Hedging the Currency Devaluation

By

Shahina Qurban Jan

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Department of Econometrics and Statistics

Pakistan Institute of Development Economics

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Submitted By

Shahina Qurban Jan

Supervised By:

Dr. Saud Ahmed Khan

Pakistan Institute of Development Economics

CERTIFICATE

This is to certify that this thesis entitled: **"Hedging the Currency Devaluation"** submitted by Ms. Shahina Qurban Jan is accepted in its present form by the Department of Econometrics and Statistics, Pakistan Institute of Development Economics (PIDE), Islamabad as satisfying the requirements for partial fulfillment of the degree in **Master of Philosophy in Econometrics**.

Supervisor:

Dr. Saud Ahmed Khan
Assistant Professor
Department of Econometrics and Statistics
PIDE, Islamabad

External Examiner:

Dr. Arshad Ali Bhatti
Assistant Professor
International Institute of Islamic Economics (IIIE)
International Islamic University
Islamabad

Acting Head,
Department of Econometrics and Statistics

Amena Urooj

Dedication

Dedicated to My parents

Declaration

I hereby solemnly declare that this thesis entitled **"Hedging the *Currency Devaluation*"**, submitted by me for the partial fulfillment of Master of Philosophy in Econometrics, is my own work and it's also confirmed that this research work is completed by own self and under full supervision of my supervisor. It has not been submitted in support of any application for any other degree in any other university.

Date. ______________

Signature. ______________

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List of Abbreviations

Abbreviation	Descriptive of Abbreviation
USD	United States Dollar
EUR	European Union Euro
GBP	Great Britain Pound
JPY	Japanese Yen
CHY	Chinese Yuan
PKR	Pakistani Rupees
ER	Exchange Rate
RMB	Reh Min Bi
UK	United Kingdom
ECM	Error Correction Model
OLS	Ordinary Least Square
ARCH	Auto-Regressive Conditional Heteroscedasticity
GARCH	General Autoregressive Conditional Heteroscedasticity
MGARCH	Multivariate General Auto-Regressive Conditional Heteroscedasticity
EGARCH	Exponential General Autoregressive Conditional Heteroscedasticity
DBEKK	Diagonal Baba Engel Kraft and Korner
RMSE	Root Mean Square Error
JSE	Johnston, Stein and Ederington
HKM	Herbst, Kare and Marshal
FNM	Fractional Brownian Model

BSM	Black-Scholes Model
CCC	Constant Conditional Correlation
VARMA	Vector Auto-Regressive Moving Average
DCC	Dynamic Conditional Correlation
DVECH	Diagonal Vector Error Correction Heteroscedasticity
UPS	United Parcel Services
MV	Minimum Variance
MVHR	Minimum Variance Hedge Ratio
OHR	Optimal Hedge Ratio
VR	Variance Reduction
HR	Hedge Reduction
HE	Hedge Effective
BEKK	Baba Engel Kraft and Korner
VEC	Vector Error Correction
ACF	Auto –Correlation Function
PACF	Partial Autocorrelation Function
CPEC	China Pakistan Economic Corridor

Table of Contents

List of Tables

List of Figures

ABSTRACT

This study analysis, the importance of diversification as a hedging instrument in currency devaluation. It elaborates the non-conventional way of hedging i.e. diversification without using conventional hedging instrument. Optimal Hedge ratios are estimated using Minimum Variance approach proposed by Ederington (1979). Multivariate GARCH, Diagonal Baba Angel Kraft and Kroner (DBEKK) model is employed to estimate Optimal Hedge Ratios (OHR). Two phases of gross portfolios haven been considered in respect of Pakistan based on political parties regimes i.e. from 2010-2012 and 2013-2015. The exchange rate of Dollar (USD), Euro, Great Britain Pound (GBP), Japanese Yen (JPY) & Chinese Yuan (CHY) in terms of Pakistani rupee are taken as being the reserve and international currencies. Daily data of the currencies from Jan 2010- July 2015 are collected. The gross portfolios are further segregated in various portfolios for in-depth analysis and identifying the best portfolio having higher Hedge reduction for currency devaluation. Overall it's concluded that portfolios including CHY have higher Risk Reduction percentages. Thus CHY along EURO and JPY should be kept in liquid asset to tackle the problem of currency devaluation.

CHAPTER 1

INTRODUCTION

In the era of international trade and globalization countries face uncertainty and risk regarding exchange rate fluctuations. Exchange rates are volatile financial instruments that hardly move in the same directions. Traders have to be concerned about the fluctuations in currency values in which they trade their goods. Insecurity is attached with currency in the forms of currency devaluation and appreciation. One of the best way to make one currency secure from currency devaluation is hedging. It is common practice in many countries dealing in international trade.

Hedging essentially is a risk management strategy used to compensate or limit the probability of loss or fluctuation in prices, currency, commodities or securities. It's a transfer of risk without buying insurance policy. In literal sense hedging means something that provides safety and security. Hedging employs various techniques and involves equal and opposite position in two different markets such as cash and future markets. Hedging lessens, the risk attached with foreign currencies fluctuations and volatilities, a hedge can be developed from various financial instruments known as derivatives.

Derivatives have a range of characteristics that make them required as assets. "These instrument values are connected to the value of other assets without the owner of the derivative having to take a fully paid up position in the other assets." (McClintock, 1996)

These include Forward, Future, Options and Swaps. The most commonly used among these hedging instruments are Forward and Future. Hedging plays a vital and emerging role in international trade as a result of fluctuations and volatility in exchange rates. Countries involved in international trade (exports/imports) use several hedging techniques to reduce the risk of currency fluctuations like depreciation and appreciation of currencies. Currency depreciation has more impact in the economic progress of a country. According to Siegel (2003), Hedging is a zero sum game while inequality theorem by Jensen (1906) states that the profit made when a currency appreciates is always greater when it depreciates it is known as Siegel paradox .

Thus its recommended not to hedge whole of the portfolio but prefer partial hedging. Currency devaluation is a decrease in domestic currency value in terms of foreign currency. Consequently, Currency hedging is used by financial investors and businesses to abolish risks they come across when conducting businesses worldwide. Currency Hedging limits the foreign exchange risk.

According to Hillion et.al (2012) Currency risk hedging internationally addressed in both the academic and practitioner literature as a free lunch. In deed if currencies have zero expected returns and positive volatility, currency hedging lessens volatility while leaving portfolio expected returns unaffected. In this case, currency risk hedging improves risk returns tradeoffs of international portfolio is at no cost while if currency risk is priced, currency risk hedging may affect the expected return on the portfolio in addition to its risk. Certainly there is increasing evidence of a premium for currency risk. Even several pricing models show that at equilibrium currency risk brings deviation from Purchasing Power Parity; investors require to be compensated for bearing exchange rate risk. These results suggest that bearing exchange rate risk may actually improve the performance of international portfolio and that currency risk hedging is not surely costless.

advanced and emerging nations need different hedging techniques to reduce foreign exchange risks.[1]For example

Cross hedging is one of the suggested derivative techniques for developing countries that lack derivative markets, because it increases the opportunity set of hedging substitutes. Cross hedging is a method of a hedge developed in a currency whose worth is extremely correlated with the value of the currency in which the receivable is dominated. Cross hedging is not practical and beneficial to secure from exchange rate devaluation. Even hedging derivatives techniques hold costs as banks charge high price for these hedging derivative contracts where swaps is the most expensive hedging technique as compared to other techniques. (Wong and Zilcha, 1999)

The ideal technique for currency hedging is through diversification. Diversification stands alone reducing the risk. Diversification is strength and by investing in various currencies in a portfolio reduces risk to great extent. This technique opposes that a portfolio of different kinds of investment or currencies will, on average, profit higher returns and poses a lower risk than any individual found within the portfolio. The benefits of diversification will hold only if the stocks/shares are not perfectly correlated.

Thus the positive performance of some investment neutralizes the negative performance of others.

In modern Finance the importance of diversifications is central. Mean–variance framework initiated and led by Markowitz (1952) emphasized investors to include more than one asset to their portfolios for gaining benefits of assets returns of non-perfect correlations.

[1] Js.research@js.com JS research is available on Bloomerg, Thomas Reuters, CapitalIQ

Moreover in case of currency devaluation, the devaluation can be hedged using diversification technique. This is a new recipe for currency hedging through portfolio diversification of currencies that requires no hedging instrument and is free of cost. This study presents a non-conventional way of currency hedging by diversifying the currency risk in several portfolios of possessing different foreign currencies. Internationally diversification has become an established practice for most of the investors while the debated key issue is exchange rate risk how to overcome the risk while diversifying the currency risk in other currencies portfolios.

Exchange rate fluctuation can also be adjusted with diversification if investors/market players ignore currency value unpredictability. The investor only has to collect the right currencies and stocks.

Hedging using derivative instruments are costly and involve counterparty risk, and the advantage from hedging therefore disappears. In case of diversification there is no cost and it can be adopted by diversifying risk in several currencies without using any cost bearing hedging instrument i.e. forward, future or options. Septon, (1993) Kumar (2012) and Chang et.al (2012)

Hard currencies act as ordinary hedges against international (and local) portfolio losses, since they tend to appreciate with respect to evolving market currencies when the world portfolio return is negative. (Walker, 2007)

The emerging markets are mostly commodity oriented and there for their currencies depreciates as a result of inflation thus emerging markets should opt for such diversified portfolios of currencies that are strong, reserve and bold currencies. For international equity investors the Euro and USD are attractive stores of values as these currencies appreciate when international stock market falls. As a result, creating demand for the US dollar and Euro denominated bills reducing volatility of international stock portfolios.

These strong currencies basically have negative relationship with inflation and stock prices and one should have portfolios with stocks having negative relationship. The US dollar, Euro and Swiss Franc are known as bold currencies and appreciates even inflation takes place in emerging market. (Viceira, 2008)

Among these bold currencies the internationalization of Yuan to be declared as reserve currency is on its verge. It has been suspected in literature that by 2020 Yuan/RMB will replace US dollar if reforms regarding financial markets are speed up and interest rate are liberalized. While in case of East Asia and regional trades are already undertaken in Yuan while many East Asian countries have started keeping Yuan in their reserves and are making trade payments as being allowed license by Chinese governments to make payments in (Renminbi) RMB. Overall only the financial reforms will make an important breakthrough only than Yuan will be able to make meaningful progress.[2]

The Chinese Yuan has been included on the basis of East and South Asia influence of Chinese currency for regional trade.

The US dollar after the financial crisis of 2008 depreciated and its stability was adversely affected. In this scenario China claimed to introduce and promote Yuan/ Renminbi as international currency. In this regard China encouraged the use of its currency in global trade, swap engagements between central banks, bank deposits and issuance of bonds in Hong Kong. (Yu, 2012)

[2] The World in 2020 According to China: Chinese Foreign Policy Elites Discuss By Shao Binhong

(1988) show that currency risk is largely undiversifiable and that it reduces the advances from international diversification.

In this study we present a non-conventional hedging strategy utilizing Minimum Variance approach to estimate the Dynamic Optimal Hedge Ratios (OHRs). Several Reserve currencies are employed in distinct diversified portfolios used in terms of local currency (Pakistani rupees) exchange rates minimizing the risk of currency devaluation. These reserve currencies are the USD, Euro (EUR), German British Pound (GBP), Japanese Yen (JPY) and Chinese Yuan/Renminbi (CHY/RMB). The first four currencies are internationally recognized as reserve and strong currencies while the fifth one is Chinese currency i.e. Yuan/Renminbi. It's an emerging currency in Asia specific and International Monetary Fund (IMF) declared its fifth Special Drawing Rights (SDR) and will be implemented from 1st October, 2016.[3]

The data has been segregated into two phases i.e. from 2010-2012 and 2013-2015 on the basis of two different regimes of political parties[4] highlighting the influence of China Pakistan Economic Corridor (CPEC)[5] that was initiated in first phase in form of paper work and implemented in second phase. In this study will estimate Dynamic Optimal ratio and for this purpose Minimum Variance Approach has been used. The econometric technique that has been employed to estimate Dynamic Optimal Hedge Ratio is Diagonal Baba Engel Kraft and Korner (DBEKK) Multivariate General Autoregressive Conditional Heteroscedasticity (MGARCH) model. In this regard we will estimate Hedge Reductions (HR) and considers those portfolios

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[3] www.telegraph.co.uk

[4] The Pakistan People's Party (PPP) and Muslim League Nawaz (PML-N) party regime. PPP officially took over the government in July 2009 and Muslim League Nawaz (PML-N) party officially took over in September 2013.

[5] The CPEC was first proposed by the Chinese Premier Li Keqiang on 5th May 2013 while his visit to Pakistan (Tiezzi, 2014). CPEC is one of the mega projects of development and trade between China and Pakistan. It was signed by Prime Minister Nawaz Sharif during visit to China. It will be constructed from 2014-2030

The main difference of current study in comparison with previous study is that it deals with currency devaluation by introducing a hedging technique that is unique it avoids inclusion of hedging derivatives techniques and using actual values of currencies in terms of Pakistani rupees. In previous study only conventional currency hedging techniques were used (spot, forward, future and option contracts), [(Zilcha, 1999), (Septon, 1993), (Sultan and Kroner, 1993)], while no specific study till now has considered diversification solely for currency devaluation using currencies in actual values in terms of domestic country.

Another major contribution of the study is the inclusion of Yuan among other three stable and reserve (international) currencies; in literature no single study has used Chinese Yuan or Renminbi in currency portfolio for hedging currency devaluation in terms of Pakistani rupee.

Same techniques can be utilized by individuals, lenders and market players to avoid currency devaluation. Currency hedging is essential in International trade dealing with foreign currency fluctuations that results losses and gains for those involved in the transaction. This technique of currency hedging the devaluation is beneficial for both developed and developing countries. It depends on diversifying the risk of devaluation of local currency in other stable and renowned currencies. Diversification is the best way to reduce the risk without incurring any financial cost attached with conventional way of hedging techniques. Thus by using non-conventional way of hedging currency devaluation both develop and developing countries can enjoy the benefits of free lunch the concept given by Markowitz(1952) in Portfolio Theory. The study recommends that Pakistan can safe its economy from negative aspects of currency devaluations by using diversified portfolios of stable and strong currencies such as US Dollar (USD), Euro (EUR), Japanese Yen (JPY) and Chinese Yuan (CHY). Such analysis will contribute in reshaping exchange rate policies and strategies for economic development of the country.

1.3: Organization of the Study

The organization of the study is based on six chapters where introduction is given in first chapter while second chapter deals with various literatures regarding the study is reviewed while conceptual framework and working hypothesis is given in Chapter three. Chapter four is regarding data sources and methodology. Results and discussions are given in Chapter five. In sixth chapter conclusion and recommendations are given.

Chapter 2

LITERATURE REVIEW

The Literature Review on various studies has been segregated based on seven subsections i.e. Hedging through diversification, Hedging and Hedge Effectiveness, Hedging and Derivative/Instrument Tools, Hedging based on stocks and Equities, Hedging Techniques, Hedging and Foreign Exchange and Hedging in Pakistan.

2.1: Literature on Basis of Diversification

Markowitz (1952) examined the second rule of an investor i.e. Expected return and variance of an unanticipated return in rejection of first rule that is maximizing anticipated return. It was suggested using Geometrical relation that for minimum variance concern investors should diversify risk across industries for having low covariance's rather in same industries.

Moreover Bugar and Maurer (2000) explained the importance of International Diversification for emerging market (Hungary and Germany) creating multi-currency portfolios. Its indicated that international diversification benefits, also prominent and visible for emerging countries. The Sharpe ratio and SSDR efficiency, gave best results. The results suggested that full hedging was not beneficial for Germany while for Hungary the full hedge dominated.[6]

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[6] The Sharpe ratio is an approach of estimating risk-adjusted return and become industry standard of such estimations. It was given by Nobel Laureate William F. Sharpe. It's the average return obtained in addition of the risk-free rate per unit of volatility or total risk.

Likewise White (2003) analyzed importance of International currency diversification with a comparison of short and long term risk. In short term currency risk is riskless in real terms while in long term currency risk is not riskless as real interest rate varies over time.

Viceira (2008), explored relationship of exchange rates with diversified portfolios of bonds and equities investing in foreign asset. It was indicated using Mean-Variance Approach that countries take short positions in currencies positively with equities while long positions in reserve currencies (US dollar, Swiss Franc and Euro) negatively related with equities. Currencies need to be fully hedged for bond holding for minimizing risks.

However Haefliger et.al (2010) investigated the importance of currency hedging of foreign investment. The study considers bonds and equities of five major currencies that are US, Japan, EU, Switzerland and Germany from 1985 to 2000. It concluded that global bond diversification needs complete currency hedging and for global equities diversification it requires partial currency hedging.

2.2: Hedging and Hedge Effectiveness

Berggrun (2005) evaluates currency risk Reduction Effectiveness and hedge strategy for different portfolios. It's concluded that fully hedging bond portfolios results significant risk reduction while the equities portfolios' show insignificant risk reduction. While case of mixed portfolio using static approach results no significant reduction was obtained while using the second approach resulted in reduction of risk while the volatility of hedged and unhedged portfolios were the same and improving hedge portfolio returns

Likewise Drosos et.al (2008) investigated about the Hedging Effectiveness using weekly data of Standard and Poor (S & P) 500 stock index future contracts from 3 July 1992- 30 June 2002.Both constant and time varying models were used to estimate MVHRs and compared to identify the appropriate model. Its concluded that ECM outperforms OLS , GARCH, GARCH errors and EGARCH(1,1) models for estimating Hedging effectiveness on basis of higher R^2,significantly lower Residual Mean Square Errors (RMSE) and Chow test indicated consistent parameters for estimated hedge ratios.

Moreover Pinho and Madaleno (2010) evaluated the effectiveness of the minimum variance hedge ratios and expected utility in the EU-ETS carbon market for the first time. Daily spot and future data of Carbon Do-oxide (CO2) for four years have been considered from June 24,2005 to 9 October, 2009.Hedge effectiveness is analyzed using both OLS and MGARCH DBEKK models. It's concluded that Dynamic model provides higher Hedging Effectiveness values than static model. It's because of considering leptokurtic distribution. Results are obtained on the basis of in and out of sample on basis of utility increases as result of investor's importance over of risk increases.

2.3: Hedging and Derivative/Instrumental Tools

Sultan and Kroner (1993) investigated an alternative hedging model that estimates risk minimizing hedge ratios and compares its effectiveness with conventional hedging model. Several models of hedging were compared that included conventional hedge, naïve hedge and Error correction model using a GARCH error structure model. The spot and future exchange rate were considered. The conventional model ignores existence of co integration and dynamic nature of the distribution of the assets therefore bivariate GARCH error correction model that was employed. The first moment was modelled with a bivariate error correction model and second moment with a bivariate correlation model. The bivariate GARCH model outperform conventional hedge model .

Moreover Sephton (1993) analyzed significance and superiority of multivariate GARCH model in comparison traditional method of estimating optimal hedge ratio. It was indicated that calculating Hedge Ratio by GARCH model was more efficient. Traditional method was criticized based on restrictive assumptions i.e. expected return must be zero, covariance metrics between cash and future prices must be constant over time .The results concluded that multivariate GARCH model was superior , as it accounts for temporal evolution and leads to lower conditional variance of market returns.

However Wong and Zilcha (1999) identified the hedging opportunities for countries where there are no future market for own currency like Latin America and Asia pacific by availing cross hedging strategy that can reduce currency risk and manage it. Hedge Model was employed and it was analyzed that cross hedging has no impact on production but has impact on exports even unbiasedness of cross country future market does not ascertain nonrandom profit.

Likewise Rao and Thakur (2008) inspected Optimal Hedge Ratio and Hedge Effectiveness using future and options hedging tools in respect of India. Daily data of (1-1-2002 to 28-3-2002) future and option index of National Stock Exchange price risk was considered .Johnston Stein and Ederington (JSE) and Herbst Kare Marshal (HKM) methodologies are used to estimate optimal hedge ratios and hedge efficiency in Indian financial future market and Black -Scholes Model (BSM) and Fractional Brownian Motion (fBM) were used for option market. Overall, it is concluded that the optimal hedge ratios estimated by lateral models are significantly better than traditional models in case of future and option while no significant difference in returns from hedged positions.

However Chang et.al (2012) estimated variances and covariance using future agreement hedging daily currency risk. Two future contracts were used that was near month and next to near month future contract. Four multivariate GARCH volatility models were employed namely CCC, VARMA-AGARCH, DCC and BEKK. It was indicated that CCC and VARMA-AGARCH model were having same results for OHR, portfolio variance reduction and hedging effectiveness even not empirically critical to be estimated while DCC and BEKK model showed some difference regarding estimation.

Further Kumar (2012) conducted a study considering four national commodity future indices of India to analyze the price fluctuations and hedging behavior. A GARCH (1, 1) model was used in this regard to estimate spot return volatility using 2175 daily closing prices of commodities from 2005-2012. For estimating time varying hedge ratio and hedge reduction, DVECH, BEKK, CCC GARCH models were employed. It's concluded that the hedge ratios and hedge reductions estimated from all the GARCH type models reduce risk in contrast to unhedged portfolios' while DCC-GARCH and CCC-GARCH models outperform other models.

2.4: Hedging Based On Stocks and Equities

Haefliger et.at (2010) analyzed whether currency risk is a zero sum game. In this regard bond and equities were taken in to consideration. The method depends on several strategies in which average return and standard deviation of the reference currencies were estimated. Five financial markets were focused these included Germany, Switzerland, UK, US and Japan. It was suggested that hedging currency risk was beneficial for global bonds portfolio as compared to domestic bond and diversification plays a vital role in offsetting the currency risk reduction for foreign investment in case of equities.

However Gerald (2014) conducted a study regarding the importance of hedging instruments to compete and stand in the global financial environment .The paper is based on logistic industry i.e. United Parcel Services (UPS), hedging instruments can overcome the foreign exchange risk and interest rate risk in develop and developing countries. It was indicated that developing countries readily lack currency derivative markets therefore it has been suggested to avail cross hedging strategy because they require different hedging strategy. There is need of accountability of these derivative markets as a result of swaps among develop and developing countries specifically used by UPS.

Further Filipozzi & Harkmann (2014) investigated the extension of foreign investment bond hedging for minimizing portfolio risk. Weekly data of euro based investor is used and Optimal Hedge Ratio (OHRs) are compared by employing Ordinary Least Square (OLS) approach and Dynamic Conditional Correlation (DCC) GARCH. Both approaches give same results for Optimal Hedging while DCC GARCH outperforms standard OLS in terms of risk adjusted returns. The Sharp Ratios are better with dynamic approach but OLS hedge ratio results minimum variance. Overall its concluded that hedging be preferred for short term to attain perfect risk return trade off and foreign bond investment is sensitive to foreign currency risk should be partially hedged in case of multiple asset portfolios

2.5: Hedging Techniques

Schmittmann (2010) conducted a study on currency hedging based on Froot (1993) statement that currency hedging for longer horizons results in natural hedging by mean reverting behavior. The German, Japan, British and American investors were considered for analyzing the importance of international bond and equity portfolios using the Minimum Variance strategy. It was analyzed that on longer horizon there were few cases where variance of bond fully hedged were higher in case of US investors in UK bonds and Japan investors in US, German and UK bond. Even variance of equities hedged portfolios were higher than unhedged once portfolios in few cases. It was concluded that currency hedging was observed beneficial in long horizon as such there was no visible and authentic relationship in investment horizon and currency hedging.

However Roon et.al. (2012) investigated that Currency Hedging is no more a free lunch if price is attached with risk. The study is a comparison between hedged, unhedged currency and equity portfolios. The currency that are considered are US $, Euro, Australian dollar and Swiss franc. It considers the higher moments i.e Sharpe Ratio, skewness and kurtosis. Its concluded that unhedged currency portfolios outperform hedged currency portfolios regarding returns and higher moments.

2.6: Hedging and Foreign Exchange

Buesser (2011) the study investigates whether Markowitz (1952) Mean-Variance optimal hedge ratio upgrades the ex-post portfolio performance. Monthly data of the analysis is taken from 1995 to 2010. Swiss based CHF has been considered, investing in international portfolio having currency of USD, EUR, GBP and YEN. The analysis is twofold first based on ex-ante OHRs to be determined than comparison of OHRs with unhedged and fully hedged portfolio. It has been concluded that in long run the strategic portfolio combination of currencies lead to suitable results.

However Chang (2009) draws attention regarding hedging importance due to fluctuations in exchange rate markets, whether currency hedging is a 'Free Lunch'. For equity investors hedging is not a 'Free Lunch' rather it depends on higher risk means higher return and lower risk means low returns. Data has been taken on daily and monthly basis from 1987-2008, for hedged and unhedged indices while for five reserve currencies (USD,AUD,EUR, GBP and JPY) produces hedged indices by MSCI Barra and for 40 indices currencies .Thus its concluded that hedging depends on investors goals, reserve currencies , market and prospects of hedging .

2.7: Hedging in Pakistan

Akbar and Chauveau(2009) study evaluates exchange rate risk focusing Euro, American Dollar and Japanese Yen currency risk on Public Debt Portfolio of Pakistan (PDPP) by employing Value –at-Risk (VAR) technique. The study concludes that Pakistan lacks hedging strategies with respect to exchange rate exposure on the basis of component and Best Hedge analysis of VAR.

Moreover Afza and Alam (2011) explained the factors effecting firms hedging policies that highlights the foreign currency and interest rate derivative. Logit model was employed by taking 105 non-financial listed companies for the period of 2004-2008. Thus it was concluded that firms facing higher foreign currency exposure use hedge instruments.

Likewise Uppal and Mudakkar (2013) examined the importance of future hedging in oil imports of Pakistan. Portfolio model has been employed to assess the cost and benefits of hedging strategies from 1990-2013 using annual based simulating hedges. Thus on basis of exante cross analysis it was concluded that future hedging avails effective risk reduction benefits for Pakistan.

2.8: Critical Analysis and Conclusion

Overall in previous literature as discussed above hedging derivatives tools (spot, forward, future and options) were used to analyze their specific roles and importance relating to exchange rates volatilities and currency devaluation, while there is no specific study based on non-conventional way of currency hedging in financial engineering specifically for currency devaluation using Minimum Variance Approach provided expected return of mean is zero. The study that were reviewed based on various hedging techniques including cross hedging in case of developing countries but till now there is no specific study emphasizing on non-conventional and using actual values of currencies in their respective currencies to identify the best diversified portfolio that minimizes the risk and identifying such currencies that are bold and reserve to minimize risk of currency devaluation in case of Pakistan. In this perspective the present study will identify the currencies that play a vital role for reducing currency devaluation through hedging using diversification in case of Pakistan. The study will be a contribution for emerging economies to take decision regarding currencies or best diversified currency portfolios other than USD and along it to reduce the currency devaluation risks using Minimum Variance Approach and Hedge Reduction while in previous studies MV approach is used but with different perspective with derivative tools. In case of Pakistan there is no single study based on currency hedging using Minimum Variance Approach. The Chinese RMB is even not used in any study before for showing its significance in reducing currency devaluation against dollar in case of Pakistan.

Chapter 3

Theoretical Frame Work

This chapter is a broad explanation of the Theoretical Frame Work of Hedging concept. It's mainly divided into four sections. Section 3.1 explains the economic concept and evolution of the concept of hedging. Section 3.2 explains various strategies of Optimal Hedge Ratios (OHRs). Section 3.4 explains the various techniques used to estimate Optimal Hedge Ratios (OHRs).

3.1: Economic Concept of Hedging

In Economics the theory of Hedging was evolved based on two main hypothesis addressed by Keynes (1930) and Hicks known as Keynes-Hicks hypothesis. According to them the essential objective of hedging is to lessen risk and transfer the risk from risk averse agents to risk seeking agents (speculators). The existence of basic risk cannot eliminate all the risk that hedgers face.

According to Workings (1953) the goal of hedging is not to lessen risk rather to profit from changes in basis. Johnson (1960) suggested that hedging and speculative activities can be combined in financial markets. He developed a theoretical framework for those who want to reduce risk and compensate themselves (premium) in financial markets.

The Modern theory of hedging is a combination of above two theories that is Keynes-Hicks and Workings contribution that hedging basically aims to reduce risk while expected profits will be determined by the level of hedging.

The hedge concept has been originated from Markowitz (1952) portfolio theory .According to Hull (2003) the Hedge Ratio is define as “the ratio of the size of portfolio engaged in future agreements to the size of the exposure”

3.2: Strategies of Hedge Ratio

There are various strategies to estimate Optimal Hedge ratios but the most commonly and frequently used strategies are three in number. These strategies have been differentiated by researchers as the traditional/ one to one hedge ratio, Beta Hedge Ratio and the Minimum-Variance Hedge Ratio suggested by Johnston (1960) and Ederington (1979).

These strategies basically aim to define the optimal hedge ratio. The traditional hedge ratio basically aims at reducing the risk by availing future contracts.it based on fixed hedge i.e. $h^*=-1$ taking a future contract that is identical in magnitude to spot position but opposite in sign i.e. one to one relationship if prices variations in future market it matches exactly the same as in future contract.

The Beta Strategy is same as traditional strategy the only difference is that the cash portfolio to be hedge is not exactly same as future contract. Thus the hedge ratio estimated is negative of the beta of cash portfolio. It can analyze that if cash portfolio underlies the future contract the two strategies will give same result. In reality the spot and future market does not move in same direction and thus accordingly the hedge ratio estimated from above mentioned strategies will not reduce the risk. Both of these strategies are defined in the framework of spot and future.

3.2.1: Minimum-Variance Strategy

The Minimum Variance strategy was introduced by Ederington (1979) based on the portfolio theory developed by Johnson (1960) and Stein (1961). Ederington findings lead to the conclusion that firms should not avail Naïve hedging strategy if their motive is to reduce risk/minimize risk. Risk return is uncertain and varies in spot market measured by variance of expected returns. Therefore Optimal Hedge Ratios (OHRs) should be estimated that aims at estimating the variance of expected returns. Minimizing the variance of expected returns. In this regard minimum variance can be calculated considering an investor who wants short position in currency market and further to hedge long position in the foreign exchange market. The hedged portfolio return P_t in time "t" can be considered as

$$p_t = (c_t - c_{t-1}) - h_t (f_t - f_{t-1}) \quad (3.1)$$

Where $(c_t - c_{t-1})$ are the returns from local currency and $(f_t - f_{t-1})$ are returns from foreign currency while h_t is the hedge ratio. The variance of the return on Hedge ratio is

$$Var(p_t) = Var(c_t) + h_t^2 Var(f_t) - 2h_t Cov(c_t, f_t) \quad (3.2)$$

The Minimum Variance strategy is mostly preferred by researchers to estimate Optimal Hedge Ratio as it incorporates the imperfect correlation between the foreign and local currency markets. It was developed by Ederington (1979) and suggested by Johnson (1960) and Stein (1961) and define hedge ratio as

$$h_t^* = \frac{Cov(c_t, f_t)}{Var(f_t)} \quad (3.3)$$

Where $Var(f_t)$ the conditional variance of foreign currency exchange rate and $Cov(c_t, f_t)$ is the conditional covariance between local and foreign currency exchange rate position being hedged. The basic assumption regarding Minimum-Variance Hedge Ratio (MVHR) is that investors are risk averse infinitely. This assumption stands not reliable regarding risk-return trade off. Thus in this way the MVHR avails a confusing statement on the basis to check hedge performance (Butterworth and Homes, 2001).

3.2.2: Performance Analysis

Performance analysis of MVHR can be estimated for naive and time varying HRs by Variance Reduction or Effectiveness approach introduced by Ederington (1979). The Hedge performance can be estimated using variance of hedged and unhedged portfolios given and explained by the formula mentioned under

$$Var(U) = \sigma_c^{\ 2} \tag{3.4}$$

And

$$Var(H) = \sigma_c^{\ 2} + h^{*2}\sigma^2{}_f - 2h^*\sigma_{c,f} \tag{3.5}$$

In above equations (3.4) and (3.5) Var (U) and Var (H) indicates variance of hedged and unhedged portfolios

Here $\sigma^2{}_c$ and $\sigma^2{}_f$ are variances of Local currency returns and Foreign currency returns. The h^* coefficient of hedge ratio while σ_{cf} indicates covariance of local and foreign currency return series.

$$HR = \frac{Var(U) - Var(H)}{Var(U)} \times 100\% \tag{3.6}$$

Here Hedge Reduction is denoted by HR where $Var(U)$ and $Var(H)$ indicates Variance of hedged and Unhedged portfolios.

3.2.3 Mean-Variance Strategy

The Mean-Variance strategy is another approach to estimate OHR that was originated on basic micro economics theory that can be explained as investor wants to maximize his expected utility from his portfolio. Where expected utility is linear function and increasing in expected returns while decreasing in variance return.

$$MaxEU(p_t) = E(p_t) - \gamma V(p_t)$$

$$= Max\{E(p_t) - \gamma \lfloor Var(s_t + h_t^2 Var(f_t) - 2h_t Cov(c_t, f_t)) \rfloor \tag{3.7}$$

Here γ is relative measure of risk preference.

$$h_t = \frac{Cov(c_t - f_t)}{2Varf_t} - \frac{E(f_t - f_{t-1})}{\gamma Var(f_t)} \tag{3.8}$$

This is first order condition of this variance with respect to h_t.

The second part of the above equation is speculative demand for future. According to Benningga, Eldor and Zicha (1984) the minimum Variance is consistent to Mean-Variance if foreign currency market is unbiased.

The unbiased hypothesis is property of many future markets. The expected return of future market is equal to zero, based on Martingale model or random walk model the second term will therefore be zero. Thus if unbiasedness property holds the Mean- Variance and Minimum- Variance hedge Ratio, s are identical.

3.3: Econometric Methods Used to Estimate Optimal Hedge Ratios

Minimum-Variance has edge over Mean-Variance Approach so researcher's mostly use Minimum-Variance to estimate OHR. In case of MV approach various econometric techniques can be employed to estimate OHRs. These methods are discussed as under.

3.3.1: Static Method

The OLS method is recognized as the static method that is used to estimate Minimum Variance Optimal Hedge Ratios (MVOHR), where MVOHR is the slope coefficient of future price when return on the spot market is regressed on the return on the future market by OLS method. The model is

$$\Delta c_t = a + h^* \Delta f_t + \varepsilon_t \tag{3.9}$$

Here the slope coefficient h^* is the OLS Minimum Variance Hedge Ratio.

The OLS method has been criticized on two main reasons

First the OLS based on unconditional variance, Covariance and the conditional information is omitted.

Second time varying characteristics are ignored in time series (Baillie and Myer; 1991)

3.3.2: Dynamic Method

The other method used to estimate Minimum Variance Hedge Ratio (MVHR) is Dynamic method, introduced by Myer and Thompson (1989). This method permits the conditional variance and covariance matrix to change over time. This shows a generalized approach that is not difficult to apply and is more reliable.

Here Optimal Hedge Ratio is

$$\left(h_t^* / X_{t-1}\right) = \frac{Cov\left(c_t, f_t / X_{t-1}\right)}{Var\left(f_t / X_{t-1}\right)} \tag{3.10}$$

Where X_{t-1} is a vector of variables that depend on variance and covariance of variables known at t-1. The traditional OLS method was modified by Miffre (2004) to conditional OLS estimate of OHR in exchange rate to future market.

The Conditional OHR equation regression attained is

$$\Delta c_t = a + a_1 X_t + h^* \Delta f_t + b \Delta f_t X_{t-1} + \varepsilon_t \tag{3.11}$$

Here X_{t-1} is a vector of mean zero predetermined instruments variables available at time t-1. The Conditional OLS is easy to estimate Instrument variables i.e. Macroeconomics factors are used as predetermined instrument variables. It's not easy to identify and search instrument variables by researchers to represent actual information used by hedgers for all future markets therefore mostly consider the lagged endogenous variable themselves as instrument variables.

3.3.3: Time Series Techniques

For Multivariate time series Vector Auto-Regressive Moving Average (VARMA) is one of the most successful models. Its basis of building other multivariate models and analyzing the dynamic behavior of time series.[7] If Co-integration relationship among variables is tested the VECM is an appropriate model to deal with such Time Series. The static approach is criticized on basis of problem of serial correlation and heteroscedasticity. It has been shown (Pindyck, 1984: Poterba and Summers, 1986; Bollerslev, 1986; Baillie and De Gennaro, 1990) that stock returns suffers from the problem of time varying heteroscedasticity and hence violates assumption of variance-covariance matrix of return is constant over time. Thus for improvement of estimation of hedge ratio the time varying assumption of second moment based on recent work by (Bailie and Myer 1991; Myer 1991; Sephton,1993;Park and Switzer, 1995)proposed strategies based on General Autoregressive Conditional Heteroscedasticity (GARCH) models. Various researcher come to the conclusion that GARCH class of models for hedging strategies outperform other methods or techniques for estimating hedge ratio and permit the conditional variance and covariance to be time varying as used inputs to the hedge ratio.

3.4: Estimation Method of Optimal Hedge Ratio

Modelling volatility in financial time series was the concern of much consideration ever since the starter of ARCH model in the serial paper of Engel (1982). Thus further the extension of these ARCH models has been such GARCH, Exponential Autoregressive Conditional Heteroscedasticity (EGARCH) and multivariate GARCH models. The Multivariate GARCH models are burdensome in estimation and are not easy as univariate GARCH models.

[7] The ARMA model was introduced and described in 1951 by Peter Whittle and in1971 it was popularized by George E.P Box and Gwilym Jenkins,s Book. ARMA model is combination of Autoregressive (AR) and Moving Average (MA) model.It is mentioned as the ARMA (p,q) model where p is the order of AR and q is the order of MA model.

In the current study will use Multivariate GARCH model to estimate Minimum-Variance Optimal Hedge Ratio by Baba Engel Kraft and Kroner Model (BEKK) introduced by Engel and Kroner (1995).BEKK is an alternative dynamic model that has an attractive property of conditional covariance matrices are positive definite. BEKK suffers from problem of so called "curse of dimensionality". The BEKK (p,q,k) model for multivariate GARCH $(1,1)$ is given as under

$$H_t = CC' + \sum_{i=1}^{q}\sum_{k=1}^{k} A'_{ki}\varepsilon_{t-1}\varepsilon'_{t-i}A_{ki} + \sum_{i=1}^{p}\sum_{k=1}^{k} B_{ki}'H_{t-1}B_{ki} \qquad (3.12)$$

Here $A_{ki}, B_{ki}\, and C$ are T X T parameters matrices while C is a lower triangular matrix; C guarantees the positive definiteness of H_t in BEKK model. This representation is general form of model it comprises all positive definite diagonal demonstrations and almost all positive definite Vector Error Correction model (VECM) representation.[8]

The conditional variances are function of their own lagged values and own lagged return shocks while the conditional covariances are function of the lagged covariance's and lagged cross-products of the corresponding returns shocks. The BEKK construction assurances H_t to be positive definite surely for all t.

BEKK models suggest a unique VEC model, which then produces positive definite conditional covariance matrixes. Engel and Kroner (1995) offer sufficient conditions for two models Baba Engel Kraft and Korner (BEKK) and VEC to be equivalent. Estimation of a BEKK model still involves fairly hard calculation due to several matrix transposals. The sum of

[8] A Vector Error Correction model is a dynamic system with the features that the deviance of the current condition from its long run relation ship will be served into its short-run dynamics.

parameters (p,q,k) is $(p+q)KT^2+T(T+1)/2$ in full BEKK model .The BEKK type models are nonlinear in parameters therefore convergence difficulty results in the models.

3.4.1: Merits of BEKK model

The BEKK advantages is that the construction spontaneously confirms positive definiteness of H_t, so this does not required to be forced separately. Mathematical problems are mutual in the estimation of BEKK models therefore assumed p=q=k=1 in application. Positive definiteness on parameters restrictions are not rated in the matric exponential GARCH model suggested by Kawakalsle (2006). While the positive definiteness of covariance's matrix H_t follows from the fact that for any symmetric matrix.

Models contain large number of parameters, Kawakatsle (2006). It's clear that the original VEC model comprises two many parameters to be easily applicable and research has been concentrated on finding parsimonious alternatives too. In this regard two points are visible regarding VEC and BEKK models,

First restriction is imposed on parameters of VEC models. Second there is the idea of modelling conditional covariance's over conditional variance and covariances.

3.4.2: DBEKK Model

The highly simplified version of BEKK model by empirical applications is when A and B in general model of BEKK models are supposed to be diagonal. This is called Diagonal BEKK model suggested by Bollerslev, Engle and Wooldridge (1988). The basic merit of this model is that the sum of parameters decreased while still maintaining positive definiteness of H_t.

In present study will imply DBEKK technique to evaluate the Minimum-Variance Optimal Hedge Ratio and Hedge Effectiveness. The DBEKK model imposes restriction on the number of parameters to be estimated while in full BEKK model even the estimation is burdensome so use DBEKK model that resultantly cuts the sum of parameters to be estimated as the formula given below.

$$(p+q)KT+T\,(T+1)/2 \qquad (3.13)$$

in the diagonal one, is still quite large. The DBEKK model is less restricted than Scalar Baba Engel Kraft and Korner (SBEKK) model and parsimonious on other way. The returns are found to be non-normal/Guassian therefore will use Student "t" distribution. The student t distribution introduced as the distribution of innovation with an additional parameter to be estimated. The multivariate student t distribution assumption the log likelihood the t distribution is given as under.

$$l\left(\frac{\varepsilon_t}{\eta_t}\right)=\left(\frac{\Gamma((N+V)/2)}{\Gamma\left(\frac{v}{2}\right)[\Pi(v-2)]^{N/2}}\right)^{T} x \qquad (3.14)$$

$$\prod_{t=1}^{T}|H|^{-1/2}\left\{1+\frac{1}{v-2}(R_t-X_t(\beta_t))' H^{-1}{}_t(R_t-X_t(\beta))\right\}^{-N+v/2} \qquad (3.15)$$

Where $\Gamma(.)$, gamma function and v is degree of freedom and R stands for returns.

Conclusion:

Thus on the basis of in-depth explanation of the theoretical framework of the Hedging concept the Minimum-Variance (MV) approach dominates Mean-Variance approach. The dynamic model outperforms static models on the basis of drawbacks of static models for estimating Optimal Hedge Ratios (OHRs).Thus on the basis of the above analysis will use DBEKK model for estimation of Minimum-Variance and Hedging Effectiveness as it imposes restrictions on the number of parameters to be estimated as compared to BEKK and SBEKK model.

Chapter 4

Data and Methodology

This chapter discusses the data, Optimal Hedge Ratio and methodology framework of the study

4.1: Data

Daily exchange rates returns are taken in local to foreign currencies from 2010-2015. The exchange rates in Pak Rupee of currencies used are US Dollar ($), Euro (€), British Pound, Japanese YEN(¥) and Chinese Yuan (CHY) . These currencies are known to be prominent and stable; these currencies represent Europe, US and Asia. All the exchange rates return series are found to be skewed leptokurtic and hence non-normal as usually financial time series are expected to be.

The source of data is Business Recorder, Foreign exchange Pakistan and State Bank of Pakistan (SBP). Data has been collected on daily basis from 1st January 2010 to 31st July, 2015. These five years are divided into two separate phases i.e. from 2010-2012 and 2013-2015 specifying political party phases. The inclusion of CHY currency in the portfolio is to represent the influence of Chinese currency in currency devaluation. During these five years Pakistan's economy suffered from several changes like experience of high inflation including fuel and food inflation, Floods that effected Pakistani currency.[9]

4.2: Optimal Hedge Ratio (OHR)

Optimal Hedge Ratio aims at minimizing risk of investment in a diversified portfolio that reduces the investment risk. The Optimal Hedge Ratio is an extension of Markowitz (1952)

[9] www.brecorder.com, www.forex.pk.com & www.sbp.org.pk

Portfolio theory. There are several approaches that have been developed to estimate Optimal Hedge Ratio (OPH) known as Minimum Variances (MV). The approaches are incorporated on basis objective functions. There is no consent which one OHR is superior to others Chen et.al (2004).Naive strategy was used to estimate OHRs in old time while the naïve strategy assumed hedger to be risk averse and completely eliminate risk. In real grounds no two assets are perfectly and negatively correlated. Johnson(1960) and Stein(1961) introduced the new portfolio hedging approach. Johnson (1960) introduced the Minimum Variance Hedge Approach (MV) as an alternative to the traditional hedge ratio He was the first to apply Modern portfolio theory to the hedging problem and was the first to incorporate mean and variance as risk and return in hedge problem. He kept the traditional objective function of hedge as minimization of risk and defined risk as the variance of return on a two asset hedged portfolio. On the basis of this new approach Ederington (1979) introduced a famous theory on hedging that assumes investor to be a risk averse. In previous studies derivatives were used to hedge currencies fluctuations i.e in spot and future perspective while in this study actual values of currencies in local terms are used to estimate the OHR by using MV approach.

4.2.1: Minimum Variance (MV) Technique

MV approach is based on new portfolio theory in this new approach Ederington (1979) assumed that investor is risk averse and desires to minimize risk. MV is not only easy to understand and implement but also superior case of all other methods that is Optimum Mean-Variance approach, Maximum Expected Utility Approach, Mean Extended Gini Coefficient

Hedge Ratio approach under the condition that expected return of security is zero.[10] Empirically it is establish that expected return of mean is around zero, also return series are mean reverting. These findings persuade to follow Minimum Variance approach to follow objective of Minimum Variance.

4.2.2: Estimation of Optimal Hedge Ratio

Let, B_{t1}, B_{t2}, B_{t3}, B_{t4} and B_{t5} are the five distinct exchange rates in local currencies, Here $r_i = \log(B_{ti}/B_{ti-1})$ for (i=1,2,3,4,5) show their returns and r_p indicates hedged portfolio returns that consists of five currencies while the analysis has been undertaken on tetra variate basis by using bi,tri and tetra portfolios of currencies. Thus the Minimum Variance strategy is described as under

Minimum Variance (MV) strategy

Risk= Variance of returns on Hedged portfolio

$r_p = r_1 - \alpha r_2 . \beta r_3 . \rho r_4 . \delta_5$

Risk = $Var(r_p) = Var(r_1 - \alpha r_2 . \beta r_3 . \rho r_4 . \delta_5)$

Thus MV formula to get Optimal Hedge Ratio is

$$\sigma_{ij} = \text{cov}(r_i, r_j) \text{ for } i \neq j$$

$$\sigma_{ii} = \text{var}(r_i)$$

$$\text{Hedge Ratio} = Cov(r_i, r_j) / Var(r_i) \quad (4.1)$$

Here the OHR formula is given in general form for bivariate analysis where Cov stands for covariance. r_i stands for return of local currency and r_j return of foreign currency divided by

[10] These are the distinct Hedge Ratios having different objective functions i.e Optimum Mean-Variance HR objective to maximizes expected return and minimize risk, Maximize expected utility HR objective maximize utility and Minimum MEG coefficient HR to Minimize the risk.

Variance of foreign currency. In the same way OHRs are estimated for each portfolio on tetra variate analysis basis.

The Optimal Hedge Ratio are estimated in the last step using Multivariate Generalized Autoregressive Conditional Heteroscedasticity (MGARCH) (p,q) i.e. DBEKK technique.

4.2.3: Baba Engel Kraft and Korner (BEKK)

BEKK is another dynamic conditional model. BEKK has the property that conditional covariance matrices are positives certain. Although BEKK has the major drawback of "Curse of Dimensionality"[11] (McAleer et.al 2014). The multivariate GARCH (1,1) BEKK model is explained as under

$$H_t = C'_H \; C'_H + A'\varepsilon_{t-1}\varepsilon'_{t-1}A + B'H_{t-1}B, \qquad (4.2)$$

Where C_H, A and B are the individual matrices given as

$$A = \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix}, B = \begin{pmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{pmatrix}, C = \begin{pmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{pmatrix}$$

In case of BEKK the conditional variances are function of their particular lagged values and particular lagged return shocks in the same way the covariance are function of lagged and cross-product lagged of respective shock returns. Thus because of the drawback of BEKK model we used DBEKK technique to estimate OHR using MV approach.

4.2.4: Multivariate DBEKK (p,q,k) model

The Multivariate DBEKK (1994) model that will be used to estimate the OHRs for the several portfolios is discussed as under.

[11] Curse of Dmensionality arises when investigating and organizing data in high dimensional spaces (often with hundreds or thousands of dimensions) that do not arise in low- dimensional setting. In case of BEKK model the problem arises as result of too many parameters to be estimated.

$$H_t = C'C' + \sum_{t=i}^{q}\sum_{k=1}^{K} A'_{ki}\varepsilon_{t-1}\varepsilon'_{t-i}A_{ki} + \sum_{i=1}^{p}\sum_{k=1}^{K} G'_{ki}H_{t-i}G_{ki} \tag{4.3}$$

Where $H_t = \begin{bmatrix} h_{11,t}h_{12,t}h_{13,t}h_{14,t} \\ h_{21,t}h_{22,t}h_{23,t}h_{24,t} \\ h_{31,t}h_{32,t}h_{33,t}h_{34,t} \\ h_{41,t}h_{42,t}h_{43,t}h_{44,t} \end{bmatrix}$, C = $\begin{bmatrix} c_{11}000 \\ c_{21}c_{22}00 \\ c_{31}c_{32}c_{33}0 \\ c_{41}c_{42}c_{43}c_{44} \end{bmatrix}$

$DiagA = [a_{11}, a_{22}, a_{33}, a_{44}]$

$DiagG = [g_{11}, g_{22}, g_{33}, g_{44}]$

In the study optimal hedge ratio is estimated by tetra variate DBEKK diagonal model and then Hedge Reduction are also estimated. In this concern for analyzing the robustness residual analysis was estimated. In case of Pakistan highest percentage of reserve currencies are kept in dollar and dollar is used as a reserve currency. For hedging purpose used dollar in terms of local to foreign currency with other four currencies i.e. Euro, GBP, Yen and CHY. These four currencies are known as reserve currencies. CHY is recently declared as the fifth Special Drawing Rights (SDR) currency. China having strong economic and regional ties with Pakistan.

These portfolios are separately explained as under in general form while for each phase undertaken separately.

Portfolio 1: Dollar returns on four hedging currency returns Euro, Pound, Yen and Chinese Yuan

Portfolio 2: Dollar returns on two hedging currency returns Euro and Pound

Portfolio 3: Dollar returns on three hedging currency returns Euro, Yen and Yuan

Portfolio 4: Dollar returns on three hedging currency returns Pound, Yen and Yuan

Portfolio 5: Dollar returns on two hedging currency returns on Yen and CHY

Portfolio 6: Dollar returns on single hedging currency return on CHY

Here in the general model r_1 is the return of Dollar while r_2, r_3, r_4 and r_5 are returns of Euro, Pound, Yen and Yuan. r_p is return of Hedged Portfolio.

This is our general portfolio as mentioned below and accordingly the general model is further segregated into different combination of strong/reserve currencies in combination of distinct various portfolios

$$r_1 = \alpha + \beta r_2 + \delta r_3 + \phi r_4 + \lambda r_5 \quad (4.3)$$

$$r_p = Var(H) = Var(rp) = Var(r_1 - \alpha - \beta r_2 - \delta r_3 - \phi r_4 - \lambda r_5) \quad (4.4)$$

4.3: Hedge Reduction/Hedge Effectiveness (HR/HE)

The hedging effectiveness is estimated to relate the performance of OHRs from multivariate conditional volatility models. In the present study Hedging Reduction are estimated for each portfolios in each phase for analyzing the best portfolio among the several portfolios showing the best hedging effectiveness. A higher HR shows a higher hedging effectiveness and large risk reduction higher Hedge Reduction (HR) explains greater hedging strategy. The HR was introduced by Johnson(1960) to estimate the hedging effectiveness (E) of the hedged situation in terms of the reduction in variance of the hedge VAR (H) over the variance of the unhedged position VAR (U).

Reduction in Risk is calculated as below. Let Var (U) and Var (H) are variances of returns of unhedged and hedged portfolios correspondingly, where β,δ,ϕ and λ are the optimal hedge ratios.

Hedge Reduction = $[Var(U) - Var(H)] / Var(U)$ (4.5)

Where $Var(U) = r_1$

Here $r_1 = \alpha + \beta r_2 + \delta r_3 + \phi r_4 + \lambda r_5$ (4.6)

And $Var(H) = Var(rp) = Var(r_1 - \alpha - \beta r_2 - \delta r_3 - \phi r_4 - \lambda r_5)$ (4.7)

Conclusion:

Johnson (1960) introduced the Minimum Variance Hedge Approach (MV) as an alternative to the traditional hedge ratio .He was the first to apply Modern portfolio theory to the hedging problem and was the first to incorporate mean and variance as risk and return in hedge problem. MV technique is based on new portfolio theory in this new technique Ederington (1979) assumed that investor is risk averse and desires to minimize risk. MV is not only easy to understand and implement but also special case of all other methods In the study DBEKK model is used to estimate OHRs for the two phase's portfolios separately. Tetra Variate analysis has been undertaken employing MV approach.All the portfolios of currency returns were explained being used in the two phases. Hedge Reductions are also estimated for assessing hedge performance of each portfolio of currency returns for the two phases for reducing currency devaluation.

Chapter: 5

Empirical Results and Discussion

This chapter is a detail explanation of the empirical results obtained from the study. In the initial level the visual inspection and diagnostic analysis has been deliberated in section 5.1 than empirical results are discussed in section 5.2 based on the Minimum variance Approach using Multivariate Diagonal Baba Angel Craft and Model (DBEKK).In this regard the empirical analysis is undertaken in two phases based on political parties regime i.e. the first phase from 2010-2012 and second phase from 2013-2015.

5.1: Visual Analysis of First Phase (2010-2012)

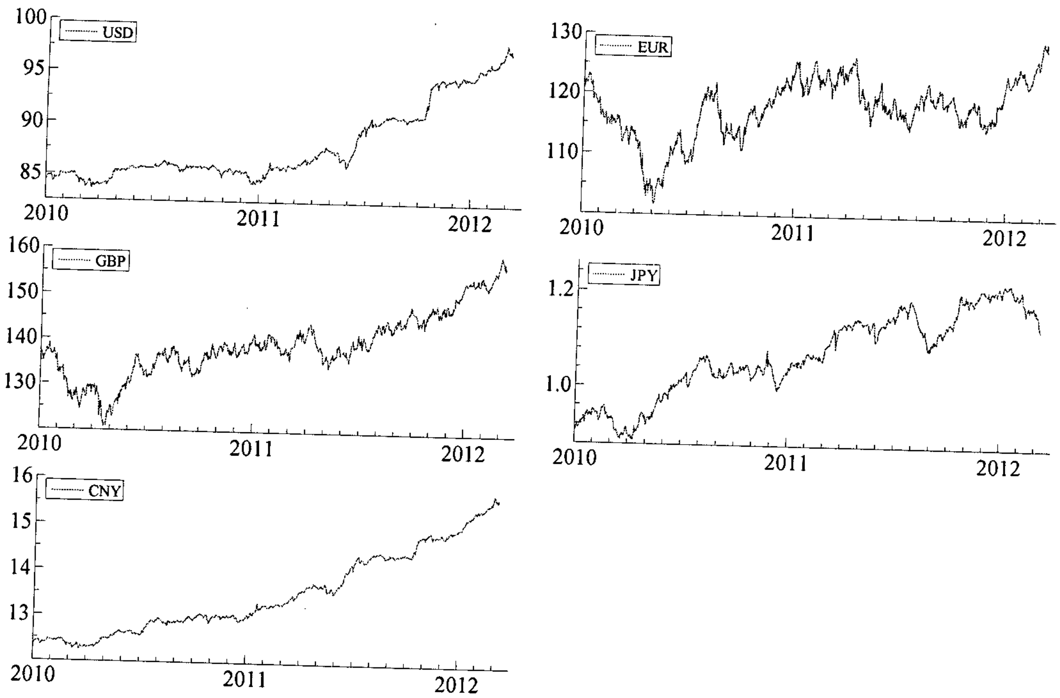
In this section visual inspection of the five currencies are explained and briefed. In case of financial data visual inspection is essential for GARCH type modelling and is a pre-requite. The visual inspection is not as reliable as diagnostic analysis for the validation of time series properties/statistics of the currencies therefore diagnostic analysis is also undertaken.

5.1.1: Actual Series

The actual graph represents the daily exchange rate of foreign currencies i.e. USD, EUR, GBP, JPY and CHY in terms of Pakistani rupees at level. It can be observed that the exchange rates show an upward trend during the first phase (2010-2012). It also depicts depreciation of domestic currency in terms of foreign currency. In case of financial data show trends at level as given in figure 5.1. Robust model estimation is not possible for trend series. For dealing with trend returns series are considered.

Robust model are not applicable in case of variables at level. In this regard returns are estimated there are two specific methods to estimate the return series these are log and growth method both gives same results. The log difference method is used to estimate return series in this study.

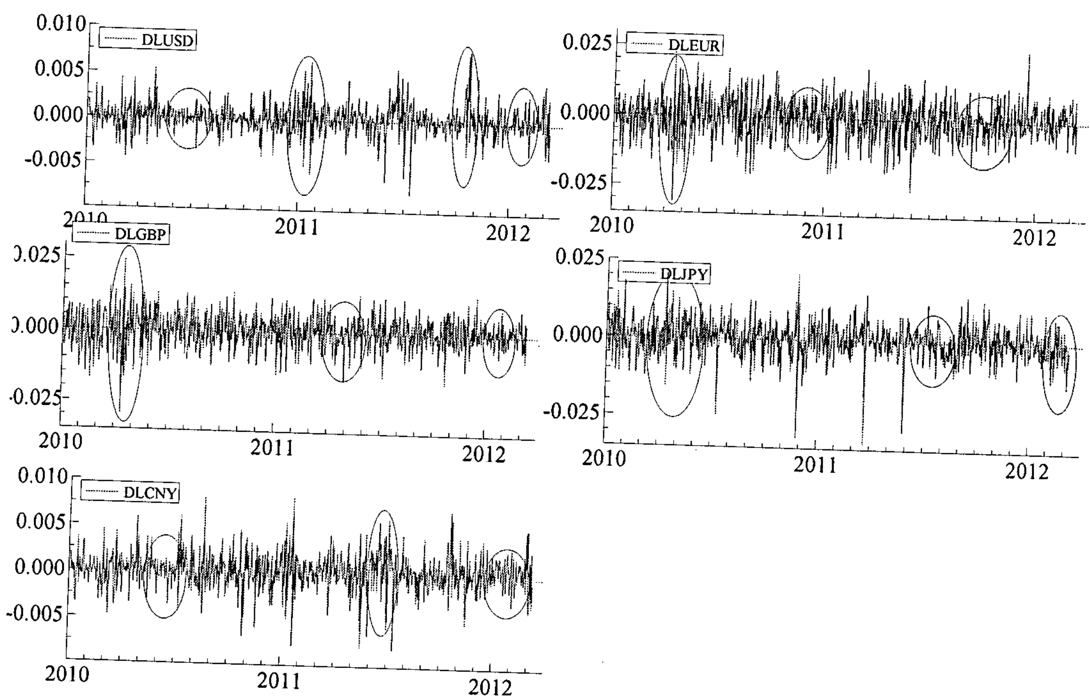
Figure 5.1: The daily Pak rupees exchange rate at level showing an upward trend



5.1.2: Volatility Clustering

Financial data are subject to Autoregressive Conditional Heteroscedasticity (ARCH) effect and volatility clustering. It's the result of good and bad news in the exchange rate and stock market. In foreign exchange market there is huge amount of uncertainty and risk that can be represented by the volatility of the exchange rate return series. In such case the variances changes over time and tends to cluster. There is no specific pattern and have mean reversion behavior .The market players are more concerned regarding the ups and downs in exchange rate, shares and bonds prices. The bullish and bearish behavior of the market is represented by the ups and downs in financial instruments. The given figure 5.2 shows the volatility in the financial market regarding the return series of USD, EUR, GBP, JPY and CHY. It can be observed that high volatilities are easily differentiated by low volatilities following the same pattern as high volatilities followed by high once and low volatilities followed by low once.

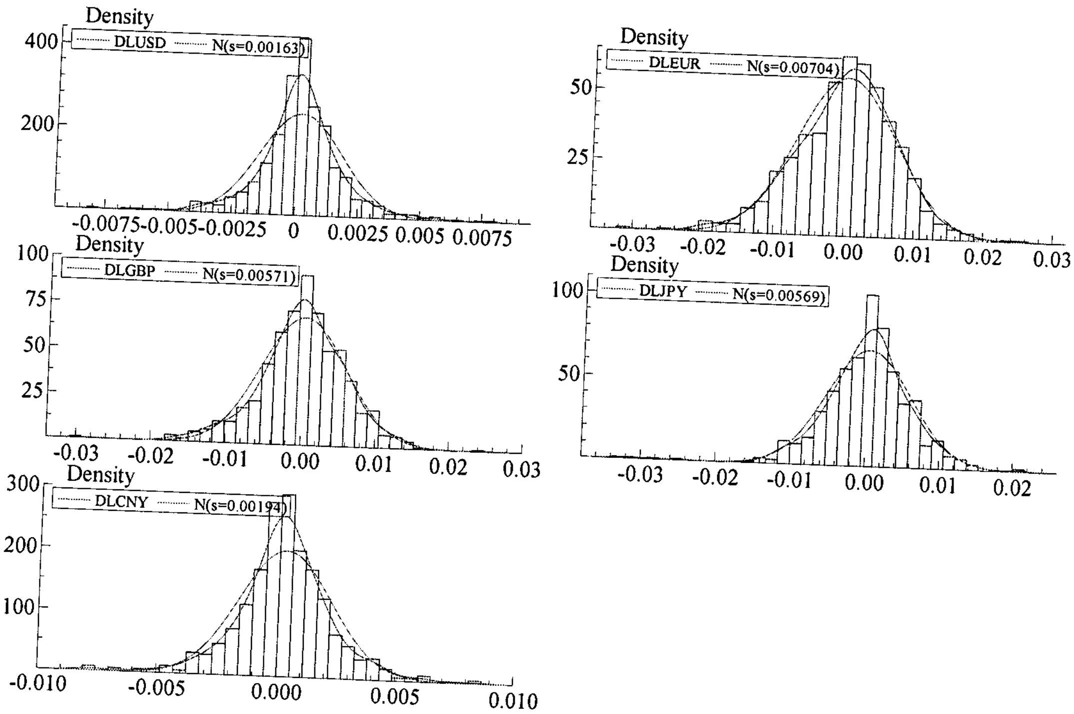
Figure 5.2: The daily exchange rate showing volatility clustering



5.1.3: Distribution of the return series

The distribution of the daily exchange rate return series shows a Non normal distribution with fat tails. It identifies leptokurtosis. It can be observed in figure 5.3 that all the return series are subject to non-normal distribution. The USD and CHY are highly skewed and non-normal while the return series of EUR, GBP and JPY are leptokurtic and maximum data is scattered on right side showing non normal distribution of the series.

Figure 5.3: The Daily Exchange rate return series showing Non normal distribution, skewness and leptokurtosis

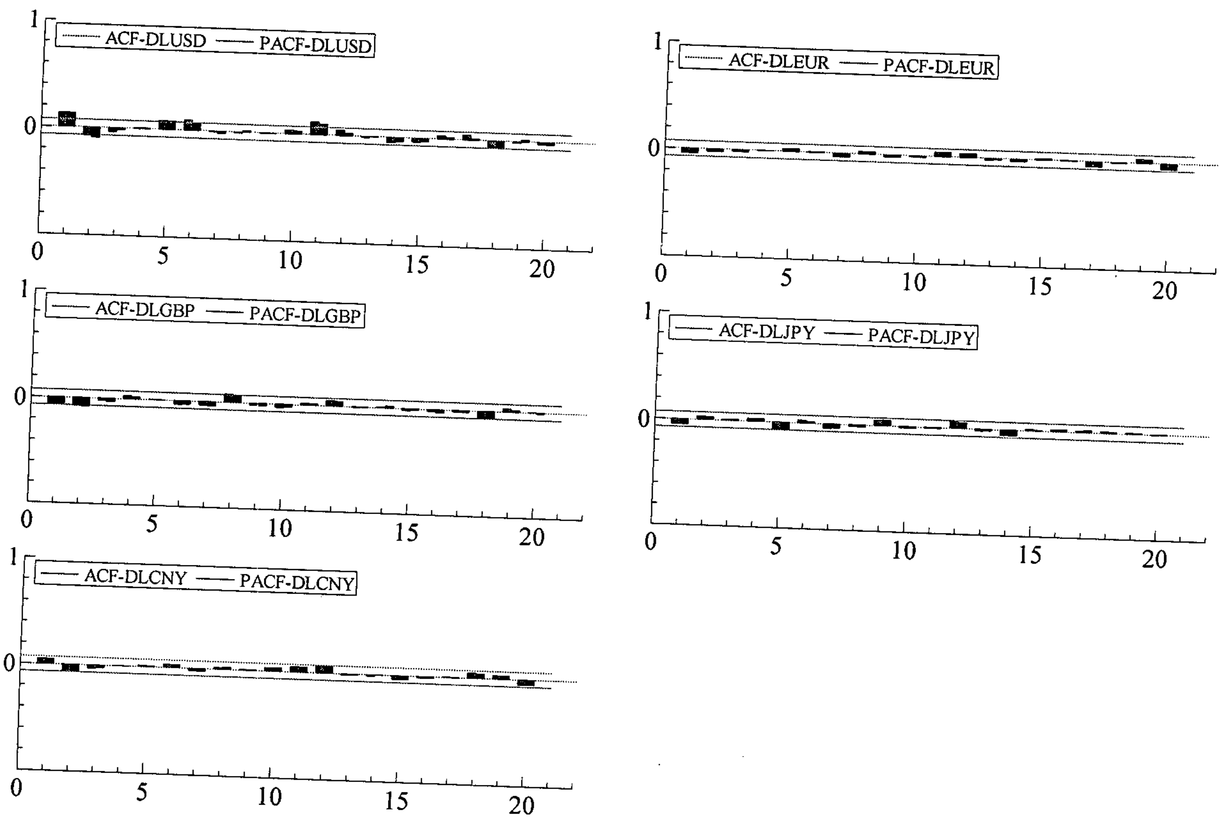


5.1.4: Autocorrelation and Partial Autocorrelation

The Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) of the daily exchange rate return series represent the short memory and dying out of return series. The autocorrelation are mostly removed by taking first difference. The spikes also represent the difference and lags to be taken to tackle the problem of autocorrelation.

The Partial Autocorrelation and Autocorrelation help to differentiate between AR (m) and MA (n) term in ARMA (m, n) model. The spikes that go outside the 95% bands represent the AR (m) and MA (n) terms in the models. It can be seen that in figure 4 in case of USD return series the first, second, fifth, sixth and tenth spikes are outside the band ensuring autocorrelation. It also represent that the autocorrelation are not persistent and die out very fast by introducing the lags. It also explains their short memory property. The other return series of EUR,GBP,JPY and CHY are showing all the spikes within the 95% band which in actual is not possible and exist, it's the reason that visual inspection is considered not reliable and never show actual picture so prefer residual analysis for ensuring the real picture of financial series problems.

Figure 5.4: The Autocorrelation and Partial Autocorrelation of the daily exchange return series

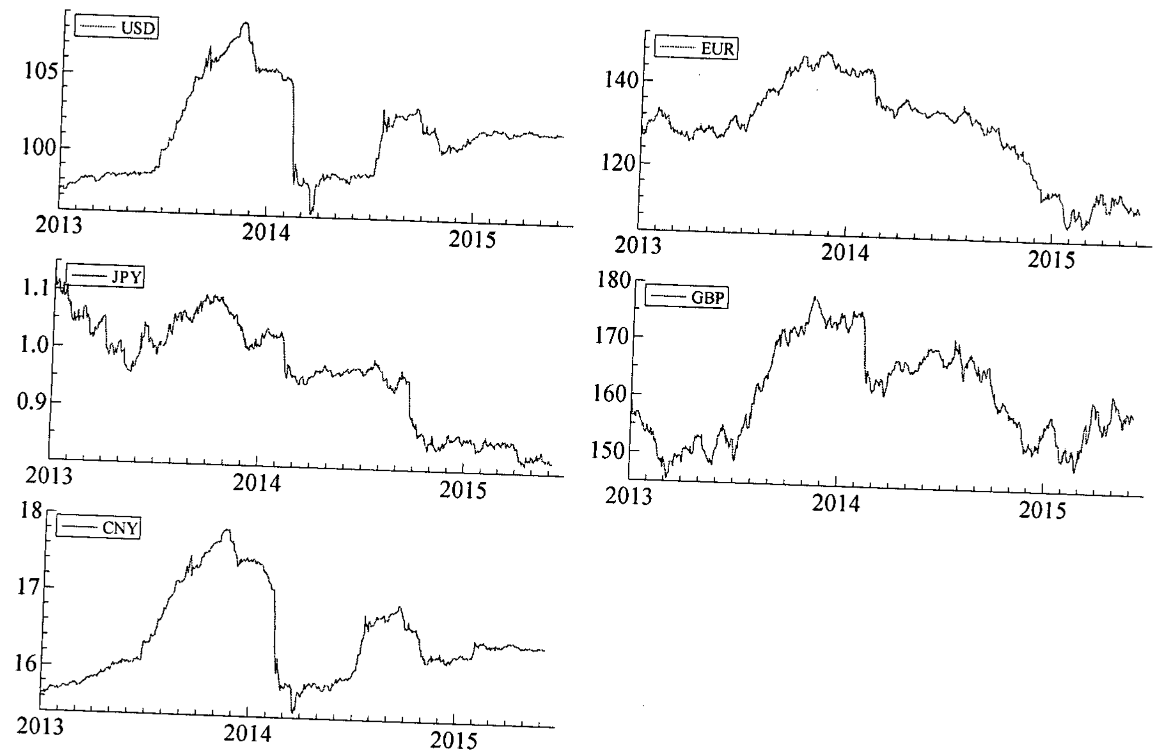


5.2: Visual Analysis of Second Phase

The Visual analysis of phase second i.e. from 2013-2015 is undertaken separately and explained as under.

5.2.1: Actual Series

Figure 5.5: Actual Series of daily exchange rate series at level Second Phase



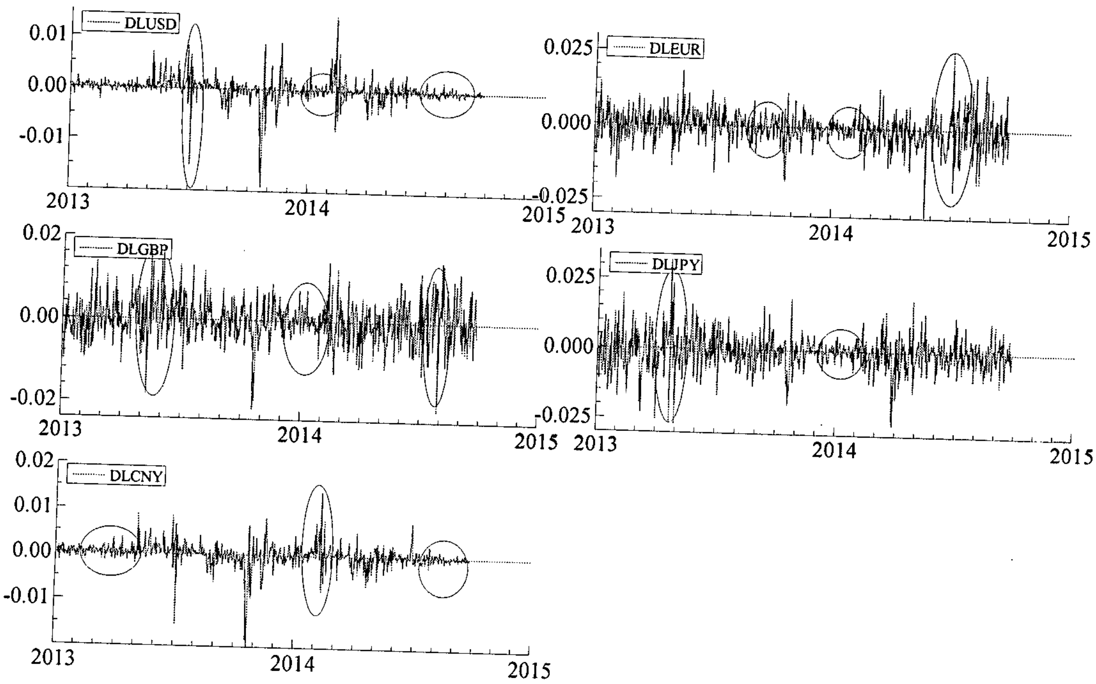
It can be observed in the above figure 5.5 that the actual series that all exchange rate series show a mixed/unidentified pattern for the time phase from 2013-15 while JPY series show downward trend. All the return series of the currencies show depreciation in terms of Pakistan rupees in 2014 that resulted from surprise receipt of a Saudi grant of US$ 1.5 billion and the expectation of deferred oil facility that Pakistan was given in 1998. The Net

International Reserve (NIR) of Pakistan was worse i.e. it was negative 2.4 billion and thus IMF set the condition for SBP to purchase $125 from Foreign Exchange market by end of 2013.

5.2.2: Volatility Clustering

Financial time series data are subject to Autoregressive Conditional Heteroscedasticity (Engel 1982) and volatility clustering. It evolves as a result of market bullish and bearish trend as the positive returns are followed by positive one and negative returns are followed by negative one. The volatility diagram as given in figure 5.6 shows the mean reversion behavior of the daily exchange rate return series with no definite pattern. It also explains volatility clustering stylized facts. Figure 5.6 shows no definite pattern and trend in the exchange rate return series and representing mean revert behavior. Even the volatility can be explained and depicted in terms of high and low volatility thus indicating Autocorrelation Conditional Heteroscedasticity (ARCH) effect in the return series.

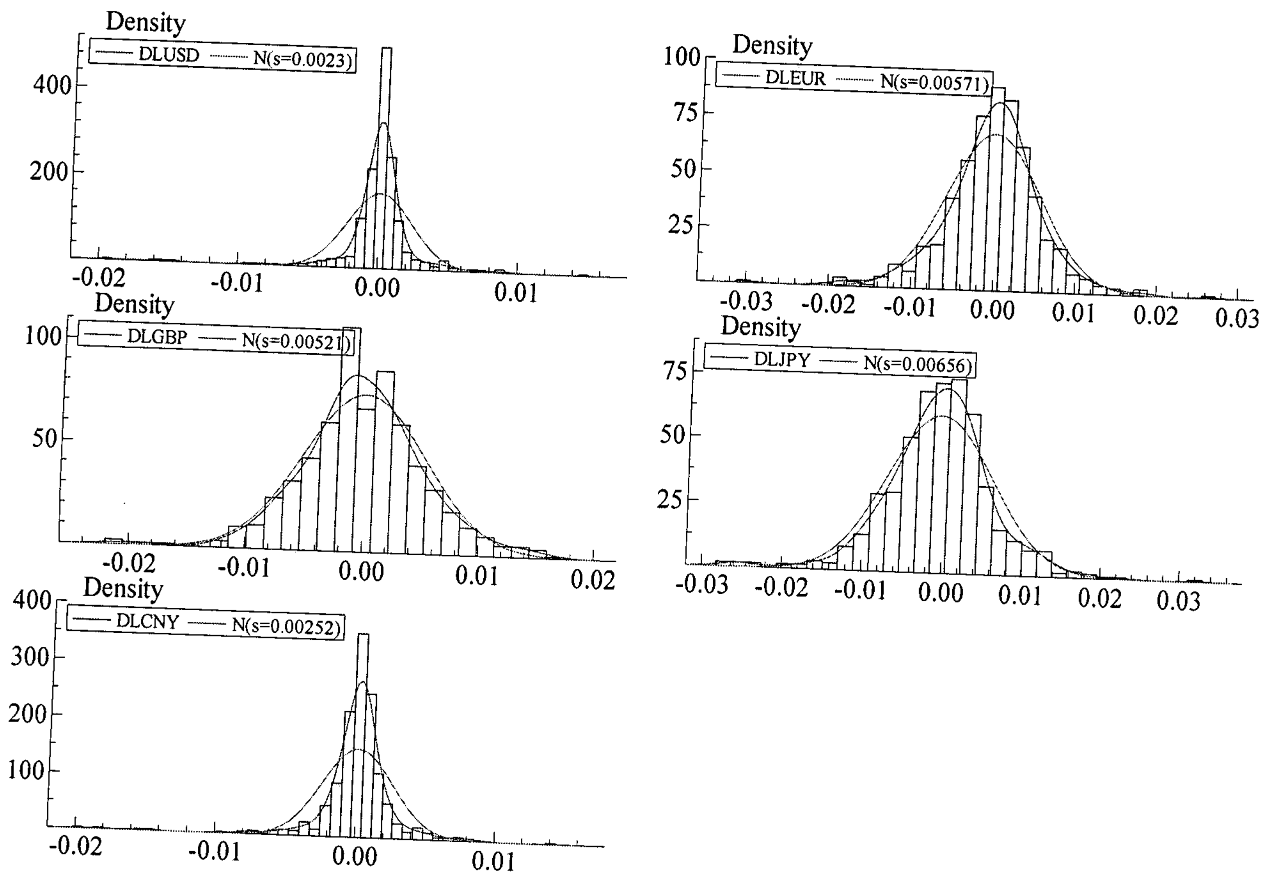
Figure 5.6: Daily exchange rate return series representing the volatility clustering and showing mean reverting behavior with volatility clustering stylized facts



5.2.3: Distribution

The distribution diagram shows the Non normal distribution, leptokurtosis and skewness. The daily exchange rate return series depict non normal distribution and skewed shaped distribution with fat tails. Figure 5.7 represents the distribution of the return series it can be observed all the return series are having non normal distribution and are leptokurtic having fat tails and positively skewed. The figure 5.7 shows the bell shaped having maximum of the data spread over the mean. In below diagram, the USD and CHY return series shows high skewness and the difference between normal and actual distribution is too high depicting non normality while the EUR, GBP and JPY returns shows skewness and leptokurtosis representing non-normality.

Figure 5.7: The daily exchange rate return series representing Non normal distribution with Skewness and lepokurtosis properties Second Phase

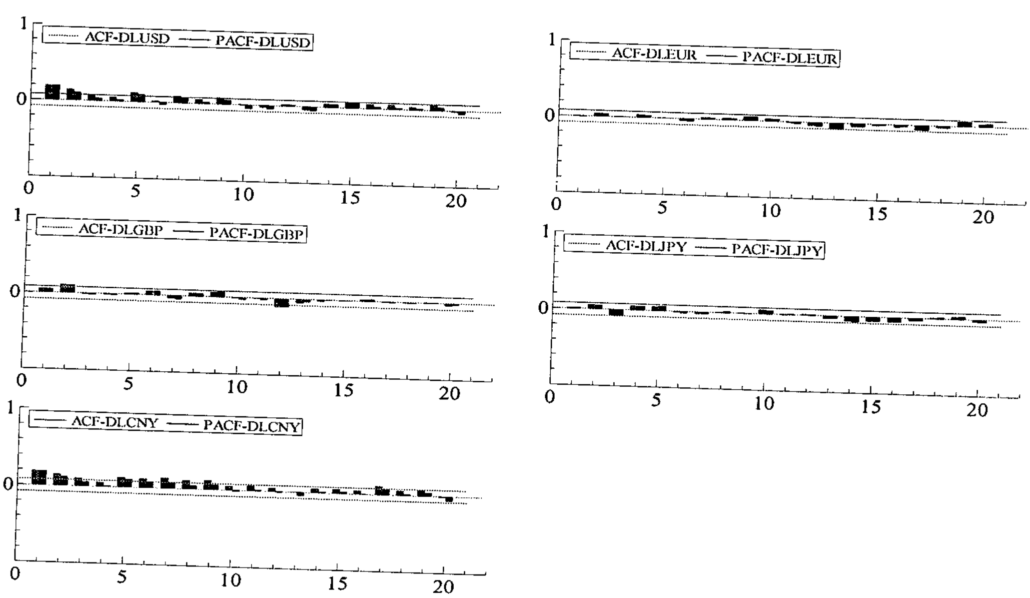


5.2.4: ACF and PACF

The ACF and PACF diagram is used to indicate the MA and AR terms with identifying the spikes coming outside the 95% band. The ACF and PACF gives an idea about MA and AR lags for conditional mean equation here each return series is explained with the help of diagram given as under in figure 5.8.

The figure 5.8 of the return series depicts that the PACF and ACF are used to get a tentative idea about AR an MA lags in conditional mean equation. PACF is helpful in identification AR (m) terms and the ACF is useful for identification of MA(n) terms. The PACF has a geometrical progression while the ACF cutoff to zero after n loss. The graphical analysis is not too reliable to depict the actual PACF and ACF even its hard to read and get an idea from the diagram that's the reason that the graphical analysis is not reliable just gives an idea about ARMA(m,n) terms and may mislead. Thus the actual ARMA(m,n) model can be attained on the basis of post residual analysis in this regard an ARMA model should be estimated and then Box- Pierce statistics should be observed whether any autocorrelation is left or to be captured. In the figure 5.8 below it can be seen in case of return series of USD, GBP, JPY and CHY the spikes of AR(m) and MA(n) being outside the 95% band showing an ARMA(m,n) process having Autocorrelation while the EUR return series showing all the spikes within the band representing zero ARMA(m,n) that in reality is not true.

Figure 5.8: Daily Exchange rate return series representing ACF and PACF depicting short memory process of Second Phase



5.3: Descriptive Analysis

The descriptive analysis for first and second phase i.e. 2010-12 and 2013-15 portfolios are explained by the self-explanatory table 5.1, 5.2, 5.3 and 5.4 given as under. The statistical properties of foreign currencies return in terms of Pakistani rupees are calculated. The descriptive analysis for each phase of currencies is undertaken separately. The distribution of the foreign exchange returns represents the skewness, kurtosis and volatility in both the phases.

The mean values of all the foreign exchange return series are almost zero that indicates mean reversion behavior of the series. The standard deviation values in case of both portfolios i.e 0.0016, 0.0070, 0.0057, 0.0056 and 0.0019 and period are 0.00220, 0.0057, 0.0065, 0.0052 and 0.0025 are minimum. The values USD and CHY coefficient for variation are 9.2356 and 6.6634 and for second phase its 32.76 and 33.49 USD and CHY positive and almost near while in second phase of portfolio its almost same. The excess kurtosis for the foreign exchange return of USD is positive showing leptokurtosis depicting heavy tails and having clustering of data around mean value. The Jarque Bera depicts the characteristics of the distribution of the foreign exchange return series. All the return series of the Pak rupee exchange rate are significant showing non normality distribution of the series. Thus it can be analyzed that all the Pak exchange rate return series are skewed, leptokurtic and non-normal.

5.3.1: Unit Root Test

Kwaitkowski-Phillips-Schmidt-Shin (KPSS) (1992) test is employed to check stationarity of all the currency return series. The Null hypothesis of the KPSS test statistics represents that for both first and second phases return series are stationary. The currencies return series show stationarity of the series and also found to have no unit root as given in the table 5.1 below.

5.3.2: Pre- Estimation Diagnostic Analysis

The Langrange Multiplier (LM) test is used to test the presence of ARCH effect in the Pakistani rupee exchange rate return series. The Null hypothesis of the test is No Autocorrelation in the series. For detection of serial correlation Ljung Box-Pierce Q-statistic is employed with Null hypothesis of No serial correlation. Lung Box –Pierce Q^2 shows evidence of ARCH effect. All the test statistics are employed for lag 5, 10, 20 and 50. The LM test depicts autocorrelation in all the Pak rupee return series except for JPY return series it shows no ARCH effect in JPY but Q^2-stats suggest autocorrelation in squared series i.e. autocorrelation is present in variance series. It shows ARCH effect in the first phase portfolios 2010-12, while in second phase portfolios i.e. 2013-15 shows auto in all the foreign exchange series .In second period r_1 and r_5 are more consistent while r_2 is more variant. Portfolios containing r_1 and r_5 can give better Optimal Hedge Ratio (OHR) and Hedge Reduction (HR). The Ljung Box test statistics represents no serial correlation for USD and GBP return series in first portfolio while in case of 2013-15 portfolios no serial correlation in case of EUR, GBP and JPY at Q (10) lag. The LM test validates the Q- statistics for presence of ARCH effect in both the portfolios. The Q^2 statistic ensures the volatility of all return series for both first and second portfolio at 5^{th} lag thus ARMA with GARCH models thus explain time varying behavior of the variables.

First Phase Portfolio 2010-2012

Table 5.1: Descriptive Analysis of the Variables of First Phase

Test	r_1	r_2	r_3	r_4	r_5
Mean	0.0001	0.0000	0.0001	0.0002	0.0002
S.D	0.0016	0.0070	0.0057	0.0056	0.0019
Coefficient of Variation	9.2356	96.2185	32.4301	20.8290	6.6634
Skewness	0.0656 (0.44794)	0.2928*** (0.0007)	-0.2540** (0.0033)	-0.5730*** (0.0000)	-0.0846 (0.3278)
Excess Kurtosis	3.3339*** (0.0000)	0.7535*** (0.0000)	1.3079*** (0.0000)	3.6744*** (0.0000)	2.3785*** (0.0000)
JB test	370.14*** (0.0000)	30.289*** (0.0000)	65.460*** (0.0000)	492.59 *** (0.0000)	189.06*** (0.0000)
KPSS Statistics	0.5011	0.1249	0.1541	0.1669	0.3302

r1 Return on US

r2 Return on EUR

r3 Return on GBP

r4 Return on JPY

r5 Return on CHY

Null Hypothesis for Jarque Berra Test : Series is normal

Null Hypothesis for KPSS test : Series is Stationary

Skewness test : Series is Symmetry

Excess Kurtosis: K-3=0

Table 5.2: Initial Diagnostic Analysis of the Variables of First Phase

Test	r_1	r_2	r_3	r_4	r_5
Q-stat (5)	25.4673*** (0.0001)	2.6427 (0.7548)	8.6752 (0.1227)	6.7264 (0.2417)	25.4673 (0.2378)
Q-stat (10)	33.5788 *** (0.0002)	4.40167 (0.9274)	16.5023 (0.0861)	11.0279 (0.3553)	8.99665 (0.5324)
Q^2-stat (5)	118.145*** (0.0000)	18.3625 ** (0.0025)	79.6712*** (0.0000)	27.2681*** (0.0000)	56.9220*** (0.0000)
Q^2-stat (10)	134.655*** (0.0000)	46.5008*** (0.0000)	99.0471*** (0.0000)	29.9211*** (0.0008)	61.7118*** (0.0000)
LM-ARCH test stat (2)	46.149*** (0.0000)	4.0912** (0.0171)	24.676*** (0.0000)	13.910 (0.2417)	24.830*** (0.0000)
LM-ARCH test stat (5)	19.035*** (0.0000)	3.2370*** (0.0067)	13.427*** (0.0000)	11.0279 (0.3553)	10.356*** (0.0000)

***** shows 1% Significance level**
**** shows 5% Significance level**
*** shows 10% Significance level**

Null hypothesis :
Box –Pierce : No Auto
LM ARCH test: No ARCH Effect

Second Phase Portfolio 2013-2015

Table 5.1: Descriptive Analysis of the Variables of Second Phase

	r_1	r_2	r_3	r_4	r_5
Mean	0.0000	-0.0002	-0.0004	-0.0000	0.0000
S.D	0.0022	0.0057	0.0065	0.0052	0.0025
Coefficient of Variation	32.76305	-24.7891	-13.33401	-909.7210	33.4921
Skewness	1.7987*** (0.0000)	-0.20138** (0.0381)	-0.066548 (0.4932)	-0.13420 (0.1670)	-1.7651*** (0.0000)
Excess Kurtosis	20.622*** (0.00000)	2.5379*** (0.0000)	1.3509*** (0.0000)	2.6418*** (0.0000)	16.473*** (0.0000)

JB test	11558*** (0.0000)	174.16*** (0.0000)	48.597*** (0.0000)	185.98*** (0.0000)	7485.9*** (0.0000)
KPSS Statistics	0.2575	0.4751	0.1447	0.0649	0.3790

r1 Return on USD
r2 Return on EUR
r3 Return on GBP
r4 Return on JPY
r5 Return on CHY

Null Hypothesis for Jarque Berra Test : Series is normal
Null Hypothesis for KPSS test : Series is Stationary/Non Stationary
Skewness test : Series is Symmetry
Excess Kurtosis: K-3=0

Table 5.2: Initial Diagnostic Analysis of the Variables of Second Phase

Test	r_1	r_2	r_3	r_4	r_5
Q-stat (5)	50.7660*** (0.0000)	1.8189 (0.8735)	8.8412 (0.1155)	10.2321* (0.0689)	112.76*** (0.0000)
Q-stat (10)	63.1061 *** (0.0000)	5.18940 (0.8781)	15.0003 (0.1320)	12.8049 (0.2347)	50.849*** (0.0000)
Q^2-stat (5)	282.176*** (0.0000)	24.8797*** (0.0001)	29.9477*** (0.000)	67.9261 *** (0.0000)	53.5705*** (0.0000)
Q^2-stat (10)	290.957*** (0.0000)	48.7434*** (0.0000)	37.6799*** (0.0000)	91.3333*** (0.0000)	90.2399*** (0.0000)
LM-ARCH test stat (2)	47.994*** (0.0000)	2.5196* (0.0813)	9.1522*** (0.0001)	21.370*** (0.0000)	287.540 *** (0.0000)
LM-ARCH test stat (5)	23.851*** (0.0000)	4.0852*** (0.0012)	4.7724*** (0.0003)	10.843*** (0.0000)	301.005*** (0.0000)

***** shows 1% Significance level**
**** shows 5% Significance level**
*** shows 10% Significance level**

Null hypothesis :
Box –Pierce : No Auto
LM ARCH test: No ARCH Effect

5.4: Portfolios Percentage Hedge Reduction (HR) for First and Second Phase

Several Portfolios of currencies were estimated for the two phases separately. The detail and their respective HR, s are given and explained in table 5.5.

Gross Portfolio:

$r_1 = r_p - r_2 - r_3 - r_4 - r_5$

Where r_1 = Return of US $

r_2= return of Euro

r_3= return of Pond

r_4= return of Japanese Yen

r_5= returns of Chinese Yuan

The currencies are taken on the basis of being international currencies and known as reserve, strong and bold currencies (Viceira, 2008). These are used by majority of the countries in the world as their reserve currency except for Chinese Yuan that is an evolving currency and declared as fifth reserve currency having Special Drawing Rights (SDR).

5.4.1: Portfolios of First Phase from 2010-31st Dec, 2012

The Hedge reduction estimated for all the portfolios for the first phase of currencies indicates various Hedge reduction values. The daily exchange rate considered i.e. foreign currency in terms of domestic currency shows combination of results. The inclusion of Chinese Yuan other than the strong and bold currencies EUR, GBP and JPY in case of Pakistan shows totally different result for analysis. The Hosking's Multivariate Portmanteau test and Li and

McLeod's Multivariate Portmanteau test with Null hypothesis of no autocorrelation, employed on raw standardized residual series and squared standard series. The significant tests on raw standardized residual series indicate no autocorrelation in multivariate residual series. The significant tests on squared standardized series indicate that no ARCH effect is left. USD, EURO and JPY are well known international currencies and developing countries use these currencies as their reserve currencies for keeping their economies save from losses like depreciation and appreciation. The highest Risk reduction value are 89.95% ,82.50% and 88.43% that is obtained from portfolios having CHY.It shows that portfolios having CHY shows highest hedge performance as compared to other portfolios against USD for reducing devaluation against dollar.

Pakistan contains its reserves in USD and USD is used as medium of exchange for Terms of Trade with other trading partners. The Hedge reduction for the portfolio having only EUR and JPY is 37.43% that is too low as compared with portfolio introducing Yuan currency in it. Moreover the percentages of these portfolios containing highest HRs are in last three portfolios of first phase showing that RMB can reduce devaluation against dollar by 64%, 44% and 65%. The highest Risk reduction other than Yuan combination portfolio is 47.30% that is too low as compared with portfolios having Yuan.

The influence of Yuan can also be considered as a result of China Pakistan Economic Corridor (CPEC) agreement between Pakistan and China. The two countries already have strong bonding and even Yuan/RMB is an emerging international currency. Declared by IMF and being applicable from October 2016.

The Hosking's Multivariate Portmanteau test and Li and McLeod's Multivariate Portmanteau test with Null hypothesis of no autocorrelation, employed on raw standardized residual series and squared standard series for first and second phase portfolios are shown in table 5.7 to table 5.18 as given under. All the portfolios indicate no autocorrelation is left in both Hockings's and Li & McLeod's Multivariate Portmanteau test.

Table 5.5: Distinct OHRs and HRs for Seven portfolios of First Phase

Portfolio	Methodology	Optimal Hedge Ratios				Percentage Hedge Reduction in Risk
		s*	t*	v*	w*	
1	DBEKK(1,4) ARMA(1,3)	0.086971758		0.056973		37.43%
2	DBEKK(1,2) ARMA(1,3)		0.14646	0.069396		47.30%
3	DBEKK(1,1) ARMA(1,1)	0.0921				28.88%
4	DBEKK(1,4) ARMA(1,3)			0.1149		20.91%
5	DBEKK(1,1) ARMA(1,2)	0.02108		0.02498	0.643556	89.95%
6	DBEKK(1,3) ARMA(1,2)		0.08603	0.0409	0.4409	82.50%
7	DBEKK(1,2) ARMA(1,3)			0.0267	0.6551	88.43%

Here s*,t*,v* and w*are OHRs of Euro,GBP,JPY and CHY.The last column represents Percentage Hedge Reduction of each portfolios of First phase

5.4.2: Percentage Hedge Reduction for Second Phase (2013-2015)

The second phase of portfolio considers daily Pak rupee exchange rate data from 2013 to 2015. The highest Risk reductions are observed in portfolios of EUR, JPY and CHY i.e. 84.04% same as observed in above portfolio of first phase from 2010-12. The other highest Risk reduction is 82.52% having again CHY in the portfolios. Moreover the percentages in the portfolios containing CHY shows highest HRs percentages i.e. 60% and 66% that shows reduction of devaluation against dollar .The other portfolios indicate and show very less percentages of Risk reduction as compared to Yuan/RMB containing portfolios. Whereas in the first portfolio the HR is -7.65% that is with negative sign which implies that there is no need to hedge against dollar for devaluation.

Table 5.6: Distinct OHRs and HRs for Five portfolios of Second phase 2013-2015

Portfolio	Methodology	Optimal Hedge Ratios				Percentage Hedge Reduction in Risk
		s*	t*	v*	w*	
1	DBEKK(1,1) ARMA(1,1)	-0.01119	0.00921	0.027251		-7.65%
2	DBEKK(1,1) ARMA(1,1)	-0.00077		0.003521		0.45%
3	DBEKK(1,1) ARMA(1,1)		0.015604	0.001496		5.78%
4	DBEKK(1,1) ARMA(1,1)			-0.0053	0.6050	84.05%
5	DBEKK(9,5) ARMA(1,5)		-0.0206	0.012183	0.6621	82.52%

s*,t*,v* and w* are OHRs of Euro,GBP,JPY and CHY.The HRs of each portfolios are given in last column of Second phase

5.5: Residual Analysis of First Phase Hosking and Li & McLeod Tests

The portfolios of first phase with their Hosking's Multivariate Statistics and Li & McLeod's values on standard and squared residuals with null hypothesis of No autocorrelation are explained in the following tables i.e. 5.7 to 5.13 for each phase separately. The significant tests on both the standardized and squared standardized series explain the robustness and appropriateness of DBEKK model. The significance of the tests shows no autocorrelation on raw standardized residual and squared standardized series shows no ARCH effect is left in multivariate residual series.

The significance of the tests for First period portfolios are given up to tenth order and shown in the following tables given below.

Table 5.7: Residual Analysis of Portfolio First

Portfolio No.1: Dollar Return on EUR Return and Yen Return		
DBEKK Methodology (1,2) and ARMA (1,1)		
Tests	**Coefficients DBEKK**	**P-value**
Hosking,s Multivariate Portmanteau Statistics on Standardized residuals		
Hosking,s Multivariate Portmanteau test (5)	67.2126	0.0105405
Hosking,s Multivariate Portmanteau test (10)	100.350	0.1735155
Hosking,s Multivariate Portmanteau Statistics on Squared Standardized residuals		
Hosking,s Multivariate Portmanteau test (5)	74.1512	0.0016097
Hosking,s Multivariate Portmanteau test (10)	101.191	0.1417986
Li and Mcleod Multivariate Portmanteau Statistics on Standardized residuals		
Li and Mcleod Multivariate Portmanteau test (5)	67.1684	0.01063
Li and Mcleod Multivariate Multivariate Portmanteau test (10)	100.431	0.1720
Li and McLeod Multivariate Portmanteau Statistics on Squared Standardized residuals		
Li and McLeod Multivariate Multivariate Portmanteau test (5)	74.1060	0.0016
Li and McLeod Multivariate Multivariate Portmanteau test (10)	101.337	0.1395

Table No: 5.8 Residual Analysis of Portfolio Second

Portfolio No.2 :Dollar Return on Pound Return and Yen Return		
DBEKK Methodology (1,2) and ARMA (1,3)		
Tests	**Coefficients DBEKK**	**P-value**
Hosking,s Multivariate Portmanteau Statistics on Standardized residuals		
Hosking,s Multivariate Portmanteau test (5)	51.4172	0.1276595
Hosking,s Multivariate Portmanteau test (10)	93.5011	0.2720505
Hosking,s Multivariate Portmanteau Statistics on Squared Standardized residuals		
Hosking,s Multivariate Portmanteau test (5)	54.9664	0.0866105
Hosking,s Multivariate Portmanteau test (10)	86.7152	0.4884454
Li and Mcleod Multivariate Portmanteau Statistics on Standardized residuals		
Li and Mcleod Multivariate Portmanteau test (5)	51.4059	0.1278
Li and Mcleod Multivariate Multivariate Portmanteau test (10)	93.5336	0.2712
Li and Mcleod Multivariate Portmanteau Statistics on Squared Standardized residuals		
Li and Mcleod Multivariate Multivariate Portmanteau test (5)	54.9709	0.0865
Li and Mcleod Multivariate Multivariate Portmanteau test (10)	86.8632	0.4839

Table 5.9: Residual Analysis of Portfolio Third

Portfolio No.3 :Dollar Return on Euro Return		
DBEKK Methodology (1,1) and ARMA (1,1)		
Tests	**Coefficients DBEKK**	**P-value**
Hosking,s Multivariate Portmanteau Statistics on Standardized residuals		
Hosking,s Multivariate Portmanteau test (5)	24.4610	0.1276595
Hosking,s Multivariate Portmanteau test (10)	93.5011	0.2720505
Hosking,s Multivariate Portmanteau Statistics on Squared Standardized residuals		

Hosking,s Multivariate Portmanteau test (5)	22.4121	0.2142010
Hosking,s Multivariate Portmanteau test (10)	38.0479	0.4673026
Li and Mcleod Multivariate Portmanteau Statistics on Standardized residuals		
Li and Mcleod Multivariate Portmanteau test (5)	24.4440	0.1410
Li and Mcleod Multivariate Multivariate Portmanteau test (10)	42.0899	0.2983
Li and Mcleod Multivariate Portmanteau Statistics on Squared Standardized residuals		
Li and Mcleod Multivariate Multivariate Portmanteau test (5)	22.3897	0.2151
Li and Mcleod Multivariate Multivariate Portmanteau test (10)	38.0795	0.4658

Table 5.10: Residual Analysis of Portfolio Fourth

Portfolio No.4 :Dollar Return on Yen Return		
DBEKK Methodology (1,3) and ARMA (1,4)		
Tests	**Coefficients DBEKK**	**P-value**
Hosking,s Multivariate Portmanteau Statistics on Standardized residuals		
Hosking,s Multivariate Portmanteau test (5)	24.4004	0.0585991
Hosking,s Multivariate Portmanteau test (10)	36.5279	0.3976136
Hosking,s Multivariate Portmanteau Statistics on Squared Standardized residuals		
Hosking,s Multivariate Portmanteau test (5)	32.2958	0.0091
Hosking,s Multivariate Portmanteau test (10)	44.3882	0.1591338
Li and Mcleod Multivariate Portmanteau Statistics on Standardized residuals		
Li and Mcleod Multivariate Portmanteau test (5)	24.3963	0.0586
Li and Mcleod Multivariate Multivariate Portmanteau test (10)	36.6036	0.3942
Li and Mcleod Multivariate Portmanteau Statistics on Squared Standardized residuals		
Li and Mcleod Multivariate Multivariate Portmanteau test (5)	32.2888	0.0091
Li and Mcleod Multivariate Multivariate Portmanteau test (10)	44.4643	0.1572

Table 5.11: Residual Analysis of Portfolio Fifth

Portfolio No.5 :Dollar Return on Euro Return, Yen Return & Yuan Return		
DBEKK Methodology (1,1) and ARMA (1,2)		
Tests	**Coefficients DBEKK**	**P-value**
Hosking,s Multivariate Portmanteau Statistics on Standardized residuals		
Hosking,s Multivariate Portmanteau test (5)	21.7430	0.1948065
Hosking,s Multivariate Portmanteau test (10)	51.3000	0.0591701
Hosking,s Multivariate Portmanteau Statistics on Squared Standardized residuals		
Hosking,s Multivariate Portmanteau test (5)	19.4459	0.3648641
Hosking,s Multivariate Portmanteau test (10)	35.7613	0.5734139
Li and Mcleod Multivariate Portmanteau Statistics on Standardized residuals		
Li and Mcleod Multivariate Portmanteau test (5)	21.7348	0.1951
Li and Mcleod Multivariate Multivariate Portmanteau test (10)	51.2056	0.0602
Li and Mcleod Multivariate Portmanteau Statistics on Squared Standardized residuals		
Li and Mcleod Multivariate Multivariate Portmanteau test (5)	19.4339	0.3655
Li and Mcleod Multivariate Multivariate Portmanteau test (10)	35.7955	0.5718

Table 5.12: Residual Analysis of Portfolio Sixth

Portfolio No.6:Dollar Return on Pound Return, Yen Return & Yuan Return		
DBEKK Methodology (1,3) and ARMA (1,2)		
Tests	**Coefficients DBEKK**	**P-value**
Hosking,s Multivariate Portmanteau Statistics on Standardized residuals		
Hosking,s Multivariate Portmanteau test (5)	94.440	0.0862
Hosking,s Multivariate Portmanteau test (10)	173.177	0.1786
Hosking,s Multivariate Portmanteau Statistics on Squared Standardized residuals		

Hosking,s Multivariate Portmanteau test (5)	84.6461	0.2327
Hosking,s Multivariate Portmanteau test (10)	126.209	0.9615
Li and Mcleod Multivariate Portmanteau Statistics on Standardized residuals		
Li and Mcleod Multivariate Portmanteau test (5)	94.4376	0.0862
Li and Mcleod Multivariate Multivariate Portmanteau test (10)	173.213	0.1781
Li and Mcleod Multivariate Portmanteau Statistics on Squared Standardized residuals		
Li and Mcleod Multivariate Multivariate Portmanteau test (5)	84.6973	0.2315
Li and Mcleod Multivariate Multivariate Portmanteau test (10)	126.682	0.9589

Table 5.13: Residual Analysis of Portfolio Seventh

Portfolio No.7 :Dollar Return on Yen Return & Yuan Return		
DBEKK Methodology (1,2) and ARMA (1,3)		
Tests	**Coefficients DBEKK**	**P-value**
Hosking,s Multivariate Portmanteau Statistics on Standardized residuals		
Hosking,s Multivariate Portmanteau test (5)	60.3241	0.0262050
Hosking,s Multivariate Portmanteau test (10)	100.151	0.1411644
Hosking,s Multivariate Portmanteau Statistics on Squared Standardized residuals		
Hosking,s Multivariate Portmanteau test (5)	52.8979	0.1208397
Hosking,s Multivariate Portmanteau test (10)	74.3883	0.8303197
Li and Mcleod Multivariate Portmanteau Statistics on Standardized residuals		
Li and Mcleod Multivariate Portmanteau test (5)	60.3163	0.0262
Li and Mcleod Multivariate Multivariate Portmanteau test (10)	100.205	0.1403
Li and Mcleod Multivariate Portmanteau Statistics on Squared Standardized residuals		
Li and Mcleod Multivariate Multivariate Portmanteau test (5)	52.9277	0.1202
Li and Mcleod Multivariate Multivariate Portmanteau test (10)	74.6661	0.8243

5.6: Residual Analysis of Second Phase Hosking and Li & McLeod Tests

The residual analysis for second phase of DBEKK model regarding Hosking and Li and Mcleod with Null hypothesis of No autocorrelation are mentioned in the table 5.14 to 5.18 for each portfolios in second phase. The significance of the test shows the robustness and appropriateness of the models. The significance tests on raw standardized residuals shows no Autocorrelation is left in multivariate residual series and significance of the squared standardized series shows no ARCH effect is left in multivariate residual series. The significance of the tests for second phase portfolios are given up to tenth order and shown in the following tables given below.

Table 5.14: Residual Analysis of Portfolio First

Portfolio No.1 :Dollar Return on Euro Return, Pound Return & Yen Return		
DBEKK Methodology (1,1) and ARMA (1,1)		
Tests	**Coefficients DBEKK**	**P-value**
Hosking,s Multivariate Portmanteau Statistics on Standardized residuals		
Hosking,s Multivariate Portmanteau test (5)	78.0752	0.4763089
Hosking,s Multivariate Portmanteau test (10)	159.651	0.4482764
Hosking,s Multivariate Portmanteau Statistics on Squared Standardized residuals		
Hosking,s Multivariate Portmanteau test (5)	95.3841	0.0880946
Hosking,s Multivariate Portmanteau test (10)	168.027	0.2776447
Li and Mcleod Multivariate Portmanteau Statistics on Standardized residuals		
Li and Mcleod Multivariate Portmanteau test (5)	78.1218	0.4748
Li and Mcleod Multivariate Multivariate Portmanteau test (10)	159.631	0.4487
Li and Mcleod Multivariate Portmanteau Statistics on Squared Standardized residuals		
Li and Mcleod Multivariate Multivariate Portmanteau test (5)	95.3508	0.0884
Li and Mcleod Multivariate Multivariate Portmanteau test (10)	168.124	0.2758

Table 5.15: Residual Analysis of Portfolio Second

Portfolio No.2 :Dollar Return on Euro Return and Yen Return		
DBEKK Methodology (1,1) and ARMA (1,1)		
Tests	**Coefficients DBEKK**	**P-value**
Hosking,s Multivariate Portmanteau Statistics on Standardized residuals		
Hosking,s Multivariate Portmanteau test (5)	54.6909	0.1089451
Hosking,s Multivariate Portmanteau test (10)	87.1661	0.5050814
Hosking,s Multivariate Portmanteau Statistics on Squared Standardized residuals		
Hosking,s Multivariate Portmanteau test (5)	30.4913	0.9241773
Hosking,s Multivariate Portmanteau test (10)	69.7163	0.9244958
Li and Mcleod Multivariate Portmanteau Statistics on Standardized residuals		
Li and Mcleod Multivariate Portmanteau test (5)	54.6661	0.1093
Li and Mcleod Multivariate Multivariate Portmanteau test (10)	87.2911	0.05013
Li and Mcleod Multivariate Portmanteau Statistics on Squared Standardized residuals		
Li and Mcleod Multivariate Multivariate Portmanteau test (5)	30.5996	0.9220
Li and Mcleod Multivariate Multivariate Portmanteau test (10)	69.9200	0.9219

Table 5.16: Residual Analysis of Portfolio Third

Portfolio No.3 :Dollar Return on Pound Return and Yen Return		
DBEKK Methodology (1,1) and ARMA (1,1)		
Tests	**Coefficients DBEKK**	**P-value**
Hosking,s Multivariate Portmanteau Statistics on Standardized residuals		
Hosking,s Multivariate Portmanteau test (5)	57.0105	0.0745923
Hosking,s Multivariate Portmanteau test (10)	94.4611	0.2995942
Hosking,s Multivariate Portmanteau Statistics on Squared Standardized residuals		
Hosking,s Multivariate Portmanteau test (5)	69.6179	0.0062494

Hosking,s Multivariate Portmanteau test (10)	104.419	0.1116848
Li and Mcleod Multivariate Portmanteau Statistics on Standardized residuals		
Li and Mcleod Multivariate Portmanteau test (5)	56.9849	0.0749
Li and Mcleod Multivariate Multivariate Portmanteau test (10)	94.5139	0.2982
Li and Mcleod Multivariate Portmanteau Statistics on Squared Standardized residuals		
Li and Mcleod Multivariate Multivariate Portmanteau test (5)	69.4815	0.00064
Li and Mcleod Multivariate Multivariate Portmanteau test (10)	104.426	0.1115

Table 5.17: Residual Analysis of Portfolio Fourth

Portfolio No.4: Dollar Return on Yen Return and Yuan Return		
DBEKK Methodology (1,2) and ARMA (1,3)		
Tests	**Coefficients DBEKK**	**P-value**
Hosking,s Multivariate Portmanteau Statistics on Standardized residuals		
Hosking,s Multivariate Portmanteau test (5)	55.1288	0.0691696
Hosking,s Multivariate Portmanteau test (10)	99.3648	0.1536684
Hosking,s Multivariate Portmanteau Statistics on Squared Standardized residuals		
Hosking,s Multivariate Portmanteau test (5)	45.0729	0.3446437
Hosking,s Multivariate Portmanteau test (10)	81.1699	0.6559366
Li and Mcleod Multivariate Portmanteau Statistics on Standardized residuals		
Li and Mcleod Multivariate Portmanteau test (5)	55.1020	0.0694
Li and Mcleod Multivariate Multivariate Portmanteau test (10)	99.2955	0.1548
Li and Mcleod Multivariate Multivariate Portmanteau Statistics on Squared Standardized residuals		
Li and Mcleod Multivariate Multivariate Portmanteau test (5)	45.1130	0.3431
portfolios Li and Mcleod Multivariate Multivariate Portmanteau test (10)	81.3104	0.6518

Table 5.18: Residual Analysis of Portfolio Fifth

Portfolio No.5 : Dollar Return on Pound Return, Yen Return and Yuan Return		
DBEKK Methodology (1,5) and ARMA (9,5)		
Tests	**Coefficients DBEKK**	**P-value**
Hosking,s Multivariate Portmanteau Statistics on Standardized residuals		
Hosking,s Multivariate Portmanteau test (5)	83.0576	0.0763491
Hosking,s Multivariate Portmanteau test (10)	151.982	0.3503760
Hosking,s Multivariate Portmanteau Statistics on Squared Standardized residuals		
Hosking,s Multivariate Portmanteau test (5)	83.0576	0.0024521
Hosking,s Multivariate Portmanteau test (10)	175.152	0.1166945
Li and Mcleod Multivariate Portmanteau Statistics on Standardized residuals		
Li and Mcleod Multivariate Portmanteau test (5)	83.0954	0.0759
Li and Mcleod Multivariate Multivariate Portmanteau test (10)	152.098	0.3479
Li and Mcleod Multivariate Portmanteau Statistics on Squared Standardized residuals		
Li and Mcleod Multivariate Multivariate Portmanteau test (5)	112.713	0.0025
Li and Mcleod Multivariate Multivariate Portmanteau test (10)	175.250	0.1156

Conclusion:

Overall in the first and second phase portfolios it can be observed that portfolios having Chinese RMB has dominant influence regarding hedging against currency devaluation. This is because of the influence of China Pakistan Economic Corridor (CPEC) that was initially undertaken in People party era that is in the first phase that includes the paper work of the CPEC. In the second era that is of the Nawaz shows great difference as the practical implementation of CPEC can be observed in the economy as the completion of Karakorum Highway (KKH) reconstruction and new trade agreements. Even it can be observed that the percentages of RMB in the second phase portfolios i.e. 60% and 66% are higher than first phase that were 64%, 44% and 65% that shows a huge difference in currency devaluation against dollar.

Chapter 6

CONCLUSION AND IMPLICATIONS

Diversification plays a vital rule in reducing risk and is one of the main instruments of hedging of Portfolio theory. Hedging through diversification is a zero sum game (Siegel, 2003) while other conventional hedging tools incur cost for availing it. The present study regarding hedging the currency devaluation through diversification emphasis that developing countries hold strong and bold currency (USD, EURO, and GBP & JPY) for hedging purposes. Dollar among these reserve currencies is the dominant and an international currency, in case of Pakistan highest percentage of foreign reserves are kept in dollars. Chinese Yuan (CHY) one of the Asian specific emerging currencies on basis of regionalism having its impacts in both south and East Asian countries and recently declared as Special Drawing Rights (SDR) currency is also considered.

The current study using DBEKK model concludes that dollar and Chinese Yuan are the best and suitable currency for diversifying currency devaluation as compare to other currencies and portfolios. Even Chinese Yuan along dollar can be used as a reserve currency for Pakistan. The analysis undertaken on the basis of two distinct phases based on political parties regime i.e. from 2010-2012 and 2013-2015.The portfolios that contain Chinese Yuan show higher risk reductions than portfolios having other currencies. Thus Chinese Yuan plays major rule in reducing currency devaluation. Overall it can be concluded that dollar and Chinese Yuan play prominent role reducing currency devaluation in Pakistan. Thus in case of Pakistan portfolios having Dollar and Chinese Yuan show highest Hedge Reduction identifying significance of dollar and CHY as reserve currency.

Thus on the basis of above results and analysis it's suggested that dollar and Chinese Yuan can be used as reserve currencies for reducing currency devaluation in Pakistan. Even CHY influence on currency devaluation is more than USD.CHY being recently declared as fifth SDR currency and its regional ties can influence currency devaluation to great extent. It's also suggested that SBP should develop and establish various diversified portfolios of currencies with dollar along Chinese Yuan (CHY) that will be beneficial for investors, firms and other institutions to get maximum benefit out of it. It will also reduce cost of conventional hedging that already is not in practice, also will encourage traders and attract capital inflows. Its analyzed from the estimation that portfolios comprising currencies EURO, JPY, and especially CHY/RMB provides highest percentages of Hedge Reductions thus it's recommended to use these portfolios for currency devaluation. It's suggested for Central banks to adopt such Minimum Variance approach for currency devaluation and instead of concentrating on US$ only it's suggested to keep liquid assets in EURO, JPY and CHY. On the basis of this study further researchers can investigate regarding prominent role of RMB on the basis of CPEC in Pakistan for currency devaluation as such CPEC is now in its initial stages, further agreements are to be fulfilled and completed like proper trade avenues and ventures than how much it can influence and reduce currency devaluation against dollar in case of Pakistan and whether it can be used along other currencies or dollar as a reserve currency in case of Pakistan although declared as an international currency by International Monetary Fund (IMF). Also whether East and South Asian countries will adopt it as their reserve currency against dollar as such RMB had been already used in regional trade in these Asian countries provided licenses by Chinese government.

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Appendix

Theoretical Estimation of Tetra-Variate Optimal Hedge Ratio. The estimation has been undertaken in terms of Tetra-Variate Optimal Hedge Ratio. The explanation has been given interms of one general model for Tetra Variate OHR while in this study undertook in sub-portfolios and estimation is done.

Let r1, r2, r3, r4 and r5 while rp represents the portfolio consisting these four return series while keeping fifth as fourth return series in next portfolio.

The first portfolio consists of r2, r3 and r4 where r1 return series of USD. Here σ_{ii} = Variance (r_i) and $\sigma_{ij} = Cov(r_i, r_j)$ for all $i \neq j$

$$r_1 = w + xr_2 + yr_3 + zr_4 + sr_5$$

For Tetra Variate-Optimal Hedge Ratio will estimate the portfolios given as under

$$r_{p1} = r_1 - w - xr_2 - yr_3 - zr_4$$

$$r_{p2} = r - w - xr_2 - yr_3 - sr_5$$

The Risk $= Var(r_p)$

$$Var(r_p) = Var(r_1 - w - xr_2 - yr_3 - zr_4)$$

$$= f(x, y, z)$$

$$= \sigma_{11} + x^2\sigma_{22} + y^2\sigma_{33} + z^2\sigma_{44} - 2x\sigma_{12} - 2y\sigma_{13} - 2y\sigma_{14} + 2xy\sigma_{23} + 2xz\sigma_{24} + 2yz\sigma_{34}$$

In case of Minimum Variance approach we minimize Var(r_p) that is function of (x,y,z) that indicates that we have to optimize f(x,y,z) subject to x,y and z. Here Hessian for such issue is tri-variate type. The Hessian for such issue is tri-variate type. The Hessian for Optimality Conditions are given as under

$$H = \begin{vmatrix} f_{xx} & f_{xy} & f_{xz} \\ f_{yx} & f_{yy} & f_{yz} \\ f_{zx} & f_{zx} & f_{zz} \end{vmatrix} \rangle 0,\ H_1 = \begin{vmatrix} f_{xx} & f_{xy} \\ f_{yx} & f_{yy} \end{vmatrix} \rangle 0, \text{ and } H_2 = \begin{vmatrix} f_{yy} & f_{yz} \\ f_{zy} & f_{zz} \end{vmatrix} \rangle 0$$

At (x^*, y^*, z^*)

Where $f_x = -2\sigma_{12} + 2x\sigma_{22} + 2y\sigma_{23} + 2z\sigma_{24}$

$f_{xx} = 2\sigma_{22} \rangle 0$

$f_{xy} = 2\sigma_{23} = f_{yx}$

$f_{xz} = 2\sigma_{24} = f_{zx}$

$f_y = -2\sigma_{13} + 2x\sigma_{23} + 2y\sigma_{33} + 2z\sigma_{34}$

$f_{yy} = 2\sigma_{33} \rangle 0$

$f_{yz} = 2\sigma_{34} = f_{zy}$

$f_z = -2\sigma_{14} + 2x\sigma_{24} + 2y\sigma_{34} + 2z\sigma_{44}$

$f_{zz} = 2\sigma_{44} \rangle 0$

Thus for Optimality Condition veification

$$H_1 = \begin{vmatrix} f_{xx} & f_{xy} \\ f_{yx} & f_{yy} \end{vmatrix} = \begin{vmatrix} 2\sigma_{22} & 2\sigma_{23} \\ 2\sigma_{32} & 2\sigma_{33} \end{vmatrix}$$

$$= 4\sigma_{22}\sigma_{33} - 4\sigma_{32}\sigma_{23}$$

$$= 4\left(\sigma_{22}\sigma_{33} - (\sigma_{33})^2\right)$$

Where $\sigma_{23} = r_{23}\sqrt{\sigma_{22}\sigma_{33}}$

And $r_{23} = Cov(r_2, r_3)$

$$H_1 = 4(\sigma_{22}\sigma_{33} - r^2{}_{23}\sigma_{22}\sigma_{33})$$

$$= 4\sigma_{22}\sigma_{33}(1 - r^2{}_{23})$$

Since $-1 \le r_{23} \le 1$

$\Rightarrow 0 \le r_{23} \le 1$

Hence $H_1 = 4\sigma_{22}\sigma_{33}(1 - r_{23}{}^2)\rangle 0$

Similarly $H_2 \rangle 0$

Thus Hessian $H = \begin{vmatrix} f_{xx} & f_{xy} & f_{xz} \\ f_{yx} & f_{yy} & f_{yz} \\ f_{zx} & f_{zy} & f_{zz} \end{vmatrix}$

$$= 8\sigma_{22}\sigma_{33}\sigma_{44}\left[1 + 2r_{23}r_{24}r_{34} - (r^2{}_{23} + r^2{}_{24} + r^2{}_{34})\right]$$

$H \rangle 0$

Provided

$$2r_{23}r_{24}r_{34} - (r_{23}^{\ 2} + r_{24}^{\ 2} + r_{34}^{\ 2}) \geq 0$$

Hence H>0 provided $2r_{23}r_{24}r_{34} \geq (r_{23}^{\ 2} + r_{24}^{\ 2} + r_{34}^{\ 2})$

Here $(x^* + y^* + z^*)$ will be estimated simultaneously solving $f_b = 0, f_c = 0, f_d = 0$

Putting

$$f_x = -2\sigma_{12} + 2x\sigma_{23} + 2y\sigma_{33} + 2z\sigma_{24} = 0$$

$$f_y = -2\sigma_{13} + 2x\sigma_{23} + 2y\sigma_{33} + 2z\sigma_{34} = 0$$

$$f_z = -2\sigma_{14} + 2x\sigma_{24} + 2y\sigma_{34} + 2z\sigma_{44} = 0$$

Provides

$$x\sigma_{22} + y\sigma_{23} + z\sigma_{24} = \sigma_{12}$$

$$x\sigma_{23} + y\sigma_{33} + z\sigma_{34} = \sigma_{13}$$

$$x\sigma_{24} + y\sigma_{34} + z\sigma_{44} = \sigma_{14}$$

Using Cramers Rule to solve the above system

$$|A| = \begin{vmatrix} \sigma_{22} & \sigma_{23} & \sigma_{24} \\ \sigma_{32} & \sigma_{33} & \sigma_{34} \\ \sigma_{42} & \sigma_{43} & \sigma_{44} \end{vmatrix}, \text{B=} \begin{bmatrix} \sigma_{12} \\ \sigma_{13} \\ \sigma_{14} \end{bmatrix}$$

$$|A_x| = \begin{vmatrix} \sigma_{12} & \sigma_{23} & \sigma_{24} \\ \sigma_{13} & \sigma_{33} & \sigma_{34} \\ \sigma_{14} & \sigma_{34} & \sigma_{44} \end{vmatrix}, |A_y| = \begin{vmatrix} \sigma_{22} & \sigma_{23} & \sigma_{24} \\ \sigma_{32} & \sigma_{33} & \sigma_{34} \\ \sigma_{42} & \sigma_{43} & \sigma_{44} \end{vmatrix}, |A_z| = \begin{vmatrix} \sigma_{22} & \sigma_{23} & \sigma_{12} \\ \sigma_{23} & \sigma_{33} & \sigma_{13} \\ \sigma_{24} & \sigma_{34} & \sigma_{14} \end{vmatrix}$$

Optimal values of x, y and z

$$x^* = {|A_x|}/{|A|}, \quad y^* = \frac{|A_y|}{|A|}, \text{ and } z^* = \frac{|A_z|}{|A|}$$

Given $|A| \neq 0$