Modeling Exchange Rate Volatility in Pakistani Context
The Application of Ardl Bounds Test Approach.

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A B S T R A C T

This study documents determinants of exchange rate fluctuations in Pakistan using an ARDL Bounds testing approach over the period of 1981-2015. The study explored the short and long-run factors of exchange rate fluctuations in Pakistan. Dependent variable was exchange rate while explanatory variables were Gross Domestic Product, Interest rate, Inflation Rate, Current Account and Foreign Direct Investment. Empirical results confirmed that Gross Domestic Product, Current Account and Foreign Direct Investment are significant determinants of exchange rate in Pakistan while Interest rate and Inflation Rate are not significant determinants. The ARDL bounds test approach confirmed lung run relationship between exchange rate and the explanatory variables. The error correction term was strongly significant and having the right sign (negative); this means that the estimated speed of adjustment to the long run equilibrium in response to the disequilibrium caused by the short run shocks of the previous period was 16 percent per year. Both ARDL long and error correction model were found to be robust because they passed all diagnostic tests such as Breusch-Godfrey Serial Correlation LM test, heteroskedasticity and normality test. Moreover, the CUSUM test confirmed the stability of both estimated models.

INTRODUCTION

To model the exchange rate behaviour is the unresolved problem in research which must should be solved. Because of the huge exchange rate's value within an economy, no one can refuse the necessity to realize the conduct of foreign exchange markets. A very crucial role is being played by exchange rate in the country's international trade. The exchange rate is a crucial macro-economic mutable used as parameter for determining international rivalry and shows the country's global economic position. The country's development is very much related to the foreign exchange rate system of that country. For better part of the 20th century, exchange rates have been constant by the actions of government instead of being decided in marketplace. Prior to first World War the values of the world's most currencies were determined with regard to gold, while for an era following the second World War the majority of the currencies of the world were valued by evaluation with according to U.S. dollar. Nevertheless, several of the world's significant rates of exchange altered often. Stability in exchange rates decided in the market of foreign exchange at a certain spot when need for and supply of foreign currency matches. A currency's requirement shows up by net exports and currency's supply shows up by net assets from foreign. Any variation in requirement for and supply of currency impacts its worth just like a fine market that is if requirement of a currency magnifies it's worth (exchange rates) will be amplified while rise in

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the currency's supply will lower it's worth (exchange rates) in the market of foreign exchange. Pakistani currency was tied to UK's currency Sterling up from 1947 to 1970 untill it became tied to the US dollar in 1971 due to the rising influence of US in the territory. The Pakistani currency was tied to the USD until 1982 . During 1982 to 1988, the value of rupee was devalued by 38.5%, when the General Zia-Ul-Haq's government changed the exchange rate system to Managed float system. It was again subjected to devaluation when the relationship with trade associations, agencies and beneficiaries became awful because of 1998's nuclear test of Pakistan. Ahmed (2016) investigated the factors affecting the exchange rate in case of Pakistani context using annual ranging from 1997-2012.The study employed regression analysis to explore the nexus between dependent variable and its determinants. The result of the model revealed that Current Account is affecting exchange rate as its R regression coefficient is 27.1. A study was employed by Monica &Santhiyavalli (2017) investigating the prime movers of exchange rate of Indian rupees against us dollar used the data of annual time series starting from 2008-09 to 2014-15. The study applied Augmented Dicky Fuller (ADF) tests to check the stationarity of data while multiple regression was employed to explore the association between dependent variable and its determinants

The trial and error studies concerned with linkage in between exchange rate's inconstancy and its elements are not indecisive. Exchange rate is actually the rate of a specific currency with respect to all other currencies dependent upon regular demand and supply forces. There are a constant number of Euros, Pounds, Dollars, Yen and Dirham etc. issued at any given time (however governments can and do publish more money to purchase other currencies and influence their currencies worth). As the demand rises or lowers for any sole currency, it controls the final rate of such currency. Inthe beginning of 1980's, it was found definite that empirical research hasn't established aid in support of any monetary method or approach to the exchange rate. However, because of the development in the econometric's capability, statistical techniques and methodology requirements, recent research of empirical study has backed up the longrun evidence for authenticity of monetary method (Wilson, 2009).

Objectives

The important and aimful objectives are;

- Analysing the Exchange Rate's determinants in Pakistani market.
- To find out the most critical determinant which is playing the key role in rate of foreign exchange system.
- To give some applicable suggestions to desired implementation of policies for issues as a result of valuation/devaluation of the currency according to the research findings.

Literature Review

The establishments of the existence of both theoretical and empirical linkage between the exchange rate with macroeconomic variables are addressed here. By use of macroeconomic variables there are huge number of researchers who used their attention of study on the exchange rate's determination. Hypothesis describes the kind of straight positive or direct relationship and sort of association between the exch-rate and other variables macro-economics. The practical study of the relationship of exchange rate and other macroeconomic variables give a mixed result. The literature review is arranged in way that individual determinant has been presented with Exchange rate. A study was carried out by Khan (2016) estimating the factors effecting the exchange rate for Pakistani data using data based on annual data which ranges from 1991-2014.The Augmented Dicky Fuller tests were used to check the stationarity of variables. Johansen cointegration test was employed to examine the cointegration between variables while least square regression of two stages was used to inspect the relation between explanatory variables and depended variable. The result indicated that the significant variables are exports, inflation and interest rate, as the p-values of these three variables are less than 5 %, and insignificant variables are found to be current account and imports. Hence, important factors are inflation, exports and interest rate which determines the exchange rate. The regression table present that a sort of association so called negative is there in between the inflation and exchange rate. As inflation increases it leads to reduce the consumer's purchasing power, risen the supply of the local currency and decreases its demand, as a result

the currency devalues. Another study was conducted by Kasif (2000) and explored that there is a negative and insignificant correlation between inflation rate and exchange rate in terms of US dollar and Pakistani rupee. Simon (1997) examined that inflation is positively related to both of the current account and exchange rate while current account is the key determinant which worstly influence the small economies. Anita (2013) investigated the macroeconomic determinants of the volatility of exchange rate at India used the time series data of 1991 to 2010. Pearson's correlation was applied to analyze data and the result showed that inflation rate has significant correlation with exchange rate. This correlation is significant at 0.01 percent level. Akpan (2009) inspected the factors of exchange rate instability in developing economy regarding Nigeria using annual data starting from 1970 to 2004.The OLS technique was used for testing the association between dependent variable and explanatory variables. Instability of the exchange rate is calculated by moving average of three consecutive years of S.D explaining the real exch-rate. The study indicated that inflation has positive and significant association with exch-rate at 0.6 percent level and 0.1 percent level. Hsing (2016) employed a study while exploring the key elements of the ZAR/USD exch-rate in case of South Africa using quarterly data spanning 1983.Q1 to 2014.Q2. The study applied the EGARCH type approach to examine the relation between dependent variable and all ivs. The DF-GLS test was used to find whether there is long-run correlation in between time series variables. The results of the research affirmed that rate of interest is positively affecting the ZAR/USD exchange rate. Particularly, the log of the ZAR/USD exchange rate will be decreased by 0.0259 if 1% increase is there in the yield of 10-year US government bond while the log of the ZAR/USD exchange rate will be decreased by 0.0402 if 1% increase is there in the yield of government bonds of South Africa. Khin, Yee, Seng, Wan & Xian (2017) also explained the vitality of exch-rate and macroeconomic determinants in the country of Malaysia based on time series monthly approach spanning from January 2010 to August 2016. The stationarity was tested through Augmented Dickey-Fuller (ADF). The study applied the different tools of econometric such as Vector Error Correction Method (VECM), the sort of Johansen Cointegration Rank test to check out the short run / long run nexus among different variables. The results confirmed that there is a significant and positive short-run nexus between consumer price index (CPI) and exchange rate. Mahmood&Ehsanullah (2012) employed a study estimating the volatility aspact of the exchange rate while understanding its relationship with macroeconomic variables in case of Pakistani context while using the data of annual time series spanning from 1975-2005. The intent of the study was to examine whether volatility in exch-rate influence the economic indicators in Pakistan. Mathew, Suvith&Rekh (2015) also explained the macroeconomic factors of exchange rate in case of India and used annual data starting from 2004 to 2013. The purpose of study was to examine different macroeconomic determinants which leads to variation in Exchange rate of a currency. The study applied correlation analysis to test the nexus between dependent variable and its drivers. The findings of the research described that GDP, Inflation Rate, External Debt and FDI are positively effecting the exchange rate and rate of interest effecting negatively the exchange rate. Another study was conducted by Ahmad, Draz& Yang (2015) investigating the various macroeconomic variables on Exchange Rates in the sort of developing Asian Countries using panel data spanning from 1981 to 2013. The Least Square Method of two stages and EGLS were carried out for pool sample while panel GMM and the OLS methods were applied for the panel data. The stationarity was checked through the Fisher-ADF. The result declared that that developments in local economic and political systems are essential for an efficient exchange rate policy. The research concluded that the all variables's coefficients are significant and GDP is influencing the exchange rate. Ahmed (2016) investigated the factors affecting the exchange rate in case of Pakistani context using annual ranging from 1997-2012.The study employed regression analysis to explore the nexus between dependent variable and its determinants. The result of the model revealed that Current Account is affecting exch-rate as its R regression coefficient is 27.1. A study was employed by Monica &Santhiyavalli (2017) investigating the prime movers of exchange rate of Indian rupees against us dollar used the data of annual time series starting from 2008-09 to 2014-15. The study applied Augmented Dicky Fuller (ADF) tests to check the stationarity of data while multiple regression was employed to explore the association between dependent variable and its determinants. The findings

revealed that Balance of payment -current account have positive impact exchange rate of Indian rupees against US dollar and the results are found to be statistically significant. Benazic&Skabic (2016) employed a study while investigating the factors of exchange rate in Croatia. The stationarity was investigated by Augmented Dicky Fuller tests. The study carried out the bounds testing (ARDL) approach for co-integration and confirmed the cointegration between variables. The ECT is negative (means has the correct sign) and that is very significant, showing a relatively strong adjustment to the cointegration. The study concluded that FDI and consumer prices have significant nexus with the exchange rate. Ashok &Vikram (2016) determined the volatility of exchange rate & its effect on macro economic indicators in India applying Linear Regression technique. The study included explanatory variables i.e. GDP, Inflation, rate of interest, and FDI (Inflows) while exchange rate is dependent variable using annual data spanning from 1996-2014.The result of study confirmed that the inflation and GDP are negatively and insignificantly effecting exchange rate but rate of interest has negative and significant correlation with exchange rate whereas a positive and insignificant relationship exists between exchange rate and FDI.

Conceptual Framework

In the following diagram, the independent variables are shown on the left while the dependent variables are shown at the right side of diagram.

Independent Variables   **Dependent Variable**
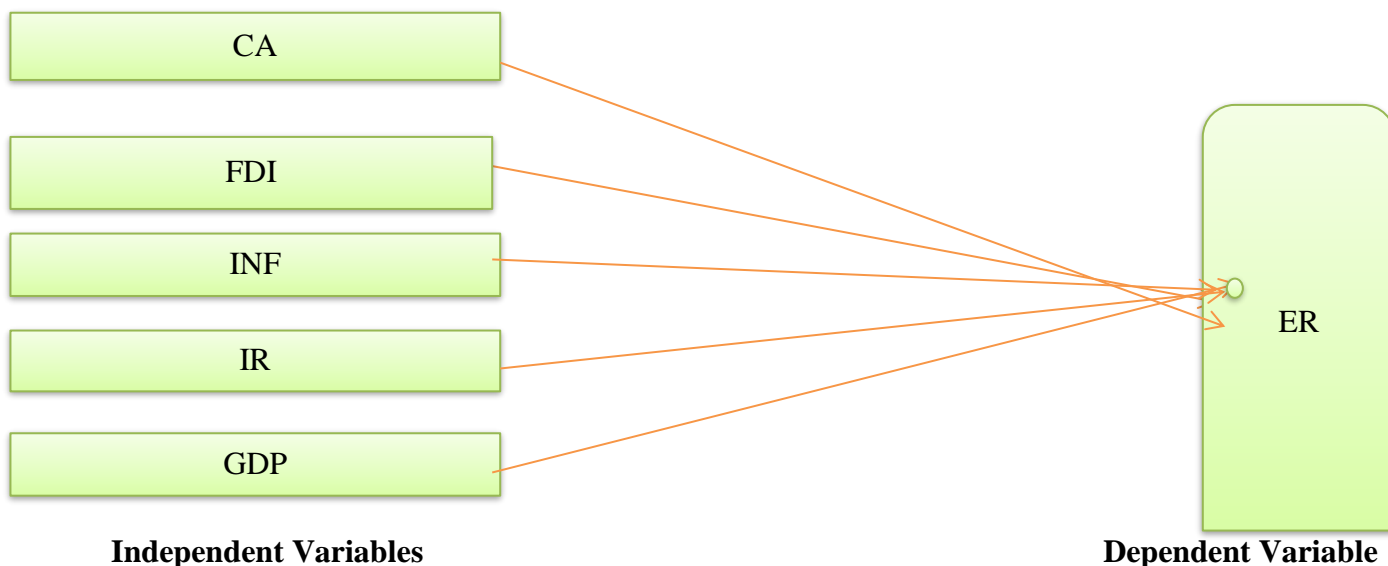
Data and Methodology

Data
This research is awning the era of managed float or flexible exchange rate system of Pakistan. The research used the data of annual time series spanning from 1981-2015 to explore the volatility of PKR against USD exchange rate and association of exchange rate volatility with other macroeconomic variables. The Inflation (CPI), Interest rate, Current Account, GDP and FDI are taken as explanatory variables while exchange rate is used as a dependent variable in the study. Nature of all the variables which are used in this research is Quantitative and provides 35 observations. The data have been gained from World Development Indicators (WDI) and International Financial Statistics (IFS).

Methodology
Babbie (2010) wrote that the analysis of the data is conducted on the data which is obtained in order to commute it to a form which is more suitable for the use of finding results that resonate theories and ideas which started the inquiry. In order to analyze the elements of exchange rate within the Pakistan, the (Augmented Dickey Fuller) ADF was used for testing variable's stationarity while ARDL model was

employed for estimating the long-term relationship in between the exchange rate and independent variables.

Model Specification
The empirical model is given as follows:
ER = ƒ (INFL, IR, CA, FDI, GDP) …………………….…………….. (1)
The econometric model is given as:
ER = β0 + β1INF +β2INTR+β3CA+ β4FDI+ β5GDP+μ …………. (2)
Where

  ER = Exchange Rate
  GDP = Gross Domestic Product
  INTR = rate of Interest
  INF = Inflation Rate
  CA =Current Account
FDI=Foreign Direct Investment

Unit Root Test
Traditionally, the generally accepted assumption of establishing and checking the economic model which underlies variables is stationary, however is sadly not usually true. Before going to estimate this model in equation no 3, we have a tendency to checkout the data with time series properties. This is often important as a result of time series econometricians like granger and Newbold, (1974); Eagle and granger, (1987), Dickey and Fuller, (1981); in between others, determined that results deriving from most economic determinants are probably to be "Spurious" if the properties of the time series of such data aren't analyzed. So, the data should be examined according to the properties of time series victimization increased Augmented Dickey Fuller (ADF) check. during this study, increased Augmented Dickey Fuller (ADF) test was accustomed test the stationary of the elements. This study additionally adopted the increased Dickey Fuller each at I (0) and (1) for additional supportive test because there should be no autocorrelation biasness according to ADF assumptions, thus ADF's control assures that the term of error may be a good white noise according Wooldridge, (2003).

$$\Delta Y_t = \partial 1 + \theta Y_t\_1 + \lambda \sum_{t\_1}^{n} \Delta Y_t\_1 + \mu_t \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots . \dots (3)$$

ARDL bound test approach for Cointegration
In the research study cointegration is applied to find out whether or not the predictors and criterions (variable) are having a linear sort of stationary combination within the long-standing time. according to Dora, (2009) the aim of cointegration check is to know whether or not variables within the system alien from one another and square measure on an individual basis stable l (1) within the short run. If the variables square measure cointegrated, they're going to be expected to make a stationary relationship within the long-standing time. Pesaran and et al, (2001) created ARDL model and used the certain take a look at during a crucial sure to examine the semi-permanent equilibrium relationship among variables. The bounds take a look at technique cointegration has sure political economy benefits compared to alternative strategies of cointegration that square measure the following: The model's all variables square measure assumed to be Dependent variable. Secondly, it take a look at technique for determining and measuring the co-integration sort of approach is being used no matter the sequence represent the integration of variable, either initial order I (1) or I (0). finally, each short-term and sort of unbiased long-standing time coefficients of the model will be calculable at the same time Harris and Sollis, (2003). The ARDL take a look at is comparatively additional economical within the case of little and finite sample information sizes.

Computing F-statistic
This research study tested the existence of co-integration by comparison where the price of F-test which is being calculated while compared with the important price which is given in Table CI (iii) of Pesaran et al. (2001). The Wald check (F-Test) was calculated to discriminate the long run relations between the

involved variables. The alternative hypotheses and null hypothesis are as follows:

Null hypothesis H0= $\partial1$= $\partial2$= $\partial3$ =$\partial4$ =$\partial5$ =0 (not a long run relationship) i.e., there is no cointegration between the used variables. All sort of alt- hypothesis i.e H1 $\neq\partial1$ $\neq\partial2$ $\neq \partial3$ $\neq \partial4$ $\neq \partial5$ $\neq 0$ (there is relationship having long run existence) i.e., co-integration between the variables exists.

ARDL Model Specification

$$\Delta ER_t = \alpha0 + \sum_{i=0}^{s} \beta1i\, \Delta FDI_{t\_i} + \sum_{i=0}^{s} \beta2i\, \Delta IR_{t\_i} + \sum_{i=0}^{s} \beta3i\, \Delta GDP_{t\_i} + \sum_{i=0}^{s} \beta4i\, \Delta CA_{t\_i} + \sum_{i=0}^{s} \beta5i\, \Delta INF_{t\_i} + t\_i\varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

Here the symbol **Δ** indicates first discriminate term, **β1** indicates coefficients and ε is the residuals. ER represents exchange rate, GDP represents growth domestic product, IR shows rate of interest, INF is inflation, FDI stands for Foreign Direct Investment, and CA is current account.

Diagnostic Tests and Stability Test

It was necessary to investigate the strength of every single calculable model during this study so as to work out the extent to that calculable results might be dependent on. The power of the used models are tested by many diagnostic tests. In this study the tests which were assumed to be necessary are; SR-correlation, hetero problem, normality and sort of CUSUM check to look at the stability check of models.

Results and Discussion

We know that the first step of time series is to check the stationarity of variables and for that reason, the study has employed ADF test to test the stationarity. The result is reported in table 1 as below:

ADF Unit Root Tests			
Variables	**At 1st Difference**		**Status**
	T-statistics	**Critical Values at 5 %**	
Exchange rate	-5.697873	-2.971853	I(1)
Inflation	-6.544382	-2.971853	I(1)
Interest rate	-4.757780	-2.971853	I(1)
Current A/C	-4.635343	-2.971853	I(1)
GDP	-6.362788	-6.971853	I(1)
FDI	-3.443653	-2.971853	I(1)

Results of ADF test

The stationary relation of variables was tested by ADF (Augmented Dicky Fuller) tests and the findings of the ADF test show that Exchange rate at level was non-stationary but it became stationary at its first difference. Similarly, when Inflation was tested through ADF test and it was not stationary at I(0) but became stationary at 1st difference. There was no stationarity in interest rate at level but as it was subjected to first difference then it became stationary. Similarly, Current account, GDP and FDI were not stationary at levels but converted into first difference then they all became stationary. Except the GDP the remaining all variables are not stationary at levels. The study hence, found that except GDP which was stationary both at I(0), all other variables are stationary at first difference level. Hence, it gives room to employ an ARDL approach to cointegration.

ARDL Bounds Test

Test Statistic	Value	k
F-statistic	12.32852	5

Critical Value Bounds

Significance	I0 Bound	I1 Bound
10%	2.08	3
5 %	2.39	3.38
2.5 %	2.7	3.73
1 %	3.06	4.15

Results of ARDL Bound test for cointegration

To investigate the presence of long run nexus between response variable and other related variables, Bound test was conducted to explore the cointegration. The Wald test wascalculated to confirm the long run association between the used indicators (i.e. exchange rate, inflation, GDP, current account, IR and FDI). The calculated F-Test values were compared with the sitrical values. The null hypothesis which have no cointegration against alternative hypothesis of having cointegration was subjected to test and findings are represented in the table.The computed F-statistic value was turned out to be higher than the upper bound critical value (that is 3.99 at 5 percent significance level). Though, it leads to go for formal rejection of null- hypotheses which tells about that there is no cointegration, revealing that the features under consideration are cointegrated.

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
FDI	0.089474	0.022123	4.0443	0.000
GDP	-0.565212	0.214517	-2.6348	0.0403
CA	-0.120213	0.026954	-4.4599	0.000
INF	-32.049754	102.078917	-0.313970	0.7568
IR	-27.127134	81.826173	-0.331521	0.7437
C	1253.066854	3764.237547	0.332887	0.7427

Long Run Relationship

In the above table, the estimated coefficients describe that FDI effects exchange rate significantly with positive magnitude. The influence of GDP on the rate of exchange is negative and statistically significant. Similarly, CA has negative and statistically significant effect on exchange rate. The remaining variables impact is insignificant on exchange rate.

Short Run Results

Error Correction Representation of Selected ARDL (1,2,2,2,1,1) Model Dependent Variable ER

Cointegrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(FDI)	2.272699	0.730949	3.109245	0.0055
D(FDI(-1))	2.427702	0.783809	3.097311	0.0057
D(GDP)	-0.449826	0.186619	-2.410398	0.0257
D(GDP(-1))	0.452717	0.217619	2.080323	0.0506
D(CA)	-1.054594	0.260260	-4.052079	0.0006
D(CA(-1))	-0.969897	0.203541	-4.765120	0.0001
D(INF)	-0.146738	0.116029	-1.264665	0.2205
D(IR)	0.072798	0.232342	0.313322	0.7573
CointEq(-1)	-0.06578	0.00646	-10.187106	0.0000

Cointeq = ER - (29.5589*FDI -182.5469*GDP -37.4384*CA -32.0498*INF +

27.1271*IR + 1253.0669)

Short Run Results

A long run correlation exists as far as the bound test is used. Findings for short run as well long run coefficients are given in table -3. All the above are short-run coefficients. The results describe that FDI seems to have significant effect on exchange rate. Like FDI, GDP is also related to exchange rate significantly. CA has significant impact on exchange rate with negative sign. Furthermore the results indicate that the coefficient of error correction term, CointEq(-1) has significant with negative magnitude, providing an additional evidence of a stable long term relationship between exchange rate and its determinants. The value of coefficient CointEq(-1) is the speed of adjustment parameter and it should be negative and significant and implies the whole system would get back to long term stable relationship. The estimated value of CointEq(-1) is -0.06, almost 6 percent disequilibrium will be corrected in the present year

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	1.522437	Prob. F(2,18)	0.2450
Obs*R-squared	4.774599	Prob. Chi-Square(2)	0.0319

Serial Correlation

The Lagrange Multiplier (LM) test was applied to identify the existence of sr-correlation. This test was carried out to check the null hypotheses of no autocorrelation against the rival hypotheses of autocorrelated residuals. The result is reported as the F-statistic is 4.774 with the corresponding p-value 0.393 that was above than 5%. In that case, as there is no serial correlation issue in this estimated model so we cannot subject the null hypothesis to be rejected.

Graphical presentation of the Cusum Test
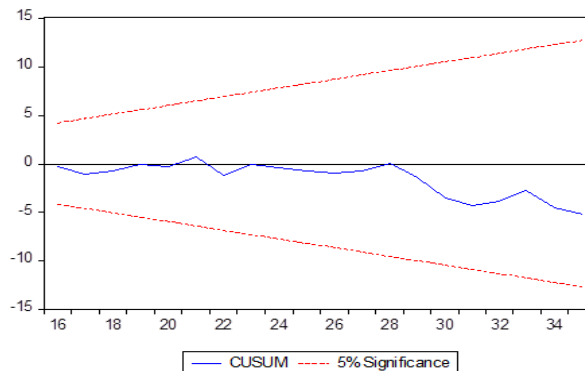
Cusum/Stability Test

The parameter's stability in the model was explored by using the test of (CUSUM) presented by Brown et al. (1975). In this study, the model's own stability was also tested with Cusum Test. As the blue line is falling within the red boundaries, the current figure indicates that the stability exists in the model. As the CUSUM test falls in the 5% critical bound, the findings.

CONCLUSION

The present study estimates empirical analyzation anticedents of exchange rate volatility within the Pakistan by employing ARDL Bounds test for the annual time series data spanning from 1981 to 2015. The findings of the test of unit root analysis indicates that there is stationarity at I(1) in all variables. The ARDL bound testing technique confirmed the long-run relationship between exch- rate and its determinants. The ECT also indicated the convergence of variables to their long-run position. The findings of the study show that GDP and current account are significantly and negatively affecting exchange rate in the long run duration in Pakistan. Similarly, FDI has positive and significant nexus with exchange rate in the long-run. The results further indicated that inflation and interest rate have insignificant association with exchange rate in the long-run in Pakistan. The stability test was used to test the model's stability and shows that the long run estimated model of ADRL was stable according to structure and dynamics. The current study is not absolute final, but it can open a new way for future research. The study applied annual data and in the further research, researchers can use the data of quarterly or monthly based time series if it is possible, that will obviously provide better and more complete results. Furthermore, this research may be explored in the future by taking some other indicators of macroeconomics in it.

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