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REVIEW ARTICLE

AN ECONOMETRIC ANALYSIS OF DETERMINANTS OF EXCHANGE RATE IN NEPAL

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ABSTRACT

Exchange rate is an important macroeconomic variable which influence internal and external balance and indicates external competitiveness of an economy. It plays a role of catalyst for macroeconomic stability. The main objective of this research is to investigate the relationship of exchange rate with different macroeconomic variables such as GDP, inflation, interest rate, broad money supply, and trade openness in order to reveal significant determinants of exchange rate of Nepal. The research uses secondary annual average data obtained from NRB, WB, and IMF from time period of 1993 to 2022 AD. The study uses ADF test to test the stationarity of variables. ARDL approach to co-integration is used for estimation of long run relationship and ECM is applied for estimating short run relationship between dependent and independent variables. The study also uses CUSUM and CUSUM of square test to validate stability of coefficient of long run model. Results from ARDL bound co-integration test shows evidence of long run co-integration between dependent variable and regressors as calculated F-statistics (3.989) is greater than critical value for upper bound I(1). The results of estimated long run coefficients using ARDL approach shows that inflation and money supply have negative long run relation with exchange rate whereas GDP, interest rate and trade openness have a positive long run relation with exchange rate. The coefficient of the error term is found to be –0.33 using ECM. Results from ECM indicate positive and significant effect of interest rate on exchange rate in short run, while the effects of GDP, inflation, money supply, and trade openness are found insignificant in short runs. The findings of this study may aid policy makers of Nepal to formulate such monetary and fiscal policies that makes exchange rate less volatile and more productive for sustainable economic growth of the nation.

KEYWORDS

Exchange rate, co-integration, ARDL, ECM, GDP, Inflation, trade openness

1. INTRODUCTION

Exchange rate is an important macroeconomic variable which refers to the amount of one currency needed to exchange one unit of another currency (Heller, 1978). Exchange rate influences internal and external balance and indicates the external competitiveness of the economy (Gala and Lucidna, 2006). Generally exchange rates are of two types; fixed exchange rate and floating exchange rate. In fixed exchange rate, monetary authority or the government firmly sets the value of its currency against another currency with the purpose to keep value of currency within a narrow band. In floating exchange rate, value of currency is set by demand and supply forces of the market such that higher demand for the currency leads to higher value of currency and vice versa (Chin and Miller, 1998).

Exchange rate has direct effect on price, wage, interest rate, production level, employment opportunities, export etc. of a country (Thapa, 2002). Thus, it has dominant role in economic prosperity. Volatility of exchange rate increases uncertainty and hampers trade flow. It is one of the hurdles for macroeconomic policy makers (Hayakawa and Kimura, 2009). Stability in exchange rates results in improved foreign investments, boost of exports and favorable change in balance of trade of the country. It plays a role of catalyst for the macroeconomic stability (Thapa, 2002). In long run exchange rate reflects macroeconomic fundamentals of an economy such as GDP growth, international trade, inflation, interest rate, currency convertibility, bond price, cumulative trade, and economic policies (Dahal and Raju, 2022). Due to enormous significance of exchange rate in an economy, there is a need to assess its determinants and behavior in details.

Exchange rates are the lifeblood of international trade and finance, serving as the economic arteries that connect nations and facilitate the flow of goods, services, and investments across borders. For a country like Nepal, nestled within the rugged terrain of the Himalayas, understanding the intricate web of factors that influence its exchange rates is not merely an academic exercise but a vital necessity (Paudel and Burke, 2015). As a landlocked nation, Nepal stands at the crossroads of regional trade and geopolitics, making its exchange rate dynamics particularly intriguing (Paudel and Burke, 2015). While Nepal's economy is relatively modest in scale compared to global economic giants, its exchange rates are subject to a multitude of domestic and international forces (Pari, 2022).

This research aims to reveal the determinants of exchange rates in Nepal, shedding light on the different macroeconomic factors that influence the value of the Nepalese Rupee. This study considers macroeconomic variables such as, money supply, trade openness, inflation rate, gross domestic product (GDP), and interest rate and aims to derive their relationship with exchange rate of Nepal using time series data from 1993 to 2022. The findings of this study may aid policymakers to formulate effective policies for the productive exchange rate for Nepal to attain sustainable economic growth of the nation.

2. LITERATURE REVIEW

As exchange rate is a matter of concern for all in this integrated world, there have been previous studies on the determinants of exchange rate. Before 1970s, studies were carried out with fixed price assumption that

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assumes static price level between two countries (Mundell, 1963). Researchers and economists determine exchange rate with diverse approaches and theories. Diverse approaches are useful in identifying key determinants of exchange rate in diverse conditions.

Elbadawi and Soto applied error correction model and co-integration techniques and revealed larger degree of trade openness is assured by depreciated exchange rate and rising interest rate brings devaluation to exchange rate (Elbadawi and Soto, 1997). Ahmed using vector error correction model found that terms of trade and trade openness significantly influence equilibrium exchange rate (Ahmed, 2009). Kumar using ARDL approach revealed that terms of trade has negative significant relationship whereas trade openness has positive significant relationship with exchange rate in India in long run (Kumar, 2010).

However, Hau revealed inverse relationship between trade openness and real exchange rate (Hau, 2002). Bergval applied Johansen's co-integration technique and confirms that terms of trade significantly influence long term movement in exchange rate (Bergval, 2004). Joyce and Kamas used Johansen's co-integration technique and found long run relationship of exchange rate with terms of trade and productivity in Colombia however Milessi-Ferretti and Lane found no evidence of connection between terms of trade and Irish exchange rate (Joyce and Kamas, 2003; Milessi-Ferretti and Lane, 2010).

A group researchers applied ARDL and error correction model and found long run significant positive relation of money supply to exchange rate in Pakistan however in short run there is no such relation in between them (Saeed et al., 2012). Similarly, Khan and Qayyum revealed money supply and inflation differential as positive significant determinants of exchange rate in Pakistan (Khan and Qayyum, 2011). A group researchers conclude significant long run relationship of money supply and real GDP with exchange rate in South Africa (De Bruyn et al., 2013). However in Thailand, GDP and interest rate are inversely associated with exchange rate (Liew et al., 2009). Similarly, some researchers found real GDP and interest rates have negative significant relationship with exchange rates in Pakistan (Khattak et al., 2012).

Mirchandani found that high inflation leads to an appreciation of exchange rate of currency and also exchange rate has positive correlation with GDP growth rate in India (Mirchandani, 2013). Ramasamy investigated nine macroeconomic variables' influence on exchange rate and found interest rate, BOP and inflation rates are positively related to the exchange rate Ramasamy, 2015). Khan applied ARDL model found GDP and trade openness has positive effect of exchange rate however interest rate and inflation rates have inverse effect to exchange rate in China (Khan, 2019).

Pari investigated various macroeconomic variables including inflation rate, interest rate, FDI, current account balance and GDP aiming to find their association with exchange rate in Nepal using ARDL model and found that FDI, current account balance, trade deficit and GDP has strong positive association with exchange rate (Pari, 2022). However, inflation rate (CPI) and interest rates are insignificantly related with exchange rates of Nepal.

3. METHODOLOGY

The study employs a quantitative research design to investigate the determinants of exchange rate in Nepal. The research design is primarily based on analysis of time series data of exchange rate and other macroeconomic variables. This study covers time period of 1993 to 2022 AD to ensure a comprehensive analysis of exchange rate determinants. Data sources for this study includes; Nepal Rastra Bank (NRB), international financial institutions like; International monetary fund (IMF), World Bank (WB) etc. The dependent variable in this study is nominal exchange rate of Nepalese rupee against USD and the independent macroeconomic variables include money supply, trade openness, inflation rate, gross domestic product (GDP), and interest rate. Software like STATA, and MS-Excel are used for the analysis of collected data.

3.1 ARDL approach of co-integration

The study uses augmented dickey fuller (ADF) test to test stationarity of variables. Autoregressive distributed lag (ARDL) approach to co-integration is used for estimation of long run relationship between dependent and independent variables (Nkoro and Uko, 2016). Error correction mechanism (ECM) has been employed to estimate short run relationship (Alogoskoufis and Smith, 1991). ARDL approach has certain advantages over other co-integration approaches. This approach simultaneously provides long run and short run estimates for empirical investigation (Nkoro and Uko, 2016). It separately examines long run and short run casual relationships. In the situation where variables are of endogenous nature, bound testing approach normally provides unbiased long run estimates and valid t-statistics (Saeed et al., 2012).

The ARDL model is developed for estimations as follows:

$$\Delta ERt = \alpha 0 + \alpha 1 \sum_{i=1}^{p} \Delta ERt\text{-}1 + \alpha 2 \sum_{i=1}^{p} \Delta GDPt\text{-}1 + \alpha 3 \sum_{i=1}^{p} \Delta INFt\text{-}1 + \alpha 4 \sum_{i=1}^{p} \Delta INTt\text{-}1 + \alpha 5 \sum_{i=1}^{p} \Delta MSt\text{-}1 + \alpha 6 \sum_{i=1}^{p} \Delta TOPt\text{-}1 + \beta 1\ ERt\text{-}1 + \beta 2\ GDPt\text{-}1 + \beta 3\ INFt\text{-}1 + \beta 4\ INTt\text{-}1 + \beta 5\ MS\ t\text{-}1 + \beta 6\ TOPt\text{-}1 + \mu t$$

Where, α0 is a constant and α1 is the white noise error term, ER is the currency exchange rate of Nepal against the US, GDP is real gross domestic product as a proxy of economic growth, INF is inflation rate computed by using the CPI, INT is average annual central bank policy rate considered as interest rate in this study, MS is broad money supply in the economy, and TOP is trade openness that is measured by import plus export divide by GDP.

ARDL bound testing approach to co-integration involves two steps procedure. First step is testing existence of co-integration by comparing calculated value of conditional F-test of lagged level variables through variable addition test with the critical bounds provided by Pesaran and Pesaran (Pesaran and Shin, 1995; Pesaran et al., 2001). If calculated value of conditional F-statistics is greater than upper bound critical value then, it indicates existence of long run relationship whereas if the calculated value is smaller than lower critical bound, then it indicates no long run relationship. However if the value lies in between lower and upper bound, then it is inconclusive (Pesaran and Shin, 1995; Pesaran et al., 2001). The model used to estimate the long-run coefficients is as follow:

$$ERt = \Omega 0 + \Omega 1 \sum_{i=1}^{p} \Delta ERt\text{-}1 + \Omega 2 \sum_{i=1}^{p} \Delta GDPt\text{-}1 + \Omega 3 \sum_{i=1}^{p} \Delta INFt\text{-}1 + \Omega 4 \sum_{i=1}^{p} \Delta INTt\text{-}1 + \Omega 5 \sum_{i=1}^{p} \Delta MSt\text{-}1 + \Omega 6 \sum_{i=1}^{p} \Delta TOPt\text{-}1 + \mu t$$

3.2 Error correction model

For estimation of short run coefficient, the model used is as follow:

$$\Delta ERt = \alpha 0 + \alpha 1 \sum_{i=1}^{p} \Delta ERt\text{-}1 + \alpha 2 \sum_{i=1}^{p} \Delta GDPt\text{-}1 + \alpha 3 \sum_{i=1}^{p} \Delta INFt\text{-}1 + \alpha 4 \sum_{i=1}^{p} \Delta INTt\text{-}1 + \alpha 5 \sum_{i=1}^{p} \Delta MSt\text{-}1 + \alpha 6 \sum_{i=1}^{p} \Delta TOPt\text{-}1 + \delta\ ECMt\text{-}1 + \mu t$$

Where, δ is the coefficient of error correction term (ECM) in the model which indicates the speed of adjustment needed for restoration of long run equilibrium following short run shock. The study also used CUSUM and CUSUM of square test to validate stability of coefficient of long run model.

4. RESULTS AND DISCUSSIONS

4.1 Nature and trend of exchange rate and other macroeconomic variables

The trend of exchange rate, inflation, interest rate, and trade openness is shown in figure 1. The graph shows a rising trend of Exchange rate (NRs/USD) in comparison to other variables. Increasing exchange indicates reduction in the value of Nepalese currency in the international market. Interest rate doesn't seem to change much as compared to other variables under study.

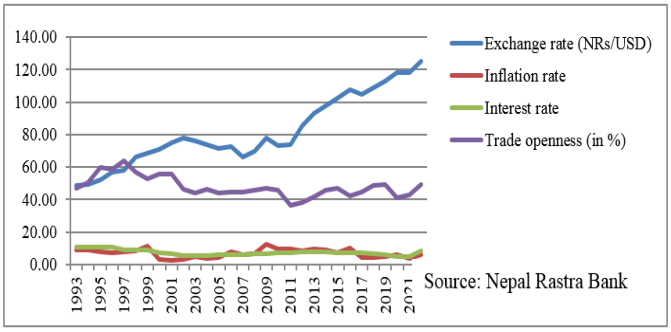

Figure 1: Average annual exchange rate, inflation rate, interest rate and trade openness of Nepal during study period

Similarly, figure 2 shows rise of both GDP and money supply. However, money supply is seen to rise more compared to GDP. The value of GDP was higher than broad money supply before 2019. However, after 2019, average annual GDP gets lower than money supply. This indicates how money supply is increasing in recent years.

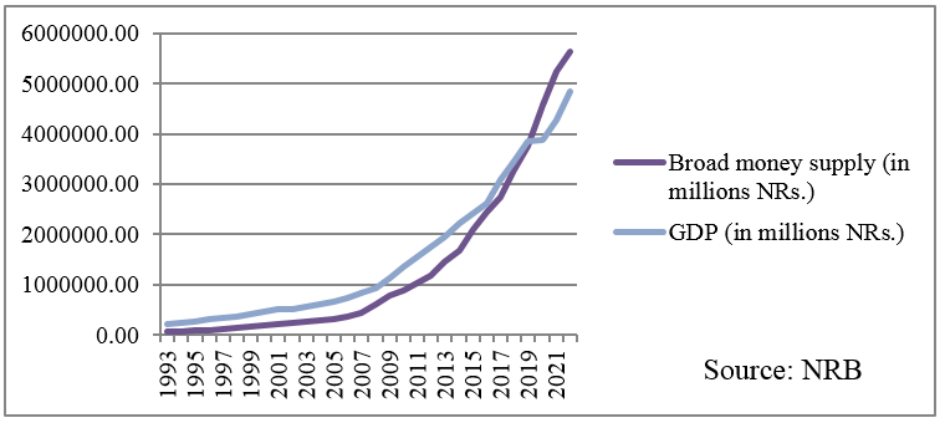

Figure 2: Average annual GDP and broad money supply trend in the study years

4.2 Descriptive analysis

Table 1 provides a summary of sample descriptive analysis. Minimum annual average value of exchange rate is NRs 48.61 per USD and the maximum value is NRs 125.2 per USD with an average value of Nepalese rupee 81.70 per USD. The fluctuation is measured by standard deviation which is 21.88 per US dollar. Similarly, Minimum value of interest rate is 5% and the maximum value is 11% with an average value of 7.43%. The fluctuation in interest rate is measured by standard deviation which is 1.81.

Inflation rate is another macroeconomic variable under study which has minimum, maximum and average value of 2.44, 12.62 and 6.96 respectively. The standard deviation of inflation is 2.65. Likewise, trade openness of Nepal during the study period has its maximum, minimum and average value of 64.04, 36.3 and 47.87 percentage respectively. The maximum, minimum and average value of GDP is NRs 4851.6 billion, 215.09 billion and 1547.8 billion respectively with the standard deviation of 1391.9 billion. Likewise money supply (M2) of Nepal has its maximum, minimum and average value of NRs 5653.02 billion, 61.2 billion and 1351.4 billion respectively.

Table 1: Descriptive statistics of the variables

Variables	Obs.	Mean	Standard deviation	Minimum value	Maximum value
Exchange rate	30	81.70	21.88	48.61	125.20
Inflation	30	6.96	2.65	2.44	12.62
Money supply	30	1351.49b	1646.6b	61.2b	5653.02b
Interest rate	30	7.43	1.81	5	11
Trade openness	30	47.87	6.42	36.30	64.04
GDP	30	1547.84b	1391.91b	215.1b	4851.63b

Note: b indicates that the values are in billions of NRs.

4.3 Augmented dickey fuller unit root test

ADF test was performed to check whether the data used for regression analysis are stationary or not. If the data are not stationary, it is necessary to convert them to stationary. This study uses natural logarithm of money supply and natural logarithm of GDP as a transformed data of money supply and GDP. All the variables under study were found to be non-stationary at level both with trend and without trend except inflation as shown in table 2. However interest rate with drift was found stationary at level as shown by table 4. ADF unit root test performed at first difference level revealed all the variables which were non-stationary at level to be stationary at their first difference except interest rate as shown in table 3.

Table 2: Results of ADF test at level

Variables	Without trend	With trend	Status
Exchange rate	0.409	-1.118	I(0) non-stationary
Inflation	-3.064	-3.009	I(0) stationary
ln.Money supply	-0.099	-1.829	I(0) non-stationary
Interest rate	-2.140	-1.285	I(0) non-stationary
Trade openness	-1.963	-2.592	I(0) non-stationary
Ln.GDP	0.053	-1.367	I(0) non-stationary

Critical value with an intercept but not a trend = -2.989 at 5% significance
Critical value with an intercept and Trend = -3.584 at 5% significance

Table 3: Results of ADF test at first difference level

Variables	Without trend	Status	With trend	Status
Exchange rate	-4.614	I(1) stationary	-4.611	I(1) stationary
ln.Money supply	-4.432	I(1) stationary	-4.329	I(1) stationary
Interest rate	-2.596	Non-stationary	-2.876	Non-stationary
Trade openness	-4.901	I(1) stationary	-4.777	I(1) stationary
ln.GDP	-3.636	I(1) stationary	-3.574	I(1) stationary

Critical value with an intercept but not a trend = -2.992 at 5% significance
Critical value with an intercept and trend = -3.588 at 5% and -3.233 at 10% significance

Table 4: Results of ADF test at level		
Variables	With drift	Status
Interest rate	-2.140	I(0) stationary
Critical value for the ADF statistic with an intercept and drift = -1.703 at 5% significance		

4.4 ARDL bound co-integration test

Results of F-statistics using ARDL bound testing approach to co-integration are presented in the table 5. With optimum lag value of selected based on Akaike Information Criterion (AIC) as 1,1,0,2,2 and 2 for exchange rate, inflation, interest rate, trade openness, money supply and GDP respectively, the results shows evidence of long run co-integration between dependent variable and regressors as calculated F-statistics (3.989) is greater than critical value for upper bound I(1). Thus null hypothesis of no co-integration is rejected indicating the presence of long run relationship of exchange rate with the independent variables under study.

Estimated long run coefficient using ARDL approach is presented in table 6. Adjusted R-square value for long run ARDL approach is 0.979, indicating about 98% of variation in exchange rate is explained by independent variables in the study. Inflation, interest rate, and GDP are significant at 1% level of significance with the exchange rate. Money supply is significant with exchange rate at 5% level of significance. However, trade openness is significant at 10% level of significance with exchange rate. Inflation and money supply have negative long run relation with exchange rate whereas GDP, interest rate and trade openness have a positive long run relation with exchange rate as shown in table 6.

Kumar revealed positive significant long run relationship of exchange rate and trade openness (Kumar, 2010). Khan found positive relation of trade openness and GDP with exchange rate and inverse relation of inflation rate with exchange rate in China which are similar to our findings (Khan, 2019). Khan and Qayyum also found results that are in line with our findings of relationship of money supply and exchange rate (Khan and Qayyum, 2011). Ramasamy revealed positive relation of exchange rate with interest rate which is also similar to our results (Ramasamy, 2015).

Table 5: Results of ARDL co-integration test		
	Lower bound I(0)	Upper bound I(1)
F-statistics	Critical value (5%)	Critical value (5%)
3.989	2.62	3.79
t-statistics	Critical value (5%)	Critical value (5%)
0.618	-2.86	-4.19
H0 : no level relationship Accept if f < critical value I(0) Reject if f > critical value I(1) Or, Accept if t > critical value for I(0) Reject if t < critical value for I(1)		

Table 6: Estimated long run coefficients using ARDL approach				
Variables	Coefficient	Std. error	t-statistics	Prob.
Exchange rate (L1)	0.63	0.11	5.6	0.00
Inflation (L1)	-0.78	0.26	-2.99	0.00
Interest rate (L0)	1.54	0.47	3.27	0.00
Trade openness (L2)	0.21	0.13	1.7	0.10
Ln. money supply (L2)	-19.2	8.65	-2.22	0.03
Ln. GDP (L2)	38.17	12.77	2.99	0.00
Constant	-517.1	129.9	-4	0.00
R-square : 0.984 Adj. R-square : 0.979 F-statistics : 219.9 F-Prob. : 0.00				

4.5 Error correction model

Error correction model is used to estimate the short run relationship between dependent variable and independent variable. Table 6 represents the results of error correction model. Results indicate valid short run relationship between exchange rate and regressors under study in Nepal. The coefficient of the error term is –0.33 which is significant at 1% level of significance. It indicates about 33 percent of disequilibrium is corrected within a year. Results also indicate positive and significant effect of interest rate on exchange rate in short run as well, while the coefficient of GDP, inflation, money supply, and trade openness are found insignificant in short runs.

Table 7: Results of error correction model test			
Variables	Coefficient	t-statistics	Probability
Constant	-97.09	-0.68	0.504
Residuals (ECM)	-0.33	-2.92***	0.008
Inflation	-0.43	-1.36	0.188
ln.Money supply	-2.15	-0.19	0.855
Interest rate	1.38	1.92*	0.068
Trade openness	0.008	0.06	0.955
Ln.GDP	5.45	0.33	0.744
Adj. R2	0.329		
F-statistics (prob.)	3.29 (0.018)		

The results from Breusch-Godfrey test indicate no autocorrelation as the value of Chi-square is insignificant at 10% significance level. The results are presented in table 8.

Table 8: Breusch-Godfrey LM test for autocorrelation		
Lags	Chi-square	P-value
1	0.55	0.45
Ho : no serial correlation		

The results from white's test shows presence of homoscedasticity as p-value of chi-square is greater than 0.1 (10% significance level) which makes failure of rejection of null hypothesis. The results are presented in table 9.

Table 9: White's test for homoscedasticity		
Source	Chi-square	P-value
Heteroscedasticity	28.82	0.37
Skewness	3.91	0.69
Kurtosis	0.53	0.47
H0 : Presence of homoscedasticity Ha : Heteroscedasticity		

4.6 CUSUM and CUSUM of square test

CUSUM and CUSUM of square test on recursive residuals are used for evaluation of stability of coefficient of the long run model in the sample period.

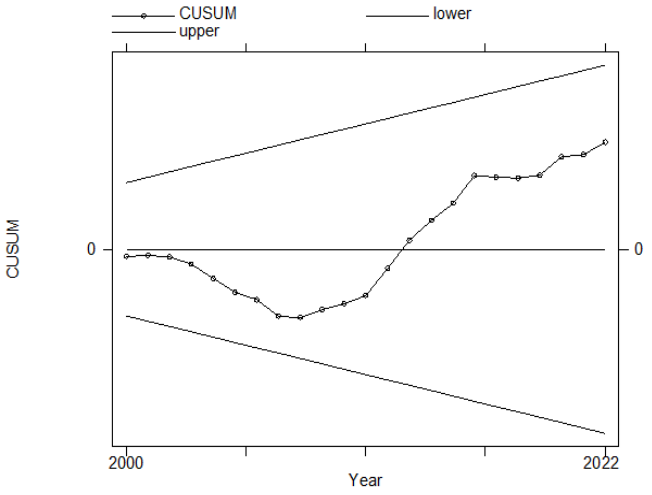

Figure 8: Plot of CUSUM test

CUSUM test detects systematic changes whereas CUSUM of square test detects sudden changes of regression coefficient, (Brown et al., 1975). The findings from Figures 8 and 9 indicates that both CUSUM and CUSUM of square tests lie within the interval band at the level of significance of 5 per cent. This implies the absence of structural instability in the residuals of the exchange rate model in the short run.

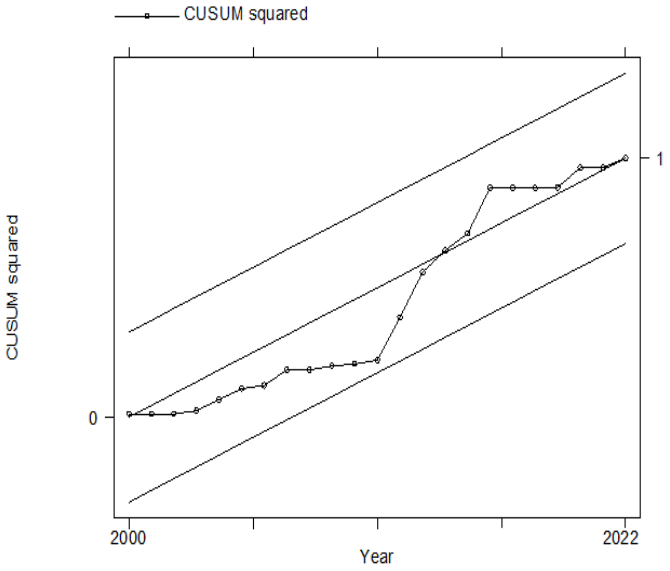

Figure 9: Plot of CUSUM squared test

5. Conclusion

The study concludes long run co-integration between exchange rate and regressors. Inflation and money supply have negative long run relation with exchange rate whereas GDP, interest rate and trade openness have a positive long run relation with exchange rate. Coefficient of error correction term using ECM indicates about 33 percent of disequilibrium is corrected within a year. There is positive and significant short run effect of interest rate on exchange rate whereas GDP, inflation, money supply, and trade openness have no short run relationship with exchange rate in Nepal. As the macroeconomic variables under our study (GDP, inflation, money supply, trade openness, and interest rate) are related to monetary and fiscal policies, thus, policy makers in Nepal should formulate such monetary and fiscal policies that makes exchange rate less volatile and more productive for sustainable economic growth of the nation.

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