon other factors which have not been included in the model as econometric problems may arise. In this study fundamental models are Purchasing Power Parity (PPP), Interest Rate Parity (IRP), Dornbusch Frankel Monetary (DB) Model and Artificial Neural Network (ANN).

Technical school of thought

This school of thoughtis based on past price trends. It argues that buy and sell signals are generated on the basis of trends and repetitive price patterns. Most useful technical models are measuring averages, filters and momentum indicators. Momentum based models measure the change in velocity of asset's price rise or falls. A sell signal is produced when price decreases quickly and vice versa. The filter method creates the buy signals when exchange rate rises to the highest position and it creates sell signals when asset's price falls below the previous peak. According to Rosenberg (2003) moving average has great importance in foreign exchange market.

Random walk School of thought

Third School of thought is based on random walk hypothesis which states it is not possible to predict the exchange rate because it moves randomly. According to this school of thought exchange rate cannot be predicted through economic variables and past information.

Theoretical Framework of Exchanges rate models

Purchasing Power Parity and Exchange Rate

In 1916, Cassel gave the theory of Purchasing Power Parity (PPP), this theory states that if prices of home and foreign currencies and also the nominal exchange rate are given the real exchange rate can be calculated. Purchasing Power Parity performed differently in short run and in long run. It performed well in the long run but in the short run it does not perform well. According to Bhatti (1996) Purchasing Power Parity still exists because of performing well in the long run.

Basically there are two types of PPP; first is called Relative PPP and the other is known as Absolute form of the Purchasing Power Parity (PPP). Due to various factors it is very difficult to maintain absolute purchasing power parity. According to the PPP theory the demand for the substitute product will change if inflation changes with respect to other country. For example if a similar product is produced in two countries, say in Pakistan and China, and suppose the price is increased in home country then the demand will shift to China's product because the price of home country goods increased and there is no more price competitiveness for international buyers. This will cause topressure on home currency and upward pressure on foreign currency.

The symbols used in the purchasing power parity are as below,

P_h = price in home country

P_f = price in foreign country

I_h = inflation in home country

I_f = inflation in foreign country

e_f = percentage change in the value of the foreign currency

Assuming that at the beginning of the period the prices are same in home country as well as in foreign country so,

$P_h = P_f$

at the end of year price will be

$P_h (1+I_h)$

$P_f (1+I_f)$

if inflation occurs in foreign country then

$P_f (1+I_f)(1+e_f)$

According to PPP theory

$P_f (1+I_f)(1+e_f)=P_h (1+I_h)$

Solving for "ef"

$$(1+e_f)=\frac{P_h (1+I_h)}{P_f (1+I_f)}$$

$$e_f = \frac{P_h (1+I_h)}{P_f (1+I_f)}-1$$

As, $F=S*(1+e_f)$

Putting the value of e_f in the above equation

$$F=S*(1+\frac{P_h (1+I_h)}{P_f (1+I_f)}-1)$$

$$F=S*\left[\frac{P_h (1+I_h)}{P_f (1+I_f)}\right]..........(PPP)$$

This PPP equation tells us that when foreign country inflation is more than that of domestic country, and then foreign currency depreciates and vice versa. It is also argued that when inflation is higher in domestic country then the demand of the domestic product will be less and have no more price competition in international market for international buyers.This leads to less demand of home currency which will cause domestic currency to be depreciated. The relationship between exchange rate and inflation is therefore negative. According to Lane (1999), keeping all other things constant when home country export falls with that the demand for local currency also falls. When home country demand falls then there is downward pressure on local currency. According to Lillie, Laurence and wing (2008) on the basis of root mean square error purchasing power parity is the best model among the interest rate parity and monetary models.

Interest Rate Parity Theory and Exchange Rate

In real life the difference in interest rate affects the capital account of the country and difference in inflation affects the current account of the country. Now a daysinterest rate has gained more importance because of the mobility of the capital from one country to another. Higher real interest rate leads higher foreign investment into the country. This causes to increase the local currency demand in forex market that puts upward pressure on the prices and vice versa. Thus theoretically it can be concluded that real interest rate has positive expected relationship with exchange rate. It is also said that there is negative relationship between nominal interest rate and exchange rate. According to interest rate parity theory the return should be same in local investment as well as in foreign investment. Suppose this theory holds then the currency having higher interest rate should decline in order to keep its value equal to local currency. This shows that nominal interest rate should have negative relationship with exchange rate. Theoretical justification by the interest rate parity theory is that if real interest rate remains same and only nominal interest rate changes then this is due to inflation premium. So we can deduce that higher interest rate leads to higher inflation which has opposite effect on exchange rate.

The symbols used in the Interest rate parity are given below,

R= return earned on foreign investment

i_h = return on home interest rate

V_h = beginning value of home currency

V_f = ending value of foreign investment

S = spot exchange rate

F = forward exchange rate

i_f = foreign interest rate

If Interest rate parity holds then return should be equal on investment which is made domestically as well as in foreign country. So mathematically the equation is as under:

$$R = i_h$$

Formula of Return is

$$R = \frac{V_f - V_h}{V_h}$$

$$V_f = \frac{V_h}{S}(1+i_f)*F$$

As, $F = S*(1+P)$

putting the value of "F″ in the above equation

$$V_f = \frac{V_h}{S}(1+i_f)*S*(1+P)$$

$$V_f = V_h*(1+i_f)*(1+p)$$

$$R = \frac{V_h*(1+i_f)*(1+p)-V_h}{V_h}$$

$$R = (1+i_f)*(1+p)-1$$

As, $R = i_h$

So writting i_h at the place of R

$$I_h = (1+i_f)*(1+p)-1$$

Rearranging this equation

$$\frac{1+i_h}{1+i_f} = 1+p$$

$$\frac{1+i_h}{1+i_f} - 1 = p$$

so Putting the value of P in following equation

$$\text{As } F = S^*\left(1+P\right)$$

$$F = S^*(1+\frac{1+i_h}{1+i_f}-1)$$

$$F = S^*(\frac{1+i_h}{1+i_f})\text{..........(IRP)}$$

According to Interest rate parity theory the country that has higher interest rate will be on discount side than the country that has lower interest rate. As higher nominal interest rate leads to higher inflation, which badly affects exchange rate,so it can be concluded that there is negative relationship between interest rate and exchange rate. It is also supported by the IRP equation, mentioned above, that forward rate is directly proportional to home interest rate and it is inversely proportional to foreign interest.

DORNBUSCH FRANKEL STICKY PRICE MONETARY (DB) MODEL

Dornbusch Frankel sticky price monetary model combines both the short structures as well as long term structure. A short term structure is the Mundell Fleming model and long term structure is the monetary model. Relationship among the exchange rate with money supply, interest rate, and inflation arises through the model which is presented by Dornbusch, which is usually known as the monetary model of exchange rate. Income level is also used in this model to measure the variations of income level. Relative share price is also included for better forecasting the exchange rate. The equation of this model is given below,

$$Fx_t = \alpha_0 + \beta_1 rinf_t + \beta_2 rint_t + \beta_3 rri_t + \beta_4 rms_t + \beta_5 rsp_t + \in_t$$

Fx = foreign exchange rate measured in direct quotations

$r\inf$ = Inf-Inf* = Relative inflation level

$r\text{int}$ = I-I* = Relative interest rate

rri = Y-Y* = Relative real income

rms = M-M* = Relative money supply

rsp = Sp-Sp* = Relative share price

$\in$ = error term

Artificial Neural Network (ANN)

According to Picton (1994),artificial neural network has two parts. First part is that why someone calls it artificial neural network. The logic behind this is that it is interconnection of elements. Actually these elements are like biological nervous system, so one can conclude that artificial neural network tries to create a machine in such a way that it acts like a human brain by mapping the elements to create biological neurons. The second part of the question describes what it does. To answer this part, it is just like a human brain, artificial neural network generates output when someone gives the inputs. According to widrow et al. (1994) Artificial Neural Network has lot of practical applications like business, industry and science. Among the applications of ANN one is the forecasting (sharda, 1994). There are some advantages of ANN over the traditional models. The first one is that it is not model based method rather it is data driven self-adaptive method. ANN learns from data then makes a relationship among the data, even if it is very difficult to know the relationship between the data. The second characteristic of the ANN is that it has the ability of generalization, for example after learning from the data it can correctly infer the data which is not presented in population. The third important characteristic of ANN is that it acts as universal approximators. It has the characteristics of more flexible functional forms. Most important characteristic of ANN is that it has the ability of handling nonlinear relationship. According to Granger and Terasvirta (1993) in real life, it is often seen that real world system is nonlinear system.

The question arises, how ANN forecasts.The answer is that it is like a nonlinear model that imitates biological neural network. To build artificial neural network is an important issue because it affects the forecasting performance of the models. The factors that affect the neural networks are architecture of the networks, activation function and learning algorithm. Architecture means number of layers, numbers of nodes in each layers and the number of arcs which interconnect the nodes. There are no general rules to build the best architecture. In literature there are different artificial neural network models, one commonly used in the literature and found extensively in the studies which produced best result, is known as feed forward neural network. This architecture has a single hidden layer and a single output. The other main part of the neural network is learning algorithm and its task is to determine the weights of all inputs for getting desired output. There are numerous training algorithms, among those only back propagation algorithm is used. The third part of the neural network is activation function; this part is the responsible, to find the relationship between output and inputs of the architecture. Among well-known activation functions someare hyperbolic, tangent, sine, cosine and logistic. According to Zhang (1998) logistic activation function is widely used activation function in the literature. This logistic activation function isused in the study. The equation of logistic function is given below.

$$f(x) = (1 + \exp(-x))^{-1}$$

The use of ANN is not new.In developed countries its use dates back to 1960s. Hu (1964) used ANN and forecast the weather through the Widrow's adaptive linear network. This is model which has the characteristics to handle nonlinear relationship between dependent variable and independent variables. In linear model it is assumed that there is linear relationship between dependent variable and independent variable, but in nonlinear model the nonlinear relationship between the independent variables and depend variable can be handled easily. Some differences between linear models and nonlinear models are given below.

Linear model

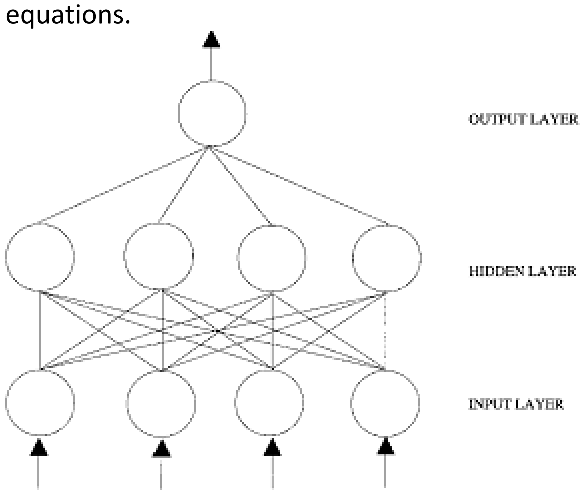
$$Y_t = \alpha_0 + \beta_1 x_1 + \beta_2 x_2 + ... + \beta_n x_n$$

The techniques usually used for linear relationships are regression models and ANOVA.

Nonlinear Model

$$y = F(x_1, x_2, ...x_n)$$

The commonly used techniques in nonlinear models are probit, logit, exponential growth and machine learning techniques. The above equation is the nonlinear model; y is dependent variable which is function of the explanatory variables or independent variable which are shown in the equations.



In the above figure the layer which is at the lowest is known as the input layer which is the external information and has independent variables or explanatory variables. These explanatory variables can be macroeconomic variables or lagged value of dependent variable. The layer at the top is known as the output layer which is also known as solution or output of the whole process. The upper and lower layers are separated by the layers known as hidden layers. These hidden layers are important for the neural networks because these hidden layers and nodes allow the artificial neural network to extract the features and also calculate the behavior in the data. This makes nonlinear relationship between input and output variables. The above figure also tells that if there are no hidden nodes then it becomes simple linear model. This model is known as feed forward neural network, it handles the fundamental variables as well as the technical analysis. Technical analysis is based only on the past price patterns or it is time series data. The future value can be determined on the previous value of the dependent variable, so ANN model under this type of data the equation becomes;

$$y_{t+1} = F(y_t, y_{t-1}, \ldots\ldots\ldots, y_{t-n})$$

Here y is dependent variable, its lag values are the independent variables.

Auto Regressive Integrated Moving Average model (ARIMA)

This model is introduced by the Box and Jenkins (1976), it is based on previous values of the dependent variable and on the error term. The acronym ARIMA is the combination of following three parts;

AR =Auto Regressive

I = Integrated

MA =Moving Average

One lagged auto regressive model is given below,

$$y_t = \beta_0 + \beta_1 y_{t-1} + u_t$$

It is also observed that moving average also hasa significant contribution to explain the dependent variable and the simple moving average model is given below;

$$y_t = \beta_1 u_{t-1} + u_t$$

When combined, both the above equations give the ARMA equation. The difference between ARMA and ARIMA equations is that if a variable is stationary at a level it is known as ARMA and symbolically it is written as I (0), and if the variable is stationary at first difference it is known as ARIMA model and symbolically it is written as I (1) and if the variable is stationary at second level then shown as I (2). The equation of ARMA model is given below;

$$y_t = \alpha_0 + \beta_1 y_{t-1} + \ldots. + \beta_n y_{t-n} + u_t + \gamma_1 u_{t-1} + \ldots. + \gamma_n u_{t-n}$$

Auto Regressive Conditional Heteroskedasticity (ARCH)

This model was introduced by Engle in (1982). It assumes that the error term is not independently and identically distributed with zero mean and constant variance. So when this situation happens it leads to variance of the residual depending on the past values of the squared error terms. According to Engle (1982, 1983) and cragg (1982) variance of the error term depends on past values of the error term that suggests heteroskedasticity in the variance of the error term. This model has the ability to capture heteroskedasticity in the error term, as this model is the best alternative over other traditional time series models. If there is heteroskedasticity in error term then this is the best model in spite of ARIMA model. The equation of model is given below.

Mean equation

$$y_t = \alpha_o + \beta_1 y_{t-1} + u_t$$

ARCH equation

$$h_t = \beta_0 + \beta_1 u^2_{t-1}$$

ARCH "q" process

$$h_t=\beta_0+\beta_1u_{t-1}^2+\beta_2u_{t-2}^2+.......+\beta_qu_{t-q}^2$$

It can also be written as:-

$$h_t=\beta_0+\sum_{i=1}^{q}\beta_iu_{t-i}^2$$

There are draw backs in ARCH specification, one of them is that it considers moving average but it is also seen that autoregressive terms of the conditional variance are the more important. The GARCH model captures both the terms efficiently. GARCH equation is given below

$$h_t=\beta_0+\beta_1h_{t-1}+\beta_2u_{t-1}^2$$

Random Walk Model

A special form of AR can be written as AR (1) model with some restrictions i.e. $\beta_1 = 1$

$$S_t=\beta_0+\beta_1S_{t-1}+\in_t$$

After putting $\beta_1 = 1$, equation becomes;

$$S_t=\beta_0+S_{t-1}+\in_t$$

The formula of change in exchange rate is.

$$\Delta S_t=S_t-S_{t-1}$$

$$\Delta S_t=\beta_0+\in_t$$

Research Methodology

This chapter contains a description of the methodology of this study. This covers population, sample, variables, data collection, data analysis and techniques which measure the forecasting power of exchange rate models. This study focuses on the emerging Asian economies. According to IMF the countries given the status of Emerging Asian economies include, Pakistan, China, India,Indonesia, Malaysia, Philippines and Turkey.Frequency of data is daily, monthly and quarterly. Data is taken from the different sources, including International Financial Statistics which is the publication of International Monetary Fund (IMF) and World Bank. Exchange rate data is taken from the oanda website for all the countries included in this study.Stock market index datais taken from yahoo finance. Measuring the variables is critical because whole analysis is based on these variables. The variables included in this study are given below.

Exchange rate

Measuring exchange rate gives rise to some important questions, whether it should be in nominal form or real form, whether to use direct quotations or indirect quotations. Similarly whether to use bilateral exchange rate or weighted basket exchange rates. In this study nominal exchange rate is used because both types of exchange rates are highly correlated and statistically there is no difference between them. As regards direct quotations or indirect quotations, both are same with respect to economic sense, but only interpretation is different or opposite. It is also mentioned that interpretation of coefficient also depends upon how the particular independent variable is measured in the equation. Exchange rate measuring should be either weighted basket exchange rate or bilateral exchange rates. In literature bilateral exchange rate used and base currency is United States dollar. In this study bilateral exchange rate used and three base currencies are United States dollar, Great Britain pound and Japanese yen.

Inflation

Inflation is calculated from the consumer Price Index, taking natural log of consumer price index. It is calculated as follows,

$$\text{Inflation}=\text{Ln}\left[\frac{(\text{CPI})_t}{(\text{CPI})_{t-1}}\right]*100$$

Interest Rate

The government's fiscal branch borrows from the central bank or from the commercial banks on the rate which implies on Treasury bills (T-bill) for six months. In literature T-bill rate is used as interest rate in these types of models (Khurum, 2011).

Real Income

The proxy of real income is real GDP, as GDP is not monthly form of the countries income included in this study. It has been taken the monthly data of industrial production as a proxy of real income.

Money Supply

M2 form of money supply is used in this study. It includes the sum of currencies in circulation, short term deposits and long term depositsin private sector. M2 money supply is the monetary aggregate which is most commonly quoted because its movement has close relationship with economic growth and interest rate.

Share prices

Share prices are calculated by taking the proxy of stock market of that country. It is worked out by taking natural log of stock market index.

$$(\text{Stock price})_t = \text{Ln}\left[\frac{(\text{Index})_t}{(\text{Index})_{t-1}}\right]*100$$

Relative measures of Variables

Y-Y* = Relative Income

I-I* = Relative Interest rate

M-M* = Relative Money Supply

Inf-Inf* = Relative Inflation

Sp-Sp* = Relative Share Price

Symbols having stars show the foreign variables and without star show the home country variables. For example, obtaining relative inflation, foreign country inflation is subtracted from the home country inflation. Methodologically forecasting models are written below,

Forecasting with purchasing power parity

$$F = S*\left[\frac{(1+I_h)}{(1+I_f)}\right]$$

Where F is forecasted exchange rate and S is spot exchange rate at time t and I_f and I_h are foreign and home inflation respectively.

Forecasting with interest rate parity

$$F = S*\left[\frac{(1+i_h)}{(1+i_f)}\right]$$

Where F is forecasted exchange rate and S is spot exchange rate at time t and i_f and i_h are foreign and home interest rate respectively.

Forecasting with Dornbusch Frankel Sticky Price monetary model

$$Fx_t = \alpha_0 + \beta_1 rinf_t + \beta_2 rint_t + \beta_3 rri_t + \beta_4 rms_t + \beta_5 rsp_t + \in_t$$

Fx = foreign exchange rate measured in direct quotations

$r\inf$ = Inf-Inf* = Relative inflation level

$r\text{int}$ = I-I* = Relative interest rate

rri = Y-Y* = Relative real income

rms = M-M* = Relative money supply

rsp = Sp-Sp* = Relative share price

$\in$ = error term

Forecasting with Artificial Neural Network

The future value can be determined on the basis of previous valuesof the dependent variable, so ANN model under this type of data the equation becomes;

$$y_{t+1} = F(y_t, y_{t-1}, \ldots\ldots\ldots, y_{t-n})$$

Here y is dependent variable, its lag values are the independent variables.

Forecasting with ARIMA

$$y_t = \alpha_0 + \beta_1 y_{t-1} + \ldots. + \beta_n y_{t-n} + u_t + \gamma_1 u_{t-1} + \ldots. + \gamma_n u_{t-n}$$

Above equation tells that exchange rate depends on lagged values of depend variable and moving average.

Forecasting with GARCH

$$h_t = \beta_0 + \beta_1 h_{t-1} + \beta_2 u_{t-1}^2$$

Above equation is called GARCH equation, as it is beneficial when error term has not constant variance.

Forecasting with Random Walk Model

$$S_{t+h} = S_t + \varepsilon_t$$

Equation shows that the future spot rate will differ from current spot rate by random error term, which can negative as well negative.

Techniques which measure forecasting power of exchange rate models

In this research following five techniques are used to measure the predicting power of exchange rate models.

Root Mean Square Error (RMSE)

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(e_i)^2}$$

$$where \quad e_i = Actual\ value - Forecasted\ Value$$

Root mean square error is simply the standard deviation which measures performance power of the model. The drawback of this technique is that the square of the difference of the values, because squaring small values makes them further smaller and squaring large values yield very larger values. To cope up with this problem absolute values are taken.

Mean Absolute Error (MAE)

$$MAE = \frac{1}{n}\sum_{i=1}^{n}|e_i|$$

$$where \quad e_i = Actual\ value - Forecasted\ Value$$

This is comparatively better than the root mean square error because it takes absolute value for measuring the error, but it cannot predict the outlier in the data. To solve the outlier problem the Median of Absolute Deviation (MAD) parameter are adopted to measure the performance of the model.

Mean Absolute Percentage Error (MAPE)

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{e_i}{A_i}\right| * 100$$

$$where \;\; e_i = Actual\,value - Forecasted\,Value$$

$$A_i = Actual\,value$$

When the model is a perfect fit then the mean absolute percentage error is zero. This technique also tells the accuracy of the model. MAPE value should be minimum for ideal model. This technique also has the lacks ability to diagnose the outlier. Solving outlier problem Median of Absolute Deviation is required.

Median of Absolute Deviation (MAD)

$$MAD = median(|F_t - median(Ft)|)$$

This parameter is very useful because it handles the outliers in the data. Therefore, this technique is superior to others discussed earlier. But it does not tell whether the models are predicting in the right or wrong direction. For solving this problem success ratio technique is required which measures the right direction of the predicted values.

Success Ratio (SR)

$$SR = \frac{1}{n}\sum_{i=1}^{n} I(r_a r_f > 0)$$

This technique is very useful as it tells us the direction of the predicted values of the exchange rate. For example if any model predicts that exchange rate will increase and in real life exchange rate also increases then it can be said that the model predicted the exchange rate in right direction and vice versa.

Results and Discussions:

Forecasting Pakistani currency with respect to US Dollar

Forecasting Measures					
Forecasting Models	Root Mean Square Error	Mean Absolute Error	Mean Absolute Percentage Error	Median of Absolute Deviation	Success Ratio
PPP	1.19	0.87	0.96	2.91	0.57
IRP	1.07	0.74	0.81	3.04	0.57
DB	1.25	0.93	1.02	2.73	0.57
ARIMA	1.26	0.84	0.92	3.04	0.57
GARCH	1.26	0.90	0.99	2.85	0.57
ANN	5.01	4.54	4.89	1.00	0.71
RW	1.17	0.84	0.92	3.02	0.64

Forecasting Pakistan's exchange rate with respect to United States dollar, the interest rate parity theory shows minimum value of root mean square error, mean absolute error and mean absolute percentage error which means that this model is better than other because this model has minimum error. According to median of absolute deviation and success ratio, ANN produced better result because it has less MAD value and maximum value of success ratio. As ANN predicts better in right direction, in this case this model predicts 71% of the time in right direction.

Forecasting Pakistani currency with respect to Pound Sterling

Forecasting measures					
Forecasting models	Root Mean Square Error	Mean Absolute Error	Mean Absolute Percentage Error	Median of Absolute Deviation	Success Ratio
PPP	42.99	41.73	28.65	5.56	0.64
IRP	42.37	41.90	28.83	0.70	0.29
DB	44.70	43.64	30.0	3.57	0.57
ARMA	1.99	1.41	0.97	5.18	0.50
GARCH	1.99	1.51	1.03	5.84	0.64
ANN	6.32	5.49	3.72	2.87	0.64
RW	1.99	1.49	1.02	5.82	0.64

Forecasting Pakistan's exchange rate with respect to Pound Sterling, all the models performed in one way or the other except, DB model. Auto Regressive Moving Average model has minimum value of root mean square error, mean absolute error and mean absolute percentage error, which shows that this model is better than others. According to MAD, IRP model is better for having minimum value. PPP, GARCH, ANN and RW have same capacity to forecast the exchange rate in right direction which is 64%. It is concluded that above discussed model are equally good to predict the exchange rate in right direction.

Forecasting Pakistani currency with respect to Japanese Yen

Forecasting measures					
Forecasting models	Root Mean Square Error	Mean Absolute Error	Mean Absolute Percentage Error	Median of Absolute Deviation	Success Ratio
PPP	0.02	0.02	1.59	0.03	0.71
IRP	0.02	0.02	1.62	0.71	0.71
DB	0.02	0.02	1.59	0.03	0.79
ARMA	0.02	0.02	1.87	0.04	0.64
ANN	0.43	0.40	35.27	0.04	0.42
RW	0.02	0.01	1.63	0.03	0.64

Forecasting Pakistan's exchange rate with respect to Japanese Yen, Dornbusch Frankel Sticky Price Monetary (DB) and PPP models have minimum value of root mean square error, mean absolute error and mean absolute percentage error, which shows that these models are better than other because of having minimum error. PPP, DB and RW are better models on the basis of median of absolute deviation having value 0.03, which is less than all other models. Success ratio is the measure which tells about the right direction, Dornbusch Frankel Sticky Price Monetary model has the capacity to beat other models in the perspective of forecasting exchange rate in right direction which is 78%, i.e. greater than all other models. It can be concluded that overall DB model is better than any other models included in this study.

Forecasting Chinese currency with respect to US Dollar

Forecasting measures					
Forecasting models	Root Mean Square Error	Mean Absolute Error	Mean Absolute Percentage Error	Median of Absolute Deviation	Success Ratio
PPP	0.02	0.02	0.24	0.01	0.43
IRP	0.02	0.02	0.24	0.02	0.36
DB	0.02	0.02	0.34	0.01	0.50
ARIMA	0.01	0.01	0.24	6.30	0.35
GARCH	0.02	0.01	0.25	6.31	0.50
ANN	0.42	0.42	6.66	6.72	0.57
RW	0.00	0.00	0.00	6.30	0.71

Forecasting China's exchange rate with respect to United States dollar, random walk model has outperformed all the models included in the study, except median of absolute deviation. Random

Walk model has minimum values of root mean square error, mean absolute error and mean absolute percentage error and also has maximum success ratio, which shows that this model is better than other because of higher performance of this model. Random walk model predicts exchange rate in the right direction. According to MAD, PPP and DB model are better because of having less value.

Forecasting Chinese currency with respect to Pound Sterling

Forecasting models	Root Mean Square Error	Mean Absolute Error	Mean Absolute Percentage Error	Median of Absolute Deviation	Success Ratio
	Forecasting measures				
PPP	0.13	0.10	0.99	0.09	0.50
IRP	0.13	0.11	1.08	0.09	0.50
DB	0.13	0.10	1.05	0.09	0.43
ARIMA	0.12	0.10	1.10	9.96	0.50
GARCH	0.12	0.10	1.10	9.98	0.50
ANN	0.38	0.35	3.59	10.31	0.28
RW	0.13	0.11	1.11	9.97	0.57

Forecasting China's exchange rate with respect to Pound Sterling, ARIMA and GARCH models have minimum value of root mean square error. According to mean absolute error; PPP, DB, ARIMA and GARCH have the minimum value but with perspective of mean absolute percentage error and median of absolute deviation, PPP model is better having minimum percentage error. With perspective of right direction Random walk model predicts exchange rate better.

Forecasting Chinese currency with respect to Japanese Yen

Forecasting models	Root Mean Square Error	Mean Absolute Error	Mean Absolute Percentage Error	Median of Absolute Deviation	Success Ratio
	Forecasting measures				
PPP	0.00	0.00	1.51	0.00	0.57
IRP	0.00	0.00	1.50	0.00	0.64
DB	0.00	0.00	1.44	0.00	0.57
ARMA	0.00	0.00	1.43	0.07	0.57
GARCH	0.00	0.00	1.40	0.07	0.57
ANN	0.00	0.00	4.82	0.07	0.57
RW	0.00	0.00	1.40	0.07	0.57

Forecasting China's exchange rate with respect to Japanese Yen, random walk and GARCH models have minimum value of root mean square error, mean absolute error and mean absolute percentage error. According to median of absolute deviation and success ratio, IRP is better having less median of absolute deviation value and maximum value of success ratio.

Forecasting Indian currency with respect to US Dollar

Forecasting Models	Root Mean Square Error	Mean Absolute Error	Mean Absolute Percentage Error	Median of Absolute Deviation	Success Ratio
	Forecasting Measures				
PPP	1.52	1.37	2.62	2.07	0.50
IRP	1.58	1.41	2.68	2.06	0.50
DB	1.48	1.34	2.54	2.13	0.50
ARIMA	1.75	1.52	2.87	2.17	0.50
GARCH	1.46	1.30	2.47	2.47	0.50
ANN	2.85	2.59	4.82	0.71	0.50
RW	1.47	1.31	2.52	2.52	0.50

Forecasting Indian exchange rate with respect to United States dollar, according to root mean square error, mean absolute error and median of absolute deviation, GARCH model has outperformed all the models included in the study. Artificial Neural Network has minimum value of median of absolute deviation. Predicting the exchange rate in right direction all the models have the same capacity to predict but they are not predicting well because only 50 percent values is forecasted in right direction.

Forecasting Indian currency with respect to Pound Sterling

Forecasting Measures					
Forecasting Models	Root Mean Square Error	Mean Absolute Error	Mean Absolute Percentage Error	Median of Absolute Deviation	Success Ratio
PPP	2.11	1.88	2.27	3.42	0.57
IRP	2.01	1.76	2.13	3.44	0.64
DB	2.12	1.84	2.24	3.19	0.57
ARIMA	2.18	1.93	2.31	2.97	0.57
ANN	3.25	2.92	3.44	1.63	0.50
RW	2.02	1.78	2.16	3.28	0.57

Forecasting Indian exchange rate with respect to Pound Sterling IRP has minimum value of root mean square error, mean absolute error and mean absolute percentage error, which shows that this model is better than other because this has minimum error. ANN model is better on the basis of median of absolute deviation having value 1.63 which is less than all other models. Success ratio is the measure which tells about the right direction, IRP model also has the better power to predict the exchange rate in right direction having 64% success ratio.

Forecasting Indian currency with respect to Japanese Yen

Forecasting Measures					
Forecasting Models	Root Mean Square Error	Mean Absolute Error	Mean Absolute Percentage Error	Median of Absolute Deviation	Success Ratio
PPP	0.02	0.02	2.95	0.02	0.50
IRP	0.02	0.02	3.00	0.02	0.50
DB	0.02	0.02	2.95	0.02	0.50
ARIMA	0.02	0.01	2.85	0.02	0.57
GARCH	0.02	0.01	2.71	0.02	0.50
ANN	0.14	0.13	20.73	0.00	0.42
RW	0.02	0.01	2.73	0.02	0.50

Forecasting Indian exchange rate with respect to Japanese Yen, random walk model has minimum value of root mean square error, mean absolute error and mean absolute percentage error which shows that this model is better than other because it has minimum error. ANN is better model on the basis of median of absolute deviation, which is less than all other models. Forecasting exchange rate in right direction, ARIMA model is better than other models included in this study.

Forecasting Indonesian currency with respect to US Dollars

Forecasting Measures					
Forecasting Models	Root Mean Square Error	Mean Absolute Error	Mean Absolute Percentage Error	Median of Absolute Deviation	Success Ratio
PPP	103.08	75.45	0.82	258.37	0.71
IRP	75.53	59.43	0.65	222.95	0.86
DB	311.31	258.70	2.78	179.23	0.71
ARMA	72.34	64.00	0.69	145.47	0.71
ANN	129.15	116.59	1.25	162.13	0.79
RW	75.54	67.44	0.73	184.34	0.86

Forecasting Indonesian exchange rate with respect to United States dollar, according to root mean square error, ARMA model has outperformed than all the models included in this study. IRP model is better with respect to MAE, MAPE. Random walk model and IRP have the same capacity to forecast the exchange rate in right direction as both have 86% success ratio. ANN model has less median of absolute deviation. So according to median of absolute deviation ANN model is better.

Forecasting Indonesian currency with respect to Pound Sterling

Forecasting Measures					
Forecasting Models	Root Mean Square Error	Mean Absolute Error	Mean Absolute Percentage Error	Median of Absolute Deviation	Success Ratio
PPP	655.72	586.47	4.05	110.66	0.29
IRP	874.63	734.86	5.13	8.82	0.43
DB	641.16	447.31	3.07	423.32	0.43
ARMA	160.10	118.36	0.81	355.13	0.64
ANN	910.02	879.71	6.18	389.65	0.50
RW	164.65	121.25	0.83	329.32	0.57

Forecasting Indonesian exchange rate with respect to Pound Sterling, ARMA model has outperformed through all the measures included in the study except median of absolute deviation. ARMA model has minimum value of root mean square error, mean absolute error and mean absolute percentage error and maximum value of success ratio. But according to Median of Absolute Deviation, IRP model performed better than any other model included in this study, as 64% of the time ARMA model predicted better exchange rate in the right direction.

Forecasting Indonesian currency with respect to Japanese Yen

Forecasting Measures					
Forecasting Models	Root Mean Square Error	Mean Absolute Error	Mean Absolute Percentage Error	Median of Absolute Deviation	Success Ratio
PPP	33.06	32.91	28.15	0.23	0.57
IRP	29.00	28.84	24.66	0.08	0.43
DB	28.88	28.73	24.58	0.97	0.50
ARMA	3.06	2.66	2.28	2.46	0.64
ANN	9.43	9.07	7.72	1.00	0.64
RW	3.20	2.84	2.43	2.22	0.64

Forecasting Indonesian exchange rate with respect to Japanese Yen, ARMA model has outperformed through all the measures included in the study except median of absolute deviation. ARMA model has minimum values of root mean square error, mean absolute error and mean absolute percentage error and maximum value of success ratio. But according to median of absolute deviation, IRP model performed better than any other models included in this study, as 64% of the time ARMA, ANN and RW models predicted exchange rate in right direction.

Forecasting Malaysian currency with respect to US Dollar

Forecasting Measures					
Forecasting Models	Root Mean Square Error	Mean Absolute Error	Mean Absolute Percentage Error	Median of Absolute Deviation	Success Ratio
PPP	0.53	0.53	17.03	0.00	0.57
IRP	0.39	0.38	12.43	0.00	0.36
DB	0.39	0.39	12.58	0.02	0.43
ARMA	0.05	0.04	1.52	0.03	0.57
GARCH	0.04	0.03	1.03	0.04	0.71
ANN	0.06	0.05	1.78	0.07	0.64
RW	0.05	0.04	1.58	0.04	0.71

Forecasting Malaysian exchange rate with respect to United States dollar, GARCH model has outperformed. This model has minimum value of root mean square error, means absolute error, means absolute percentage error and also has maximum value of success ratio. But according to Median of Absolute Deviation PPP and IRP theories produced minimum values. Random walk model also has the same capacity as GARCH model as it also has 71% success ratio.

Forecasting Malaysian currency with respect to Pound Sterling

Forecasting Measures					
Forecasting Models	Root Mean Square Error	Mean Absolute Error	Mean Absolute Percentage Error	Median of Absolute Deviation	Success Ratio
PPP	0.06	0.05	1.10	0.05	0.36
IRP	0.06	0.05	1.01	0.03	0.43
DB	0.07	0.06	1.16	0.06	0.43
ARIMA	0.02	0.02	0.31	4.88	0.93
GARCH	0.02	0.01	0.29	4.90	0.93
ANN	0.07	0.06	1.13	0.03	0.43
RW	0.06	0.05	0.98	4.90	0.43

Forecasting Malaysian's exchange rate with respect to Pound Sterling,GARCH model performed better than other models included in this study. This model has minimum value of root mean square error, means absolute error and means absolute percentage error and also has maximum value of success ratio. But according to Median of Absolute Deviation IRP and ANN have minimum values. ARIMA model also has the same capacity as GARCH model as it has 93% success ratio.

Forecasting Malaysian currency with respect to Japanese Yen

Forecasting Measures					
Forecasting Models	Root Mean Square Error	Mean Absolute Error	Mean Absolute Percentage Error	Median of Absolute Deviation	Success Ratio
PPP	0.00	0.00	2.20	0.00	0.64
IRP	0.00	0.00	2.14	0.00	0.71
DB	0.00	0.00	2.17	0.00	0.64
ARIMA	0.00	0.00	2.13	0.04	0.64
GARCH	0.00	0.00	1.96	0.04	0.71
ANN	0.01	0.01	14.00	0.00	0.29
RW	0.00	0.00	2.02	0.04	0.71

Forecasting Malaysian exchange rate with respect to Japanese Yen, GARCH has the minimum values of root mean square error, mean absolute error and mean absolute percentage error and maximum success ratio which shows that this model is better than other for having minimum error. PPP, IRP and ANN are better models on the basis of median of absolute deviation having minimum value than all other models included in this study. It can be concluded that RW model is the best model to forecast the Malaysian exchange rate with respect to Japanese Yen.

Forecasting Philippines currency with respect to US Dollar

Forecasting Measures					
Forecasting Models	Root Mean Square Error	Mean Absolute Error	Mean Absolute Percentage Error	Median of Absolute Deviation	Success Ratio
PPP	0.44	0.34	0.80	0.64	0.36
IRP	0.45	0.33	0.79	0.85	0.29
DB	0.44	0.34	0.80	0.64	0.36
ARIMA	0.45	0.38	0.89	0.55	0.36
GARCH	0.43	0.35	0.82	0.54	0.36
ANN	1.86	1.80	4.27	0.34	0.50
RW	0.43	0.36	0.84	0.54	0.36

Forecasting Philippine's exchange rate with respect to United States dollar, GARCH and RW models show the minimum value of root mean square error. According to mean absolute error and mean absolute percentage error, IRP model has less error than any other model included in this study. ANN model outperformed all other models included in this study, with the perspective of median of absolute deviation and success ratio. ANN has minimum MAD value and maximum success ratio.

Forecasting Philippines currency with respect to Pound Sterling

Forecasting Measures					
Forecasting Models	Root Mean Square Error	Mean Absolute Error	Mean Absolute Percentage Error	Median of Absolute Deviation	Success Ratio
PPP	0.86	0.63	0.95	0.87	0.57
IRP	0.81	0.64	0.96	0.65	0.57
DB	1.10	0.83	1.25	1.15	0.57
ARIMA	0.72	0.59	0.89	0.88	0.71
ANN	2.99	2.89	4.33	0.67	0.36
RW	0.79	0.64	0.96	0.92	0.57

Forecasting Philippines' exchange rate with respect to pound sterling, ARIMA model has outperformed through all the measures included in the study except median of absolute deviation. ARIMA model has minimum values of root mean square error, mean absolute error, mean absolute percentage error and success ratio. According to Median of Absolute Deviation, IRP model performed better than any other model included in this study.

Forecasting Philippines currency with respect to Japanese Yen

Forecasting Measures					
Forecasting Models	Root Mean Square Error	Mean Absolute Error	Mean Absolute Percentage Error	Median of Absolute Deviation	Success Ratio
PPP	0.01	0.01	2.02	0.01	0.50
IRP	0.01	0.01	1.99	0.01	0.43
DB	0.01	0.01	2.15	0.01	0.43
ARIMA	0.01	0.01	1.92	0.02	0.50
GARCH	0.01	0.01	1.92	0.02	0.50
ANN	0.03	0.02	4.37	0.00	0.50
RW	0.01	0.01	1.93	0.02	0.50

Forecasting Philippine's exchange rate with respect to Japanese Yen, ARIMA and GARCH models outperformed through all the measures included in this study except median of absolute deviation. Both models discussed above have less root mean square error, mean absolute error and mean absolute percentage error and also have higher success ratio. PPP, ANN and RW also have the same success ratio which is 50%. Therefore ANN model is better on the basis of median of absolute deviation which is less than all other models.

Forecasting Turkish currency with respect to US Dollar

Forecasting Measures					
Forecasting Models	Root Mean Square Error	Mean Absolute Error	Mean Absolute Percentage Error	Median of Absolute Deviation	Success Ratio
PPP	0.03	0.02	1.34	0.01	0.43
IRP	0.03	0.02	1.37	0.01	0.50
DB	0.03	0.02	1.30	0.01	0.43
ARMA	0.04	0.03	1.66	0.02	0.43
GARCH	0.04	0.03	1.63	0.01	0.43
ANN	0.16	0.16	8.78	0.01	0.36
RW	0.04	0.03	1.61	0.01	0.43

Forecasting Turkish exchange rate with respect to United States, Dornbusch Frankel Sticky Price Monetary model has minimum value of root mean square error, mean absolute error, mean absolute percentage error and median of absolute deviation, which show that this model is better than others. IRP has the maximum power to predict the exchange rate in right direction with 50% success ratio. On the basis of the result it can be concluded that Dornbusch Frankel Sticky Price Monetary model is the best model to forecast the exchange rate of Turkey against United States dollar.

Forecasting Turkish currency with respect to Pound Sterling

Forecasting Measures					
Forecasting Models	Root Mean Square Error	Mean Absolute Error	Mean Absolute Percentage Error	Median of Absolute Deviation	Success Ratio
PPP	0.04	0.04	1.26	0.03	0.43
IRP	0.04	0.04	1.30	0.03	0.43
DB	0.04	0.03	1.09	0.02	0.50
ARMA	0.03	0.03	0.92	0.04	0.93
GARCH	0.02	0.01	0.49	0.03	0.79
ANN	0.12	0.12	4.14	0.01	0.36
RW	0.04	0.04	1.29	0.03	0.43

Forecasting Turkish exchange rate with respect to Pound Sterling, GARCH model has minimum values of root mean square error, mean absolute error, mean absolute percentage error and maximum success ratio which show that this model is better than any other models included in this study because this model has minimum error and maximum Success ratio. ANN is better model on the basis of median of absolute deviation which is less than all other models.

Forecasting Turkish currency with respect to Japanese Yen

	Forecasting Measures				
Forecasting Models	Root Mean Square Error	Mean Absolute Error	Mean Absolute Percentage Error	Median of Absolute Deviation	Success Ratio
PPP	0.00	0.00	2.27	0.00	0.43
IRP	0.00	0.00	2.32	0.00	0.50
DB	0.00	0.00	2.22	0.00	0.50
ARIMA	0.00	0.00	2.19	0.00	0.50
GARCH	0.00	0.00	2.19	0.00	0.50
ANN	0.00	0.00	12.55	0.00	0.43
RW	0.00	0.00	2.20	0.00	0.57

Forecasting Turkish exchange rate with respect to Japanese Yen, ARIMA and GARCH models have minimum root mean square error, mean absolute error and mean absolute percentage error and also minimum value of median of absolute deviation, which shows that this model is better than any other models included in this study, because these models have minimum error. RW model is better on the basis of Success ratio having 57% forecasting accuracy. On the basis of analysis it can be concluded that ARIMA and GARCH models are better to forecast Turkey's exchange rate with respect to Japanese yen, but predicting right direction of the exchange rate random walk model is much better than any other model included in this study.

CONCLUSION

Exchange rate prediction is a complicated method and no single method generates perfect results. A number of options have been discussed in this study and conclusion have been drawn which are given hereunder. According to Root Mean Square Error (RMSE), Mean Absolute Error (MAE) and Mean Absolute Percentage Error (MAPE) some models predict better exchange rates with respect to United States dollar. For forecasting exchange rate for Pakistani rupee, Indonesian rupiah and Philippines peso with respect to United States dollar, the IRP model is better. For Chinese currency with respect to US dollar, RW model is better.These findings support the study of Musa(1979), Meese and Rogoff (1983), Wolff (1988) and Rossi (2006). Performance of GARCH model is much betterfor the India's currency and Malaysian currency with respect to United States dollar. The better performance of GARCH model supports the findings of Pacelli (2012). Forecasting exchange rate of Turkish lira with respect to United States dollar Dornbusch Frankel sticky price monetary model has the minimum error hence predicts exchange rate better. DB model is supported in the literature with the study of Hwang (2003).According to Median of Absolute Deviation (MAD) criteria Artificial Neural Network (ANN) has the minimum deviation for the country namely Pakistan, India, Indonesia and Philippine. DB model is better for China and Turkey. For Malaysia PPP model is better. So according to median of absolute deviation, the criteria performance of ANN model is much better, than any other models included in this study.According to Success Ratio (SR), most of the time it is observed that the performance of Random Walk model is better. For China, India, Indonesia and Malaysia, Random walk model has the highest success ratio, which supports the findings of Musa(1979), Meese and Rogoff (1983), Wolff (1988) and Rossi (2006). ANN is better in case of Pakistan, India and Philippines. According to success ratio, IRP is better for the countries like, India, Indonesia and Turkey. Forecasting Indian exchange rate with respect to United States dollar all the models have equal success ratios. So in the case of India, it can be concluded that all the models are equally good with respect to success ratio.

According to Root Mean Square Error (RMSE), Mean Absolute Error (MAE) and Mean Absolute Percentage Error (MAPE), the following models predict better exchange rate with respect to Pound Sterling. ARIMA model performance is much better for Pakistani, Chinese, Indonesian and Philippine currencies against pound Sterling, following the GARCH which is better for China, Malaysia and Turkey. For India IRP has minimum error. So on the bases of mentioned criteria no one model is better for all the countries but comparatively ARIMA model's performance has been found better than other models included in this study.

According to Median of Absolute Deviation (MAD), for most of the countries the interest rate parity theory has minimum deviation, following ANN, which has also less deviation for some countries like India, Malaysia, and Turkey.The findings of the study support the findings of Appiah and Adetunde (2011). PPP theory is only better for Chinese currency against pound sterling. So according to median of absolute deviation criteria it is observed that most of the time IRP is better. According to Success Ratio (SR), ARIMA model performance is better for the countries namely Pakistan Indonesia, Malaysia and Philippines, following the GARCH which is producing better results for the countries like, Pakistan, Malaysia and Turkey. Random walk model is better for Chinese currency and IRP is better for Indian currency. For Pakistani currency against UK pound it is also observed that the models namely, PPP, GARCH, ANN and ARIMA have same success ratio. As contingency theory says that context always matter, therefore no single model is better for all countries, some models are better for some countries and others for the remaining study.

According to Root Mean Square Error (RMSE), Mean Absolute Error (MAE) and Mean Absolute Percentage Error (MAPE), GARCH model is better for China, Malaysia, Philippines and Turkey. ARIMA model is also better for some countries like Indonesia, Philippines and Turkey. Third best model is random walk which is producing better result for two countries namely China and India. DB and PPP models are equally good for Pakistan. Some measures are equally good as ARIMA and GARCH are equally good for Philippines and Turkey.

The most effective models with respect to median of absolute deviation are IRP and ANN. IRP is better for China, Indonesia and Malaysia. ANN model is better for India, Malaysia and Philippine. Other models are also effective for other countries but they produce minimum errors for only one country. So it can be concluded that IRP and ANN are better than other models. According to Success Ratio (SR), ARIMA model is better for countries namely India, Indonesia and Philippines. GARCH and random walk models are also better to some extent but not much effective than ARIMA model. From the analysis it is also observed that economic models are not as good as technical models. In this case it can be concluded that comparatively technical models produced better result.

On the basis of the empirical evidence it can be concluded that all models have importance for forecasting exchange rates. Some are better on the basis of predicting in right direction which is measured by the Success ratio and some are better on the bases of low root mean square error, mean absolute error and mean absolute percentage error and others are better on the basis of Median of absolute deviation. All models when compared on monthly data, it has been found that most of the time ARIMA model predicted betterexchange rate. Second best model which predicted the exchange rate better is random walk model. GARCH model also forecasted exchange rate in right direction. It is therefore deduced that technical models forecasted exchange rate better in right direction. In quarterly data, due to less number of observations, ANN could not be run successfully, and it is observed that most of the time sample economies have no arch effect in their series.So both models e.g. ANN and ARCH could not be performed in quarterly data.Forecasting capacity of exchange rate models though could not be compared in absolute terms but among them the RW and ARIMA were consideredbest models. In daily data again, the forecasting capacity of exchange rate models, could not be compared because fundamental based models could not be run due to non-availability of daily data. However it is found that in daily data ANN model outperformed other models included in this study. ANN has high success ratio and low RMSE and MAPE than other models. On the basis of daily data this study concludes that ANN is much better than any other model. On the basis of low errors on monthly data, it can be concluded that comparatively ARIMA model is better than any other models included in this study. Technical based models are better than fundamental based models. It is also concluded that non-linear model (GARCH) model is better than linear models discussed in this study. Overall ARIMA model has been found much better than any other models included in this study. So evidence comes in the favor of contingency theory that, context always matter, that there is no single model which dominates all other models included in this study in the sample economies.

Practical Implications

The Practical Implications of this study are of immense significance, as this concern, directly or indirectly, the world largest markets. This study can help the countries that are concerned more with balance of payments and can also have direct effect on the firms, operating internationally.

Future Research Direction and Limitations of Study:

Studies can be undertaken to forecast exchange rates with latest Linear and Non-linear models and also to increase the sample economies as well as data. This study is focused only on emerging Asian Economies. Only eight models have been used to forecast the exchange rates.

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