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Article history

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Abstract

Purpose: The study seeks to explore whether the positive or negative shocks to money has symmetrical effects on the exchange rate and price formation in Zimbabwe.

Materials and Methods: The methodology follows the Nonlinear Autoregressive Distributed Lag modeling (NARDL) by Shin, Yu, Greenwood and Nimmo (2014). The exchange rate is regressed on the negative and positive changes in reserve money and broad money, using monthly data from 2018M01 to 2023M6. The model explores the impact of money growth on the exchange rate and prices in Zimbabwe.

Findings: The findings are that monetary shocks impact on the exchange rate and prices are subject to nonlinearities. Monetary policy formulation based on the assumption of symmetry oversimplifies the relationship between money, the exchange rate and prices. A nonlinear modelling approach appropriately captures the cointegrating long run underlying relationships and has material implications for policy formulation and implementation.

Implications to Theory, Practice and Policy: Authorities to consider adopting a nonlinear modelling framework in the formulation and implementation of monetary policy for Zimbabwe. This has potential to optimise on the timing and magnitude of monetary policy changes.

Keywords: *Bounds Test, Cointegration, Test Symmetry, Nonlinear, Dynamic Multipliers, Partial Sums, Nonlinear*

1.0 INTRODUCTION

The nonlinear Autoregressive distributed lag (NARDL) model examines the non-symmetrical relationships among macroeconomic variables following the seminal paper by Shin, Yu, Greenwood and Nimmo (2014). They developed an asymmetric generalisation of the Autoregressive Distributed Lag (ARDL) model of Pesaran and Shin (1998) and Pesaran, Shin, and Smith (2001). The NARDL model is an error correction model that can accommodate asymmetry in the long-run equilibrium relationship and/or the short-run dynamic coefficients, using partial sum decompositions of the explanatory variables. The uptake of the NARDL model in applied research has rapidly gained momentum with applications in diverse fields. Essentially, I(1) and I(0) time series variables can be combined in an estimation process that generates consistent unbiased parameters, if the variables have a cointegrating long run relationship.

The current reserve money targeting monetary policy, assumes a symmetrical relationship between monetary aggregates, the exchange rate and the price level in Zimbabwe. The assumption is very strong and there is no basis for assuming that an expansionary monetary policy is symmetrical in its effects to a contractionary monetary policy. The research examines whether the positive and negative partial sums to reserve money have symmetrical effects on the exchange rate and price level. Cointegration tests are undertaken as proof that consistent, unbiased estimators (BLUE) can be derived from a combination of stationary and non-stationary variables (I (1) and I(0) variables. The linear combination of the variables exhibits a testable long run stable relationship and the bounds test for symmetry is carried out to confirm cointegration, both the long run parameters and short run adjustment dynamics. The short run dynamics particularly give insight into the process of adjustment to long run following shocks. Importantly, the short run dynamics provide critical information on how the effects of a shock are distributed over time, the adjustment process towards long run steady state.

Theoretical Review

Pesaran, Shin and Smith proposed modeling cointegration using the Autoregressive Distributed Lag model (2001) (ARDL) in which, a variable is regressed on its own lags and lags of the explanatory variables. Within this framework, cointegration and therefore long run relationship could be proven through Bounds testing, to determine the existence of either long run or short run relationship. Through the dynamic multipliers, they were able to characterise the dynamics of adjustment following a shock.

Shin et al. (2014) expanded on the ARDL framework and suggested a method for modelling asymmetric cointegration and dynamic multipliers in a NARDL framework. They decomposed the explanatory variables into positive and negative partial sums and introduced short run and long run nonlinearities, hence the Nonlinear Autoregressive Distributed Lag (NARDL) model. Through the NARDL model, the idea is to test whether positive and negative shocks are symmetrically distributed. Shin et al. (2014) demonstrated that the NARDL model can be estimated by OLS, and that consistent and reliable estimators can be derived, hypothesis testing, and inferential analysis can be achieved through bounds-testing, regardless of whether the variables are levels stationary or stationary after first differencing (variables must not be second order stationary).

Shin et al. (2014) commenced by drawing attention to the vast literature developed over the decades around the time series analysis and modelling non-stationary variables, which commenced with the work of (Dickey and Fuller 1979; Engle and Granger 1987; Johansen 1988; Kwiatkowski et al. 1992), Phillips and Hansen (1990). These represent major theoretical landmarks and progression over the years. They also highlight that since the mid-1990s, progress in time series analysis has often considered the joint issues of nonstationarity and nonlinearity, which gave rise to the development of the Markov regime switching models, among others to address this endemic problem.

Their approach reflects a general concern that simple linear regression analysis may be excessively restrictive in many real-world circumstances, particularly in respect of policy where positive and negative policy shocks cascade non symmetrically in the economy. For instance, monetary policy formulation and implementation in many countries, particularly developing countries is conducted on a strong assumption that the economy responds symmetrically to a monetary expansion, as to a monetary or interest rate induced contraction. In practice, firms and households respond unevenly to a monetary contraction or expansion.

Prior to Shin et al (2014), there had not been extensive research on nonlinear cointegration, with few notable exceptions. Schorderet 2001, 2003), proposed a bivariate asymmetric cointegrating regression of unemployment on output, in which output was decomposed into partial sum processes of positive and negative changes. Granger and Yoon (2002) proposed at the cointegrating relationship may be defined between the positive and negative components of the underlying variables, which they termed ‘hidden cointegration’. They note that variables are cointegrated because they respond to shocks together displaying common stochastic trends. (Granger and Yoon 2002, p. 5).

Van Treeck (2008) used a NARDL model to analyse asymmetric wealth effects on US consumption. Delatte and López-Villavicencio 2010, 2011 also used a NARDL in their analysis of long-run asymmetries in the pass-through from exchange rates to consumer prices in developed economies. Nguyen and Shin (2010) applied NARDL models to high frequency exchange rate data, to explore patterns of asymmetry in the pricing impacts of the order flow. Allen and McAleer (2020) apply a NARDL cointegration analysis between the inflation-adjusted levels of the DOWJONES Index and the Crude oil price series.

Allen and Mcleer (2021) also examined the link between the behavior of the FTSE 100 and S&P500 Indexes in both an autoregressive distributed lag ARDL, plus a nonlinear autoregressive distributed lag NARDL framework modelling, combining short run and long-run asymmetries. “Shin et al. (2014) extend the work and develop a simple and flexible nonlinear dynamic framework that is capable of simultaneously and coherently modelling asymmetries both in the underlying long-run relationship and in the patterns of dynamic adjustment”. They derive the dynamic error correction representation associated with the asymmetric long run cointegrating regression, hence the nonlinear autoregressive distributed lag (NARDL) model.

They follow Pesaran et al. (2001) and use a Bounds testing approach to test for the existence of a stable long-run relationship, which is valid irrespective of whether the underlying regressors are I(0), I(1), or mutually cointegrated. The two sets of critical values, as suggested by Pesaran et al. (2001), provide a band covering all the three possible classifications. They also derive asymmetric cumulative dynamic multipliers that permit the display of the asymmetric adjustment patterns following positive and negative shocks to the explanatory variables. Prior to the development of this flexible approach suggested by Shin et al. (2014), there had been a few other studies that employed a NARDL framework.

Zhang, Tsai and Chang apply the nonlinear autoregressive distributed lag model, advanced by Shin, Yu and Greenwood-Nimmo [(2014) to investigate the interest rate (IR) pass-through (IRPT) mechanism in Taiwan from 1971 M07 to 2014 M11. They found that the incomplete IRPT mechanism of deposit rates shows an asymmetric adjustment in the short run and symmetric adjustments in the long run. They also concluded that the short-run and the long-run IRPT channels from the policy rate to the lending rate are also incomplete in the short run but not in the long run. The empirical research for Zimbabwe challenges the hypothesis that the assumption of a symmetrical relationship between monetary expansion and monetary contraction. There is material evidence that over the past decade, the effects of monetary policy expansion and tightening have been non-symmetrical.

This largely reflects the reality that high and variable exchange rate depreciation induced inflation and excessive monetary expansion have led to de-anchored inflation expectations and amplified currency volatility. Embedded inflation expectations occasioned higher inflation, creating a cyclical vortex and nexus of exchange rate depreciation, feeding into inflation and inflation expectations and currency volatility. Typically, an environment of accruing inflation expectations implies a very low probability for symmetrically distributed monetary policy effects – asymmetry is likely the dominant feature of the inflationary process in Zimbabwe.

Over the past decade, monetary injections were accompanied by immediate exchange rate depreciation and escalation in prices, while a monetary policy tightening has not led to appreciation of the exchange rate (occasionally tightening monetary policy was accompanied by temporary currency stabilization and hence inflation deceleration). The study for Zimbabwe seeks to test the hypothesis of non-symmetrical monetary policy distributed lag effects. Particularly to explore the proposition that monetary shocks have differential implications for the exchange rate pass through and hence the evolution of prices in Zimbabwe. Monetary policy tightening, likely, has a different cascading process from monetary policy loosening.

Asymmetrical monetary policy distributed lag effects essentially imply that monetary policy effectiveness can be measurably enhanced through the adoption of non-symmetrical policy implementation. This implies varying the magnitude and timing of monetary policy intervention, depending on whether Authorities are tightening or loosening, reducing or increasing reserve money in the economy.

Nonlinear Autoregressive Distributed Lag Exchange Rate Model

The equation below shows the nonlinear relationship between the exchange rate and monetary aggregates, (reserve money and broad money). The equation examines how both broad money and reserve money impact on the exchange rate.

The equation has both short run dynamics and long run steady state parameters.

Dependent Variable: DLOG(NPER)				
Method: ARDL				
Date: 06/23/24 Time: 08:42				
Sample: 2018M04 2023M06				
Included observations: 63				
Dependent lags: 4 (Automatic)				
Automatic-lag linear regressors (3 max. lags): LOG(M3ZZW)				
Automatic-lag dual non-linear regressors (3 max. lags): LOG(RMZZW)				
Static regressors: DUM19M4 DUM20M5 DUM22M4 DUM22M6				
DUM23M5				
Deterministic: Restricted constant and no trend (Case 2)				
Model selection method: Akaike info criterion (AIC)				
Number of models evaluated: 64				
Selected model: ARDL(2,0,2)				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.***
LOG(NPER(-1))	**-0.138960**	**0.043220**	**-3.215185**	**0.0023**
LOG(M3ZZW)	**0.074803**	**0.037838**	**1.976931**	**0.0538**
@CUMDP(LOG(RMZZW(-1)))	**0.192516**	**0.059962**	**3.210649**	**0.0024**
@CUMDN(LOG(RMZZW(-1)))	**0.274307**	**0.103787**	**2.642992**	**0.0111**
C	-1.075043	0.583105	-1.843653	0.0714
DLOG(NPER(-1))	**0.668093**	**0.082309**	**8.116910**	**0.0000**
@DCUMDP(LOG(RMZZW))	**0.462846**	**0.108672**	**4.259114**	**0.0001**
@DCUMDN(LOG(RMZZW))	**-0.151740**	**0.203254**	**-0.746553**	**0.4590**
@DCUMDP(LOG(RMZZW(-1)))	0.164496	0.123874	1.327933	0.1905
@DCUMDN(LOG(RMZZW(-1)))	-0.379362	0.210206	-1.804717	0.0774
DUM19M4	0.389389	0.069901	5.570619	0.0000
DUM20M5	0.278432	0.074740	3.725320	0.0005
DUM22M4	0.402621	0.071099	5.662844	0.0000
DUM22M6	0.274786	0.072008	3.816045	0.0004
DUM23M5	0.416838	0.074632	5.585234	0.0000
R-squared	0.863487	Mean dependent var		0.130395
Adjusted R-squared	0.823671	S.D. dependent var		0.159853
S.E. of regression	0.067125	Akaike info criterion		-2.360277
Sum squared resid	0.216274	Schwarz criterion		-1.850007
Log likelihood	89.34872	Hannan-Quinn criteria.		-2.159585
F-statistic	21.68682	Durbin-Watson stat		1.965957
Prob(F-statistic)	0.000000			
*Note: p-values and any subsequent test results do not account for model				

Cointegrating Specification

Deterministic: Rest. constant (Case 2)
CE = LOG(NPER(-1)) - (0.538306*LOG(M3ZZW) + 1.385399 *@CUMDP(LOG(RMZZW(-1)),"2018M02") + 1.973995 *@CUMDN(LOG(RMZZW(-1)),"2018M02") - 7.736328)

Cointegrating Coefficients

Variable *	Coefficient	Std. Error	t-Statistic	Prob.
LOG(M3ZZW)	0.538306	0.244199	2.204374	0.0314
@CUMDP(LOG(RMZZW(-1)))	1.385399	0.409425	3.383768	0.0013
@CUMDN(LOG(RMZZW(-1)))	1.973995	1.002952	1.968186	0.0538
C	-7.736328	3.839509	-2.014927	0.0485

Note: * Coefficients derived from the CEC regression.

Results Interpretation

The results of the model are summarised below:

i. The exchange rate depreciation is caused by both long run determinants and short run dynamics;

ii. The coefficient of adjustment is -0.1389. This means that for every shock to the exchange rate, about 13.89% is cleared in the first month and 13.89% of the balance is cleared the following month. This process continues until a new equilibrium is established.

iii. The long run determinants are broad money and reserve money.

    a. A 1% increase in broad money leads to a 0.538% exchange rate depreciation.

    b. A 1% increase in reserve money leads to a 1.385% exchange rate depreciation.

iv. The short run determinants are changes in the parallel market exchange rate (they create expectations of exchange rate depreciation) and reserve money growth.

v. The increase in reserve money causes instant depreciation in the same month.

Long Run Coefficients

The long run coefficients are shown below:

	Estimated Coefficient	Long Run Coefficient
LOG(NPER(-1))	-0.13896	
LOG(M3ZZW)	0.074803	0.538
@CUMDP(LOG(RMZZW(-1)))	0.192516	1.385
@CUMDN(LOG(RMZZW(-1)))	0.274307	1.974

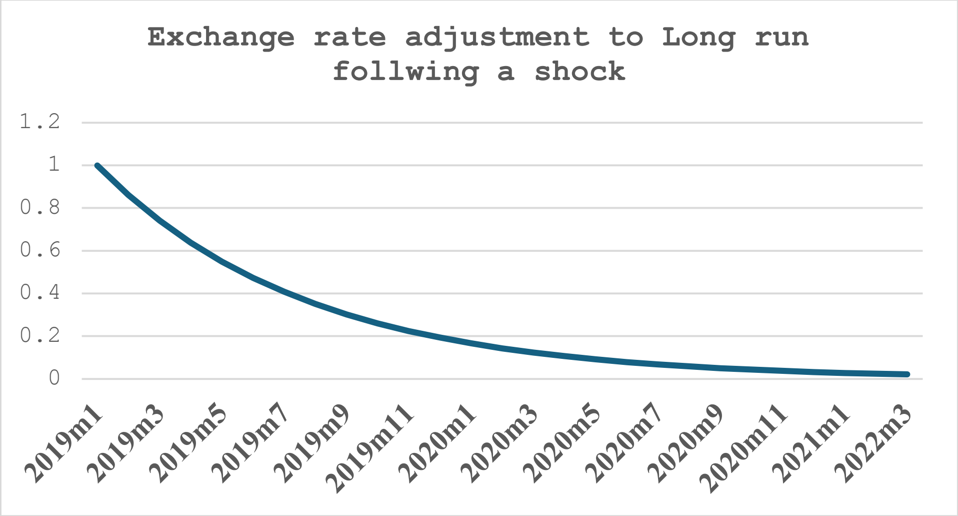

Figure 1: Adjustment to Long Run Following a Monetary Shock

The adjustment to long run shows persistence. Any shock to the parallel market exchange rate remains in the system for 30 months, accentuating exchange rate volatility.

Bounds Test for Long Run Cointegration

Null hypothesis: No levels relationship
Number of cointegrating variables: 3
Trend type: Rest. constant (Case 2)
Sample size: 63

Test Statistic	Value
F-statistic	**4.097444**

Bounds Test Critical Values

	10%		5%		1%	
Sample Size	**I(0)**	**I(1)**	**I(0)**	**I(1)**	**I(0)**	**I(1)**
60	2.496	3.346	2.962	3.910	4.068	5.250
65	2.492	3.350	2.976	3.896	4.056	5.158
Asymptotic	2.370	3.200	2.790	3.670	3.650	4.660

* I(0) and I(1) are respectively the stationary and non-stationary bounds.

The Bounds Test results show that there is a long run cointegrating relationship between the parallel market, broad money and reserve money (The F- statistic value 4.097 is greater than 3.910, the 5% Bounds Test Statistic).

Test for Symmetry

Coefficient symmetry tests
Null hypothesis: Coefficient is symmetric
Degrees of freedom (simple tests): F(1,48), Chi-square(1)
Degrees of freedom (joint tests): F(2,48), Chi-square(2)
Equation: EQ003NPER

Variable	Statistic	Value	Probability
Long-run			
LOG(RMZZW)	F-statistic Chi-square	0.925501 0.925501	0.3409 0.3360
Short run			
LOG(RMZZW)	F-statistic Chi-square	9.729933 9.729933	0.0031 0.0018
Joint (Long-Run and Short-Run)			
LOG(RMZZW)	F-statistic Chi-square	5.515098 11.03020	0.0070 0.0040

The null hypothesis (H0) is that there is symmetry, that is, a positive and negative shock are symmetrically distributed, in terms of impact on the exchange rate.

The test results show that there is evidence of asymmetry, that is a long run nonlinear relationship. The relationship between reserve money and the exchange rate is nonlinear and this has implications for policy formulation and implementation.

Specification and Diagnostic Tests

Correlogram of Residuals

```
Date: 06/14/24   Time: 18:27
Sample: 2019M01 2023M12
Q-statistic probabilities adjusted for 11 dynamic regressors

Autocorrelation   Partial Correlation        AC      PAC     Q-Stat   Prob*

     . | .   |        . | .   |        1   -0.033   -0.033   0.0699   0.791
     . | .   |        . | .   |        2   -0.038   -0.039   0.1622   0.922
     **| .   |        **| .   |        3   -0.294   -0.298   5.8102   0.121
     . | .   |        .*| .   |        4   -0.034   -0.066   5.8886   0.208
     . | .   |        .*| .   |        5   -0.045   -0.084   6.0262   0.304
     . | .   |        . | .   |        6    0.063   -0.043   6.2956   0.391
     . | .   |        .*| .   |        7   -0.029   -0.073   6.3537   0.499
     . | .   |        . | .   |        8   -0.008   -0.061   6.3581   0.607
     . |*.   |        . |**   |        9    0.211    0.224   9.6182   0.382
     .*| .   |        .*| .   |       10   -0.140   -0.171   11.072   0.352
     . |*.   |        . |*.   |       11    0.094    0.111   11.737   0.384
     .*| .   |        . | .   |       12   -0.100    0.009   12.511   0.406
     . | .   |        .*| .   |       13   -0.058   -0.140   12.774   0.465
     .*| .   |        .*| .   |       14   -0.126   -0.074   14.059   0.445
     . | .   |        .*| .   |       15   -0.027   -0.135   14.117   0.517
     . | .   |        .*| .   |       16   -0.036   -0.084   14.225   0.582
     . | .   |        .*| .   |       17    0.002   -0.149   14.225   0.651
     . | .   |        .*| .   |       18    0.001   -0.161   14.225   0.714
     . |*.   |        . |*.   |       19    0.081    0.102   14.819   0.734
     . |*.   |        . | .   |       20    0.116   -0.023   16.061   0.713
     . | .   |        . | .   |       21   -0.023   -0.005   16.113   0.763
     .*| .   |        . | .   |       22   -0.106   -0.052   17.219   0.751
     .*| .   |        .*| .   |       23   -0.142   -0.126   19.241   0.687
     . | .   |        . | .   |       24   -0.035   -0.054   19.367   0.732
     . | .   |        .*| .   |       25    0.045   -0.088   19.586   0.768
     . |*.   |        . | .   |       26    0.102    0.001   20.724   0.756
     . | .   |        . | .   |       27    0.025   -0.059   20.797   0.796
     . | .   |        .*| .   |       28    0.053   -0.069   21.121   0.820
```

Correlogram of Squared Residuals

```
Date: 06/14/24   Time: 18:29
Sample: 2019M01 2023M12
Included observations: 60
Autocorrelation      Partial Correlation         AC      PAC     Q-Stat   Prob*
================================================================================
   .*| .   |            .*| .   |        1   -0.112   -0.112   0.7944   0.373
   . | .   |            . | .   |        2    0.012   -0.000   0.8039   0.669
   . |*.   |            . |*.   |        3    0.176    0.179   2.8154   0.421
   . | .   |            . | .   |        4   -0.001    0.041   2.8155   0.589
   . | .   |            . | .   |        5   -0.008   -0.009   2.8193   0.728
   . | .   |            . | .   |        6   -0.002   -0.038   2.8196   0.831
   .*| .   |            .*| .   |        7   -0.086   -0.102   3.3368   0.852
   . | .   |            . | .   |        8    0.056    0.040   3.5604   0.894
   . | .   |            . | .   |        9   -0.004    0.022   3.5615   0.938
   .*| .   |            . | .   |       10   -0.067   -0.035   3.8951   0.952
   . |**   |            . |*.   |       11    0.222    0.208   7.6342   0.746
   . | .   |            . | .   |       12   -0.047   -0.004   7.8024   0.800
   . | .   |            . | .   |       13   -0.015   -0.020   7.8201   0.855
   . | .   |            .*| .   |       14   -0.048   -0.143   8.0061   0.889
   . | .   |            . | .   |       15   -0.005   -0.030   8.0084   0.923
   .*| .   |            .*| .   |       16   -0.077   -0.072   8.5043   0.932
   . | .   |            . | .   |       17   -0.056   -0.037   8.7782   0.947
   . | .   |            . | .   |       18   -0.044    0.002   8.9518   0.961
   . | .   |            . | .   |       19   -0.021   -0.014   8.9903   0.974
   .*| .   |            . | .   |       20   -0.067   -0.061   9.4107   0.978
   .*| .   |            .*| .   |       21   -0.073   -0.085   9.9125   0.980
   . | .   |            .*| .   |       22   -0.021   -0.091   9.9563   0.987
   . | .   |            . | .   |       23   -0.011   -0.005   9.9691   0.991
   . | .   |            . | .   |       24   -0.058   -0.037   10.320   0.993
   .*| .   |            . | .   |       25   -0.082   -0.038   11.037   0.993
   . | .   |            . | .   |       26   -0.012   -0.034   11.053   0.995
   .*| .   |            .*| .   |       27   -0.095   -0.083   12.065   0.994
   . | .   |            . | .   |       28   -0.039   -0.048   12.244   0.996
================================================================================
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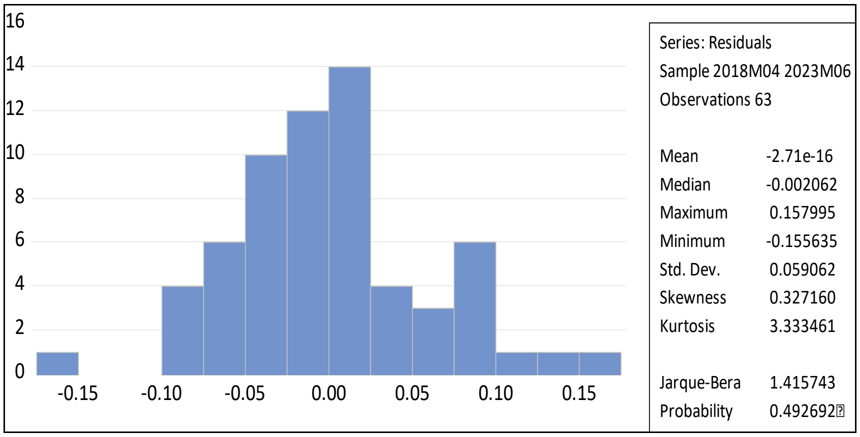


Figure 2: Histogram and Normality Tests

The residuals are normally distributed.

Serial Correlation Test

Breusch-Godfrey Serial Correlation LM Test: Null hypothesis: No serial correlation at up to 2 lags			
F-statistic	0.065801	Prob. F(2,46)	0.9364
Obs*R-squared	0.179723	Prob. Chi-Square(2)	0.9141

The LM Test for serial correlation shows that the residuals have no serial correlation.

Heteroscedasticity Test

Heteroskedasticity Test: Breusch-Pagan-Godfrey Null hypothesis: Homoskedasticity			
F-statistic	2.026099	Prob. F(11,48)	0.0463
Obs*R-squared	19.02519	Prob. Chi-Square(11)	0.0606
Scaled explained SS	22.26192	Prob. Chi-Square(11)	0.0224

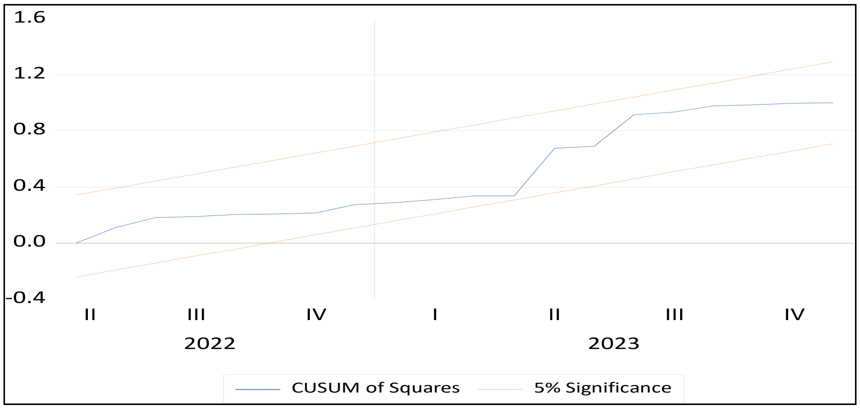


Figure 3: Stability Test

The results shows that the parameters are stable.

Price Level Nonlinear Autoregressive Distributed Lag Model

The NARDL price level equation is generated using monthly data (2018m1 to 2023M3)

The Price Level NARDL Equation

Dependent Variable: DLOG(CPI)				
Method: ARDL				
Date: 06/23/24 Time: 10:23				
Sample: 2018M05 2023M03				
Included observations: 59				
Dependent lags: 4 (Automatic)				
Automatic-lag linear regressors (3 max. lags): LOG(RMZZW)				
Automatic-lag dual non-linear regressors (3 max. lags): LOG(NPER)				
Static regressors: DUM19M6 DUM18M10 DUM20M1 DUM20M5				
Deterministic: Restricted constant and no trend (Case 2)				
Model selection method: Akaike info criterion (AIC)				
Number of models evaluated: 64				
Selected model: ARDL(4,3,0)				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.***
LOG(CPI(-1))	**-0.283490**	**0.036827**	**-7.697970**	**0.0000**
LOG(RMZZW(-1))	**0.131627**	**0.044441**	**2.961853**	**0.0049**
@CUMDP(LOG(NPER))	**0.200397**	**0.024681**	**8.119516**	**0.0000**
@CUMDN(LOG(NPER))	**0.404472**	**0.172072**	**2.350603**	**0.0233**
C	-0.653448	0.550946	-1.186047	0.2420
DLOG(CPI(-1))	**0.522137**	**0.084222**	**6.199515**	**0.0000**
DLOG(CPI(-2))	**-0.193535**	**0.095013**	**-2.036941**	**0.0477**
DLOG(CPI(-3))	**0.394602**	**0.073438**	**5.373281**	**0.0000**
DLOG(RMZZW)	**0.151499**	**0.038626**	**3.922158**	**0.0003**
DLOG(RMZZW(-1))	**-0.100358**	**0.043460**	**-2.309226**	**0.0257**
DLOG(RMZZW(-2))	0.083489	0.043834	1.904651	0.0634
DUM19M6	0.140036	0.036692	3.816555	0.0004
DUM18M10	0.085924	0.032981	2.605232	0.0125
DUM2020	-0.153798	0.037806	-4.068076	0.0002
DUM20M5	-0.089337	0.034318	-2.603238	0.0125
R-squared	0.898643	Mean dependent var		0.100195
Adjusted R-squared	0.866393	S.D. dependent var		0.084908
S.E. of regression	0.031036	Akaike info criterion		-3.892237
Sum squared resid	0.042381	Schwarz criterion		-3.364050
Log likelihood	129.8210	Hannan-Quinn criteria.		-3.686054
F-statistic	27.86504	Durbin-Watson stat		2.169102
Prob(F-statistic)	0.000000			

Cointegrating Equation

Deterministic: Rest. constant (Case 2)

CE = LOG(CPI(-1)) - (0.464309*LOG(RMZZW(-1)) + 0.706893
*@CUMDP(LOG(NPER),"2018M05") + 1.426759
*@CUMDN(LOG(NPER),"2018M05") - 2.305012)

Cointegrating Coefficients

Variable *	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
LOG(RMZZW(-1))	0.464309	0.122217	3.799056	0.0004
@CUMDP(LOG(NPER))	0.706893	0.066370	10.65077	0.0000
@CUMDN(LOG(NPER))	1.426759	0.654746	2.179104	0.0336
C	-2.305012	1.802205	-1.278995	0.2063

Note: * Coefficients derived from the equation

Bounds Test

Null hypothesis: No levels relationship
Number of cointegrating variables: 3
Trend type: Rest. constant (Case 2)
Sample size: 59

Test Statistic	Value
F-statistic	**16.537280**

Bounds Critical Values

	10%		**5%**		**1%**	
Sample Size	**I(0)**	**I(1)**	**I(0)**	**I(1)**	**I(0)**	**I(1)**
55	2.508	3.356	2.982	3.942	4.118	5.200
60	2.496	3.346	2.962	3.910	4.068	5.250
Asymptotic	2.370	3.200	2.790	3.670	3.650	4.660

* I(0) and I(1) are respectively the stationary and non-stationary bounds.

The Bounds Test results show that there exists a cointegrating long run relationship between the price level, reserve money, and the parallel market exchange rate.

Symmetry Test

Coefficient symmetry tests
Null hypothesis: Coefficient is symmetric
Degrees of freedom (simple tests): F(1,44), Chi-square(1)

Equation: EQ003CPI

Variable	Statistic	Value	Probability
Long-run			
LOG(NPER)	F-statistic	1.403709	0.2425
	Chi-square	1.403709	0.2361

The test results show that there is no evidence of long run asymmetry. This means that collapsing the parallel market will reduce the price level escalation in the economy.

Interpretation of the Price Level Equation

The price level model is a cointegrating equation, where the price level is predominantly explained by the parallel market exchange rate (nper) and reserve money (rmzzw). The parallel market exchange rate impact on the price level has been decomposed into positive and negative partial sums. Through the decomposition, it is possible to explain what happens to the price level when the exchange rate depreciates and when the exchange rate appreciates. Both are significant, implying that exchange rate depreciation increases the price level (inflation), while exchange appreciation has the opposite effect (reduces the price level) and the later effect is stronger. This has implications for policy – exchange rate stability is a prerequisite for achieving price level stability.

Short Run Dynamics

The short run dynamics accentuating price level escalation are strong, mainly the lagged effects of the price level and lagged effects of reserve money, though reserve money also has contemporaneous effects.

Coefficient of Adjustment

The coefficient of adjustment (-0.283) shows that following a shock to the price level, about 28.3% is cleared in the following month. About 28.3% of the balance is cleared in the following month. The process continues until the disequilibrium is cleared. The inflationary process in Zimbabwe is subject to strong persistence.

Inflation Persistence

The Figure below shows adjustment following a shock to the price level.

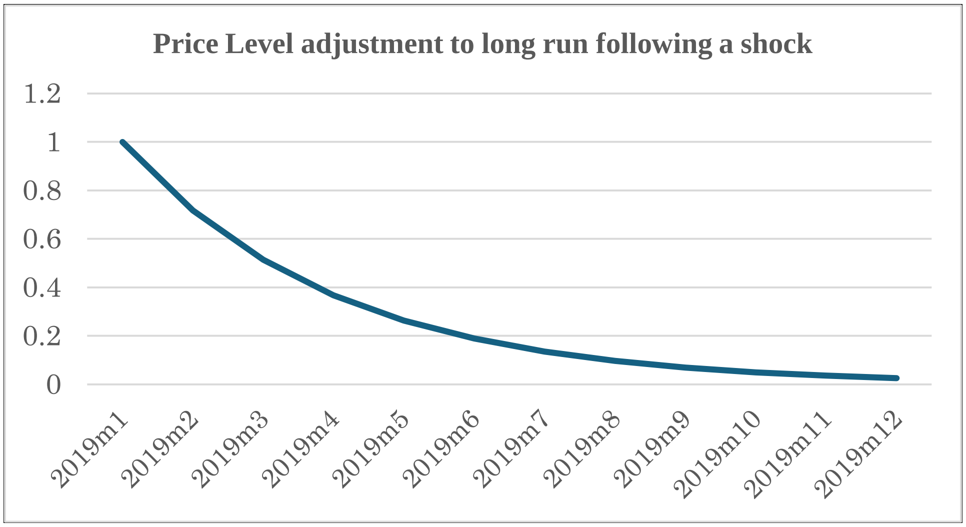


Figure 4: Inflation Persistence

The slow adjustment process means that a single shock to the price level remains in the system for over 12 months, hence inflation persistence. The persistence is predominantly a reflection of the dynamic terms of inflation expectations and contemporaneous effects of reserve money growth.

Long Run Coefficients

	Estimated Coefficient	**Long Run Coefficient**
LOG(CPI(-1))	-0.28349	
LOG(RMZZW(-1))	0.131627	0.464
@CUMDP(LOG(NPER))	0.200397	0.707
@CUMDN(LOG(NPER))	0.404472	1.427

In the long run, a 1% increase in reserve money increases the price level by 0.464%, while a 1% exchange rate depreciation leads to a 0.707% increase in the price level. A 1% appreciation of the exchange rate leads to a 1.427% decrease in the price level.

Specification and Diagnostic Test

The specification and diagnostic tests on the residuals are summarised below.

Correlogram of Residuals

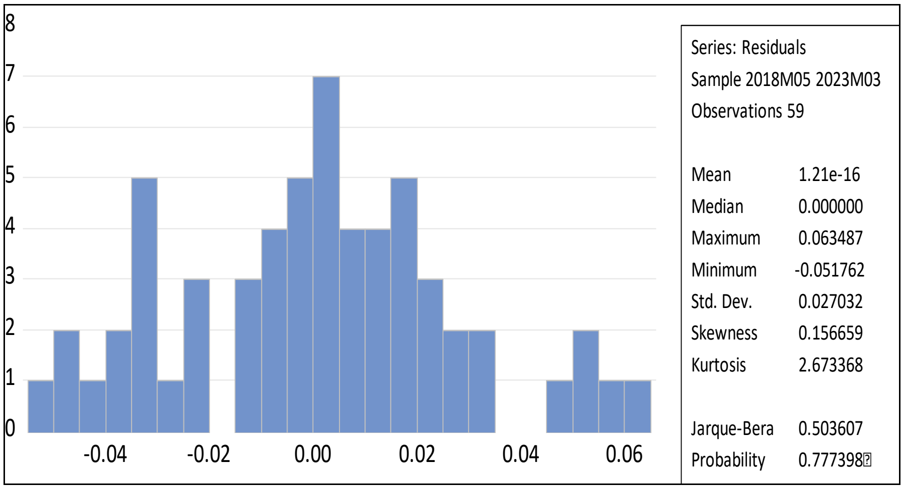
```
Date: 06/16/24   Time: 09:37
Sample: 2018M10 2024M03
Q-statistic probabilities adjusted for 13 dynamic regressors

Autocorrelation   Partial Correlation        AC       PAC     Q-Stat   Prob*

     .*| .   |        .*| .   |        1   -0.099   -0.099   0.6765   0.411
     . | .   |        . | .   |        2    0.046    0.036   0.8238   0.662
     . | .   |        . | .   |        3   -0.042   -0.034   0.9476   0.814
     . | .   |        . | .   |        4   -0.030   -0.039   1.0113   0.908
     . | .   |        . | .   |        5    0.070    0.068   1.3762   0.927
     . | .   |        . | .   |        6   -0.018   -0.004   1.4007   0.966
     **| .   |        **| .   |        7   -0.280   -0.295   7.3492   0.393
     . |*.   |        . |*.   |        8    0.196    0.166   10.329   0.243
     .*| .   |        . | .   |        9   -0.088   -0.035   10.940   0.280
     .*| .   |        **| .   |       10   -0.183   -0.282   13.628   0.191
     .*| .   |        .*| .   |       11   -0.071   -0.097   14.039   0.231
     .*| .   |        .*| .   |       12   -0.127   -0.070   15.388   0.221
     . | .   |        .*| .   |       13    0.039   -0.071   15.517   0.276
     . | .   |        . | .   |       14    0.042   -0.051   15.668   0.334
     **| .   |        .*| .   |       15   -0.218   -0.141   19.835   0.178
     . |*.   |        . | .   |       16    0.085   -0.039   20.478   0.199
     .*| .   |        .*| .   |       17   -0.077   -0.197   21.020   0.225
     . | .   |        .*| .   |       18   -0.019   -0.101   21.055   0.277
     . | .   |        . | .   |       19    0.035   -0.065   21.174   0.327
     . | .   |        . | .   |       20    0.058    0.005   21.499   0.368
     . | .   |        . | .   |       21    0.063   -0.059   21.894   0.406
     . | .   |        .*| .   |       22    0.069   -0.132   22.373   0.438
     . | .   |        . |*.   |       23    0.040    0.090   22.539   0.488
     . |*.   |        . | .   |       24    0.099   -0.002   23.592   0.485
     . | .   |        .*| .   |       25   -0.020   -0.157   23.637   0.540
     . | .   |        . | .   |       26    0.009   -0.031   23.645   0.596
     . | .   |        . | .   |       27   -0.006   -0.058   23.650   0.650
     . |*.   |        . | .   |       28    0.084   -0.002   24.478   0.656
```

Correlogram of Squared Residuals

```
Date: 06/16/24   Time: 09:38
Sample: 2018M10 2024M03
Included observations: 66
Autocorrelation      Partial Correlation          AC      PAC     Q-Stat   Prob*
==================================================================================
    . | .  |            . | .  |          1    0.065    0.065   0.2902   0.590
    . | .  |            . | .  |          2   -0.047   -0.051   0.4421   0.802
    . | .  |            . | .  |          3   -0.060   -0.054   0.7005   0.873
    .*| .  |            .*| .  |          4   -0.070   -0.066   1.0574   0.901
    . |*.  |            . |*.  |          5    0.121    0.126   2.1301   0.831
    .*| .  |            .*| .  |          6   -0.080   -0.109   2.6113   0.856
    . |*.  |            . |**  |          7    0.195    0.223   5.5182   0.597
    . |*** |            . |*** |          8    0.416    0.412   18.922   0.015
    .*| .  |            .*| .  |          9   -0.071   -0.115   19.316   0.023
    . | .  |            . | .  |         10   -0.047   -0.013   19.494   0.034
    .*| .  |            . | .  |         11   -0.077    0.039   19.979   0.046
    . | .  |            . | .  |         12   -0.016   -0.065   20.000   0.067
    . |*.  |            . | .  |         13    0.076   -0.020   20.496   0.084
    .*| .  |            . | .  |         14   -0.074   -0.021   20.967   0.102
    . | .  |            .*| .  |         15    0.042   -0.164   21.121   0.133
    . | .  |            **| .  |         16   -0.020   -0.205   21.158   0.173
    . | .  |            . |*.  |         17   -0.035    0.080   21.271   0.214
    . | .  |            . | .  |         18   -0.034   -0.056   21.376   0.261
    . | .  |            . | .  |         19   -0.060   -0.053   21.716   0.299
    . | .  |            . | .  |         20   -0.018    0.013   21.747   0.354
    . | .  |            . | .  |         21    0.019    0.033   21.782   0.412
    . | .  |            . | .  |         22   -0.019    0.015   21.818   0.471
    . | .  |            . |*.  |         23   -0.005    0.114   21.820   0.531
    . | .  |            . |*.  |         24   -0.028    0.083   21.904   0.585
    . | .  |            .*| .  |         25   -0.028   -0.066   21.988   0.636
    . | .  |            . | .  |         26   -0.055   -0.025   22.327   0.671
    .*| .  |            . | .  |         27   -0.067   -0.023   22.836   0.694
    . | .  |            . | .  |         28    0.011   -0.018   22.850   0.740
==================================================================================
```



Series: Residuals
Sample 2018M05 2023M03
Observations 59

Mean	1.21e-16
Median	0.000000
Maximum	0.063487
Minimum	-0.051762
Std. Dev.	0.027032
Skewness	0.156659
Kurtosis	2.673368
Jarque-Bera	0.503607
Probability	0.777398

Figure 5: Histogram and Normality Test

The residuals are normally distributed.

Serial Correlation Test

Breusch-Godfrey Serial Correlation LM Test:
Null hypothesis: No serial correlation at up to 2 lags

F-statistic	0.392146	Prob. F(2,42)	0.6781
Obs*R-squared	1.081548	Prob. Chi-Square(2)	0.5823

The serial correlation test shows that the residuals have no serial correlation.

Heteroscedasticity Test

Heteroskedasticity Test: Breusch-Pagan-Godfrey
Null hypothesis: Homoskedasticity

F-statistic	1.493821	Prob. F(14,44)	0.1536
Obs*R-squared	19.00832	Prob. Chi-Square(14)	0.1646
Scaled explained SS	8.845174	Prob. Chi-Square(14)	0.8408

The residuals are homoscedastic.

Stability Test

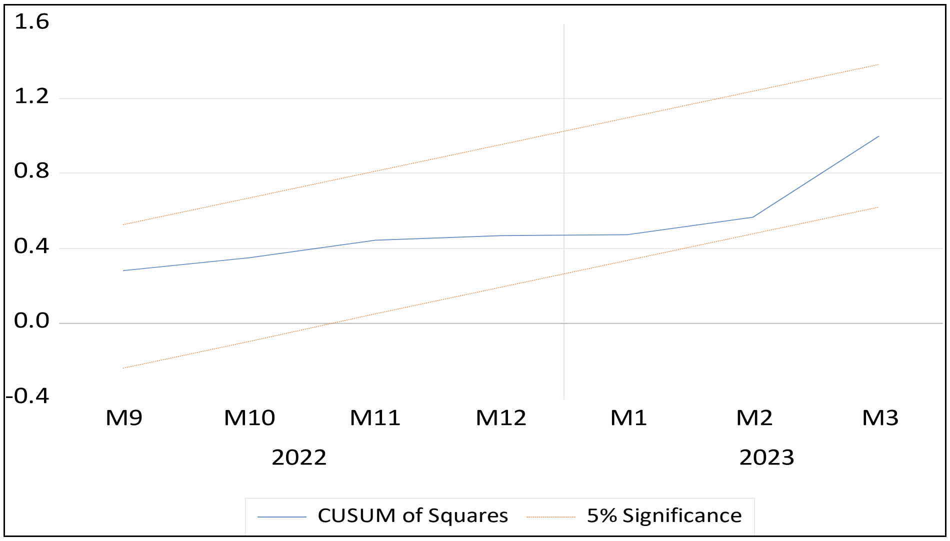


Figure 6: Cusum of Squares Test

The Cusum of squares test shows that parameters of the model are stable.

A 1% Shock to the Parallel Market Exchange Rate, Impact on the Price Level

The results below show the impact of a 1% shock to the parallel market exchange rate, impact on the Price Level.

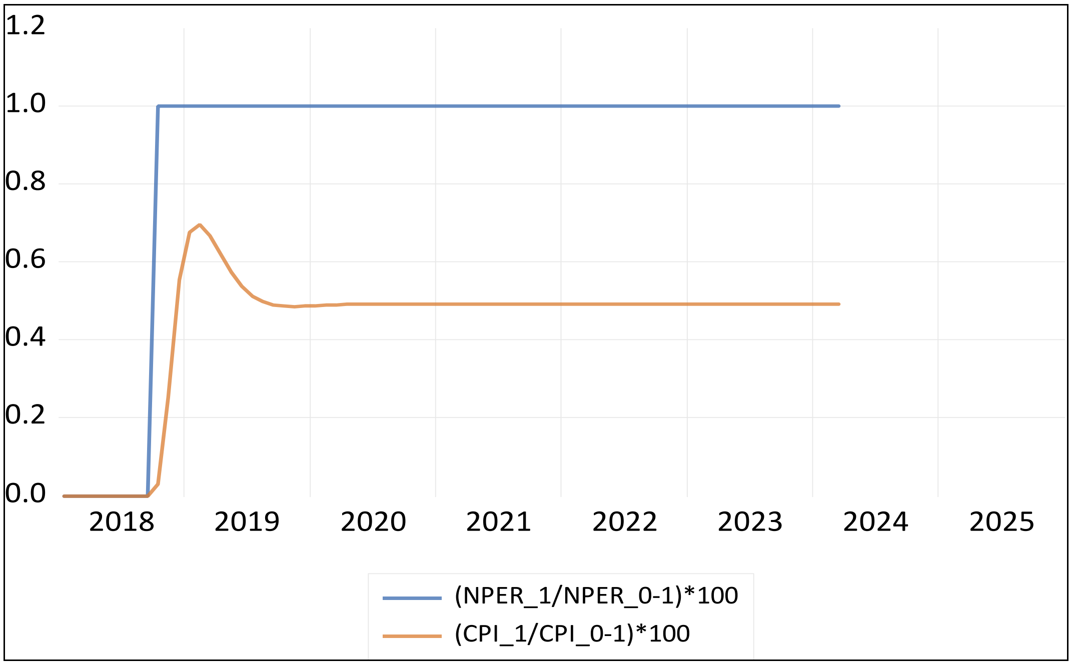


Figure 7: Monetary Shock Transmission and Pass Through

The exchange rate transmission mechanism is shown below:

	1% shock to the exchange rate	Response of the price level		Months
2018M10	1	0.029946	6.1%	1
2018M11	1	0.252082	51.4%	2
2018M12	1	0.553431	112.9%	3
2019M01	1	0.676296	137.9%	4
2019M02	**1**	**0.695922**	**141.9%**	**5**
2019M03	1	0.665466	135.7%	6
2019M04	1	0.618624	126.2%	7
2019M05	1	0.573268	116.9%	8
2019M06	1	0.537284	109.6%	9
2019M07	1	0.512382	104.5%	10
2019M08	1	0.497178	101.4%	11
2019M09	1	0.489167	99.8%	12
2019M10	1	0.485934	99.1%	13
2019M11	1	0.485427	99.0%	14
2019M12	1	0.486243	99.2%	15
2020M01	1	0.487523	99.4%	16
2020M02	1	0.48871	99.7%	17
2020M03	1	0.489696	99.9%	18
2020M04	1	0.490318	100%	19
2020M05	**1**	**0.490716**	**100%**	20

The exchange rate shock transmission mechanism shows that any shock to the exchange rate remains in the economy for about 20 months. In the month of the shock, a 6.1% exchange rate pass through is realised and this increases to 51.4% in the second month following the shock. The exchange rate shock leads to price level overadjustment for 9 months from the third month, peaking at 141.9% in the 5th month. The inflationary process in Zimbabwe is characterised by overadjustment and inflation persistence. This reflects the impact of endogenous inflation expectations and expectations of exchange rate depreciation, implying that inflation stabilisation first requires anchored inflation expectations. The economy is characterised by de-anchored inflation expectations.

2.0 CONCLUSIONS AND RECOMMENDATIONS

Achieving lasting and durable price level stability in Zimbabwe, requires anchored inflation expectations (that is to collapse of inflation expectations and expectations of exchange rate depreciation) as a prerequisite for inflation stability. This will restore normality to the money demand function and restoration of stability fundamentals. Collapsing inflation expectations implies control of reserve money and broad money growth, as well as an interbank determined exchange rate. An interbank determined exchange rate is important as an equilibrating mechanism demand and supply for foreign currency in the economy.

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