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Testing the Dornbusch Overshooting Theorem in Malawi

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Abstract: The overshooting theorem as pioneered by Rudiger Dornbusch has facilitated the creation of effective monetary policies in the past years. This paper re-examined the validity of the overshooting phenomenon based on the autoregressive distributed lag (ARDL) bound test approach. To achieve the main objective the paper firstly examined if the United States/Malawi Kwacha (USD-MWK) exchange rate overshoots or undershoots its long run exchange rate. In addition, the research paper has prior tested if there exist any significant fundamental macroeconomic fluctuations that may dictate spot exchange rate movements. In a theoretically derived price-flex model. The study has used a forty-one-year span of yearly nominal (USD-MWK) exchange rate data and that of monetary fundamentals data. Furthermore, empirically it has been found that only the inflation rate differential is economically significant in triggering spot rate rapid movements in the Price-Flex model. Conclusively, exchange rate overshooting has tested to be evident in Malawi. Solely attributed by the significant inflation rate differential where the other fundamentals are not statistically significant at 5% level of significance. This has been accounted to the constrained workability of the specified Price-Flex mathematical model in our economic environment. The study also discovered and concluded that inflationary pressures (irdif) emanating from the money market might be the key contribution of currency instability, fluctuations, and extreme exchange rate overshooting in Malawi. The limitation of this theoretical examination was that the overshooting theorem was tested on a single significant macroeconomic fundamental. The reason can be that the Price-Flex mathematical model has constrained full workability in our economic environment in explaining spot-exchange rate fluctuations. Further studies may want to improve on this

Keywords: Over shooting theorem; exchange rate; Malawi; short and long run; autoregressive distributed lag

JEL Classification: E4; E43

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1. Introduction

The history of the term overshooting is traced back in the late 70s, pioneered by Rudiger Dornbusch in the year 1976. Dating back before the Dornbusch overshooting phenomenon was introduced, a couple of classical models lay a succinct explanation on exchange rate determination. The Purchasing Power Parity condition is considered as one of the first price theorems that seek to outlay the dynamics of the Spot- exchange rate (Rogoff, 2002) which is also argued to be driven by a free interplay of market forces in both the goods and financial market. Further, the Mundell-Fleming Model came into play explaining issues concerning the exchange rate in accord to differentials in money supply and demand for money. In this model exchange rate determination was rigorously shown using the reserve flow equation. The model further invokes the notion of varying degrees of international capital mobility and the monetary-exchange rate channel (Mkenda, 2001).

The monetary models of exchange rate determination constitute the flexible Price model (Price-Flex) and Dornbusch overshooting model. In trying to differentiate them, Pilbeam (2006) contends that the price flex model assumes that the law of one price is valid in a longer time frame and further explains by illustrating the long run fundamental fluctuations that dictate spot exchange rate dynamics. Whereas the Dornbusch's overshooting model explains the effects of monetary shocks as one with both the spot and the forward rate movements. Frankel (1982) describes the overshooting phenomenon, as the state which the spot rate overtakes the long run exchange rate. Ibid further, the event of an employed expansionary monetary policy the exchange rate usually exceeds its long run equilibrium rate. Conversely undershooting will occur under a tight monetary policy where the spot exchange rate will be surpassed by its long run rate.

The topic of testing Dornbusch's overshooting theorem has escalated some serious debatable issues, which has prompted many scholars to venture into researching on this overshooting hypothesis. This has been a source of debate and attracted considerable research interest. Most research work done pertaining to this phenomenon has yielded incredible results. For instance, Pratomo (1984), Dornbusch (2004) and Papell (1984) agree with the underlying fundamentals of this theorem whilst the findings of Hacche and Townend (1981), Meese and Rogoff (1983), Kim and Roubini (2000) found evidence that refuted the overshooting theorem. However, most of the empirical tests of the models are often vague and controversial (Simwaka, 2004). A flaw is quite prevalent in emerging economies like Malawi, most research on exchange rate overshooting has laid much emphasis on emerged markets, however, there hasn't been much research prevalent in the emerging countries like Malawi. The study therefore re-examined the Dornbusch's overshooting phenomenon in the context of emerging markets, for this case Malawi.

Due to an existing striking incompatibility of mathematically devised theoretical models and their respective empirical support.

This research paper has attempted to test the validity of Dornbusch (1976) ‘overshooting’ hypothesis. The examination of this phenomenon has enabled the researcher to have a concrete understanding of exchange rate behavior and fundamental macroeconomic fluctuations. This will be of significance for informing effective monetary policies (Mishkin, 2006). It will also enable economic authorities to stringently contemplate exchange rate volatility.

2. Literature Review

2.1. The History of Malawian Kwacha Currency

This section gives a background of the history of Malawi kwacha currency dating back from the 70s to have a clear picture as to why it is important to address the issue in topic. In the early 70s the Malawi economy was running on a fixed exchange rate system, it was until the year 1994, when the economy was subjected to shift to a flexible exchange rate system (Floating the kwacha) which the nominal exchange rate itself is dynamically determined by a free interplay of Market forces (Simwaka, 2004). The implemented change in exchange rate systems was executed emanating from a new economic policy. From that time after the floatation of the exchange rate. The economy has been experiencing prolong series of currency depreciation which has attracted the attention of International economic organizations to invoke structural adjustment programs that will aid in sustaining minimal deviations of the exchange rate from its equilibrium rate, thus minimizing extreme exchange rate volatility. The continuous encounters of devaluations paved a path for the emergence of black markets in the country which later accelerated the tendency of smuggling leading to most failures to adhere to the exchange control policies (Ibid). Figure 1 presents a graphical illustration of historical fluctuations of the exchange rates in the country. It shows that from 1980 the currency has been depreciating in a fashion of continuity. However, monetary authorities are working tirelessly to maintain its momentum to construe preferable currency stability. The next section discusses the theoretical background of the Dornbusch overshooting model and further the empirical studies done so far.

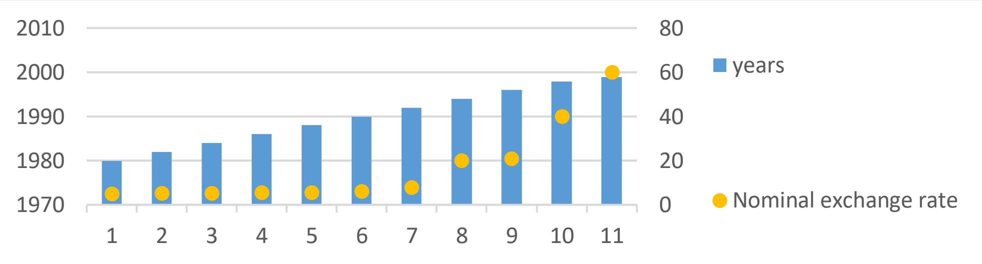

Figure 1. Graph of Historical Nominal Exchange Rates

Note: An Increase Indicates Nominal Exchange Rate Depreciation

2.2. Theoretical Background of Dornbusch Overshooting Model

The overshooting model consists of two core equations namely the money demand and the uncovered interest rate parity condition (UIPC). It claims that the interest rate differential between two countries alters the spot exchange rate, defined as;

$$E = \emptyset(r^f - r^H) + \bar{E} \quad (1)$$

Where r^f and r^H refers to foreign and home interest rates, the *"E and$\bar{E}$ "* is the spot and forward rate. The UIPC model further assumes rational expectations and that capital markets quickly react to any shocks. The money demand equation is shown as,

$$m - p = ky - lr \quad (2)$$

Where *m* is the log of domestic money supply *p* is log of domestic price level, *y* is the log of domestic real income and *r* is the nominal domestic interest rate, *k* and *l* are coefficients of transitionary component and speculative component.

Combining equations (1) and (2) and an anticipated increase in money supply will reduce interest rates under a free interplay of money market forces creating a disequilibrium that will be restored when demand for money starts rising in response to the lower interest rate as now the opportunity cost of holding money will be lower. This implies the less inclination to invest in interest rate earning assets but rather hold liquidity (Branson.W, 1986).The declining interest rates from the monetary shock creates a capital outflow as based on the uncovered interest rate parity condition. The capital freight reacts the foreign exchange market causing an excess demand of foreign currency and a depreciation. Hence creating a short run overshoot of the spot exchange rate. As earlier stated, the declining interest rate, from excess currency and rising demand for money balances will gradually start raising the interest rates that will trigger a capital inflow tantamount to an increased supply of foreign currency thus a currency appreciation (Driskill, 1981).The explained forces will restore the equilibrium in the goods and financial markets (Rogoff, 2002).Conclusively the illustrated equations show that the validity of this model is contingent on Keynesian model's assumption of nominal sticky prices in the short run.

2.3. Price-Flex Model of Exchange Rates

This model will be developed from the law of one price (LOP) and the Fischer's Quantity theory of money (Bahmani-Oskoee M & Kara, 2000).The absolute version of the LOP is stated as,

$$E = \frac{P_m}{P_f} \quad (3)$$

Where *E,,P_m and P_f* is the nominal exchange rate ,domestic price and foreign country price level respectively. The US dollar is the foreign currency and Malawi Kwacha is the domestic currency. Irving's Quantity theory stated as,

$$MV=PY \quad (4)$$

Where M is the money supply, "V" is the velocity of money, "P" is the price level and "Y" is the output level. Its extension to two economies, it is as follows,

$$M_m V_m = P_m T_m \quad (5)$$

$$M_f V_f = P_f T_f \quad (6)$$

And then using equation (5) and (6) we will solve for P_m and P_f then substituting into equation (3) and making E, the exchange rate, the subject of the formula, we get

$$E = \left(\frac{M_m}{M_f}\right)\left(\frac{V_m}{V_f}\right)\left(\frac{T_m}{T_f}\right) \quad (7)$$

The equation above shows that the nominal exchange rate is determined by relative money supply, relative velocity, and the relative output level. By adopting the approach in Bahmani-Oskoeee and Kara (2000) in which the velocity of money is dependent on the interest rates and inflation rates,

$$\frac{V_m}{V_f} = \frac{R_m}{R_f} + \frac{\pi_m}{\pi_f} \quad (8)$$

Where "R and π" is the real interest rate and inflation rate, respectively. By substituting $(\frac{V_m}{V_f})$ for $(\frac{r_m}{r_f})$+$(\frac{In\pi_m}{In\pi_f})$ into equation (9), replacing T by Y taking natural logs of both sides, we arrive at the monetary model of exchange rates (Chiliba, 2014). This is represented as,

$$InE = In(M_m - M_f) - In(Y_m - Y_f) + In(R_m - R_f) + In(\pi_m - \pi_f) \quad (10)$$

2.4. The Dornbusch Overshooting Hypothesis

The overshooting phenomenon is analyzed from two sectors namely, the monetary sector and the real sector which are inextricable. The monetary sector will be denoted as the Q-Q curve. An equation from this sector will be derived following the uncovered interest parity condition. As shown below,

$$E = \bar{E} + \delta(m - p) = \bar{E} + \delta(\bar{P} - P) \quad (11)$$

$$\frac{\partial E}{\partial P} = -\delta \quad (12)$$

Where *"E, $\bar{E}, \bar{P}$,m,p"* is the spot exchange rate, long run exchange rate, long run price, real money stock and spot price respectively. That shows the inverse relationship between spot exchange rate and spot price (Dornbusch, 1976). The real sector in this analytical study is subsumed into a positively sloped PPP (Purchasing Power Parity) curve.

2.5. Empirical Literature

This section outlines the empirical literature on studies conducted on overshooting theorem, further a presentation of studies done in Malawi pertaining to the exchange rate dynamics. The sticky price model as devised by R. Dornbusch explains that the exchange rate whose fluctuations are dictated by macroeconomic forces can be subjected to either an overshoot or an undershoot. The concept of the exchange rate overshooting has sparked the interest of research in international finance, particularly issues concerning currency stability. Tu and Feng (2009) puts much focus on the assessment of this model, specifically the advantages and disadvantages of this model in formulating monetary and exchange rate policies (Chiliba, 2014). Tu and Feng (2009) found that overshooting is not fully consistent with the mechanical nature of foreign exchange rate market but rather depends on the elasticity of money and capital mobility to fuel the correcting mechanism in the real and monetary sector. Frankel's (1979) real interest differential model supports the overshooting theorem. This scholar made an important observation that the susceptibility of exchange rate overshooting and the real interest differential exhibited a direct correlation. However, it wouldn't be advisable to concretize the contemplation of this theorem based on a real interest rate differential but rather include other determinants.

Pratomo (2005) seeks to examine the overshooting theorem by basing his work on an ordinary least squares approach and cointegration techniques. He implemented these econometric approaches in studying the Indonesian Rupiah currency in the aftermath of the 1988 crisis. It was later discovered that the currency had its exchange rate overshooting the equilibrium rate. Despite the empirical literature in support of this overshooting hypothesis. There are still some studies that have been conducted in repudiating the Dornbusch's overshooting model. Several studies provide evidence against the overshooting model. Following are some of the studies in reference to the topic. Hacche and Townend (1981) conducted an examination on the effect of monetary influences on exchange rate behavior for the United Kingdom after floating its currency in 1972. It was found that exchange rate overshooting was not evident in the United Kingdom. This was due to the reason of having suspected the existence of long run monetary neutrality which does not conform to explaining exchange rate dynamics, thus overshooting.

Studies that pertain to exchange rate overshooting on the Malawian currency haven't been executed yet. In 1995 a study was conducted on the role of exchange rate and monetary policy in the monetary approach to the balance of payments in Malawi. In the study, the reserve flow equation (RFE) was tested. (Silumbu.E.B, 1995). Causality was observed to be from credit to reserves. It was then found to have exhibited a bilateral causality on a quarterly basis.

3. Methodology and Data Analysis

Empirical studies on examining the overshooting theorem have been based upon the ARDL methodology using monetary aggregates (Nieh & Wang, 2005; Bahmani-Oskooee & Kara, 2000). Similarly, this study utilizes the following variables; nominal exchange rates (e), money supply (m), real GDP(y), interest rates (monthly nominal) and inflation rates (π). The annual data spans a forty one year period from 1981 to 2020.GDP data for both Malawi and South Africa were sourced from World Bank development indicators (WDI) and the National statistical office (NSO),The other data for each country were sourced from the International Financial Statistics(IFS). All the exchange rate data will be used from the Reserve Bank of Malawi (RBM). The data collected for the monetary model aggregates is on an annual basis. The GDP data has undergone a transformation from that which is quarterly to an annual GDP data. The spot-exchange rate "e" is defined as the number of Malawi kwacha units per one US-Dollar (MWK/$). Below are the definitions of the variables fed into the mathematically specified Price-Flex model.

Logexrate =*log of exchange rate* (13)

Mdif = $BroadMoney_{Malawi}$ - $BroadMoney_{SouthAfrica:}$ *Money Supply differential* (14)

Gdpdif = GDP_{Malawi} - $GDP_{SouthAfrica}$: *GDP differential* (15)

Rdif = $InterestRate_{Malawi}$ - $InterestRate_{SouthAfrica}$: *InterestRate differential* (16)

IRdif= $InflationRate_{Malawi}$-$InflationRate_{SouthAfrica}$: *InflationRate differential* (17)

Where the differentials are defined from a Malawian and South Africa as its trading partner. The Price-Flex model has been specified in a log-linear econometric fashion. This has been done to counter the problems of having missing values, arising from the computation of logarithms on negative differentials. Knowing that it is mathematically erroneous to capture the log of a negative value. The test for this phenomenon may be ingrained to the Autoregressive Distributed Lag (ARDL) bound test procedure. The ARDL that is based on a single equation does not take into consideration bilateral Grangean causality that may exist in the Price-flex modelled regression equation.

3.1. Tests of Stationarity

To begin with, it must be stated that the proposed ARDL methodology is valid only if *I (0) and I (1)* holds) from the results of Unit Root. The test of unit root for this theorem has been grounded on an Augmented –Dickey-Fuller. In augmenting the ADF test we had to also run a Phillip-Peron test (Phillip-Perron, 1988).

The Augmented Dickey Fuller test has been mathematically modelled as follows,

$$\Delta y_t = c_0 + c_1 t + \delta y_{t-1} + \beta \sum_{i=1}^{k} \Delta y_{t-1} + u_t \quad (18)$$

Where C_0 is the constant term and C_1 is the trend term, k is the number of lagged terms and u_t is a white noise error term. For the ADF, we hypothesize that the series is non-stationary, implying the existence of a unit root (Nieh and Wang, 2005).

The PP (Phillip-Perron, 1988) is a semi-parametric methodology. It significantly deals with serial correlation and heteroscedasticity. Its test statistic has been mathematically modelled as follows,

$$\widetilde{t_\alpha} = t_\alpha \left(\frac{\gamma_0}{f_0}\right)^{\frac{1}{2}} - T\left(\frac{(f_0-\gamma_0)(se(\hat{\alpha}))}{2f_0^{\frac{1}{2}}s}\right) \quad (19)$$

Where γ is the error variance estimate and t_α is the ratio of $\alpha, \hat{\alpha}$ is the estimate coefficient, *se* is the standard error of the coefficient is residual and “s” is the standard error of the test regression.

3.2. Price-Flex Specified Auto Regressive Distributed Lag (ARDL) Model

The error correction ARDL model for the Price-Flex model has been specified as follows,

$$\Delta e_t = \alpha_0 + \sum_{j=1}^{n} a_{1j}\Delta e_{t-j} + \sum_{j-1}^{n} a_2 \Delta m_{t-j} + \sum_{j=1}^{n} a_3 \Delta y_{t-j} + \sum_{j=1}^{n} a_4 \Delta r_{t-j} + \sum_{j=1}^{n} a_5 \Delta \pi_{t-j} + \delta_1 e_{t-1} + \delta_2 m_{t-1} + \delta_3 y_{t-1} + \delta_4 r_{t-1} + \delta_5 \pi_{t-1} + \varepsilon_t \quad (20)$$

Where e =logexrate, y = GDP differential, π =inflation rate differential, r =interest rate differential and m = money supply differential.

To run the ARDL test, in checking for cointegration, the null will be defined as;

$H_0: \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5$ whose alternative hypothesis will be $H_1: \delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq \delta_5$. Then we used the F-test procedure coupled with the error correction ARDL approach.

The bounds test for cointegration has been used to check if there is a long run relationship between the macroeconomic fluctuations and the spot rate. Then we resort to the error correction mechanism (ECM) upon accepting that there exists cointegration among the variables in the specified econometric model. The ECM has been used to check for the speed at which the variables adjust to the equilibrium (Baltagi, 2008). The optimal number of lags in the specified ARDL equation have been chosen using the Akaike information criterion (AIC), which seeks to control autocorrelation, imperative for our time series data. (Gujarati, 2003; Chiliba, 2014).

3.2.1. Diagnostic Checks

The following are some of the tests that have been conducted as part of diagnosing the specified model if it contains some econometric ailments for validity's sake.

3.2.2. Autoregressive Conditional Heteroscedasticity Effects (ARCH) Test

This test has been done in seeking to analyze the error-volatility of our specified Price-Flex monetary model, specifically the residual of our determined logarithm of spot exchange rate in a 41-year time frame (Baltagi, 2008).

3.2.3. Heteroskedasticity Test

This test has been done using the white's robust test. Heteroskedasticity creates minimum inefficiency on our variance as such the estimators can no longer be BLUE (Gujarati, 2003).

3.3. Ramsey's RESET Test

This test has been done using an F-test on fitted values to check for model misspecification. (Gujarati, 2003).

3.3.1. Recursive Tests

The test is carried out to check for parameter stability in the residuals. This has been run using the CUSUM test and CUSUM of square tests (Frenkel, 1982).The Parameter stability has been checked from a graphical visualization.

The test statistic of the CUSUM test is as follows,

$$W_t = \sum_{r=k+1}^{t} {W_r}/{S} \qquad (21)$$

The statistic of the CUSUM of square tests is given as,

$$S = {\sum_{r=k+1}^{t} W_r^2}/{\sum_{r=k+1}^{T} W_r^2} \qquad (22)$$

4. Results

4.1. Descriptive Statistics

Table 1 is the statistical description of the variables used in this analytical study. The mean is positive for variables with an exception of the money supply differential (m). Standard deviation is positive for all variables, with that of money supply differential being the highest and the GDP differential as the variable with the lowest standard deviation. The kurtosis is less than three for the variables; logexrate (e) and money supply differential (m) only. This implies that the two variables with a kurtosis of less than 3 interprets that their observations are platykurtic (flat). Skewness is positive for the inflation rate differential(π) and the GDP differential(y) only.

Table 4. Statistical Description

Variable	Mean	Standard Deviation	Min	Max	Kurtosis	Skewness
Logarithm Of exchange rate(logexrate)	3.57946	2.283418	-.1105974	6.704905	1.608378	-.2030402
InflationRate differential(irdif)	10.76932	14.64473	-5.77525	74.64535	10.03567	2.206107
InterestRate differential(rdif)	4.575007	11.81998	-32.3805	26.29131	4.446144	-1.05273
MoneySupply differential(mdif)	-6.10e+13	6.50e+13	-2.13e+12	-2.06e+12	2.428976	-.8992302
GDP differential(gdpdif)	1.83e+12	1.45e+13	-1.77e+12	9.19e+13	38.48216	6.09979

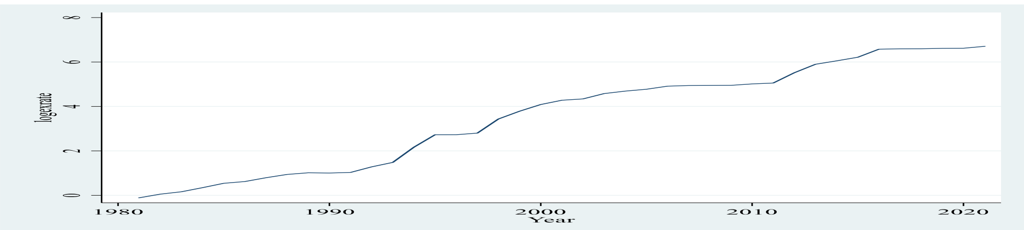

Figure 2. Visual Description

The figure 2 shows that the logexrate (e) has been increasing from 1980 when the economy was operating on a fixed exchange rate regime. In the event of a flexible exchange rate regime. From the year 2000 the logexrate has shown a sharp rise and later a steady rise. The same applies for the year 2010 where the logexrate has depicted a sharp rise and later a constant logexrate growth till the year 2020.The non-decreasing logexrate over the years illustrates currency depreciation of kwacha against the United States dollar.

4.2. Tests of Stationarity

A summary of the results is presented in Table 2. The unit root test results derived from an ADF and PP tests on detrended variables and those variables that detected no trend (non-detrended).

Table 5. Unit Root Test Results

Variables	**Logexrate(e) Detrended, *ehat_logexrate* *"it's residual"***	**Money supply differential (m) Detrended, *uhat_mdif* *"it's residual"***	**GDP differential (y)**	**Interest rate differential (r) Detrended to *uhat_rdif* *"its residual"***	**Inflation rate differential(π)**
ADF test					
Test statistic z(t)	**-1.442**	**-1.795**	**-2.549**	**-1.752**	**-2.471**
1% Critical level	-3.662	-3.655	-3.696	-3.689	-3.662
5% Critical level	-2.964	-2.961	-2.978	-2.975	-2.964
10% Critical level	-2.614	-2.613	-2.620	-2.619	-2.614
PP test					
Test statistic z(t)	**-1.405**	**-2.316**	**12.383**	**-6.796**	**-3.565**
1% Critical level	-3.648	-3.648	-3.648	-3.648	-3.648
5% Critical level	-2.958	-2.958	-2.958	-2.958	-2.958
10% Critical level	-2.612	-2.612	-2.612	-2.612	-2.612

Beginning with the Augmented Dickey Fuller test results conducted on the logexrate (e) and the differential variables. It has shown that the detrended logexrate (e) exhibits non stationarity on all critical levels. The money supply differential which has been detrended to uhat_mdif (m) is also nonstationary on all critical levels. Similary non detrended GDP differential (y) and the detrended inflation rate differential (π) exhibit non stationarity on all critical values. Then after conducting the Phillip-Peron test on all the variables. It has registered non stationarity on all critical levels for the detrended logexrate (e), money supply differential (m) and the non-detrended GDP differential. However, the detrended interest rate differential has shown to be stationary on all critical levels. The case is different for the inflation rate differential which is nonstationary on 1% critical level, stationary on 5% critical level and 10 % critical level. Based on the Augmented Dickey Fuller test and Phillip-Peron unit root tests we can conclude that all our variables are integrated of order zero I (0) and order one I (1) as such we are certain that if we resort our analysis to the usage of an ARDL model of estimation, will not us yield spurious regression results.

4.3. Specified Price-Flex ARDL-ECM Model

Detecting the number of lags is so imperative for the validity of results. In this case the appropriate number of lags was selected using the Akaike Information Criterion (AIC).

Table 6. Lag Selection Criteria

Selection-order criteria
Sample: 1985 – 2021
Number of observations = 37
Endogenous: ehat_logexrate uhat_rdif uhat_mdif gdpdif irdif
Exogenous: _cons

Lag	**AkaikeInformation Criterion (AIC)**	**HannanQuinn Information Criterion (HQIC)**	**SchwartzBayesian Information Criterion (SBIC)**
0	144.461	144.537	144.678
1	139.21	139.67	**140.516***
2	138.46	139.304	140.855
3	138.922	140.15	142.405
4	**137.109***	**138.721***	141.681

The results from the table 3 show that four is the optimal lag length. We therefore specify a static model given four is the optimal lag length. Then extracting the optimal lag length for each variable. The extracted optimal lag lengths for each variable will now be used to run the bounds test of cointegration as follows.

Table 4. ARDL Bounds Test Results

F-Statistics	**10% level of significance**		**5% level of significance**	
	Lower Bound	**Upper bound**	**Lower Bound**	**Upper Bound**
3.520	2.860	4.010	3.250	4.490

Null hypothesis: no cointegration among the variables.

Alternative hypothesis: variables are cointegrated.

If “F > Critical value” on both the lower and upper bound, we reject the null hypothesis of no cointegration, If "F < Critical value", we accept the null hypothesis of no cointegration.

From the results shown in table 4 our F-statistic is greater than the critical values on both levels of Significance thus we reject the null hypothesis of no cointegration or no long run relationship among the variables in the econometrically specified Price-Flex model. Note that the null hypothesis has been rejected at a 10% level of significance and 5% level of significance. Having accepted that the variables are cointegrated or exhibit a long run relationship, we now resort to the estimation of an error correction model, (ECM) to trace out the speed at which the variables adjust to the equilibrium in the long run.

Table 7. ARDL, Error Correction Model Results

Variables	**Coefficients**	**T-statistic**
Adjustment Parameter		
Log of exchange rate	-0.148*	(-2.31)
Long run		
Interest rate differential	0.0194	(1.35)
Moneysupply differential	1.11e-14	(1.84)
GDP differential	-2.47e-14	(-1.83)
Inflation rate differential	0.0557*	(2.21)
Short run		
Interest rate differential(differenced)	0.00288	(1.49)
Moneysupply differential(differenced)	1.65e-15	(1.84)
GDP differential(differenced)	-3.65e-15	(-1.83)
Inflation rate differential (1st difference)	0.00985***	(5.81)
Inflation rate differential (2nd difference)	-0.00243	(-1.50)
_constant	-0.106**	(-3.30)
Sample Size	39	

The error correction model tabulated in table 5 regression results show *a negative 14.81%* and a statistically significant adjustment parameter. Indicating a slow speed at which the fundamentals adjust to the equilibrium. In the long run criteria only "*irdif*" (inflation rate differential) is statistically significant at 5% level of significance. Similarly, the short run results show an economically significant inflation rate differential "*irdif*". However, inflation rate differential has shown to be significant on two lags thus for clarity we need to augment the results with a Joint test of significance shown in table 6 as follows,

Table 8. Joint-Test of significance results

Order of difference	Short-run variable	P-value	F-Statistic "F (2,31)"
First differenced	Inflation rate differential (1)	0.0000	16.88
Second differenced	Inflation rate differential (2)	0.0000	16.88

At "0.0000" Probability level on both orders of difference, it indicates that the inflation rate differential is highly significant. In accord to the flexible price monetary model, out of the four derived macro-economic differentials, the inflation rate differential has shown to be the only significant long run fundamental.

4.4. Determination of the Long Run Exchange Rate

This subsection specifies the equation which has been empirically used to estimate the long run exchange rate series to be used as a benchmark for testing the spot-long run rate overshoot.

The equation is specified as follows,

Where ***"c"*** is a constant, ***"γ, θ, δ and φ"*** are macroeconomic fundamental's coefficients and ***"LR"*** index defines a long run fundamental. The four ingredients have been mathematically derived from the bombarded Gustav's PPP-Irving Fischer's quantity theory of money.

$$Log\bar{E} = c + \theta irdif^{LR} + \gamma gdpdif^{LR} + \delta rdif^{LR} + \varphi mdif^{LR} \qquad (23)$$

Having specified the equation, we run the estimation of the long run rate series based on the only statistically significant macroeconomic fundamentals. In this case only *"irdif"* is macroeconomically significant, that is according to the preceding section. Next take the antilogarithm of $Log\bar{E}$ as follows,

$\exp(Log\bar{E})=\bar{E}$ *"long run determined rate"*

4.5. Results for Diagnostic checks

In an econometric study of this nature, care must be taken to ensure that the results from our model are robust. The following are the diagnostic checks and their respective results for tests that have been conducted,

Table 9. Autoregressive Conditional Heteroscedasticity (ARCH) Effects Test

Lags(p)	Chi Square-Statistic	Degrees of freedom	Probability value
1	0.027	1	0.8684

Null hypothesis: no ARCH effects vs. Alternative hypothesis: ARCH (p) disturbance exists. From the tabulation of results in table 7, we accept the null hypothesis. Therefore, Autoregressive conditional heteroscedasticity effects are nil in the model.

Table 10. White's Test for Heteroscedasticity

Source	Chi-Square Statistic	Degrees of Freedom	Probability
Heteroscedasticity	35.99	35	0.4220

Null hypothesis: non-heteroscedastic or homoscedastic Residual, **Alternative hypothesis**: heteroscedastic residual.

As shown on the table 8 of results the "0.4220" probability value is less than a 5% level of significance. Therefore, we fail to reject the null hypothesis, thus the predicted error term is non-heteroscedastic or homoscedasticity. Then we run Ramsey's test for model specification. The following were the results for Ramsey's RESET using powers of the fitted values of *ehat_logexrate "the predicted residual for the logarithm of spot-exchange rate"*,

Null hypothesis: model has no omitted variables or correctly specified

Alternative hypothesis: model has omitted variables or mis-specified

F-statistic (3, 28) = 0.88

Probability > F = 0.4614

With a 0.4614 probability value with respect to a 5 % level of significance, we accept the null hypothesis. Therefore, the estimated econometric model has not been excluded of any variables thus correctly specified. Finally, to test for parametric stability we had to run the **CUSUM test and CUSUM of squares test.** The figures below portray a visualization for parameter stability test results which have shown construed parametric stability in all the observed years for CUSUM and CUSUM of square tests.

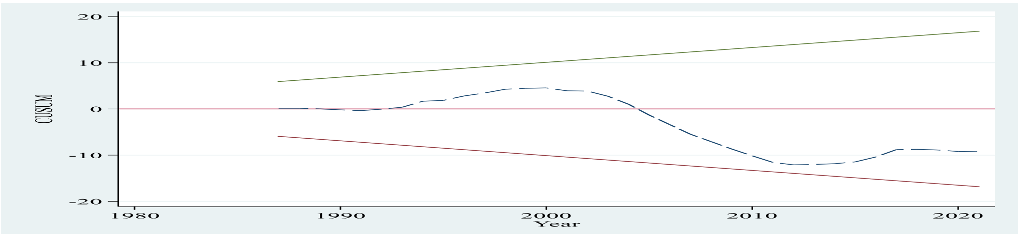

Figure 3. CUSUM 1

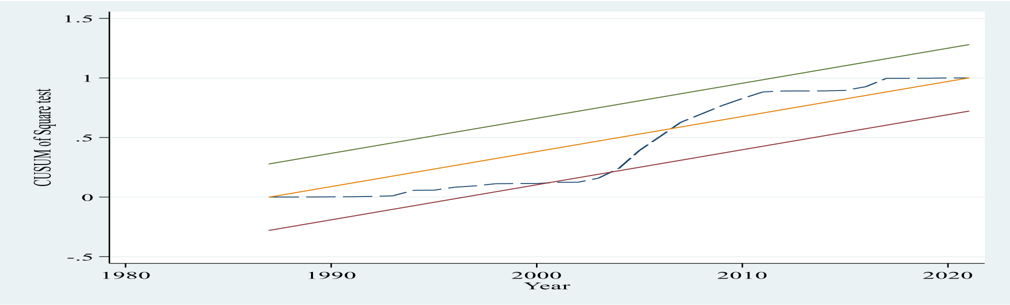

Figure 4. CUSUM of Squares Test

After running an ARDL-ECM test and diagnostic checks on our model, it has been found that the specified model exhibits robust results. Having established the veracity of our model we shall conclude our discussion in the next chapter.

5. Conclusion

In conclusion the results indicate that firstly, in 1980 when the exchange rate was operating under fixed exchange rate regime the spot-long run rate exhibited no overshoot nor undershoot. In 1994 after the kwacha was relaxed and left to float. A free interplay of market forces in the forex market triggered a sharp undershoot as shown graphically on the second mark. This undershoot indicates currency appreciation against the United States dollar. However, upon failing to maintain its momentum the spot rate gradually and further overshot its long run rate in the year 2000 implying currency depreciation. In the mid-2000 and 2010 the spot overshot its long run at a constant rate, showing that the currency construed a regulation of some sort. Unlike in 2012 and 2014 the spot rate sharply overshoots its long run.

The period which IMF instructed Malawi to devalue its kwacha, which Professor Bingu declined and later a sudden switch of political structures after the death of Professor Bingu wa Muntharika exacerbated the failure of the currency to hold its momentum thus became unstable. In 2020 the spot rate further overshot its long run rate escalating from the COVID-19 shock that hit the financial and real sector. With the utilization of the Price-Flex model to postulate fundamental fluctuations and testing spot exchange rate overshooting in a Malawian economic environment. It has been discovered that inflationary pressures *(irdif)* emanating from the money market might be the key contribution of currency instability, fluctuations, and extreme exchange rate overshooting in Malawi.

Limitations of the study

The detected limitation of this theoretical examination was that the overshooting theorem was tested on a single significant macroeconomic fundamental. The reason can be that the Price-Flex mathematical model has constrained full workability in our economic environment in explaining spot-exchange rate fluctuations.

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