Testing Random Walk Behavior of Real Exchange Rate Using Different Methodologies

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DECLARATION

I Sadia Riaz honestly declare that I myself authorized/write this M.Phil thesis with my hard work and guidance of my supervisor. I have not used any unfair mean or copy pasting in this thesis. All study based on literature and proper citation is mentioned in the reference section.

Sadia Riaz

DEDICATION

This thesis is dedicated to my parents, specially my beloved Husband Mr. Mutee-ul-Rehman and my brother Mr. Muhammad Nadeem Riaz.

Pakistan Institute of Development Economics

CERTIFICATE

This is to certify that this thesis entitled: "Testing Random Walk Behavior of Real Exchange Rate Using Different Methodologies" submitted by Ms. Sadia Riaz is accepted in its present form by the Department of Economics, Pakistan Institute of Development Economics (PIDE), Islamabad as satisfying the requirements for partial fulfillment of the degree of **Master of Philosophy in Economics**.

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Sadia Riaz

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ACRONYMS

ARIMA: Autoregressive Integrated Moving Average

GARCH: Generalized Autoregressive Conditional Hetroskedasticity

ANN: Artificial Neuron Networks

LM: Lagrange Multiplier

LR: Likelihood Ratio

SV: Stochastic Volatility

SSS: Small Shuffle Surrogate

ABSTRACT

The purpose of this study is to examine whether the real exchange rate follow random walk or not. Different literature shows that the behavior of exchange rate is random walk. This is an attempt to check the random walk behavior of exchange rate. Different methodologies are used to examine this behavior of real exchange rate. For this purpose, the sample countries are China, Canada, Japan, United Kingdom, America, Switzerland and Pakistan from the period of 1990 M1 to 2016 M10S. These countries are selected because except Pakistan, the other countries including China, Canada, Japan, United Kingdom, America and Switzerland all are developed countries and a lot of literature has been studied about the movements of exchange rate in these countries and gave mixed results. Some researchers are in the favor of PPP theory, some are in the favor of monetary model for exchange rate determination. Some authors are also in the favor of random walk behavior of real exchange rate, and data is also available for these countries. Non Parametric "The Runs Tests" and "The Sequence Reversal Tests" are used to check the random walk behavior of reach exchange rate. Literature used parametric tests to check the random walk pattern of exchange rate so this study used non parametric testing to identify the random walk pattern of real exchange rate. The study also includes descriptive statistics and results from all non-parametric tests and all graphs and tables shows that the behavior of exchange rate is random walk. So we cannot predict or forecast exchange rate using fundamentals especially in the short run.

CHAPTER I

INTRODUCTION

1.1 Background of the Study

The random walk hypothesis in financial theory states that prices in stock market develop gradually according to random walk pattern and it can't be predicted. The first concept of random walk introduced by the French agent Jules Regnault in his book that was published in 1863. Then later on, in 1900 the French statistician Bachelier was the first who find that in financial market the stock prices follow a random walk. However, this random walk is a signal of irrationality and not a result of the market efficiency. Random walk is a wide concept, almost every filed defined it. Like in probability theory the random walk is defined as it is stochastic process in which the change in random variable is uncorrelated to the past changes. So, the change in random variable can't be predicted. For a random process, there is no pattern to changes in variable, as the presence of any pattern means that the changes can be forecasted.[1]

In financial market the random walk is defined as the previous price changes can't predict the future price changes. However, some other information may affect the future price changes but past prices can't predict future prices, if the market is not efficient even though the stock price follow random walk.[2]

In term of exchange rate, the random walk pattern is defined as when the fluctuation and changes in exchange rate can't be predicted. According to this theory considering the real exchange rate random walk model are defined as "the exchange rate

[1] Bachelier, L. (2011). Louis Bachelier's theory of speculation: the origins of modern finance. Princeton University Press.
[2] Cootner, P. H. (1964). The random character of stock market prices.

fluctuation does not follow any pattern and the exchange rate is unpredictable". The random walk model based on efficient market hypothesis. There are two types of random walk models in financial theory, the random walk models with drift and the random walk models without drift. Exchange rate is an important tool to achieve sustainable economic growth [Isard & Synansky (1999)] Exchange rate has direct effect on the globalization and production structure of an economy [Mauro & Roffer (2008)]. Moreover, stability in exchange rate also create a good environment for investment and trade and results in the improvement of balance of payments [Nawaz et al (2014)].

Predictability along with stability of exchange rate is very necessary for the investors whether they are investing in financial market or trading in exports and imports market. So, it is important to know about the exchange rate fluctuations. Several authors have presented various models which enlighten the movements of exchange rate in the period of long run also in short run.

The very first theory for exchange rate determination was Purchasing Power Parity (PPP) theory which was presented by Cassel (1918) states that follow the assumption of free trade the absolute purchasing power theory is expressed as it is the equilibrium exchange rate among two currencies is equivalent to the ratio of prices in both countries. The results show that the PPP theory describe the long run equilibrium in exchange rate but it fails to describe short run disparity/ fluctuation in exchange rate due to various reasons discussed in Taylor and Taylor (2004).

Besides PPP, uncovered interest parity (UIP) also fails to establish significant short run movements in real exchange rate. Similar to PPP and UIP monetary model for the determination of exchange rate is valid only in long run but in short run these models

support the random behavior in the real exchange rate. Thus it is now unanimously decided that economic theory is yet not provide the exact forecasting model for exchange rate fluctuations despite numerous studies tried to work on this [Vincenzo (2012).

Most of the studies given in Section II concludes that for forecasting of exchange rate, the random walk models gave better results compared to all other economic models such as Messe and Rogoff (1985). However, Stock and Watson (2004) suggest that parametric instability considered as extensive phenomenon for practical investigation in time series date. The study demonstrate that for certain countries the exchange rate did not show random walk behavior.so the literature gives mixed results regarding movements in exchange rate. Moreover the study of Watson (2004) shows that the current macroeconomics model was unable to calculate exchange rate fluctuations.

Random walk model is one of simplest and most important models in time series forecasting. In this model suppose tha*t* "in each period the variable takes a random step away from its past value and these steps are independent and identically distributed in its size*".* Same as the first difference of the variable is a series to which the mean model should be applied. So, when begin with a time series that walks all over the map, but find that its first difference looks like it is an i.i.d. sequence, then a random walk model proves a potentially good model. [3]

Random walk models have many benefits for its usage. These model uses in different areas. Finance is one of the important application area for these tests, the reason is that in finance there is a very good theoretical reason for believing that prices of assets for which speculative markets exist ought to perform like random walks.

[3] 2014 by Robert Nau, all rights reserved. Last updated on 11/4/2014.
Main web site: people.duke.edu/~rnau/forecasting.htm

Because, if it is easy to predict whether the market would go up or down tomorrow, it should have already gone that way today. However, the random walk model also have many non-financial applications.

Another very important use of random walk models is as a benchmark against which to compare more complicated time series models, particularly regression models. There is a tendency in regression analysis to think of R-squared as a measure of the predictive power of the independent variables in the model. This may not always be the case! R-squared measures the amount by which the error variance of the regression model is lower than that of the mean model for purposes of predicting the dependent variable. But if the mean model is not an appropriate reference point, this is a meaningless statistic. If the time series is nonstationary, a random walk model will often have a much lower error variance than the mean model, and a better question would then be: how much lower is the error variance of the regression model than the error variance of the random walk model? A poorly chosen regression model may actually do worse than a random walk model for predicting a time series, even if it has a big R-squared.

So, the random walk model is an important tool in your toolkit regardless of whether it is the model you end up using for your forecasts at the end of the day.

Random walk of exchange rate is defined as when fluctuations in exchange rate are unpredictable or forecastable. Many economists are in the favor of random walk behavior of real exchange rate. Meese & Rogoff and West & Engel talk a lot about random walk. Meese & Rogoff concluded that the random walk model are superior to other macroeconomic models. Similarly, the West & Engel states that the exchange rate approximately follow random walk. the evidence of random walk does not mean

that it is against the other model but it suggests that the random walk models are better than other models.[4]

Literature involves different types of parametric and semi parametric techniques to examine the random walk behavior of exchange rate. Here in this study used non parametric techniques to check the random walk behavior of real exchange rate.

1.2 Objective of the Study

The aforementioned literature shows different models for the behavior of exchange rate. These models include PPP theory, interest differential models, monetary models etc. explain the fluctuations in exchange rate but none of all these exactly explains the movements of exchange rate specially in short run. Some studies in literature shows that behavior of exchange rate is a random walk and can't be explained by economic fundamentals, So, the literature provide mixed results about the behavior of exchange rate.

In this study, main purpose is to examine whether the real exchange rate is behaving like a random walk model or not. We used the real exchange rate data of different OECD countries including, Canada, UK, USA, France, China, Japan and Pakistan. The reason of selecting these countries is that except Pakistan the all other countries are developed and the data of exchange rate is easily available. Moreover, previous literature has studied extensively other macroeconomic fundamental theories like PPP, Interest rate parity theory on these countries. For random walk pattern, the literature also considered these countries and results provide mixed results. So, this study selects these countries to check that using non-parametric technique whether the

[4] C. Engel and K. D. West, "Exchange Rates and Fundamentals," NBER Working Paper No. 10723, September 2004, published in Journal of Political Economy 113 **(**June 2005): pp. 485-517.

real exchange rate follow random walk or not. As for as Pakistan in concerned, my contribution is to check and compare that whether other developed countries, Pakistan which is developing country follow random walk or not. So, its type of comparison between other developed countries and developing country. Moreover the previous literature mostly used parametric economic techniques to examine the behavior and fluctuation in exchange rate. In this study I used non-parametric techniques to examine the fluctuation in exchange rate.

1.3 Significance of Study

The study is significant contribution in the literature of exchange rate forecasting which revolves around random walk models. This study contributes another empirical results of real exchange rate behavior using non parametric testing.

1.4 Plan of Study

The study consists of five chapters, the first chapter gives the introduction, it briefly describe the background of study, Some literature evidence and importance of study. The second chapter involves the literature review of the study, it briefly describe the over view of all theories of exchange rate, the different exchange rate systems and then the literature review of all theories. Chapter 3 contains the methodologies researchers used to estimate random walk behavior of real exchange rate. The chapter four is about data & methodology, it includes different tests to examine that whether behavior of exchange rate is follow random walk or not. Chapter 5 explains the analytical framework we used in the thesis and results of the estimations and Chapter 6 draws conclusions of the study.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

In this chapter there is a brief literature about the exchange rate behavior. Specially about random walk models of exchange rate. Before 1973 there exist fixed exchange rate system in the entire world and there was no need for the theories for exchange rate determination. Before the World War 1 there exist the gold standard period and every country determine the worth of its currency on the basic of gold. After the World War 1 the countries again want to maintain the gold standard but failed to do so. So there was a need to adjust exchange rate because exchange rate and monetary policy are the important factor for any economy or government to achieve their financial goals/targets. So, when exchange rate become flexible than there is a need to know about the pattern and behavior of exchange rate. Moreover, the factors that affect the future exchange rate and are important for the prediction of exchange rate. For the determination of exchange rate and for there future forecasting literature involves different model of exchange rate. The first model of exchange rate is purchasing power parity model than other models are also made for the understanding of the exchange rate pattern the models are, purchasing power parity model, interests rate differentials models, portfolio balanced models, monetary models and last one is random walk models which is studied here.

This study considers the random walk model for exchange rate.

2.2 Random Walk Model

The random walk model is basically a financial theory that states that prices can't be predict and fluctuation are random, didn't follow any pattern. According to this theory

considering the real exchange rate random walk model are defined as “the exchange rate fluctuation does not follow any pattern and the exchange rate is unpredictable”. The random walk model based on efficient market hypothesis. This concept was firstly introduced by Jules Regnault. This concept was popularized in Burton’s book published in 1973 “ A Random Walk Down Wall Street. While considering random walk pattern of exchange rate, there are two types of random walk models

- Random walk model with drift
- Random walk model without drift

if the first difference of time series data is random from one observation to 2nd observation then the data follow random walk. the data itself is not random but its first difference become random.

The daily exchange rate sometimes have long swing or fluctuations that can’t be justified on the basis of macroeconomics fundamentals, also these fluctuation does’t explain by the previous movement of exchange rate. A lot of literature examine the random walk pattern of exchange rate. The major contributions about the random walk pattern of exchange rate are given by the Messe & Rogoff who gave very convincing statement about the random walk theory of exchange rate determination by saying that the random walk models of exchange rate better predict and explain the movements in exchange rate rather than any other macroeconomic model. Both researcher worked from 1983 to 1988 on the random walk model of exchange rate. They used simple random walk model without drift for their analysis.

Meese & Rogoff write random walk model as in the form of random walk model without drift.

Most of the literature shows that the economic model are useless to explain the fluctuation in exchange rate. Here another problem is parametric instability because stability in parameter are better for forecasting. Stock and Watson (1996-2003) suggest that parametric instability considered as extensive phenomenon for practical investigation in time series date. The study demonstrate that for certain countries the exchange rate did not show random walk behavior. This is shown that the current macroeconomics model be unsuccessful to calculate exchange rate fluctuation.

The author believed that the random walk models are better as compare to other macroeconomic model for the prediction of exchange rate fluctuation. It is shown in literature that the macro models completely fail to describe the fluctuation in exchange rate and its one reason is parametric instability. If the parameters are stable than it is helpful in the forecast about exchange rate behavior. The current study also resolve the difficulty about model selection in macroeconomic model and random walk models for the determining the equilibrium exchange rate in the existence of instability among parameters.

Meese and Rogoff (1998) supposed the interest rate equality situation which elaborates that real exchange rate between two different countries is described by using lagged values of the real exchange rate differentials. The study shows that random walk models prove superior as compare to macro models and the study use different tests e.g. likelihood ratio test for random walkness, tests depend upon time varying parameter, optimal tests for the purpose of specification and time etc.

Muck (2012) also studied random walk pattern of exchange rate using CEE countries and conclude that random walk models provide more sophisticated results for CEE countries.

Backus (1984) studied the different empirical models of exchange rate. The study provides strong evidence in the favor of random walk behavior of real exchange rate.

West & Engel (2017) also in the favor of random walk models. And suggest that supporting the random walk models does not mean that the rejection of other model. This simply mean that the random walk models are best as compare to other models. [5]

Here is some literature evidence in the support of random walk models.

2.3 Empirical Evidence

Very first theory for exchange rate was purchasing power parity theory, the main idea of purchasing power theory was introduced in 16th century by the school of Salamanca and further developed in 1918 by Gustav Cassel. Under the assumption of free trade. The absolute theory of purchasing power parity states that the equilibrium exchange rate among two different currencies is equivalent to their price ratio in both nations. So it's the prices ratio between two nations. Further the theory explains the law of one price. In some cases the law of one price does not hold like today the purchasing power of one rupee is totally different to the purchasing power of one dollar. Due to which the arbitrage exist.

The absolute PPP theory has some drawbacks then the relative purchasing power theory came into existence. The relative purchasing power theory states that change in exchange rate in a particular period of time should be proportional to the relative changes in the prices of both nations at the same time period. There are various studies that use PPP theory for the determination of exchange rate . In the present age of globalization the exchange rate play vital role in trade among nations because fluctuation in exchange rate may affect the profits of multinational companies and

[5] Engel (2017) "exchange rate models" the national bureau of economic research.

financial institutions. Nieh and Wang (2005) , Rehman and Hossain (2003) both studies are in the favor that stable exchange rate helps financial sector to evaluate the performance of financing, hedging, investment and reduce the risk in financial markets. Changing in exchange rate directly affect the different macroeconomic variables e.g. interest rate in economy , prices level, wages of factor of production, unemployment rate and level of output. Which leads to macroeconomic disequilibrium and result of it the exchange rate devaluate to correct the external imbalance. The PPP theory explain equilibrium of exchange rate in the period of long run. it provide basic structure for the exchange rate theories.

In policy making it provides the theoretical baseline for the purpose of stabilization and structural adjustments in the policies supported by IMF and World bank. It also provide the judgment that whether the overvalued and undervalued to its equilibrium long run path. It assume that the real exchange rate maintain a constant level over time and variation in nominal exchange rate have a tendency to equalizer the effect of relative prices fluctuations. Hassan (1993) ,Bhatti (1996) ,Tang and Butiong (1994), Ahmed and Khan (2002)), Liew et al (2004), all their studies found strong evidence in the support of PPP but on the other hand some studies involves Chishti and Hasan (1993) found the results which was not in the support of PPP theory. The PPP theory is originally based on British economist David Ricard's views (1821) in the age of 19^{th} century. The core concept of PPP based upon the arbitrage which internationally equalized the prices between two nations. So the basic point in this PPP theory was law of one price. Which told that when there is no competitive market and no transportation costs, quotas, tariffs, and other trade barriers the purchasing power of both currencies are same in both nations. But in real world the law of one price did

not hold because there is always exists the transportation costs also trade barriers. There are certain studies that use PPP theory for exchange rate determination.

A study by Khan and Qayyum (2007) examine the determination of exchange rate in Pakistan and provide its evidence on the basis of purchasing power parity theory. The basic objective of here is to provide the empirical proof on the existence of purchasing power parity theory in case of Pakistani rupees and US dollar. It means that PPP hold in Pakistan or not. The data used here are consist of quarterly data from the period of 1982 Q2 to 2005 Q 4. Entire data are obtained from international financial statistics (IFS). The econometric technique used here is Johansen and Johansen and Juselius multivariate co-integration approach and other was bound co-integration approach. Before the application of co-integration test unit root of all variables and result of ADF find that at log level the exchange rate is non- stationary and at log first difference it become stationary. The result shows that on the basis of priori variables coefficient restrictions the purchasing power parity theory did not hold in the short term. For seasonality, seasonal dummy also used in the test but results remains the same. To check the co- integration between the exchange rate and level of relative prices, Juselius multivariate co-integration test used.

Here also used Two lags for VAR test, the first one was likelihood ratio test for the adjustment of degree of freedom and also for Akaike information condition. The VAR model comprises of one restricted intercept that have no trend in it, then includes three unrestricted seasonal dummies and lastly one intervention dummy which cause shift in exchange rate arrangements from the state of manage float to the state of flexible free. The results shows that the coefficients are significant but law of one price does not hold due to certain reasons, barriers on trade, different consumption pattern of countries, PPP theory only true hold in Pakistan in long run. The results

shows strong favor in the weighted price index based PPP the reason of it may be that economically development of Pakistan strongly depend upon the developed countries, the government giving trade and exchange rate liberalization policies, because these policies help the LOP to work more effectively which is in the favor of this theory. Moreover in short term there was also exist the deviation from the theory of PPP but in case of long run this deviation did not exist.

Another study by Yong and Ling (2000) studied the PPP and monetary models of exchange rate, in Singapore. The core idea of study was to decide the exchange rate among the Singapore and US by considering the PPP and monetary models. PPP theory explain the monetary case here nation's prices level is linked with nominal exchange rate. On the other side the monetary models advocate the movement occur in exchange rate in relation to money supply considering the assumption that all the non-money assert are perfect substitutes. The monetary models approach of exchange rate determination has lot of literature in the history. And till 1978 the empirical support for the existences of monetary model for exchange rate determination. So this study mainly focus on the PPP and monetary model's validity in period of long run considering the case of Singapore. In 1965 the Singapore adopt the fixed exchange rate and pegged its domestic currency with the pound sterling. In November 1967 the British devalued its currency and due to which the Singapore pegged its currency with US dollar in 1973 the US also devalue domestic currency and at that particular period the exchange rate was also fixed at that time in order to avoid the country the threat of imported inflationary pressure then authorities float the Singapore dollar in (1973). This type of float in managed dirty float.

In 1978 the exchange rate was fully flexible and determined only by market forces. Here two models are used to enlighten the exchange rate determination, first is PPP theory. The basic idea behind the PPP is arbitrage. The price arbitrage equalized the prices among two monetary centers. The literature gives mixed results of PPP theory. Wallace (1989) examined PPP theory for different economies including, Israel, Brazil , Argentina, Chile in the period of 1970's and 1980's and found that results are in the favor of PPP. Although the Bahmani-Okolee shows the results that PPP only hold four countries out of twenty five developing countries. In short run the validity of PPP has no strong prove but all literature are in the favor of validity of PPP in long run. Here co-integration econometrics technique was used to examine the validity of PPP.

Moreover considering the monetary models for exchange rate determination, that were mainly based upon the condition of perfect capital mobility. Also bonds are used as perfect substitutes. In this study used two types of monetary models the one is monetary model with flexible prices and other were real interest differential model. here an important thing was that the log for demand of money was reflected to depend upon the log of both real income and prices . other type of monetary model is developed by Frankel (1979) that were the real interest differential (monetary models), express the short run interest rate in order to capture liquidity effects. Empirical results are supported the both models. In 1978 the Hodrick and Bilson also support the FLPM model. Yao 1989 studied both flexible prices and sticky prices models for Singapore taking data from 1977 Q2 to 1987 Q2. They found that the coefficient are wrong signed and also statistically significant. Some recent studies have try to apply the co-integration technique for the estimation of monetary models.

In this study the data is taken from international financial statistics and its quarterly data from the year of 1978 Q1 to 1993 Q4. Exchange rate is average of market exchange rates. The CPI for both Singapore and US used here. The result shows that the monetary models does not show the fluctuation in Singapore exchange rate from the period of 1978 1993. The study shows that the monetary models for exchange rate determination was valid only in case of long run but in short run is shows dynamics.

Another study of Vincenzo (2012) involves the study of forecasting exchange rate; a comparative investigation. Objective of the study was to draw a comparison between the ability of different econometric techniques for the prediction of or forecasting of daily exchange rates between euro and US dollar by using following techniques like artificial natural network, ARCH, GARCH, and check which one is more reliable for forecasting process. Today in international financial market facing a lot of risks so it's necessary for banks to implement a proper system for estimating the market risks. So for estimated the risks in exchange rate it's important that the bank uses the forecasting models about exchange rate. The literature review of this study shows that the economic theory is yet not provide the exact forecasting model for exchange rate fluctuations but from 20's to current period a lot of studies tried to work on this.

Many economists like Cassel (1923), Samulson (1964), Frackle (1985), Mundell (1968), Rogoff (1999) and Taylor (2009) etc find that economic theory is not established another better models rather than the random walk models, which can forecast the exchange rate in period of 12 months. Other authors like Hsieh (1989), Brooks (1997), Tenti (1996), Gobbi (1999) etc. studied the forecasting of exchange rate dynamics using non-linear models, like artificial neutral models, expert systems, genetic algorithms which shows conflicting results. The methodology of study involves two types of models here. In first type it involves structural prediction

models or linear models like ARCH, GARCH and state space. And in second type it involves black box or non-linear models like artificial neutral networks, genetic algorithms and fuzzy models. The result shows that the ARCH and GARCH models provide results better than that of ANN for prediction in exchange rate fluctuations.

Another study by Kemal et al use monetary model to explain the exchange rate fluctuations. The study involves the different factors of exchange rate that effect the fluctuations in exchange rate in Bangladesh. firstly the paper explain the brief history of its currency Taka after that it also enlighten the period of both flexible and managed floating exchange rate systems that exist in Bangladesh. Here monthly data from the period of 1984 to the period of 2012 taken to examined the behavior of exchange rate also clarify its link with other variables. The data is taken from IFS. The variables were stock of money in economy, foreign exchange reserves of the country, total debt on Bangladesh's economy and also dummy of political instability. The econometric technique is autoregressive distributive approach to co-integration for long run relationship. For short run examination error correction mechanism technique adopted here.

The core hypothesis were as follows, firstly, the exchange rate positively related with rise in relative money supply, relative domestic country debt to foreign country debt has positive relation with exchange rate, the exchange rate negatively related with the relative rise in the balance of foreign reserves in the economy and the effect of the political instability on exchange rate. The result shows that all the variables are shown non stationary and become stationary at the 1^{st} difference. For long run relationship used conditional F test. The exchange rate coefficient proves that significant at 1^{st} lag and insignificant at 2^{nd} lag, the coefficient used for relative money supply give positive result and prove significant at 1^{st} lag also the coefficient

of relative foreign reserves proves negative and significant with nominal exchange rate. Coefficient for the relative debt and political instability are also positive and prove significant. The conclusion is that the stock of money in economy and debt of that economy both were positively and significantly had an effect on the exchange rate moreover political instability in economy and foreign exchange reserves of that economy both had negative affect on exchange rate of that economy.

Many literature involves PPP, monetary, interest rate parity etc. theories for forecasting exchange rate but at the end it is verified that exchange rate follows the random walk behavior. Many studies in the favor that exchange rate follow random walk pattern. A study by Rossi (2005) who studied about the random walk pattern of exchange rate. The literature review involves the Meese and Rogoff (1983-1988) who conclude that random walk model for anticipating exchange rate movements provide better results as compared to other economic models. Most of the literature shows that the economic model are useless to explain the fluctuation in exchange rate. Here another problem is parametric instability because stability in parameter are better for forecasting. Stock and Watson (1996-2003) suggest that parametric instability considered as extensive phenomenon for practical investigation in time series date. The study demonstrate that for certain countries the exchange rate did not show random walk behavior. This is shown that the current macroeconomics model be unsuccessful to calculate exchange rate fluctuation.

The author believed that the random walk models are better as compare to other macroeconomic model for the prediction of exchange rate fluctuation. It is shown in literature that the macro models completely fail to describe the fluctuation in exchange rate and its one reason is parametric instability. If the parameters are stable than it is helpful in the forecast about exchange rate behavior. The current study also

resolve the difficulty about model selection in macroeconomic model and random walk models for the determining the equilibrium exchange rate in the existence of instability among parameters. This study also provide the result of parameter instability of the nominal exchange rate determination models. For this reason the author use time varying parameter models for exchange rate those provide some better results.

The out of sample prediction ability of Granger test is much difficult as compare to in sample prediction because out of sample prediction depends upon the timing of structural breaks. Here in this paper the author use in sample predictions. Meese and Rogoff (1998) supposed the interest rate equality situation which elaborates that real exchange rate between two different countries is described by using lagged values of the real exchange rate differentials. The study shows that random walk models prove superior as compare to macro models and the study use different tests e.g. likelihood ratio test for random walkness, tests depend upon time varying parameter , optimal tests for the purpose of specification and time etc.

The out of sample tests have two steps in first step all the parameters of the models estimated at fraction of the selected sample then estimates used to estimate the value of dependent variable. Monthly data taken from DataStream, 1973 march to 1998 December. The model is monetary model. It considers two countries and the check the nominal exchange rate fluctuation in both nations different on the basis of their real production, nominal supply of money of the economy and nominal short term rate of interest. For stationary used rate of growth of all these variables. The result shows that there was no steady relation among the exchange rate and its fundamentals.

Another study by Ternollet al (2014) who studied the speculator's situations and their prediction about exchange rate. The literature review of this study involves that the same testing model Engle and Hamilton used to examine long fluctuation shown in exchange rate amongst the period of mid (1970) to end of (1980). Evans and Lyons (2002) estimate in short horizons the group of interbank foreign exchange market dealers can forecast exchange rate. Engel , Mark and West (2007) studied can fundamental base models beat random walk or not. Speculator's positions have useful information for the forecasting of exchange rate. This information is given by autoregressive switching models of speculator's situations in the obligation of traders report.

For the investigate of the difference between the point forecast and random walk forecast using Die-bold Mariano West test and the Clark-West test. Also use weighted directional test to check null hypothesis, which was expressed as the weighted directional prediction incapable to expand the driftless model. Binomial directional test also used in this study. The study involves the construction of 1 to 12 months horizons. In this study the Markov switching model is used for speculator's positions rather than the exchange rate. The study also involves three regimes like downtrend, uptrend and random walk. Here the currency used is Euro instead of US dollar and also five other currencies are used here. The re estimation contains switching model which was given by Marcov and rolling technique used, In which every week include the new one observation and exclude previous one in the sample.

For each currency here select a rolling window that generates highest success ratio of average forecast through the main five predicting horizons e.g. 1 to 12 months. The null hypothesis is that the weighted directional forecast or predictions were not competent to expand the driftless random walk models. Results show that the

directional forecast shows 58 % success ratio. It is also proven that the two types of forecasting is statistically significant at 0.1 level for 5 out of 6 most traded currency pairs. The exchange rate have a trend to fluctuate up and down and it follow the long fluctuates.

Muck (2012) also studied about the random walk pattern of exchange rate. The literature involve the study of Cuaresma and Hlouskova (2005), both observed a large range of the various time series models for central and eastern European CEE and conclude that these models shows a trend to perform random walk only at that horizons which were not fewer than that of 6 months. Another study by Ardic, Ergin and Senol (2008) found that as compare to time series models and structural models, random walk model provide more sophisticated results for six CEE countries. Koloch (2010) also tried to forecast exchange rate by using nonlinear models, and shows that exchange rate is un beaten by various advanced uni-variate time series model due to predictive ability of random walk.

The study used the weekly and period ended data of nominal exchange rate, against euro from the year (2000) to (2012). Euro is used here for analysis because this is most important currency for analysis. The econometrics techniques used here are the random walk, fractional random walk, VAR and VAR for the analysis of forecasting exchange rate. The main aim here to check that forecasting from these models are more accurate than random walk models. For this use two methods; the one is mean forecast error and other was root mean squared forecast error. For statistical significance test the null hypothesis about forecast unbiasedness and the null about equal forecast correctness. In order to clarify the problem of heteroscedasticity and autocorrelation, the HAC covariance matrix technique applied here. The results shows

that the random walk models are difficult to forecast exchange rate instead of other models.

Backus (1984) studied the different empirical models of exchange rate including PPP, portfolio model and monetary model using Canadian and U.S data of 1970's. The study provides strong evidence in the approval of random walk models but on the basis of certain assumptions e.g. interest rate parity and rational expectations but some variables like money supply and income also have some important role. The exchange rate equation was estimated here using different models like Dornbusch and Frackle model, Driskills's shock /flow models etc. the data used here was Canadian and U.S flexible exchange rate from the period of 1970, it was quarterly based data.

The basic idea behind the study was to observed the three equation includes relative PPP, the equation for uncovered interest rate parity, the last one is random walk equation. The results show that exchange rate was almost (closure to) random walk. The result obtained from monetary model in the presence of interest arte parity and rational expectation is in the favor of random walk because both money supply and income are very mush close to random walk. But the results from small Durban Watson suggest that a lot of disparity in exchange rate was clarified so it against the random walk. On the other hand the sticky price monetary model fail to provide any evidence of exchange rate overshooting behavior due to any monetary shocks. But at the last the results are in the favor of random walk predictions like Meese & Rogoff studies.

Giddy and Dufey (1975) studied the expectation correctness for random walk models and other models for flexible exchange rate. Forecasting exchange rate is a favorite debate for the speculators and researchers. There were alot of range of methods for

forecasting exchange rate. Prediction or forecasting always required an economic model. The study describe different model for the settlements of exchange rate and observed which one better forecast or predict the exchange rate fluctuations.

The estimation technique here was ARIMA and exponential smoothing models. The data was consist of primary data base of daily exchange rate for the three countries from the period of 1970. The study tests five hypothesis, random walk hypothesis, forward rate hypothesis, box Jenkins analysis, then interest rate hypothesis and at last the exponential smoothing. The results shows that there was contradiction with previous researchers who find that there exist systematic dependencies in flexible exchange rate system. The results also shows that the prediction accuracy based on random walk hypothesis was superior to any other forecasting hypothesis.

Ahking and Miller (1987) considered about different models of exchange rate. The study use stochastic process for generating exogenous variables. Current theories about exchange rate focus on asset approach. Like in monetary models the determination of exchange rate is at that point where overall stock of national and foreign money were gladly held by the economic agents. Similarly anticipations about the upcoming exchange rate also play significant role in determination of current exchange rate. The data used here was monthly data from the period of 1974 M4 to 1984 M6 of France, Germany, Canada, Italy, Switzerland, United Kingdom, United States and Japan. The U.S used here the domestic country.

The estimation technique was ARIMA, Box-Jenkins, the Ljung Box and Box & Pierce. Zeller and Palm methodology used here. The results were in the approval of random walk pattern of exchange rate. The results are closely related to Meese &

Rogoff who find that no other economic model is better forecast exchange rate then the random walk models.

Joseph and Whitt (1992) examined the behavior of real exchange rate in long run period. here a new test used to study whether the exchange rate follow random walk or not. Richard Roll (1979) give the financial based theory for the movements in exchange rate which shows that exchange rate must follow random walk. The random walk theory suggest that there is no long term equilibrium of exchange rate. Many authors e.g. Roll (1979), Adler (1983), Hakkio (1986) all didn't reject the null hypothesis about random walk. Estimation technique used here was Sim's test . As Sim (1988) said that Augmented Dickey Fuller technique did not correctly test the unit root. So he introduced new test.

Here U.S used as base country, monthly data for five countries of U.K, Germany, France, Switzerland and Japan used from the period of 1973 June to 1989 December. This study did not provide strong evidence on random walk model.

Similarly another study of Chilibaet al (2013) who studied whether exchange rate followed random walk. The literature shows that Gradojavic and Andjelic (2010) verify the validity of idea of random walk in euro-Serbian dinar market of exchange rate. They proved this idea by means of Lo and Mackinlay's VAR tests, wright's non-parametric rank and signs tests. Vats and Karemera (2011) studied the random walk hypothesis by applying VR tests to prove evidence on random walk hypothesis for different currencies of eight nations. Chen (2009) investigate the random walk assumption for ten different Pacific Basin overseas exchange markets and his study was not provide evidence in the favor of the random walk model by estimating through variance ratio test of Lo and Mackinlay. Lima and Tabak (2007) investigate

the different types of variance ratio assessments for the developing markets of exchange rate that have accepted managed floating exchange rate on basis of daily and weekly. The results are in the support of random walk in above both cases.

The study use the daily nominal exchange rate from august 1, 2003 to December 31, 2012. The data source is the bank of Zambia, economics department. This time period chosen here, because at that particular time period the bank of Zambia presented the interbank established framework of Zambia .The trading of foreign exchange done by using auction system. The variance ratio methodology used here also applied the augmented dickey fuller test for testing of unit root and other test was Ljunk box Q-statistic for testation of autocorrelation. Estimated results were not support the random walk model and offer a solid support for the destruction of weak system market efficiency assumption. Both Lo- Mackinlay and Wright's provide solid support contrary to the random walk hypothesis.

A study by Indian author Patra (2012) who studied about whether the exchange rate among Indian rupee- US dollar follow a random walk. Moreover, to investigate that the Indian external exchange market is either efficient or not. Literature review involves the study of Bechelier (1990) who shows that among the two different time period, price changes is independent with zero mean and variance is calculated as proportional to the interval among two time period. Mathew and Richardson and Tom Smith (1991) find that movements in stock market prices presence of overlapping observation and it reject random walk by using Wald test. Madhusoodan (1998) studied that the variance ratio test results for Indian stock market indicated rejection of random walk hypothesis in India. He proved this by considering the stock market both at individual level and aggregate level in the presence of both homoscedasticity and heteroscedasticity. Choi (1999) studied that random walk is present in US real

exchange verses different major currencies. And one can be proven it easily by taking longer period data.

In this study daily bilateral data of exchange rate used and is taken from January 1, 2003 to December 31, 2010 from central reserve board. The test of exchange rate categorized for random walk comprises three different types of approaches. Firstly for investigation of serial correlation the autocorrelation coefficient at different lags used and for this test for both unit root and variance ratio used here. Most literature shows that to check p-value bootstrap variance ratio test used. And Wald test used to enlighten the long term arrangements in exchange rate. The result indicated that due to the existence of forward premium from (2003-2004) in external exchange market of India arrived in a new stage. The box pierce test of autocorrelation Philips Peron tests suggests against the presence random walk but on the other side, two remaining tests e.g. augmented dickey fuller and KPSS provide confirmations for existence of random walk in series. The results obtained from variance ratio and others tests moreover contrary to the existence of random walk in that age. It is concluded that market is not efficient.

Then, Engel et al (2007) also examined about different models of exchange rate. The key objective of study was to observe either different models of exchange rate foresee the movements in exchange rate. Although numerous researcher found that usual models of exchange rate that were established on different macroeconomic variables as prices, interest rate and output etc., unsuccessful to describe empirically movements in exchange rate. So it is concluded that these kinds of models have low power of forecasting. The literature review of the study involves west (2005) state that assuming certain assumption the many models gives the results that exchange rate

follow nearly random walk. Mark and Groen (2001, 2005) used panel error correction models in their study to forecast exchange rate in long term horizons.

This paper involves different section to study different models of exchange rate, 1st section, describe the performance of nominal and real exchange rate by sample fit models, also include the endogeneity of monetary policy here the present value model and random walk models are used also used Taylor rule models. In 2nd section observe the capability of exchange rate to unite the news about coming future that help a researcher to forecast macroeconomic fundamentals. In 3rd section examining the recent literature that explain the response of exchange rate related to announcements of new macroeconomic news. In 4th section using survey data to estimate the models that drawn the expectations of fundamentals. Here long run expectations also used . the survey data from April (1997) to October (2006) are used for different countries as Germany, US, France, Japan, Canada, UK, Italy, Norway, Netherland, Sweden, Spain and Switzerland .

In last section the conclusion is given. The results show that for the success and un success of standard models based on their ability to predict future better than the random walk models. The results also decided that the monetary models can explain and forecast the fluctuation in exchange rate. With panel type testing techniques the results shows that these models forecast superior as compared to random walk models. And using these models the mean squared prediction error is also low. The main result of this paper is gives preference to monetary models. The main reason of this is the nominal arrangements in exchange rate based upon the monetary phenomenon. That's why it is important to check on what basic the monetary policy made because future expectations of monetary conditions perform a key character in the determination of existing exchange rate. Author also said that this paper does not

in the favor of macroeconomic models for exchange rate but many studies explain exchange rate movements using microstructural models.

Rossi **(**2013) also studied about the debate of exchange rate, the key objective of paper is to enlighten the question that does any method predict or forecast exchange rate and what are those variables that predict exchange rate. The past studies pointed out a puzzle that the changes in exchange rate is actually tough to foresee by describe on the basis of macro models, although random walk model would forecast future exchange rate superior as compared to other models. But this study gives critical review on that studies. The previous studies of Engel , Mark and West (2007) investigate the variation of exchange rate by means of particular models, nations and methodologies but this paper explain broader methodologies and more recent data. Another study by Shand (2011) studied exchange rate forecasting keeping in view financial investor's ideas but this study consider forecasting of exchange rate using macro models. Rogoff's (1996) studies based on theory of purchasing power parity which suggests that variations present in exchange rate based on fluctuations of different countries and their relatives prices.

This study also explain that the previous studies use reduced form model for empirical analysis because most work in this field is done by reduced form modeling. But this paper explain different theoretical models for exchange rate determinations. The study also involve the monthly and quarterly data. The exchange rate changes depend upon choice of predictors, model specification and linear is better, data transformations, empirical results changes on benchmark models. The different methods for the prediction of exchange rate comprises method of interest rate differentials, method of price and inflation differentials, method of money and output differentials, productivity differentials, portfolio balance, Taylor rule fundamentals, external

imbalance measures, commodity price and other predictors. the models considered here for the prediction of exchange rate involves single equation linear models, single equation CEM models, non-linear models, time varying parameter models, multivariate models and panel models.

The data of exchange rate is taken from different countries Australia, Belgium, France, Italy, Denmark, Canada, Finland, Greece, Japan, Germany, etc. and using monthly and quarterly data from IMF. The results shows the five finding, firstly the Taylor rule methods are more suitable for forecasting than other traditional models, secondly in model specification the linear models can explain it easily. The forecasting ability of the monetary models proved weak in ling horizons when estimating it by co-integration method. The choice of benchmark matters a lot e.g random walk behavior excluding drift was hard benchmark to exhausted. So it depend upon the forecast horizons, choice of estimation methods etc. Taylor rule is more appropriate in short term horizons and other monetary models in long horizons for different countries.

West and Engel (2005) studied the "exchange rate and fundamentals". They shows that assuming rational expectations and using existing value models, an assert price provide indication near to the random walk when the basics are one and the discount future basics are nearly close to one. This is very useful to solve the problem that the fundamentals variables like supply of money in the economy, output level of economy and rate of interest are considered fewer valuable to forecast the fluctuation in floating exchange rate. The past theories show that all the above described variables are very much useful to determine the exchange rate. But the problem exist when these variables can't predict the upcoming future exchange rate. First time this result is given by Meese and Rogoff (1983) both initiate that these typical models like

mean square deviation among real and expected exchange rate improved when a person forecast the exchange rate remains unchanged compared to the case when one person predict exchange rate through models. But Pascual (2002) said the opposite thing and said that it may be possible that one model forecast one exchange rate and not do it for other exchange rates. In this study the author use assert price models that states that exchange rate is anticipated existing discount value of witnessed fundamentals and unseen shocks.

When apply this model the results shows that among different countries interest rate disparities can expect exchange rate and it does not behave like random walk. It is also discover that the exchange rate indicate/follow random walk in that case when the discount component is proximate to one. This study involves different exchange rate models like money income models and Taylor rule models. The data is taken from IFS and its quarterly basis of US exchange rate and six other countries like Canada, Germany, France, Italy, Japan and UK, from (1974) to (2001). The results shows does not give strong evidence in the favor of all these models. But the granger causality test results are consistent that shows exchange rate should forecast the economic variables like money, income, interest rate and prices. It is also find that it is not necessary that exchange rate is only clarified by the observed fundamentals. Results provide strong evidence in the presence of proximate random walk behavior for exchange rate.

Alvarez (2007) studied that if exchange rate random walks, then almost everything we say about monetary policy is wrong. The main objective of monetary models are how the economy is affected by changing in rate of interest. Standard models of monetary policy based on the assumption that in bonds and other assert markets the monetary authorities have a strong control on interest rate in short term period. The utmost

significant supposition is that there present a symbolic consumer who participates in all markets. For this purpose all researchers used representative consumer model and shows it in Euler equation. Similarly more general models are also used here and these models don't assume the representative consumer. The main problem of the models are the data contradict the assumptions. The strong story of nominal exchange rate data of different nation's currencies was that these all completely estimate random walk. The reason behind the previous statement is based on the condition that when there occur any change in interest differential, it directly changes the conditional variances but have no effect on conditional means.

This analysis of models tells that the economists need new models. The results also shows that the standard models are not useless but they can explain the cross sectional pattern of short term average interest differentials. It is also shows that data in exchange rate shows that movements occur in interest rate differentials openly replicated the variations in excess returns. Then as the result the monetary models can't incorporate the excess return and so they can't explain the effect of changes in interest rate in the economy. For the purpose of understanding the changes in interest rate here used the data of exchange rate in the standard models. Also used data of short term and long term excess returns on domestic bonds. And these excess returns are controlled by federal reserves and in the model these are constant. The author emphases on the data of exchange rate relatively than interest rate for the reason that exchange rate is salient. Similarly if exchange rate follow random walk than all fluctuation in interest rate is due to fluctuation in conditional variances, not because of conditional means. But the data is opposite to the standard models assumptions. And if the data is correct then all about monetary policy proves wrong.

Engel et al (2010) studied factor model forecasts of exchange rates this study forecast exchange rate using factors models, in term of panel data estimation and then compare these forecasts with the random walk using root mean square error method. Literature also shows evidence about that the factor models forecast basic macro variables efficiently. In this study the quarterly data is used which is taken from international financial statistics and it is a panel data of 17 US dollar bilateral exchange rate with OECD countries (Australia, Canada, Belgium, Finland, Denmark, Japan, Germany ,France, Korea, Italy, Netherland, Spain, Norway, Switzerland, Sweden and UK) from the year 1973 to 2007. The prices level considered here is consumer price index of last quarter. Output considered here is total industrial production in last month of quarter and M1 represents money. This study also compared the four different type of forecasting models to benchmark model.

One of them uses only factors rather than other variables for forecasting and remaining three reflect factors and also other observed fundamentals. Here uses three methods of observed fundamentals like Taylor rule , monetary model and theory of purchasing power parity. For the purpose of anticipating performance applied econometric technique of root mean squared forecast error. In all Samples, data uses from all 17 countries for the construction of factors and panel data estimation. The results show that mining factors from the different cross sections of exchange rate provides mixed results. Other samples give option of large sample size for assessment of factors. This possibly will be also the cause of worthy results. But this is not considered the satisfactory condition for the worthy results. For the reason that when author used British pound in term of base currency then the last samples performance is worse than early one. It also shown that result for late samples are superiors.

This chapter include the detail empirical literature of different theories of exchange rate. A lot of literature in the favor of random walk models. But some studies didn't provide strong evidence on this model. The purpose of my study is to clarify to examine this hypothesis.

CHAPTER III

RANDOM WALK MODELS

Although the previous chapter explained the different models of exchange rate determination and 3the empirical evidence shows that none of the model predict value of exchange rate accurately. Models discussed in this chapter are available in the literature which were already used to check random walk and few models need sophisticated econometric techniques. In this chapter , this study estimates Runs and Cowless and Jones Sequence Reversal test, which are discussed in chapter 5. In this chapter we will explain some of the tests which are explicitly use to check the random walkness in the series.

Previous literature involves certain parametric techniques to examine the random walk behavior of real exchange rate. These tests are, Root mean square error test, Theil's U tests for random walkness, Variance ratio tests, NAÏVE models, Quandt and Andrew unknown structural break tests, Dickey fuller tests, The spectral shape tests, The average exponential LR and LM tests, Hurst exponential tests, Heston SV models, Augmented dickey fuller test, Phillip Perron test, Kwiatkowski, Phillips, Schmidt shin KPSS unit root tests.

These all tests are parametric tests for random walk pattern of real exchange rate. But in this study use non parametric test to examine the random walk behavior of real exchange rate. Two types of non -parametric tests are used the first one if runs test and second one is sequence.

3.1 The Runs Tests: (Bradley 1968)

It is a statistical procedure or method to observed that whether a data occurring randomly in a particular distribution. In short it is used to observed the randomness of data. It is also expressed as it is applied to examined whether the data set is from the random procedure or not.

The run is expressed as series of decreasing and increasing values. The very principle step of this test to count the runs. In the series of runs initially calculate median and then consider the values above the median is positive and below the median is negative runs.

Then count runs and find mean, Standard deviation, Z value and P value for all countries.

Here the null and alternative hypothesis are as,

Ho= the sequence or series is created in random manner/ the series is follow random process

H1= the sequence or series is not created in random manner/ the series is not follow random process.

It is given as,

$$Z=\frac{R-\mu_R}{\sigma^R}=\frac{R-\left[\frac{2n_+n_-}{n}+1\right]}{\sqrt{\frac{2n_+n_-(2n_+n_--n_+n_-)}{(n_++n_-)^2(n_+n_--1)}}}$$

Here n_+ , n_- are sample size of the items + and –in the return series and R explains number of runs.

The runs test reject the null hypothesis if the

$|Z| > Z_{1-\alpha/_2}$

3.2 Cowles and Jones Sequence Reversal Test

Method for the estimation of Cowles and Jones test is written as,

The basic purpose is to compare the observed number of sequences and reversals in the time series of prices with the anticipated number of reversals and sequences under RW 1.

A sequence is explained as two consecutive returns having same sign;

$\{ r_t, r_{t+1} \} > 0$ or $\{ r_t, r_{t+1} \} < 0$

A reversal is expressed as two consecutive returns having opposite signs;

$\{r_t>0, r_{t+1}<0\}$ or $\{r_t<0, r_{t+1}>0\}$.

Creation of CJ test

The model to be verified,

$r_t = p_t - p_{t-1} = \mu + \varepsilon_t$; $\varepsilon_t \sim iid\ (0,\sigma_\varepsilon^2)$,

having symmetric pdf for ε_t.

Define the indicator (signifying the sign of return):

I_t= {1, if $r_t \geq 0$

0, else

And assuming the RW, I_t is a iid Bernoulli random variable with

$\pi \equiv \text{P}\ (I_t = 1) = \text{P}\ (r_t \geq 0\ )$

$1-\pi$ = P ($I_t = 0$) = P ($r_t < 0$)

Additionally, assuming the RW1, the probability π is written by;

π { > 0.5, if $\mu > 0$

= 0.5, if $\mu = 0$

< 0.5, if $\mu < 0$

Now total number of sequence $N_s = \sum_{t=1}^{n} Y_t$ with $Y_t = I_t I_{t+1} + (1 - I_t)(1 - I_{t+1})$,

here

Y_t= {1, $I_t = I_{t+1} = 1$ *or* $I_t = I_{t+1} = 0$ (for sequence)

0, $I_t = 1, I_{t+1} = 0$ *or* $I_t = 0, I_{t+1} = 1$ (for reversal)

Now the indicator Y_t(indicating a sequence) in Bernoulli random variable having,

$\pi_s \equiv$ P ($Y_t = 1$) = P ($I_{t+1} = 1, I_t = 1$) + P ($I_{t+1} = 0, I_t = 0$)

Therefore, assuming the random walk 1 which suggests serially independent $r_t's$ and $I_t's$, this probability

For a sequence has the procedure:

π_s = P (I_{t+1}=1) . P (I_t= 1) + (I_{t+1}= 0) . P (I_t= 0)

= $\pi^2 + (1-\pi)^2$

And for a reversal:

$1 - \pi_s = 2\pi\,(1-\pi)$.

Moreover observed that

π_s {= 0.5 if $\mu = 0$

>0.5 if $\mu \neq 0$

This shows the fact that assuming a random walk without drift, sequences reversals are equally likely and assuming RW with drift, sequences are more likely than reversals. (due to deterministic trend)

The CJ statistics is given by,

$$CJ^{\wedge} = \frac{number\ of\ sequences}{number\ of\ reversals} = \frac{N_s}{n - N_s}$$

If $CJ^{\wedge} \approx 1,$ since $\pi_s = 0.5$ this indicates random walk without drift.

If $CJ^{\wedge} > 1,$ since $\pi_s > 0.5$ this indicates random walk with drift.

Chin & Zaidi (2007) applied these tests in their paper about the "tests of random walk hypothesis under drift and structural breaks, a non- parametric approach" here the data is taken from nine Malaysian stock exchange markets. The author used different types of test to examine the random walk behavior of exchange rate. Firstly used test is the **runs tests.** The null hypothesis of random walk behavior also depend on the runs as the different sequences of the price changes having the same sign. Here the positive sign indicates the return is greater than of the mean return and also negative sign indicate that the return is smaller than that of mean return and no sign indicates that the return is equal to the mean. Using null hypothesis the driftless IID random walk have maximum number of runs while in the presence of drift the number of runs decreases. Another test is **sequence reversal test**. This test is used by the Cowles and Jones for the random walkness in stock returns. The sequence involved the pairs of consecutive returns having same sign whereas the reversal involved the opposite

signs. The author finds the RW with and without drift. The results shows that Asian crisis and currency control have a large impact on the Malaysian stock market. For all sector the study found significant structural changes due to Asian crisis. The empirical results of the paper misinterpret the random walk hypothesis under under driftless frame work. But under the structural breaks the study focused on the tendency of drift's direction changes from negative to positive before and after the crisis. In short the results are not in the favor of random walk behavior of Malaysian stock market.

CHAPTER IV

DATA

The monthly data of exchange rate from 1990 M1 to 2016 M10 receives from international financial statistics (IFS) for different countries e.g. Canada, France, China, Switzerland, Japan, United Kingdom and United States. Here I used United States as base country.

4.1 Construction of Real Exchange Rate

The data of exchange rate obtained from IFS is in nominal form but here used real exchange rate. For this purpose construct the real exchange rate by my own using the following formula;

RER $= NER \times \frac{CPI^*}{CPI}$

Here RER= the real exchange rate of a country

NER= nominal exchange rate of a country

CPI^*= consumer price index of a country

CPI= consumer price index of United States

Here U.S used as base country

For example for the construction of Real exchange rate of Canada

RER of Canada= nominal exchange rate of Canada $\times \frac{consumer\ price\ index\ of\ Canada}{consumer\ price\ index\ of\ United\ States}$

The above procedure is repeated for all countries and constructs the real exchange rate for all countries.

4.2 Descriptive Statistics

In this section the graphical representation of data are given as for each country,

Figure 1: Fluctuations in Exchange Rate of Canada

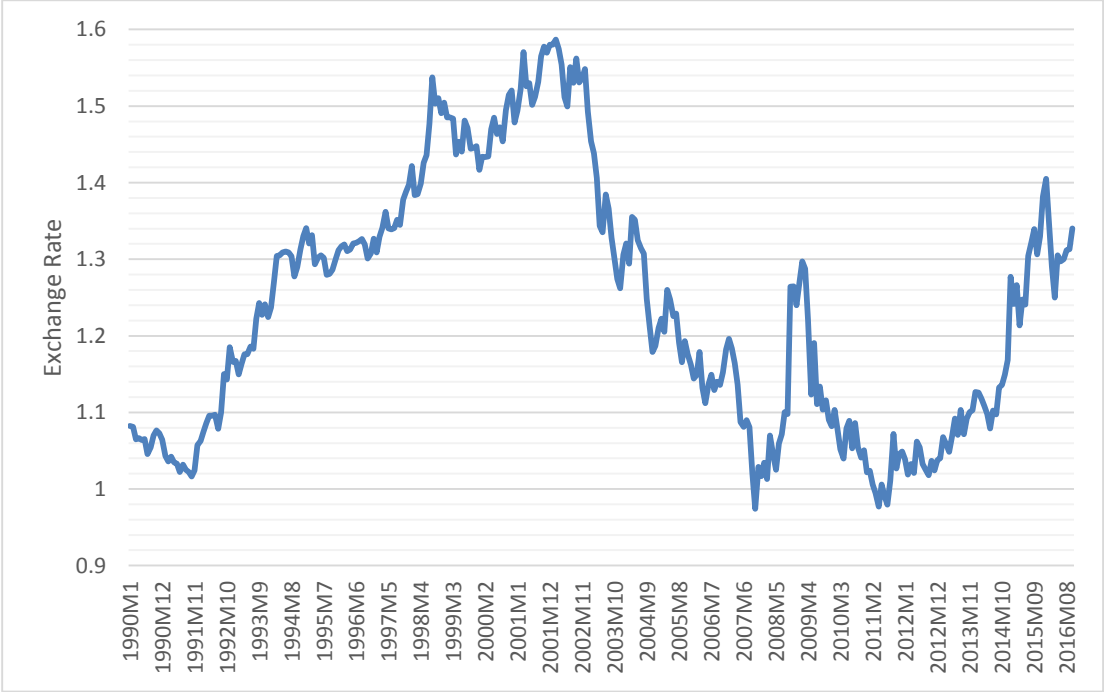
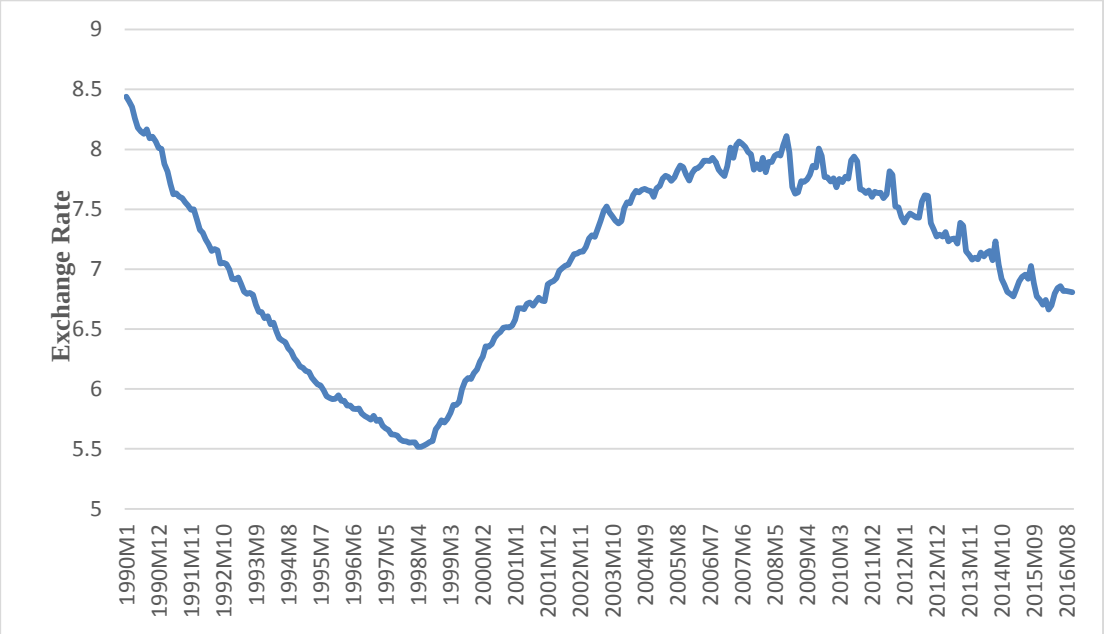


Figure 1 explains the movements of exchange rate in Canada. Horizontal axis explains the time period of years and first month of each year are shown here, and Vertical axis shows the real exchange rate in Canada. The graph shows that there is no proper pattern which the exchange rate follows its simply random walk behavior with ups and downs. From 1990 to 1992 there is decreasing trend with jumps but in 1992 M4 the exchange rate start increasing with fluctuations then after 1994M4 it again start declining then it shows random behavior and in 2008 it shows maximum decrease below the 1. It is the major minimum level of Canada ‘s exchange rate, then

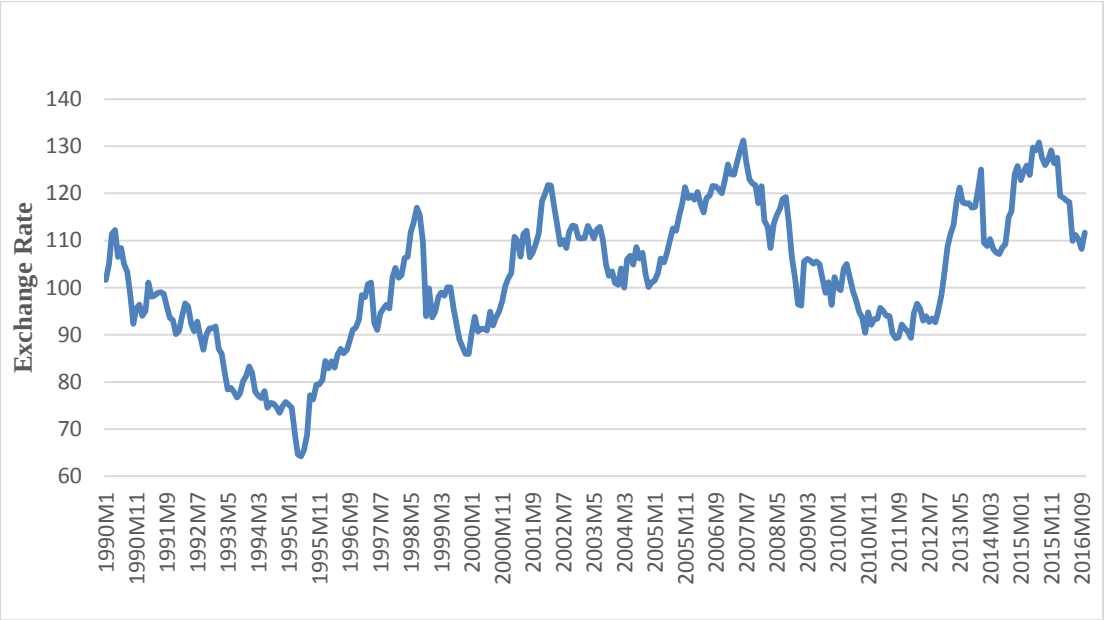
it starts moving increasing and decreasing trends which shows random walk behavior of exchange rate.

Figure 2: Fluctuations in Exchange Rate of China



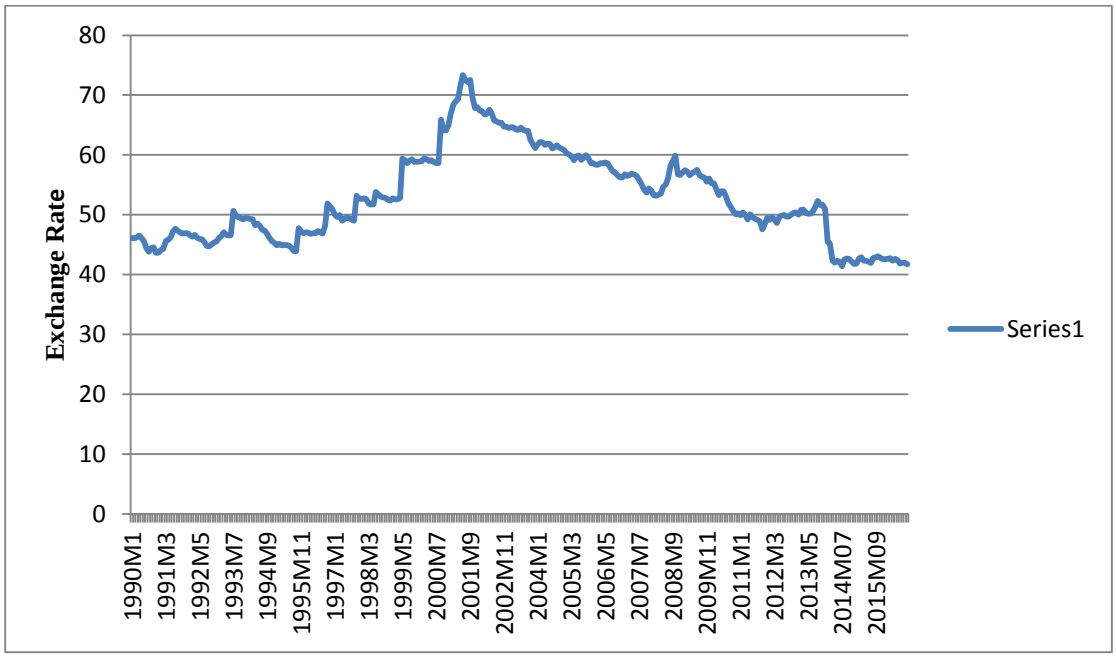
In figure 2 fluctuations of exchange rate shown in different time periods, on horizontal axis takes time period first month of each year represented here, on vertical axis takes the real exchange rate of China. The graph shows that there is small fluctuation in real exchange rate but with decreasing trend then in 1998M1 the exchange rate of China is at lowest level after this period it start increasing with small fluctuations then from 2007 to onward it shows mixed trend but with major fluctuations. The fluctuation don't follow proper pattern behave in random process.

Figure 3: Fluctuations in Exchange Rate of Japan



In the figure 3 the exchange rate movements in different time period are examined the horizontal axis gives the time period of each year and first month of each year is shows in the horizontal axis, vertical axis shows the real exchange rate of Japan. In this graph it is clearly shown that the fluctuations in real exchange rate have no proper channel sometimes these fluctuations are in decreasing trends and sometimes have increasing trends so the theory that exchange rate follows random walk prove right here. in case of Japan there is a lot of fluctuation and wide fluctuations. Its scattered exchange rate. In 1990 it shows increasing trend then in 1991 start decreasing the major decreasing trend of the exchange rate is in 1995M1 when the real exchange rate of Japan is close to 60. After that it start increasing, in 2008M1 the exchange rate is at highest level then after that it start decreasing and increasing with fluctuations.

Figure 4: Fluctuations in Exchange Rate of Pakistan



In case of Pakistan, on horizontal axis plot the time period of each year is shown here, on vertical axis plot the real exchange rate in Pakistan. This figure shows that there is no proper pattern which the exchange rate follows, the movements of exchange rate are random because it has increasing and decreasing trends but with major fluctuations. The exchange rate of Pakistan is at highest level in 2002 M10. But in general the curve of exchange rate movements shows no proper trend so the exchange rate follows random walk.

Figure 5: Fluctuations in Exchange Rate of Switzerland

In this figure of Switzerland, the time period is shown on x-axis while takes the real exchange rate of Switzerland on vertical axis. In 1990 the exchange rate of Switzerland start decreasing then after 1991 it starts increasing. From 2002 to 2004 the exchange rate of Switzerland is at highest or maximum level then in 2011 it is at lowest level. But is has no proper increasing and decreasing trend. So it said that it follow random walk.

Figure 6: Fluctuations in Exchange Rate of United Kingdom

In the graph of United Kingdom, on horizontal axis explains the time period in years represented as first month of every year, vertical axis shows the real exchange rate in United Kindom. The figure shows large fluctuations in real exchange rate of United Kingdom. In 1993 exchange rate is at lowest level and in 2016 it is at highest level. But there is no proper pattern which the exchange rate follows its simply random walk behavior. there is also a large increasing fluctuation in period of 2010 and in 2015.

CHAPTER V

ANALYTICAL FRAMEWORK AND ESTIMATION RESULTS

5.1 The Runs Tests: (Bradley 1968)

Table 1 Summary of Results (Runs Test)

Country Name	Runs	Z-value	P-value	Hypothesis Testing	Results
Canada	14	-16.5209731	1.30E-61	Accept Ho	Random Walk
China	4	-17.63469495	6.67E-70	Accept Ho	Random Walk
Japan	20	-15.8510915	6.91E-57	Accept Ho	Random Walk
Pakistan	7	-11.0869146	7.26051E-29	Accept Ho	Random Walk
Switzerland	26	-15.1789848	2.44E-52	Accept Ho	Random Walk
United Kingdom	20	-15.851331	6.88E-57	Accept Ho	Random Walk

5.1.1 Results/Interpretation

5.1.1.1 Canada

In case of Canada the number of runs are 14 here total number of observation are 322, n0 = represents as the number of runs less then mean are 163 and the n1= represents the number of runs larger then mean are 159. The standard deviation is 8.95 which shows the deviation from mean and the variance is 80.22 for the explanation of data consider Z value and P value here the Z value = -16.52 and P value = 1.29591E-61

Here the alpha is .05 so, according to formula if $|Z| > Z_{1-\alpha/_2}$ then reject null hypothesis here the Z value is -16.52 which is less than $Z_{1-\alpha/_2}$ which is 1.96 so we can't reject the null hypothesis. it means that accept H0 and the data is random walk.

5.1.1.2 China

In case of China the number of runs are 4 here total number of observation are 322, n0 = means the runs less than mean are 145 and n1= the number of runs greater then mean are 177. The standard deviation is 8.86 and the variance is 78.66, for the explanation of data consider Z value and P value here the Z value = -17.63 and P value = 6.67071E-70

alpha is .05 and according to formula if $|Z| > Z_{1-\alpha/_2}$ then reject null hypothesis here the Z value is -17.63 which is less than $Z_{1-\alpha/_2}$ which is 1.96 so we can't reject the null hypothesis. it means that accept H0 and the data is random walk.

5.1.1.3 Japan

In case of Japan the number of runs are23 here total number of observation are 288, n0 = where the binary code is zero are the values which are less than mean, negative runs are 148 and n1= number of runs above the mean value, positive runs are 140. The standard deviation is 8.46 and the variance is 71.6 for the explanation of data consider Z value and P value here the Z value = -14.4 and P value = 2.55

Here the alpha is .05 and according to formula if $|Z| > Z_{1-\alpha/_2}$ then reject null hypothesis here the Z value is -14.4 which is less than $Z_{1-\alpha/_2}$ which is 1.96 so we can't reject the null hypothesis. it means that accept H0 and the data is random walk.

5.1.1.4 Pakistan

In case of Pakistan the number of runs are 7 here total number of observation are 322. n0= values or runs which are less than mean, negative runs are 182 and n1= number of runs above the mean value, positive runs are 140. The standard deviation is 8.80

and the variance is 77.53 for the explanation of data consider Z value and P value here the Z value = -11.0869146

and P value = 7.26051E-29

alpha is .05 and according to formula if $|Z|> Z_{1-\alpha/_2}$ then reject null hypothesis here the Z value is -11.08 which is less than $Z_{1-\alpha/_2}$ which is 1.96 so we can't reject the null hypothesis. it means that accept H0 and the data is random walk.

5.1.1.5 Switzerland:

In case of Switzerland the number of runs are 26 here total number of observation are 322, n0 = where the binary code is zero are the values which are less than mean, negative runs are 166 and n1= number of runs above the mean value, positive runs are 156. The mean is 1.2. The standard deviation is 8.94 and the variance is 80.09 for the explanation of data consider Z value and P value here the Z value = -15.17 and P value = 2.43632E-52

alpha is .05 and according to formula if $|Z|> Z_{1-\alpha/_2}$ then reject null hypothesis here the Z value is -15.17 which is less than $Z_{1-\alpha/_2}$ which is 1.96 so we can't reject the null hypothesis. it means that accept H0 and the data is random walk.

5.1.1.6 United Kingdom

In case of U.K the number of runs are 20 here total number of observation are 322, n0 = where the binary code is zero are the values which are less than mean, negative runs are 162 and n1= number of runs above the mean value, positive runs are 160. The standard deviation is 8.95 and the variance is 80.24. for the explanation of data consider Z value and P value here the Z value = -15.85 and P value = 6.8817E-57

alpha is .05 and according to formula if $|Z|> Z_{1-\alpha/_2}$ then reject null hypothesis here the Z value is -15.85 which is less than $Z_{1-\alpha/_2}$ which is 1.96 so we can't reject the null hypothesis. it means that accept H0 and the data is random walk.

Overall the Z value for all countries is < 1.96 which means that we can't reject Ho. So we must accept Ho. Here Ho is that the data series is following random walk. So the results of runs test shows that for every country the exchange rate is a random walk.

5.2 Cowles and Jones Sequence Reversal Test

Method for the estimation of Cowles and Jones test is written as,

The basic purpose is to compare the observed number of sequences and reversals in the time series of prices with the anticipated number of reversals and sequences under RW 1.

Table 2 Summary of Results (Cowles and Jones Sequence Reversal tests)

Country Name	**A**	**AS**	**CJ**	**Results**
Canada	0.5	0.5	0.8	Random Walk
China	0.4	0.5	1.2	Random Walk
Pakistan	0.4	0.5	1.3	Random Walk
Japan	0.5	0.5	0.9	Random Walk
Switzerland	0.5	0.5	0.9	Random Walk
United Kingdom	0.4	0.5	1.1	Random Walk

Here the result gets using this method,

If $r_t \geq 0$ it is shown as I_t=1 and when the $r_t < 0$ it is shown as I_t=0 here r_t = real exchange rate.

Now

A= P (I_t=1)

1-A=P (I_t=0)

Now if u>0 then A>0.5

If u<0 then A<0.5

If u=0 then A=0.5

Y_t= 1 in case of sequence

Y_t= 0 in case of reversal

AS= A^2+$(1-A)^2$

AS= 0.5 if u= 0

AS>0.5 if u ≠ 0

If the CJ is close to 1 and AS=0.5 then random walk

If CJ > 1 and AS > 0.5 then no random walk

5.2.1 Canada

In case of Canada the value of A= 0.5 on the other hand P($I_t = 1$)=0.5 which means that $r_t \geq 0$

means exchange rate has some positive value because r_t shows the exchange rate. Here the AS= 0.5 and CJ =0.8 which is close to 1.

Two conditions for random walk are;

1. AS= 0.5 then u=0
2. CJ is close to 1

So the both conditions for random walk fulfill and it is concluded that exchange rate is random walk.

5.2.2 China

In case of China the value of A= 0.4 on the other hand P($I_t = 1$)=0.4 which means that $r_t \geq 0$

means exchange rate has some positive value because r_t shows the exchange rate. Here the AS= 0.5 and CJ =1.2 which is also close to 1.

Two conditions for random walk are;

1. AS= 0.5 then u=0
2. CJ is close to 1

So the both conditions for random walk fulfill and it is concluded that exchange rate is random walk.

5.2.3 Japan

In case of Japan the value of A= 0.5 on the other hand P($I_t = 1$)=0.4 which means that $r_t \geq 0$

means exchange rate has some positive value because r_t shows the exchange rate. Here the AS= 0.5 and CJ =9.2 which is also close to 1.

Two conditions for random walk are;

1. AS= 0.5 then u=0
2. CJ is close to 1

So the both conditions for random walk fulfill and it is concluded that exchange rate is random walk.

5.2.4 Pakistan

In case of Pakistan the value of A= 0.4 on the other hand P($I_t = 1$)=0.4 which means that $r_t \geq 0$

means exchange rate has some positive value because r_t shows the exchange rate. Here the AS= 0.5 and CJ =1.3 which is also close to 1.

Two conditions for random walk are;

AS= 0.5 then u=0

CJ is close to 1

So the both conditions for random walk fulfill and it is concluded that exchange rate is random walk.

5.2.5 Switzerland

In case of Switzerland the value of A= 0.4 on the other hand P($I_t = 1$)=0.4 which means that $r_t \geq 0$

means exchange rate has some positive value because r_t shows the exchange rate. Here the AS= 0.5 and CJ =1.1 which is also close to 1.

Two conditions for random walk are;

1. AS= 0.5 then u=0
2. CJ is close to 1

So the both conditions for random walk fulfill and it is concluded that exchange rate is random walk.

5.2.6 United Kingdom

In case of United Kingdom the value of A= 0.4 on the other hand P ($I_t = 1$) = 0.4 which means that $r_t \geq 0$

means exchange rate has some positive value because r_t shows the exchange rate. Here the AS= 0.5 and CJ =1.1 which is also close to 1.

Two conditions for random walk are;

1. AS= 0.5 then u=0
2. CJ is close to 1

So the both conditions for random walk fulfill and it is concluded that exchange rate is random walk.

So the overall result shows that for all countries the exchange rate follow random walk behavior because there are two conditions for random walk. The first one is AS= 0.5 and the second one is CJ is close to one. Both fulfill so the results rate in the favor of random walk.

CHAPTER VI

SUMMARY AND CONCLUSIONS

The purpose of this study is to examine whether the Real Exchange Rate is Random Walk or not. Different literature shows that the behavior of Exchange Rate is random walk. but a lot of literature gives mixed results. Moreover, the previous literature used non-parametric techniques This is an attempt to check the random walk behavior of Exchange Rate using non parametric techniques, i.e., Bradley's (1968) The Runs Test and Cowles and Jones Sequence Reversal Test. For this purpose the sample countries taken are China, Canada, Japan, United Kingdom, America, Switzerland and Pakistan because the previous literature debates on these countries about there real exchange rate pattern and gives no proper results that whether the exchange rate of these countries follow random walk or not. So, this study is attempt to provide empirical evidence in the favor of random walk pattern of real exchange rate. The data used here is from the period of 1990 M1 TO 2016 M10.

This study also provides descriptive analysis of the data which includes graphs. The results from all tests and also graphs show the acceptance of null hypothesis that is behavior of Exchange Rate is random walk. So we cannot predict or forecast Exchange Rate using the fundamentals specially in the short run.

It is therefore concluded that fundamentals may play an important role in forecasting exchange rate if we are forecasting for longer time period, however for shorter time period it is random walk. Thus it is necessary for investors to hedge their exchange rate risk in short run. It is necessary therefore, to develop derivative market which offers different options for investors.

Heston stochastic Model is another methodology which can be estimated in future studies to check the random walk behavior. It checks the pure Weiner process in the series.

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