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Do Monetary Models Really Matter to Determine the Exchange Rate Behavior: A Case for Pakistan

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Abstract

This study attempts to investigate whether monetary models of exchange rates are contributing at the same pace to determine the exchange rates across countries, or whether their role has been changed through the development process. Since the 'money demand' and 'purchasing power parity are two major elements of these models suggesting a linear association of monetary models with exchange rate fundamentals, therefore, to capture the expected long-run relationship across these models is assessed by applying the cointegration technique. Three main currencies-based exchange rates of Pakistan are evaluated within the context of monetary models including the US dollar, Euro, and Chinese Yuan. A sample of monthly data for the period 1957 to 2020 has been analyzed. The results show a weak long run relationship in the case of the Chinese Yuan-based exchange rate; however, in the short-run monetary models are significantly contributing to determining the real (nominal) exchange rate in the case of all three based currencies. Whereas in the case of both Euro and US dollar-based exchange rates the relationship is strongly evident both in the long and short runs. Chinese Yuan appears to be preferred over both US Dollar and Euro for international payments and a major share in foreign exchange reserves.

Keywords: Multivariate time series analysis, Cointegration, Monetary models, Foreign exchange rate, Pakistan.

JEL Classifications: B27, C32, E52, F31

1. Introduction

Exchange rate determination has remained an important area of concern to researchers and policy makers. Because the broad prospects of trade, terms of trade, debt and capital investments are heavily affected when exchange rates are unstable or over(under) valued because all these components involve foreign currency, US dollars mainly. As countries of the world are not running their economies in isolation and especially financial penetration has made the real sector trade and

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investment interdependent across nations as well. Fiscal and monetary policies are dominant policy tools to regulate and stabilize the economies. However, most of such policies are designed or adjusted by considering domestic situations mainly ceteris paribus regarding the strategies opted by counterpart or trade partner countries scenarios. Developing countries' dilemma is that their currencies are already weak and vulnerable due to poor economic conditions, in addition, this study tries to probe the evidence by assuming that when the major trade partner of such countries is a high-income country with a strong currency, the domestic monetary policy adjustment may not generate the expected outcomes especially when such adjustments are made to stabilize or improve the exchange value of domestic currency This is expected to happen when policy variables like interest rate, inflation or money supply of developing countries may not remain independent to any change in the same variables of the counterpart country because of economic integration through trade and investments.

The importance of monetary models has already been realized in the past literature. The investigation made by the federal bank of Richmond during the 70s by using relative money stocks, relative inflation through interest rates adjustments, and relative income levels has provided the support to exchange rates including US dollar per pound and US dollar per Lira only for a developed country (Humphrey and Lawler, 1977). Since Bilson (1978b) has also evaluated the simple monetary models of the exchange rate by assuming stability in the money demand function as well as the integrated world markets, where the monetary models are assumed to expose the speculative behavior of exchange rate determinants and equilibrium across monetary instruments, as exchange rate behavior remained broadly consistent with the predictions based on the monetary models. An investigation by (Frenkel and Clements, 1978) has already identified that many determinants of exchange rate have probably high collinearity like the money supply of counterpart countries that need to be addressed for obtaining more precise estimates. Secondly, policies that may change the domestic money supply will affect the exchange rate as well because of their intimate link.

The main objective of this investigation is to determine the impact of monetary models containing various economic policy fundamentals on shaping exchange rate behavior, so that potential restrictions may be identified when policy fundamentals are revised domestically to control the exchange rate behavior. The main motivation behind this study has emerged with the steep rise in the exchange rate initially in terms of the United States Dollar from June 2018 onwards[4] which

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[4] According to the news report 'Business Recorder'. https://fp.brecorder.com/2019/04/20190423466573/

cause the rise in debt up to Rs. 1,657 billion after taking charge by the new government of Pakistan. Since all other currencies' values are determined primarily through the US dollar consequently dwindling the par value of the rupee against the currencies of the world as well. Contractionary monetary policy has been considered the source of resolution to curb inflation and induce favorable growth in net export.

1.1 Cross Country Exchange Rates in Pakistan

Three major countries' currencies have been considered in this study including the Chinese Yuan, US dollar, and Euro as a common currency of the European Area to calculate the exchange rates of the Pakistani rupee. All three exchange rates are compared with each other in Figure 1. Exchange rate values of the Pakistani rupee (PKR) based on the United States dollar (USD) and European countries referred to by Euro Area (EU) consistently decline from 1982-3 onwards with large magnitude. Although the magnitude remained low, depreciation set in close to 1995 onwards when the base currency swiped with chinse Yuan. Interestingly the margin of depreciation of PKR remains high in the euro compared to the dollar. Chinese yuan (CHY) appreciates against the USD till 1980 but starts depreciating afterward. In the beginning of 1994-5 after a negative shock, the exchange rate became stable and in 2006-7.

The historical pattern reveals that the exchange rate of PKR in terms of USD went through various phases of stability and instabilities over the last six decades, although mainly depreciated. PKR maintained its value equal to 4.7619 per USD from 1957 to 1972 (fixed exchange rate era), but over time it has deteriorated to Rs. 158 till July 2021. However, the value of the Pakistani rupee against the currencies of each major trade partner may be considered most relevant to study but the value against the United States Dollar (USD) remains a major concern because the United States has been playing the dominant role in Pakistan's trade scenario. Because it provides a significant market for exports[5], frequent foreign aid, grants and loans for a long time and more recently becoming a source of foreign direct investment (FDI) as well. Interestingly, when patterns of inflation growth have been compared with US dollar-based exchange rate, it seems that up to 2006-07 exchange rate depreciation is primarily due to external factors including trade, aid and foreign investments because consumer prices and inflation growth follow as lag-variables however in 2007 and onwards both consumer prices and inflation escalated and outpaced the depreciation of Pakistani rupee as a lead-variable.

[5] Ishaque and Mahmood (2017), p. 45 (table 4.3)

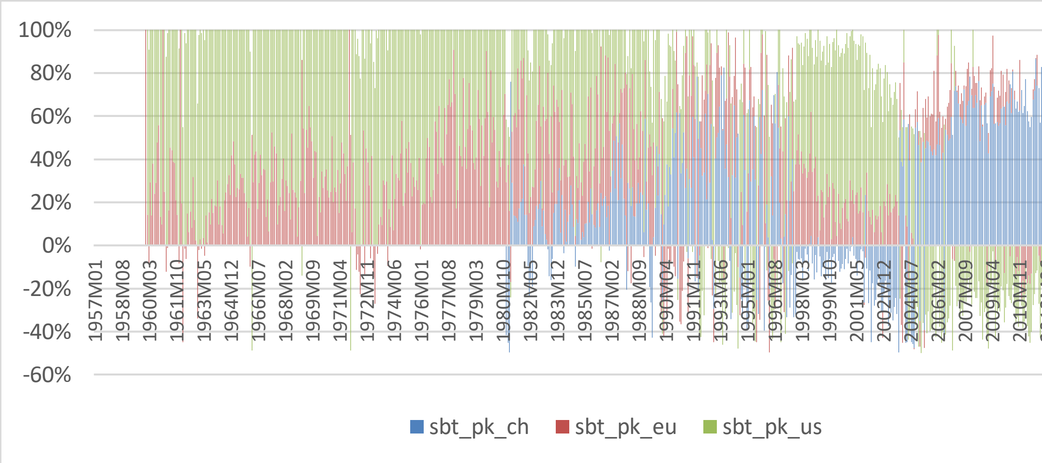
Figure 1: Nominal Exchange Rate and Real Exchange Rates over 6 - decades: Pakistani Rupee against US dollar, Chinese Yuan and Euro Area.

Source: Authors' calculations and graphical descriptions based on sampled data

As Figure 1 reveals that the Pakistani rupee has not only lost its worth significantly but experience a high rate of depreciation as well both in terms of the US dollar and Euro. Whereas the exchange rate in terms of the Chinese Yuan remains encouraging although after 2010 rate of depreciation accelerated further. The stability of the Chinese Yuan against the US dollar and Euro may become the source of opportunity to stabilize the Pakistani rupee against these currencies by increasing foreign reserves and international transactions through the Chinese Yuan. the real cross (exchange) rates ratify it as well.

The analysis of Figure 2 draws the paradigm shift-like situation where bilateral trade with China has successfully overtaken the US dependence spread over many decades, depicting a potential to further stabilize the Pakistani rupee against the US dollar in near future.

Figure 2: Proportion of Bilateral Trade Shares of Pakistan towards China, Europe, and the United States



Note: In the legend 'sbt' share of bilateral trade, 'pk', 'ch', 'EU' and 'us' for Pakistani rupee in terms of Chinese Yuan, Euro and the United States Dollar respectively
Source: Authors' calculations and graphical descriptions based on sampled data

1.2 Empirical Evidence from Pakistan

The evidence regarding Pakistan has been provided by (Khan and Nawaz, 2018) who have applied cointegration on quarterly data for US dollars only and proved that exchange rates are driven through relative money stock and real income in the long run whereas short-run variations in the exchange rates are mainly explained by inflation and interest rate. In a study by (Zakaria and Ahmad, 2009) seventeen trade partners countries of Pakistan have been evaluated with quarterly data and the flexible price monetary model proved highly effective to reflect the behavior of exchange rates in comparison to interest differential and sticky-price monetary models by using generalized methods of moment techniques in long run. The degree of dollarization has been evaluated by using annual data with modified monetary models by (Abbasi and Safdar, 2014) who have obtained long run relationships through cointegration where dollarization shows a positive relationship with exchange rates. Another study (Bashir and Luqman, 2014) evaluated annual data by using the Johansen cointegration technique and concluded that price level and terms of trade are the major sources of exchange rate depreciation in contrast to remittance. Khan and Qayyum (2011) have examined the exchange rate fundamentals by using quarterly data based on cointegration analysis, it has been proved that monetary fundamentals are highly important to determine the exchange rate behavior in Pakistan and these monetary fundamentals may be used as a stabilization tool by the policymakers in the long run while in the short run non-linearities of the exchange rate should be taken into account as well. As Hinna and Qayyum (2015) have explained the monetary model-based evaluation of exchange rate behavior in Pakistan and found that expansion of money supply appreciates exchange rate in the short-run and depreciates in the long run and exchange rate overshoots both in the short and long run as well in response to change in domestic money supply relative to change in the foreign money supply.

The literature probing concludes that cointegration techniques are more vibrantly applied in the monetary model context. First, in an international context, the determination of exchange rate through monetary models is generally a valid approach that is more precise in the case of developed countries context but remains inconclusive in case of low-income countries case. Although some of the findings of the previous studies may be generalized to an extent because each country's respective economic, financial, and monetary policy limitations are not identical and static. Second, in Pakistan's context, mostly annual and quarterly data are evaluated, and the importance of these fundamentals is found valid. Now the question is why a new study needs to be conducted if previous studies have already proved the validity of monetary models. There are some important reasons for the justification of the present study:

i) Recently during more than the last three years, a steep deterioration of the Pak-rupee in terms of the US dollar has raised the question about exchange rate fundamentals because the magnitude of debt has been magnified.
ii) Euro and especially the Chinese Yuan are emerging international currencies where the evaluation of these fundamentals may disclose some new options to maintain reserves and finance international payment. (Uppal and Mudakkar, 2020)

Therefore, an evaluation of these monetary models for Pakistan has its unique advantage to materialize the impact of fundamentals on rapidly deteriorating US dollar terms exchange rates. Further, the inclusion of monetary models for Euro and Chinese Yuan in evaluation will provide the opportunity to the policymakers, while making an international transaction, to prefer either US dollar, Euro, or Chinese Yuan by considering the appropriate behavior of fundamentals found with respect to either United States, European Union or China.

2. Review of Literature

There are numerous studies evaluating empirical models of exchange rates including studies such as those (Backus, 1984) who has found no evidence favoring sticky-price monetary models but moderately for portfolio balance models. Whereas (Marçaly, 2014) estimated country-specific variables along with fundamentals for real effective exchange rate and proved that domestic fundamentals help to derive exchange rates in the long run independently however interdependence is found in the short run. Since monetary models are considered as a 'workhorse of the exchange rate determination' where literature has diverged into five stands: first, based nonparametric methods allow the nonlinear formulation of variables to fit into linear models; second, the existence of long-run cointegration ensures nonlinear adjustments in short-run through error correction model; third, the mean-reverting property of threshold approach able to cater the short variations with long-run influences; fourth, coefficients are time-dependent; and fifth, relied upon Markov Switching approach (Zhang, 2014). According to Zhang (2014) exchange rate of the Euro and Japanese Yen in terms of the US dollar based on the Johansen cointegration technique, found a valid association between monetary fundamentals and the exchange rates using flexible price monetary models. Another study (Grauwe and Grimaldi, 2001) observed that the fundamental of the exchange rate is poorly linked in low-income countries resultantly inflation and money supply growth rates failed to determine the exchange rate behavior even in the long run money supply targeting might not be suitable in this regard. In an academic investigation for Ukraine, (Boyko, 2002) where 'dollarization' was inducted, a modified version of flexible price monetary models has provided the evidence for exchange rate determination with a large impact on domestic nominal deposit (interest) rate, dollarization ratio, domestic money supply on nominal exchange rates in contrast to foreign fundamentals. The evidence from the research department of the Reserve Bank of Malawi successfully applied Johansen's cointegration on Malawi Kwacha-US dollar exchange rates and observed a valid relationship between unrestricted monetary models and the nominal exchange rates (Simwaka, 2004). A study regarding developing countries refused the validity of monetary models because of the insignificant effect of domestic money supply on the exchange rate determination (Jegajeevan, 2011). Umoru (2013) has evaluated such models for the Nigerian economy and found that inflation significantly determines the exchange rate variations hence policy intervention is needed with a realignment of a monetary policy framework. The empirical investigations of Cupidon and Hyppolite (2016) have revealed that the 'economic fundaments' referred to flexible monetary models determine the exchange rates, especially nominal ones.

3. Model, Variables and Data

3.1 Model Specifications and Methodology

Since demand and supply of both domestic and foreign currencies determine the exchange rates where monetary policies of such countries play a key role. According to (Khan and Nawaz, 2018) monetary exchange models mainly establish a link between the purchasing power parity theory and the quantity theory of money. These models suggest that the difference between two countries in terms of money supply, real income, nominal, and real interest rate have been the prime factor(s) in the determination of bilateral exchange rate.

3.2 A Brief Note on Monetary Models of Exchange Rates

The complete description of these models has been mentioned by many researchers including (Khan and Nawaz, 2018); (Krolzig and Martin, 2012); (MacDonald, 2007); Gardeazabal, and Regulez, 1992) however, for the basic understanding some descriptions have been reported here. As per details mentioned by (Gardeazabal and Regulez, 1992), the monetary models are based on two major components (i) money demand and (ii) purchasing power parity. A linear relationship between the exchange rate and its fundamentals has been suggested by these models.

The reduced form may be referred to as:

i) Flexible price monetary model

$$S_t^d = \left(\beta_0^d - \beta_0^f\right) + \partial_1\left(m_t^d - m_t^f\right) + \partial_2\left(y_t^d - y_t^f\right) + \partial_3\left(i_t^d - i_t^f\right) \quad (1)$$

ii) The sticky Price-Asset Model refer by Hooper and Morton (1982) considers the cumulated trade (current account) balance (tb) of each partner country determines the real exchange rate in the long run.

$$S_t^d = \partial_0 + \partial_1\left(m_t^d - m_t^f\right) + \partial_2\left(y_t^d - y_t^f\right) + \partial_3\left(i_t^d - i_t^f\right) + \partial_4 E_t\left(\tilde{\rho}_{t+1}^d - \tilde{\rho}_{t+1}^f\right) + \partial_5 \sum_{i=0}^{t} tb_i^d + \partial_6 \sum_{i=0}^{t} tb_i^f \quad (2)$$

Where ‘m’ is the nominal stock of money, ‘p’ is price level, ‘y’ is real national income, ‘i’ a nominal interest rate, ‘ρ’ inflation rate, ‘tb’ as trade balance, ‘S’ spot exchange rate. With superscripts ‘d’ for domestic country (Pakistan) and ‘f’ foreign (counterpart) country, and subscript ‘t’ for time.

As the exchange rate is measured as the domestic currency per unit of foreign currency, the expected relationships are:

a) The rise in domestic money supply will depreciate the nominal exchange rate (positive sign expected) whereas an increase in foreign money supply will appreciate the nominal exchange rate (negative sign expected).

b) An increase in domestic output will raise the level of income so the demand for money so appreciates the nominal exchange rate (negative sign expected) and vice versa for the rise in foreign income (positive sign expected).

c) According to (Abas and Yusof, 2009)[6] a flexible price model assumes that when the interest rate rises it is the reflection of the increase in expected inflation, so the value of the domestic currency will depreciate (a positive sign expected) but the increased foreign interest rate will appreciate domestic currency (negative sign expected)

d) Trade balance depends on the terms of trade between partner countries, if it improves the exchange will appreciate otherwise depreciate. But generally, it may be assumed that an increase in the trade balance of a domestic country will reflect the increased openness and more trade that may induce more demand for domestic currency hence exchange rate will appreciate.

Equation 4 may be written to reflect the relationship of monetary fundamentals with exchange rate behavior.

$$S_t^d = \alpha_0 + \alpha_1(m_t^d) + \alpha_2\left(-m_t^f\right) + \alpha_3(-y_t^d) + \alpha_4\left(y_t^f\right) + \alpha_5\,(i_t^d) + \alpha_6\left(-i_t^f\right) + \alpha_7 E_t\left(\tilde{\rho}_{t+1}^d\right) + \alpha_8 E_t\left(-\tilde{\rho}_{t+1}^f\right) + \alpha_9 \sum_{i=0}^{t} tb_i^d + \alpha_{10} \sum_{i=0}^{t} tb_i^f \quad (4)$$

The testable formation of these models can be defined as:

$$\mathrm{LNER_t} = \beta_0 + \beta_1\mathrm{LNER_{t-1}} + \beta_2\mathrm{LNMSDIF_t} + \beta_3\mathrm{LNOUTPUTDIF_t} + \beta_4\mathrm{LNINTDIF_t} + \beta_5\mathrm{LNINFDIF_t} + \beta_7\sum_{t=1}^{n}\mathrm{LNTB_t^d} + \beta_8\sum_{t=1}^{n}\mathrm{LNTB_t^f} + \beta_{10}\mathrm{LNPCDIF_t} + \beta_6\mathrm{LNDEBT_t} + \beta_9\mathrm{LNFER_t} + \beta_{11}\mathrm{LNORA_t} + \mathrm{u_t} \quad (5)$$

Where,

MSDIF = Money supply gap of Pakistan from counterpart i^{th}-country

[6] See (Jegajeevan, 2011), p.58

OUTPUTDIF= Industrial production index gap of Pakistan from counterpart i^{th} - country

INTDIF=Interest rate gap of Pakistan from counterpart i^{th} - country

INFDIF= Inflation gap of Pakistan from counterpart i^{th} -country (measured through Consumer Price Index gap across respective countries)

TB = trade balance (in cumulative form)

PCDIF= production cost gap Pakistan from counterpart i^{th} -country (measured through Producer or wholesale Price Index gap across respective countries)

DEBT= Debt liabilities of the domestic country (Pakistan)

FER= Foreign exchange reserves of the domestic country (Pakistan)

NFA= Net foreign assets of the domestic country (Pakistan)

ORA= Official reserves assets of the domestic country (Pakistan)

'd' for '*domestic country'* and '*f*' for '*foreign country*' superscripts while '*t*' for *time* subscript measured in months. 'LN' for log formation.

A theoretically detailed transmission channel has been explained by Egwaikhide et al. (1994) regarding exchange rate depreciation within the context of the budget deficit and inflation by concluding that such depreciation leads to enlarging the budget deficit although not definitive but may induce inflation as well. As Lahiri and Vegh (2000) have suggested a policy mix to control the fluctuations of exchange rate either restricts fluctuation by using interest rate policy with intervention only if it is costless, or allows some fluctuations, as an optimal choice. A new approach has been applied by Liew, Lim, and Hussain (2003) by proposing that real money influences trade balance instead of variation in the nominal exchange rate in the case of ASEAN-5 countries. A study has been conducted by Adler and Grisse (2014) to examine the fundamental determinants of the real exchange rate, where they have found significant contribution by GDP per capita, government consumption, net foreign assets, real interest rate, realized volatility of exchange rate, foreign reserves and terms of trade

3.3 Data and Variables Specification

As financial sector has swift variations that can be captured through frequent observation such as monthly data, which is also reflective of the shortest possible maturity periods of various financial products[7]. As most of the time series

[7] (Frenkel and Clements, 1978), p. 30

variables sampled in this study already have monthly data available through International Financial Statistics from January 1957 to December 2020 however, industrial production and manufacturing index (IMPI) and industrial production indices (IPI) have been employed to reflect the output of Pakistan and her foreign counterpart respectively. The non-availability of relatively high-frequency data bounds us to replace the gross domestic product with a manufacturing or industrial production, and the wholesale price index (WPI) has been used as a proxy for producer price index (PPI) only in the case of Pakistan because of non-availability of PPI. The IMPI data was available based on a calculation by using two different base periods viz. first 2000=100 and second 2010=100 as a base for IMF data 2008 and 2020 respectively. Therefore, a necessary upwards scale adjustment has been made in data from 2004M07 onwards because the change in base period shifted the series to a lower scale. Data related to bilateral trade has been obtained through the Direction of Trade Statistics. These data sources are open and accessible to any researcher.

4. Estimation Procedure and Empirical Results

4.1 Stationarity of Time Series Data

The stationarity of time series data has been tested to ensure that the probability distribution of the selected variables is non-variant over time by establishing the fact that the future can be forecasted based on historical relationships (Stock and Watson 2018, p. 586). Augmented Dicky-Fuller (ADF) test along with Phillips-Perron (PP) and Elliott-Rothenberg-Stock (ERS) Point-Optimal have been applied. As ADF addresses the possible autocorrelation by allowing extra lagged terms of a dependent variable based on Akaike Information or Schwartz Bayesian Criteria.

However, the PP test is based on the less restrictive nature of the error process and is also an improved version of the ADF test where serial correlation in error terms has been accounted for (Asteriou, 2006, p 317). Further, Elliott, Rothenberg-Stock Point Optimal test is a modified form of the DF t-test when a series contains an unknown mean or trend hence escalating the power of the test substantially (Elliott, Rothenberg, and Stock, 1996). Considering that the variation due to seasonality may not cause a nuisance but is the integral component of economic variables and therefore need not be obscured in economic analysis (Darné and Diebolt, 2002), the HEGY test-based stationarity has been evaluated for the variable of interest as well where most of the variable is found stationary at levels.

4.2 Cointegration Test

According to MacDonald (2007, p.143 and 165), many previous studies' early tests were not supportive of such models because of some limitations in previously used estimations techniques that have been overcome through cointegration techniques now. Some of the fixed regressors have also been applied to extend these models by including debt, foreign reserves, official reserves assets, and cost of production disparity as well as these are moderating variables.

Table 1: Results of Unit root tests

		Augmented Dicky Fuller (ADF) test statistics H0: Series has a unit root		**Phillips-Perron (PP) test statistics H_0: Series has a unit root**		**Elliott-Rothenberg-Stock Point-Optimal test statistics H_0: Series has a unit root**	
Variable	**Order of Integration**	**Level = I(0)**	**1st Dif. = I(1)**	**Level = I(0)**	**1st Dif. = I(1)**	**Level = I(0)**	**1st Dif. = I(1)**
DEBT	I(1)	2.577	-3.109	4.954	-28.045***	102.127	0.121***
LNDEBT	I(1)	-1.546	-7.258***	-1.402	-25.819***	19.459	1.815***
EXPORT	I(1)	-2.248	-7.561***	-5.430***		18.620	0.514***
LNEXPORT	I(0)	-1.1364	-10.255***	-7.115***		1.673***	
IMPORT	I(1)	-0.746	-9.319***	-2.271	-68.44***	14.1577	1.143***
LNIMPORT	I(0)	-2.685	-20.345***	-7.132***		1.1063***	
FER	I(1)	-2.975	-8.926***	-2.668	-24.781***	7.052	1.127***
LNFER	I(1)	-2.809	-24.331***	-2.910	-24.413***	6.801*	
PCI	I(1)	0.686	-6.901***	1.282	-17.522***	200.1623	1.0284***
PCDIF	I(1)	1.127	-21.361***	1.255	-21.110***	672.683	0.273***
LNPCDIF							
NFA	I(0)	-2.907**		-3.771***		1.988***	
LNNFA							
ORA	I(1)	-0.724	-32.231***	-0.730	-32.231***	207.928	0.0658***
LNORA							
Inflation	I(0)	-4.760***	-4.106***	-23.74***	-24.251***	0.268***	0.497***
Log transformation	I(1)	-2.322		-1.498		107.222	
INFDIF	I(0)	-3.145*		-7.212***	-22.069***	1.149***	0.174***
LNINFDIF	I(1)	-1.632*		3.3451		449.307	
INTDIF	I(0)	-23.554***	-14.483***	-23.72***	-36.266***	0.344***	0.0340***
LNINTDIF	I(1)	-2.094		-2.803		0.390	
Interest rates	I(0)	-3.670**		-10.61***		0.602***	
Log transformation	I(0)	-3.830**		-9.951***		0.732***	
Industrial Prod. Index	I(0)	-3.377*		-3.562**		2.977***	
Log transformation	I(0)	-3.334*		-5.073***		3.142***	
Money Supply	I(1)	-1.996	-3.619**	-1.983	-15.740***	44.496	1.115***
Log transformation	I(1)	-0.063	-2.194	-0.116	-16.119***	32.504	1.367***
MSDIF	I(1)	-2.312	-14.19***	-2.034	-17.368***	22.076	3.381***
LNMSDIF	I(1)	-1.763	-3.621**	-1.226	-18.720***	42.486	3.613***
NER	I(1)	0.792	-10.468***	1.066	-19.832***	80.534	0.565***
LNER	I(0)	-3.450**		-3.224*		14.935	0.318***
OUTPUTDIF	I(1)	-0.100	-6.762**	-5.148***		39.176	2.283***
LNOUTPUTDIF	I(0)	-2.967**		-4.723***		2.626**	
ER	I(1)	-2.338	-13.145***	-2.203	-18.308***	9.126	0.329***
LNER	I(1)	-2.540	-17.963***	-2.440	-18.694***	7.352	0.211***
TB	I(1)	-1.102	-16.364***	-3.451**	-5.051***	24.088	0.357***
LNTB	I(0)	-2.076	-7.404***	-7.279***	-3.614**	1.347***	3.059***
Cumulative TB[d]	I(1)	1.752	-1.644	6.248		580.160	5.308**

Cumulative TB^f	I(1)	0.748	-2.236	4.064	2294.477
$LNTB^d = \sum_{t=1}^{n} LNTB_t^d$	I(0)	-1.802	-9.970***	-7.315***	1.674***
$LNTB^f = \sum_{t=1}^{n} LNTB_t^f$	I(0)	-3.031	-7.145***	-8.716***	1.252***

Log values are referred to as 'LN' with the abbreviation of a concerned variable.
* at 10%, ** at 5%, *** at 1% level of significance respectively

The cointegration process captures the behavior of macroeconomic variables that converge towards equilibrium over time assuming that any possible deviation from equilibrium resides with the error term 'u_t'. Study shows when any two or more variables are linked to establishing a long-run relationship aiming at the "equilibrium" they will move together over time and if any deviation occurs it will be stationary only (Harris and Sollis, 2006)[8]. It has been observed through literature that research on cointegration usually employs more than one testing approach. Cointegration may be determined through the Engle-Granger technique which generates one cointegrating vector otherwise Johansen's maximum likelihood cointegration approach is appropriate for two or more cointegrating vectors by considering all variables as endogenous. This happens if variables are integrated at level or higher-order, the number of cointegrating equations may become more than one because those variables that are integrated at the level may cointegrate by itself as well (Asteriou 2006, p. 344). To avoid such issues, Auto-Regressive Distributed Lag (ARDL) models may perform better due to these reasons: (a) applicability in case of variables with different levels of integration i.e., at level or order one but none have order two; (b) statistical validity even in case of small samples; and (c) ability to accommodate dummy variable (Gebrehiwot, 2013, pp.38-9). However, the existence of more than one cointegrating vector or inclusion of any variable with a higher order of integration I(2) limits the efficacy of the ARDL approach whereas Johansen's approach becomes more reliable because it can accommodate multiple long-run relationships reflected more than one cointegrating vector (Nkoro and Uko, 2016). This study primarily focuses on the ARDL approach whereas the Johansen approach has been used to describe the number of possible cointegrating vectors.

The standard form of the cointegration model[9] is

$$Z_t = A_1 Z_{t-1} + A_2 Z_{t-2} + \cdots + A_k Z_{t-k} + u_t \quad (6)$$

Converted into Vector Error Correction model

$$\Delta Z_t = \partial_1 \Delta Z_{t-1} + \partial_2 \Delta Z_{t-2} + \cdots + \partial_{k-1} \Delta Z_{t-k+1} + \pi Z_{t-1} + u_t \quad (7)$$

[8] See p. 34
[9] for details see (Harris and Sollis, 2006), p. 93; and (Asteriou, 2006), p.341

Where short-run dynamics may be represented by $\partial_i = -(I - A_1 - \cdots - A_i)$ with lag length $(i = 1,2, \dots k-1)$ and $\pi = -(I - A_1 - \cdots - A_k)$ is $(k \times k)$ matrix which holds long-run information; Z_t is the matrix of $(k \times 1)$ dimensions containing selected sampled variables; the magnitude of long-run relationship's information captured through $\pi(= \alpha\acute{\beta})$ which is the product of the speed of adjustment 'alpha' towards equilibrium coefficients and the long-run matrix coefficient 'beta'; $\acute{\beta}Z_{t-1}$refers to error correction term; t = 1, 2, … T time period with an interval equal to one month.

Let Johansen test statistics as 'j' with 'Q' the ratio of restricted to unrestricted maximized likelihood. $(H_o: j_i \leq 0; with\ i = r+1, \dots, n, hence\ H_1: j_i \geq r+1)$. The null hypothesis assumed that most cointegrating relationships are either less than or equal to 'r' viz. non-existence of cointegration vectors, with an alternative that 'r'>0 i.e., at least one or more cointegration vectors exist. Two statistics have been suggested by Johansen regarding the test of the hypothesis[10].

i) Trace Statics

$$j_{trace} = -2\ln(Q) = -T\sum_{i=r+1}^{n}\ln\left(1-\hat{\lambda}_i\right), \quad where\ r = 0,1,2,\dots, n-2, n-1 \tag{8}$$

ii) Maximal Eigenvalues Statistics

$$j_{max} = -T\ln\left(1-\hat{\lambda}_{r+1}\right), \quad where\ r = 0,1,2,\dots,n-2,n-1 \tag{9}$$

5. Analyses of Results, Findings and Conclusion

5.1 Results

Table 2: Johansen Approach: Number of Cointegrating Relations by Model Selected at 0.05 level of significance

Exchange Rates	Data Trend	None	None	Linear	Linear	Quadratic
	Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
LNER (PKR/CHY)	Trace	6 (6)	4 (5)	6(7)	4 (4)	3 (3)
	Max-Eig	3 (2)	2 (2)	2 (2)	3 (3)	3 (3)
LNER (PKR/EUR)	Trace	3 (3)	4 (4)	4(4)	4 (4)	4 (4)
	Max-Eig	3 (3)	4 (4)	3 (4)	3 (4)	3 (4)
LNER (PKR/USD)	Trace	5 (5)	5 (5)	5 (5)	5 (5)	6 (5)
	Max-Eig	5 (5)	5 (5)	5 (5)	5(5)	5 (5)

*Critical values based on MacKinnon-Haug-Michelis (1999). Values in parenthesis are for nominal exchange rates for each respective country's currency

[10] (Harris and Sollis, 2006), pp.123-24

Considering the specification of the variables this study has mainly focused on the ARDL approach to obtain the suitable models because some of the variables are stationary at level but mostly in the first order. However, except for accumulated trade balance, all fundamental variables are stationary in the same order, hence Johansen's maximum likelihood cointegration approach can be used to identify the total number of cointegrating relationships amongst exchange rate fundamentals. In Table 2, both for real and nominal exchange rates, all three currency-based models none of them identify none of them has less than two cointegrating vectors. Even the number of cointegrating vectors has no remarkable difference across nominal and real forms of exchange rates.

In the cointegration process, first, we identify the ranks for each variable to explore the number of possible cointegrating vectors in the model (Jones and Nesmith, 2007). Table 2 reveals that there is more than one cointegration vector exists in the case of all three exchange rates. Consequently, it seems that all three currencies are strongly associated with the Pakistani rupee and adjustments in their respective monetary models will permeate through exchange rates into the monetary sector of Pakistan as well. Although, it has already been explored that the more the cointegrating vectors exist more stability the system of equations would have because one of the previous studies shows that stationarity in the economic system is desirable across as many dimensions as possible and can be quantified via multiple cointegrating vectors (Dickey, Jansen, and Thornton, 1994).

Table 3: Value of Coefficients for long run models

Variables	Model 1 RER_PKR/CHY ARDL (3,1,4,2,0,2,0)	Model 1A NER_PKR/CHY ARDL (3,0,4,2,0,2,0)	Model 2 RER_PKR/ EURO ARDL (3,2,3,0,3,1,1)	MODEL 2A NER_PKR/ EURO ARDL (2,1,3,0,3,1,2)	Model 3 RER_PKR/USD ARDL (4,4,1,2,4,3,0)	Model 3A NER_PKR/USD ARDL (4,0,1,2,4,3,0)
LNER Lag1	1.446446**	1.111273**	1.135623**	1.128875**	1.327197**	1.337874**
LNER Lag2	-0.370979**	-0.408615**	-0.332992**	-0.241125**	-0.428146**	-0.467021**
LNER _Lag3	0.139696**	0.150324*	0.086385		0.155227*	0.192917**
LNER _Lag4					-0.124157**	-0.107872**
LNINFDIF	-0.286711**	0.035061	-0.376230**	0.297461	-0.735769**	-0.069605**
LNINFDIF _Lag1	0.308447**		0.369867**	-0.543008**	0.917912**	
LNINFDIF _Lag2			-0.193127**		-0.262578**	
LNINFDIF _Lag3					0.148307*	
LNINFDIF _Lag4					-0.150057**	
LNINTDIF	-0.000450	-0.001105	-0.000502*	-0.001020*	-0.000199**	-0.000274*
LNINTDIF _Lag1	0.000383	0.000981	1.07E-08	-8.24E-05	0.000238**	0.000326**
LNINTDIF _Lag2	0.000808	0.000748	0.000884**	0.001903**		
LNINTDIF _Lag3	-0.002309*	-0.003296*	-0.000828**	-0.001745**		
LNINTDIF _Lag4	0.002445**	0.003430**				
LNMSDIF	0.029824	-0.048827	0.002081*	0.003985*	0.036964*	0.068287*
LNMSDIF _Lag1	0.169752	0.271623*			0.004370	0.010637
LNMSDIF _Lag2	-0.208946**	-0.325762**			-0.054651**	-0.078767**
LNMSDIF _Lag3						
LNMSDIF _Lag4						

LNOUTPUTDIF	0.004222	0.001845	-0.007608	-0.013232	-0.010939**	-0.025826**
LNOUTPUTDIF _Lag1			0.015143*	0.033039*	0.004140	0.010480
LNOUTPUTDIF _Lag2			-0.019336**	-0.033598**	0.004878	0.003505
LNOUTPUTDIF _Lag3			0.019271**	0.031634*	0.009235**	0.017928**
LNOUTPUTDIF _Lag4					-0.009730**	-0.019523**
Acc. $LNTB^d$	0.006375**	0.007968**	-0.000238	-0.000420	0.000169	0.000221
Acc. $LNTB^d$ _Lag1	-0.000827	-0.001224	0.002816**	0.006028**	-0.002116**	-0.002827**
Acc. $LNTB^d$ _Lag2	0.003044**	0.003104			-0.000731*	-0.000468
Acc. $LNTB^d$ _Lag3					-0.001830**	-0.002207**
Acc. $LNTB^d$ _Lag4						
Acc. $LNTB^f$	0.012848*	0.015953**	-0.001424	-0.005773	-0.003303**	-0.002671
Acc. $LNTB^f$ _Lag1			0.015363*	0.034722**		
Acc. $LNTB^f$ _Lag2				-0.017262		
Acc. $LNTB^f$ _Lag3						
Acc. $LNTB^f$ _Lag4						
LNPCDIF	-0.106548**	-0.100558*	0.057790**	0.103361*	0.056590**	0.058125**
LNDEBT	0.007740	0.003176	0.006043	0.009042	0.004119*	0.003054
LNFER	-0.026395**	-0.043606**	-0.015546**	-0.031352**	-0.003150**	-0.004124
LNORA	0.027834**	0.035314**	0.030931**	0.060709**	-0.004457**	-0.002289
Constant Term	-0.289457	-0.146855	-0.263822**	-0.377569**	0.009948	0.036707
Trend	0.000289**	0.000445**	0.000214**	0.000387**	8.07E-05**	0.000114**
ECM-term	-0.145529**	-0.147018**	-0.110984**	-0.111424**	-0.073209**	-0.044103**
Bound Test:(F-stat)	2.045979	2.344496	4.985080**	5.276386**	9.768807**	5.068964**
*BGSC LM-test: Obs*R-squared [prob.]*	0.854111 [0.6524]	0.896187 [0.6388]	2.421524 [0.2980]	2.468008 [0.2911]	2.117374 [0.3469]	4.178161 [0.1238]
Heteroskedasticity (Harvey) test [prob.]	1.540350 [0.0726]	1.443873 [0.1072]	1.345042 [0.1352]	1.272732 [0.1859]	3.814909 [0.0000]	5.574175 [0.0000]
Ramsey RESET Test [prob.]	0.465872 [0.4964]	1.222788 [0.2713]	0.000113 [0.9915]	0.012735 [0.9103]	0.112371 [0.7376]	1.214970 [0.2709]
Adj R^2	0.987447	0.994471	0.977185	0.995578	0.997337	0.999807
DW- statistics	2.032302	2.056520	1.971927	1.971344	1.998069	1.957230
Observations	133	133	229	229	518	518

** and * for significance at 5% and 10% respectively; Breusch-Godfrey Serial Correlation LM Test with Null hypothesis: No serial correlation at up to 2 lags.
Heteroskedasticity Test: Harvey with Null hypothesis: Homoskedasticity; Ramsey RESET (F-stat) with the null hypothesis: no sign of misspecification
HAC standard errors and covariance (Bartlett kernel, Newey-West fixed bandwidth = 6.0000)

All relevant variables have been applied in log transformation where both log-log and level-log models are estimated, which has allowed us to cater to the potential non-linearities. In Table 1, unit root with ADF test, '*Trend and Intercept*' based models provide better outcomes. For robustness, other techniques such as PP and ERS Point Optimal remain effective. In the case of the US dollar-based model heteroscedasticity, evaluated by the Harvey heteroscedasticity test, has been addressed by using the 'HAC standard errors and covariance' specification of the model. Ramsey RESET test failed to reject the null of the correctly specified model at a 5% level of significance with the specified fitted term '1'.

The results in Table 3 reflect that most of the variables have been found significant and the direction of the relationship is consistent with theory. Since most of the variables in the model are applied in log form, the values of their respective coefficients are reflecting the elasticities as well. A comparison is made with Bilson (1978b) who has already calculated the range of long-run elasticities $\beta_1 = 0.9\ to\ 1.1$ which ensures that money demand functions are closely identical and stable across two countries; $\beta_2 = 0.5\ to\ 1.5$ because industrial production has been used as a proxy for real income and it needs to be considered that the elasticity of real income with respect to industrial production should not be equal to the unit; and $\beta_3 = 0\ to\ 3$ refers to semi-interest rate elasticity by assuming a 10 percent interest rate nominally.

This study reveals that reference values for β_1 elasticity at means ranges from 0.0026 for US-dollar to 1.56 for Chinese yuan-based exchange rates. Whereas reference value for β_2 ranges from 0.0013 for US dollar to 0.0071 for Euro-based exchange rates. The reference values for β_3 lies in the range from 0.0012 for the US dollar to 0.068 for Chinese yuan-based exchange rates. It is evident that the money supply functions of the sampled countries are neither identical nor stable however Pakistan follows the patterns of the Chinese money supply function. Industrial production elasticities in all selected four countries show highly inelastic real income with respect to industrial production.

The long run relationship and short error correction models are described in Table 2. Pakistani rupee exchange rate is referred to with three different base currencies, so three different models of real exchange rate along with their corresponding nominal variants are tested and reported here. Monetary models related to the Chinese Yuan-based exchange rate have failed to establish any long run relationship with the Pakistani rupee according to the Bound test, however, the short-run relationship remains valid because the error correction term is significant and negative viz., revert towards equilibrium with the speed of adjustment about 15% in each month in case of any deviation from the long-run equilibrium. The long run relationship of monetary models for the Pakistani rupee is validated through the Bound test in the case of the Euro area and the United States. The speed of adjustment is larger in Euro-based exchange rate models (11%) compared to US dollar-based exchange rate models (7%). Although each variable of the monetary model has been found highly significant in the case of US-dollar-based exchange rate models. The production cost gap, foreign reserves and official reserve assets remain significant across all models, but debt is significant only in the case of US-dollar-based models where it causes more depreciation of the Pakistani rupee.

Exchange rate in terms of the Chinese Yuan

The only trade balance has remained significant with positive signs for nominal and real exchange rate, although causes an appreciation of domestic currency but with very small magnitude even less than 0.01%. The role of current and last month's Inflation is significant where a 1% increase in inflation may appreciate the real exchange rate by about 0.3%. Lag values of money supply and interest rate are significant only. Both cost gap and domestic foreign reserves appreciate real (nominal) exchange rates up to 0.11% (0.10%) and 0.03% (0.04%). but domestic official reserve assets depreciate both exchange rates.

Exchange rate in terms of Euro

Most of the variables are significant in both real and nominal exchange rate models except accumulated trade balance and output difference where lags are significant. A one percent rise in Inflation and interest rate gaps lead to an appreciation of domestic currency at 0.38% and 0.0005% respectively while the same increase in the money supply gap may depreciate 0.0021% (0.004%) in the real (nominal) exchange rate. Both a 1% increase in the cost of production gaps and domestic official reserve assets leads to a depreciation of domestic real (nominal) exchange rate up to 0.06% (0.10%) and 0.031% (0.061%) respectively. Domestic foreign exchange reserves appreciate 0.016% (0.031%) respectively.

Exchange rate in terms of US Dollar

Interestingly all fundamentals and other variables have become highly significant both for real and nominal exchange rates. A one percent rise in inflation, and interest rate, will appreciate real (nominal) exchange rate 0.73% (0.07%), and 0.0002% (0.003%), respectively. The foreign trade balance appreciates domestic currency by 0.0033% in real terms. However, money supply and output gaps are depreciating 0.037% (0.68%) and 0.011% (0.026%) respectively. In case of a cost of production gap, a one percent increase may cause a 0.057% (0.58%) depreciation in the real (nominal) exchange rate. Domestic debt is highly significant and leads to a depreciation of 0.004% in the real exchange rate. Domestic foreign reserves and domestic official reserves assets if a rise by 1% may cause an appreciation of 0.0032% and 0.0044% respectively.

Results show that most of the nominal and real exchange rate models are consistent for all variables except inflation in terms of significance and sign. Mostly lag variables remained significant but reflected a cyclical pattern in exchange rates over time.

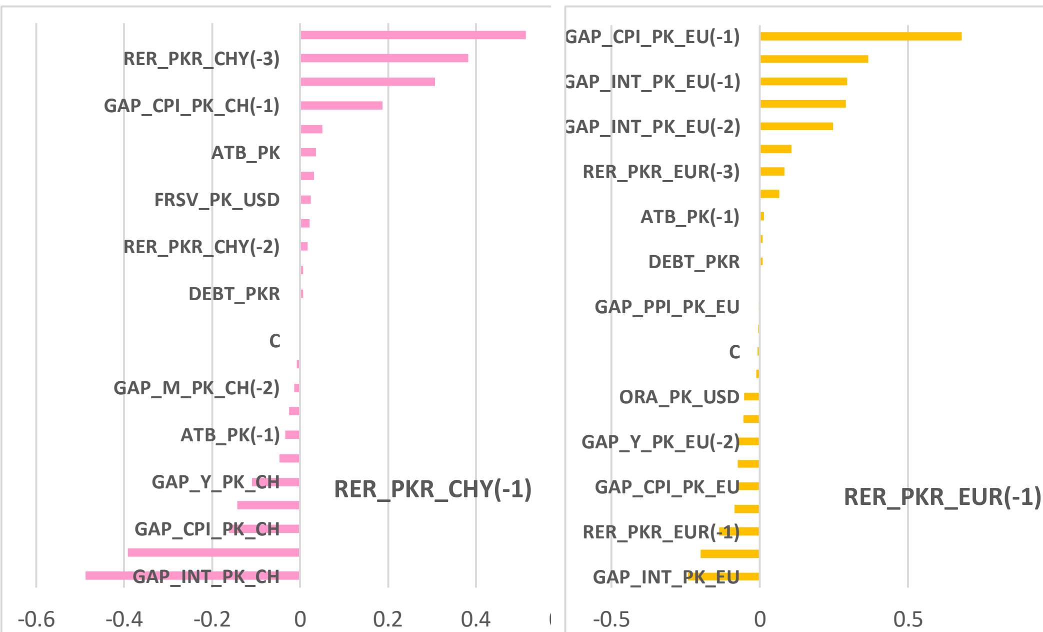
Short-run dynamics

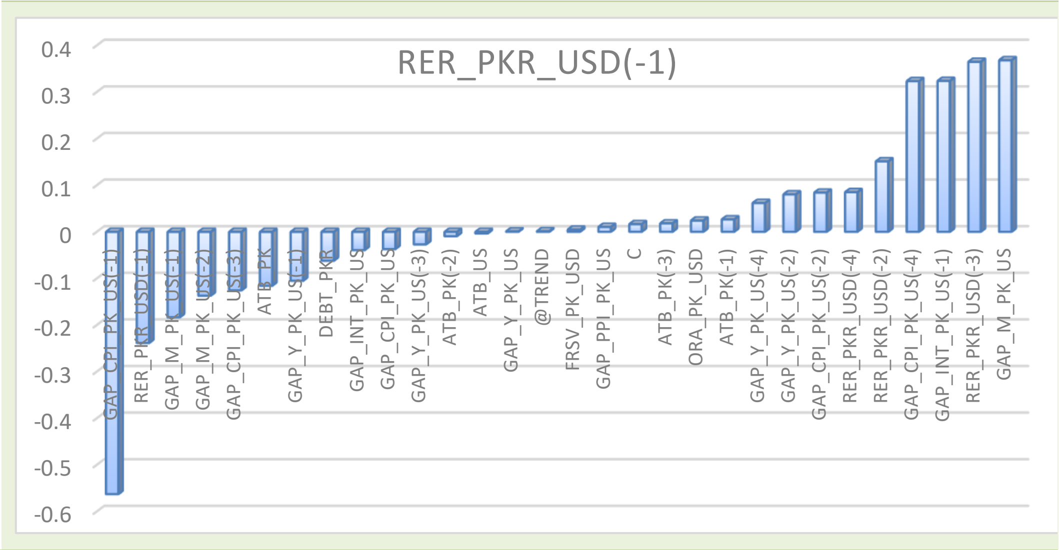
All variables are highly significant in the short run except the interest rate gap, domestic trade balance and domestic debt with a 22% speed of convergence in case of deviation from long run equilibrium in case of the Chinese Yuan.

Most variables are highly significant in the case of Euro-based exchange rates except inflation, interest rate and output gaps but their lags remain highly significant. The speed of adjustment is 15.6% to correct the long-run disequilibrium.

All main variables are highly significant in the case of the US Dollar exchange rate except the money supply gap, domestic trade balance and domestic net foreign assets. However, the speed of adjustment remains very poor 3.1% to correct in the short run for ensuring reverting to the long-run equilibrium.

Figure 3: Variance Decompositions (Eigenvalues)

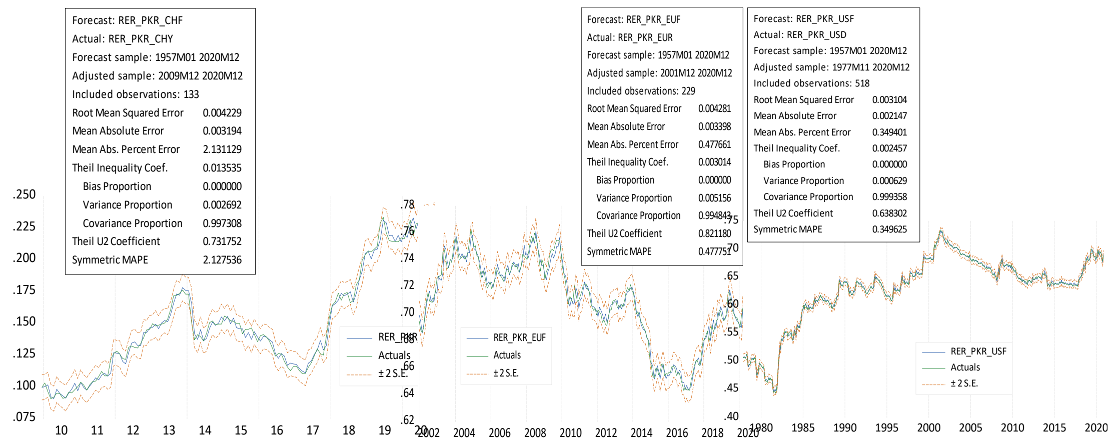




Since short-run dynamics help to observe the correction in short-run deviation from the long-run equilibrium via impulse response function as well. Results of impulse response function with Monte Carlo standard errors (not reported for brevity) identify that mostly variables are mean-reverting in response to any shock that occurs due to other variables(s) in all three exchange rates however with some the exception as in Chinese Yuan based exchange rate is unable to converge back towards equilibrium if shock arrives through domestic debt, Chinese accumulated trade balance, and official reserves assets of Pakistan; the Euro-based exchange rates fails to converge if impulse caused by domestic debt; the US dollar-based exchange rate fails to converge back towards equilibrium if a shock is a cause through domestic debt and domestic official reserves assets. Therefore, both domestic debt and domestic official reserve assets are the two main sources of disequilibria for exchange rates.

The forecasting potential of the models is explored via dynamic forecasting based on Root Means Square Errors (RMSE). Since Theil U2 Coefficient should be close to '0' where the forecast is perfect. Hence based on these values forecasting power of all three models is relatively better. The minimum values of RMSE and Theil U2 coefficient in the case of the US dollar-based exchange rate model shows its better capability to make a reliable dynamic forecast compared to others.

Figure 4: Static Forecasting



5.2 Findings

The long run relationship has been confirmed between the variables of monetary models and the real exchange rate of Pakistan in terms of all three international currencies case that is constant with the findings of (Zakaria and Ahmad, 2009) who have evaluated seventeen trade partner currencies for this purpose. These are further supported by (Khan and Qayyum, 2011), (Zhang, 2014), (Humphrey and Lawler, 1977), and (Boyko, 2002).

The price level, interest rate and money supply are the major monetary fundamentals that are responsible for variation in exchange rates as per the ARDL approach. These findings are in line with the observations of both (Bashir and Luqman, 2014) and (Hina and Qayyum, 2015). As presented in Figure 3, variance decomposition identifies interest rate, inflation and money supply are major sources of variation in all three currencies-based exchange rates, however, money supply may not cause much variance in terms of the Chinese Yuan-based exchange rate.

Chinese Yuan-based exchange rate models in the short run are better due to the high speed of convergence. But US dollar-based exchange rate model is better in terms of forecasting ability.

The outcome of the Johansen cointegration test for the number of cointegrating equations has been endorsed by the ARDL bound testing approach in the case of all three exchange rates which proves that cointegration results are consistent with rigor and cointegration analysis is a reliable strategy to explain long run and short-run behavior of exchange rate as endorsed by (Simwaka, 2004).

As far as the proportion of variation is concerned inflation and interest rate difference are found dominant as observed both by Flood and Taylor (1996) and Khan and Nawaz (2018). The long run relationship of the nominal exchange rate with inflation is supported by Khan, Sattar and Rehman (2012) as well.

The determination of real exchange rates based on the fundamental macroeconomic variables has been consistent with the findings of Adler and Grisse (2014). Since these exchange rates are filed to absorb the shocks caused by domestic 'debt' and domestic 'official reserve assets' hence policy intervention is needed to settle it. These models are found effective as well to make future forecasts related to exchange rates.

5.3 Conclusion

The study has been conducted to evaluate three major currencies of the world[11] acceptable as international currencies across the world. Monthly data for the last six decades has allowed us to observe a long-run relationship with increased precision by using cointegration techniques, which allow us to obtain both long-run and short relationships simultaneously. As the monetary models describe the macroeconomic fundamentals in the financial sector, hence dependence of real (nominal) exchange rate on such models has been fully legitimated by empirical estimation which reflects their use yet is not undermined. An important finding shows that the exchange rate monetary models have been proved relevant to describe the behavior of Pak-rupee exchange rates in terms of especially Chinese Yuan, and generally for Euro and US Dollar in the short and long run both. However, the presence of significant lags with variation in their respective sign is the indicator that these macroeconomic fundamentals induce a cyclical pattern in exchange rate behavior over time. These models also reveal the interdependence of domestic (mainly monetary) policy on the similar policies of counterpart trading countries consequently strong association means poor independence to control domestic imbalance through such policies.

A policy recommendation for better exchange rate management is that Pakistan should switch to the Chinese Yuan for all kinds of international payments as well as maintain a large proportion of foreign reserves into it. The justification is based on the outcomes of the present investigation including: first, the bilateral trade share of Pakistan with China is growing remarkably as obvious from Figure 2; Second, the value of the Pak-rupee is very high in terms of the Chinese Yuan

[11] As per recent development state bank has already approved the bilateral trade and investment with china in terms of Chinese Yuan based exchange rates. Ref: https://economictimes.indiatimes.com/news/international/business/pakistan-central-bank-allows-yuan-based-trade-with-china/articleshow/62350266.cms?from=mdr

whereas Pakistani rupee is most volatile and depreciates over the long periods against both US dollar and Euro but comparatively much stable in case of Chinese Yuan. Third, money supply, interest rate and output gaps remained insignificant for Chinese Yuan-based exchange rate models reflecting the leverage in domestic monetary policy that can be adjusted independently.

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