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Money Supply Growth, Exchange Rate and Inflation Dynamics in Zimbabwe: An Autoregressive Distributed Lag -Error Correction Model

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Abstract

Purpose: The study investigates the relationship between monetary growth, exchange rate and price level dynamics in Zimbabwe.

Methodology: The methodology follows the Autoregressive Distributed Lag Model (ARDL), following Pesaran and Shin, (1999) and Pesaran et al Bounds Testing (2001) for testing time, monthly data from 2018 to 2023.

Findings: Monetary shocks propagation has time varying distributed lag effects on the exchange rate, leading to short run dynamics of adjustment with implications for price formation in Zimbabwe. Adjustment to long run, following a monetary shock is slow, indicating persistence.

Unique Contribution to Theory, Policy and Practice: The study contributes to the literature on optimal monetary policy formulation and implementation through characterising the pass through effects from money growth to exchange rate and price formation in the economy.

Keywords: *Autoregressive distributed lag, Bounds Test, Cointegration, dynamic multipliers.*

1. Introduction

Modern monetary policy theory and practice has been heavily influenced by the ideas of mainstream macroeconomic theories; in the main; Keynesian, Monetarist, New Classical and New Keynesian theories. Keynesian macroeconomic theory gained prominence following Keynes seminal work, "The General Theory of Employment, Interest and Money (1936); published in the aftermath of the Great Depression of 1929 -1933. Keynes proposed that the great depression was primarily due to aggregate demand falling below output, creating a negative output gap and collapse in actual output and employment. Accordingly, the role of Government was to shore up aggregate demand through increased Government spending (fiscal policy) and lower interest rates (monetary policy), thus allowing aggregate demand to increase pushing the economy towards full employment.

Milton Friedman (1960), the earliest proponent of monetarism refuted many of the Keynesian theory propositions and submitted that changes in monetary aggregates had far reaching implications on the economy. He laid out his ideas which became the foundation of monetarism in his book "A Monetary History of the United States, 1867-1960", published in 1963, in collaboration with Anna Schwartz. He argued that the post World War1 collapse in monetary aggregates in many industrial economies had precipitated the Great Depression. He proposed that prudent management of money supply growth was more effective in preventing cyclical booms/burst economic cycles.

The Structuralist theory places emphasis on a wide range of structural factors such as foreign exchange constraints, food supply shocks and heterogeneous institutions as prominent causes of inflation in developing economies. This evolved against the background of high inflation in many Latin American, East Asian and Sub Saharan African economies in the 1970s – mid1980s.

High and sustained inflation dissuades capital formation and promotes rent seeking behaviour, dislocating productive economic activity. High and volatile inflation disrupts the smooth functioning of a market economy (Krugman,1995). High Inflation also reduces a country's international competitiveness, making exports relatively more expensive and imports relatively cheaper, impacting on domestic industry and the balance of payments (Atkinson & Milward, 1998).

Hyperinflation (prices rising by more than 50% per month) erodes consumers' purchasing power, impoverishing the population (Pindiriri, 2012). Zimbabwe witnessed severe hyperinflation in 2007/08, which decimated all monetary values leading to the collapse of the local currency and migration to Multicurrency in February 2009.

Authorities typically respond to high inflation threat through monetary policy – tightening monetary policy in response to the build-up in inflation pressures in the economy. Monetary and fiscal policy form the core of macroeconomic management (in addition to trade policy),

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determining the path of aggregate demand for the near and medium term, as well as the long term, jointly determining the path of actual output in the economy.

In the long run, the economy's capacity to produce goods and services is determined by supply side factors – investment in capital, labour and technology, and how efficiently these factors are combined in the production process. This defines the economy's aggregate supply, or capacity to produce goods and services (Billi, 2020); (Kirkby, 2024); (Blanchard, 2018); (Rajan, 2021); (Bernanke, 2019).

Monetary policy has defining implications for the domestic economy, affecting financial markets prices, aggregate demand, output and employment (at least in the short run), as well as the exchange rate and nominal prices. The effects of monetary policy are subject to long and variable lags, distributed over time. The role of monetary policy in the economy is widely acknowledged in literature over the decades (Friedman, 1967); (Burns, 1979); (Okun, 1978); (Blinder, 1982); (Blanchard, 1987); (Fischer, 1987); (Summers, 1988); (Romer and Romer, 1989); (Taylor, 1993); (Rogoff, 2003); (Bernanke, 2004); (King, 2005); (Batini & Nelson, 2005); (Mishkin, 2007); (Kapaya, 2020); (Abubakar and Lawal, 2022), (Majeed, 2024); Gabriel, 2024); (Borio, 2024); (Steinsson, 2024) among others.

2. Macroeconomic Theories, Money Supply Growth and the Exchange Rate

In 1971, the United States of America, suspended dollar convertibility, effectively abandoning the adjustable peg exchange rate mechanism or Gold Standard which had been agreed at Bretton Woods in 1944. By 1973, most advanced economies had floated their currencies.

This coincided with the first oil shock; sharply rising oil prices, leading to high inflation and stagnation in economic growth. A new term "stagflation" was popularised to characterise simultaneous occurrence of high inflation and stagnation in economic activity.

Keynesian theory, though still dominant, could neither adequately explain stagflation, nor address the occurrence of both high inflation and economic stagnation. The Phillps curve (Phillips, 1958), the workhorse of Keynesian macroeconomic theory, had postulated an inverse relationship between inflation and employment. After the 1973 oil shocks, unemployment and inflation occurred simultaneously, contrary to the Phillips Curve predictions. This created fertile ground for new macroeconomic thinking, and the most prominent being the New Classical theory.

New Classical theory is premised on flexible markets and flexible wage - price relationship, underpinned by rational expectations – that economic agents make decisions based on rational expectations and the expectations are formed based on the best available information.

New Classical theory proponents (among them Robert Lucas, Thomas Sargent, Neil Wallace, and Robert Barro) concluded that rational expectations meant that neither fiscal nor monetary policy could influence economic activity and aggregate demand, with the notable exception of unanticipated monetary policy. The new Classical theory was anchored on microeconomic foundations – analysing the optimising behaviour of firms (profits) and households (utility). Not surprisingly, models of aggregate demand management postulated by Keynesian macroeconomic theory were mortified in New Classical thinking, as not anchored on coherent microeconomic foundations.

New Keynesian macroeconomic theory builds on the ideas of Keynes, that prices and wages are "sticky", particularly in the short run, therefore aggregate demand management (monetary) policy has real effects on the economy in the short run, though prices and wages adjust in the long run, giving rise to long run monetary neutrality. New Keynesians (among them, Ben Bernanke, Joseph Stiglitz, Alan Blinder, Richard Clarida, Mark Gettler, David Romer, Christine Romer, Gregory Mankiw, Allan Meltzer) particularly submit that New Classical wage price flexible models cannot explain short run fluctuations in economic activity. They emphasize imperfect markets, nominal wage price rigidities, staggered and overlapping contracts as impediments to wage-price flexibility. New Keynesians also proffered microeconomic foundations to their theoretical framework.

The nexus of money supply growth, exchange rate dynamics and price formation gained prominence following the collapse of the Gold Standard in 1973, when the US dollar was de-pegged from gold convertibility, which had anchored the Bretton Woods adjustable peg mechanism since 1944.

The subsequent adoption of (managed) floating exchange rates across much of the industrial world, ignited an inflation spiral which was exacerbated by the oil price shocks of 1973 and 1979. Central Banks responded to the new inflation surge by sharply raining interest rates. Though inflation subsided by the mid1980s, the high interest rates triggered a debt crisis in many developing economies, particularly in Sub Saharan Africa and Latin America (Leven and Huhne, 1985); (Todaro, 1989); (Dornbusch, 1986) and (Carty, 1986).

The shift from the adjustable peg exchange rate mechanism fundamentally altered the relationship between money supply growth, exchange rates and inflation dynamics, since 1973.

The study explores the relationship between money supply growth, exchange rate and price level dynamics for Zimbabwe applying the Autoregressive Distributed Lag Model (ARDL). Compared to conventional Johansen Cointegration approach, the ARDL model has the following advantages:

i. Accommodates variables, both I(0), stationary in levels and I(1), stationary after first differencing or a mix of both stationary and first difference stationary variables;
ii. ARDL is a statistically significant approach for determining cointegrating relationships in small samples;
iii. Allows for parsimonious test for both short run and long run cointegrating relationships;
iv. ARDL models correct for the endogeneity problem of explanatory variables;
v. ARDL can minimize random errors that may be caused by non-stationary time series data;

vi. A variety of estimation techniques can be used, such as Ordinary Least Squares (OLS) or maximum likelihood estimation (MLE).

3. Literature Review

Zimbabwe has experienced several inflation episodes including, the hyperinflation of 2007/08 and the subsequent economic meltdown and subsequent migration to Multicurrency. The headline annual inflation rate surpassed 231 million by August 2008, and the upward drift persisted on the back excessive monetary growth, exchange rate depreciation and amplified currency volatility. In response to the exchange rate depreciation and sharply escalating inflation, Authorities re-denominated the local currency, cutting off three zeros - an exercise that was known as Sunrise/Kusile in August 2006 and increased currency denominations.

However, elevated reserve money growth (high monthly reserve money growth) fuelled by the Central Bank's expanded quasi fiscal activities sustained pressure on the exchange rate (Munoz, 2007); (Coorey, 2007, Kairiza, 2012); (Mandishara and Mupamhadzi, 2016); (Kavila and Le Roux, 2017); (Kunaka, 2020); (Kavila, 2021). By the end of 2008, the cumulative real GDP decline since 2000 was just over 50%, with severe economy wide implications – an economic meltdown compounded by currency collapse, food shortages and worsening poverty in the economy. Following the currency collapse in 2008, the economy migrated to Multicurrency which was officially adopted in the budget that was announced at the end of January 2009.

The Multicurrency ended hyperinflation, brought stability, restored the medium of exchange function of money and facilitated domestic payments. Restoration of macroeconomic and price stability in occasioned industry capacity utilization recovery, resumption of economic activity, exports and real GDP growth. The economy registered growth in 2009 of 5.5% and double digit growth rates in 2010 and 2011 on the back of macroeconomic stability and favourable international commodity prices.

During the hyper-inflationary era, studies by Makochekanwa (2007) and Pindiriri and Nhavira (2011) found money supply as the major driver of inflation in Zimbabwe. Makochekanwa found evidence that the parallel market for foreign currency was a major determinant of the hyper-inflation.

Pindiriri (2012) investigated monetary reforms and inflation dynamics in Zimbabwe, post dollrisation. While inflation post dollarization broadly remained low and stable, there were still some low intensity inflation pressures in the economy. The study found evidence that money supply, consumer inflation expectations and import prices were the major factors influencing post-dollarisation inflation.

Kavila and LeRoux examined the inflation dynamics in Zimbabwe, post dollarization applying the autoregressive distributed lag (ARDL) model with monthly data from 2009:1 to 2012:12. They concluded that the main determinants of inflation were the US dollar/South African rand exchange rate, international oil prices, lagged Zimbabwean inflation rate and the South African inflation.

This was in sharp contrast to the pre – dollarization local currency era, where inflation was mainly determined by excess money growth, parallel market exchange rate and inflation expectations (Coorey, Clausen, Funke and Munoz 2007).

Roffia and Zaghini (2007) investigated monetary growth in 15 industrial countries over three decades and examined the impact of excessive monetary growth on price dynamics in the short run. They analyse the behaviour of stock markets, housing prices as well as credit to the private sector to determine whether they help to distinguish inflation episodes of monetary expansion.

Maune, Matanda and Mundonde (2020) applied multiple linear regression analysis to model the nexus between money supply and inflation in Zimbabwe for the period 1980 – 2019. They found that inflation was directly related to money supply growth, as well as the exchange rate and fiscal deficits. Typical of many small open economies, the direction of causality emanated from large recurring fiscal deficits, monetized through the Central Bank, leading to money supply growth and inflation.

Manda (2022) investigated the nexus between money supply growth, the exchange rate and inflation in Zimbabwe. To eliminate the endogeneity problem and to allow for the feedback mechanism, the study applies a Vector Error Correction Model (VECM). He concluded that there was evidence of "long-run causality running from the money supply, parallel market exchange rate premium, output gap and inflation as well as short-run causality running from money supply and the parallel exchange rate premium to inflation"[1].

Chipili (2021) applied a Single Step Error Correction Model to assess the drivers of inflation in Zambia over the period 1994Q1 - 2019Q4. The empirical results reveal that the long-run sources of overall inflation are determined in the external sector market where the exchange rate and world non-food prices drive domestic prices. In the short-run, overall inflation is influenced by movements in the exchange rate, adjustments in energy prices. The results show that inflation exhibits persistence.

Dekkiche (2022) applied the Vector Auto regression model (VECM) to investigate the relationship between money supply and inflation in Egypt from 1990 – 2019. He concluded that a long run relationship existed between money supply, import prices, exchange rate and Gross Domestic Product. The study finds that money supply is the primary long term predictor of inflation in Egypt.

3.1 Empirical Model

[1] Manda S. (2022); Assessing Money Supply, Exchange Rate and Inflation Dynamics in Zimbabwe; international Journal of Management Studies and Social Science Research, pp 1-12

Pesaran, Shin and Smith applied cointegration modelling 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 how monetary shocks are propagated and the dynamics of adjustment following shocks.

In their seminal work, they employ the 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 set of critical values, as suggested by Pesaran et al. (2001), extend the ARDL model, providing Bounds Testing for cointegration regardless of whether the variables are stationary in levels or stationary after first differencing (No second difference stationary variables).

Feyisa (2022) applied the ARDL model to examine the sources of inflation in Ethiopia using annual data from 1990 to 2020. Unit root tests showed that variables were stationary at first difference. The bounds test indicated the existence of long-run co-integration between inflation and its determinants. The study found that money supply, exchange rate, and the gross domestic product of the service sector are significant inflation variables.

Gola et al (2023) applied the ARDL model to investigate the relationship between, money supply growth, exchange rate and inflation dynamics in Pakistan using data from 1990 -2020. Unit root tests were applied, and the data was characterised at different orders of integration. The results confirmed the presence of both short-run and long-run relationships among the variables. They concluded that money supply and exchange rates impact inflation positively. A negative and significant error correction term (ECT) indicates strong convergence.

Milanzi (2019) applied the ARDL model to examine the relationship between money supply growth, exchange rate and inflation in Tanzania, using annual time series data (1970-2015) . Using the ARDL bounds testing approach, the study concludes the existence of a long-run equilibrium relation among inflation, money supply, and exchange rates. In addition, both money supply and the exchange rate have dynamic short run causal effects on inflation. The estimated error correction coefficient of -0.73 suggests about 73 percent of the disequilibrium is corrected within a year. This speed of adjustment towards the equilibrium is quite high. Further, the exchange rate pass-through is quite pronounced.

Abasimi (2018) applied the ARDL and Error Correction models to investigate the relationship between money supply, exchange rate and inflation in Ghana, using annual data from 1990 – 2017. The results showed that money supply had no impact on inflation in the short and long run for the study period, but the exchange rate had significant long run and short run causation on inflation.

Tolasa et al (2022) investigated the determinants of inflation in Ethiopia, applying the ARDL model using annual data for the period 1981 – 2020. The ARDL bounds testing confirmed long run cointegration. The study concluded that money supply growth had short run effects on inflation.

Jahan (2024) examined the dynamics of the exchange rate, inflation, money supply and GDP in Bangladesh for the period 1995 - 2023, employing the Autoregressive Distributed Lag (ARDL) model. The empirical findings reveal a long run equilibrium cointegrating relationship among these variables. The results of the ARDL bounds test show existence of long run cointegration among the money supply, inflation, economic growth, and exchange rate showing a significant, positive coefficient.

Unit Root Tests

Unit root tests were carried out for the variables under investigation and the table below shows that all the variables were I(1), that is integrated order 1 or stationary after first differencing.

Table 1: Unit Root Tests

Variable	**Unit root Tests in Levels**	**Unit Root Tests, first difference**
LCPI	ADF t Statistic - **0.2576**	ADF t Statistic - **5.9195**
	Test Critical Values 1% -4.42	Test Critical Values 1% - 2.65
	5% -3.62	5% - 1.95
	10% -3.25	10% - 1.60
LM3	ADF t Statistic - **1.2667**	ADF t Statistic - **5.4708**
	Test Critical Values 1% -4.31	Test Critical Values 1% - 2.66
	5% -3.57	5% - 1.95
	10% -3.22	10% - 1.60
LM1	ADF t Statistic - **1.2344**	ADF t Statistic - **2.4686**
	Test Critical Values 1% -4.28	Test Critical Values 1% - 2.65

	5% -3.56 10% -3.22	5% - 1.95 10% - 1.60
LNPER	ADF t Statistic - **2.1995** Test Critical Values 1% - 4.33 5% -3.58 10% -3.23	ADF t Statistic - **6.17** Test Critical Values 1% - 2.66 5% - 1.95 10% - 1.60
LGDP	ADF t Statistic - **2.2724** Test Critical Values 1% - 4.95 5% -4.44 10% -4.19	ADF t Statistic - **8.5125** Test Critical Values 1% - 4.95 5% - 4.44 10% - 4.19
LRMD3ZW	ADF t Statistic - **0.5484** Test Critical Values 1% - 2.6534 5% -1.9538 10% -1.6095	ADF t Statistic - **2.3773** Test Critical Values 1% - 2.6569 5% - 1.9544 10% -1.6093
LM3FC	ADF t Statistic **2.6028** Test Critical Values 1% - 2.6010 5% -1.9459 10% -1.6135	ADF t Statistic - **6.9589** Test Critical Values 1% - 2.60159 5% - 1.9459 10% -1.6135

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3.2 The Autoregressive Distributed Lag Model

The Autoregressive Distributed Lag model (ARDL) characterizing money supply growth and exchange rate dynamics takes the form:

$$\mathbf{Y_t = \alpha + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \ldots + \beta_p Y_{t-p} + \phi_1 X_t + \phi_2 X_{t-1} + \ldots + \phi_q X_{t-q} + \varepsilon_t}$$

Where:

i. α is the intercept;
ii. $\beta_1, \beta_2 \ldots\ldots \beta_p$ are coefficients of autoregressive terms;
iii. $\phi_1, \phi_2 \ldots\ldots\ldots +\phi_q$ are coefficients of distributed lag terms;
iv. Y_t is the endogenous variable;
v. X_t is the explanatory variable; and
vi. ε_t is the serially uncorrelated, stochastic error term.

In the ARDL model:

i. Nper is the nominal exchange rate (*units of local currency per US dollar);*
ii. CPI is the price level;
iii. SACPI is South Africa Price Level *(South Africa is Zimbabwe's largest trading partner)*
iv. M3ZZZW is local currency broad money (net of Reserve Money)
v. RMZZW is local currency component of reserve money; and
vi. Some dummy variables

The equation estimation, compilation and simulation (in E-views) using monthly data from January 2019 to March 2024. (62 data points after adjusting endpoints).

Estimation Equation:

LOG(NPER) = C(1)*LOG(NPER(-1)) + C(2)*LOG(NPER(-2)) + C(3)*LOG(CPI) + C(4)*LOG(CPI(-1)) + C(5)*LOG(SACPI) + C(6)*LOG(RMZZW) + C(7)*DUM23M5 + C(8)*DUM23M6 + C(9)*DUM23M7 + C(10)*DUM22M4 + C(11)*DUM19M4 + C(12)*DUM20M5 + C(13)*DUM23M9 + C(14)

International Journal of Economic Policy
ISSN: 2788-6352 (Online)
Vol. 5, Issue No. 4, pp 1 - 21, 2025
www.carijournals.org

The Autoregressive Distributed Lag (ARDL) model estimated in e-views as below:

Dependent Variable: **LOG(NPER)**
Method: ARDL
Date: 03/15/25 Time: 08:41
Sample: 2018M03 2024M01
Included observations: 71
Dependent lags: 3 (Automatic)
Automatic-lag linear regressors (3 max. lags): LOG(CPI) LOG(SACPI) LOG(RMZZW)
Static regressors: DUM23M5 DUM23M6 DUM23M7 DUM22M4 DUM19M4 DUM20M5 DUM23M9
Deterministic: Restricted constant and no trend (Case 2)
Model selection method: Akaike info criterion (AIC)
Number of models evaluated: 192
Selected model: ARDL(2,1,0,0)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LOG(NPER(-1))	1.274093	0.099779	12.76917	0.0000
LOG(NPER(-2))	-0.477459	0.097636	-4.890202	0.0000
LOG(CPI)	0.386141	0.127568	3.026944	0.0037
LOG(CPI(-1))	-0.293851	0.120470	-2.439197	0.0179
LOG(SACPI)	1.085253	0.452702	2.397281	0.0198
LOG(RMZZW)	0.151364	0.045086	3.357250	0.0014
DUM23M5	0.517457	0.068638	7.538891	0.0000
DUM23M6	0.495580	0.089326	5.548011	0.0000
DUM23M7	-0.462821	0.103194	-4.484948	0.0000
DUM22M4	0.315258	0.067447	4.674179	0.0000
DUM19M4	0.318645	0.067674	4.708530	0.0000
DUM20M5	0.277666	0.068638	4.045389	0.0002
DUM23M9	0.167978	0.072985	2.301534	0.0250
C	-7.300462	2.239216	-3.260276	0.0019

R-squared	0.999458	Mean dependent var	4.677956
Adjusted R-squared	0.999335	S.D. dependent var	2.522167
S.E. of regression	0.065041	Akaike info criterion	-2.452864
Sum squared resid	0.241128	Schwarz criterion	-2.006701
Log likelihood	101.0767	Hannan-Quinn criteria.	-2.275439
F-statistic	8092.713	Durbin-Watson stat	2.078964

International Journal of Economic Policy
ISSN: 2788-6352 (Online)
Vol. 5, Issue No. 4, pp 1 - 21, 2025
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Prob(F-statistic)	0.000000

Bounds Test

Null hypothesis: No levels relationship Number of cointegrating variables: 3 Trend type: Rest. constant (Case 2) Sample size: 71	
Test Statistic	Value
F-statistic	**4.249973**

Bounds Critical Values

	10%		5%		1%	
Sample Size	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
70	2.482	3.310	2.924	**3.860**	3.916	5.088
75	2.482	3.334	2.946	3.862	4.048	5.092
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.						

Ho: No long run Cointegration

H1: There is presence of Cointegration

The null hypothesis is that there is no long run relationship between the nominal exchange rate, reserve money, the price level and South Africa price level. The alternative hypothesis (H1) is that there is presence of long run cointegration.

The Calculated F statistic (4.249973) is greater than I (1) value (3.86) at 5%, we reject, the null hypothesis of no long run cointegration and accept the alternative (H1) which acknowledges presence of long run relationship. The next step is to estimate an Error Correction model (ECM).

The Bounds test confirms a long run relationship between the exchange rate, reserve money growth, the price level, price level expectations and South Africa price level.

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www.carijournals.org

Granger Causality Tests

VAR Granger Causality/Block Exogeneity Wald Tests Date: 03/12/25 Time: 15:59 Sample: 2018M01 2024M01 Included observations: 71			
Dependent variable: LOG(RMZZW)			
Excluded	Chi-sq	df	Prob.
LOG(M1ZZZW)	6.572493	2	0.0374
LOG(NPER)	16.26293	2	0.0003
LOG(CPI)	7.814964	2	0.0201
All	28.53729	6	0.0001

The Granger Causality Tests show that RMZZW growth has causal effects on:

i. Narrow money
ii. Exchange rate; and
iii. Price Level

Wald Coefficient Tests

Wald Test: Equation: EQ101ARDLNPER			
Test Statistic	Value	df	Probability
F-statistic	14345.21	(6, 57)	0.0000
Chi-square	86071.24	6	0.0000
Null Hypothesis: C(1)=C(2)=C(3)=C(4)=C(5)=C(6)=0			

Ho: $C(1)=C(2)=C(3)=C(4)=C(5)=C(6) =0$
H1: $C(1)\neq C(2)\neq C(3) \neq C(4)\neq C(5)\neq C(6) \neq 0$

The Wald Coefficient test rejects reject the null hypothesis of no long run relationship and accepts the alternative.

3.3 Error Correction Model

Dependent Variable: DLOG(NPER)
Method: Least Squares
Date: 11/16/24 Time: 20:39
Sample: 2019M01 2024M03
Included observations: 63

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(NPER(-1))	-0.179205	0.044719	-4.007303	0.0002
LOG(M3ZZZW(-1))	0.106750	0.034650	3.080791	0.0032
LOG(RMZZW(-1))	0.135105	0.045340	2.979840	0.0043
C	-3.342543	0.860071	-3.886356	0.0003
DLOG(CPI)	0.873183	0.157396	5.547667	0.0000
DUM23M5	0.603370	0.098062	6.152940	0.0000
DUM23M6	0.851908	0.100321	8.491848	0.0000
DUM20M5	0.340343	0.099474	3.421415	0.0012

R-squared	0.712807	Mean dependent var	0.141865
Adjusted R-squared	0.676255	S.D. dependent var	0.168607
S.E. of regression	0.095935	Akaike info criterion	-1.732123
Sum squared resid	0.506195	Schwarz criterion	-1.459979
Log likelihood	62.56187	Hannan-Quinn criteria.	-1.625087
F-statistic	19.50127	Durbin-Watson stat	1.531284
Prob(F-statistic)	0.000000		

3.3.1 Error Correction Model Interpretation

The equation is a cointegrating long run relationship in which the nominal exchange rate is a function of both long run and short run determinants. The coefficient **(-0.179)** is an adjustment term, which shows that for any deviation from long run, about **17.9%** is cleared every month. This implies persistence of shocks in the economy.

The long run determinants are broad money and reserve money growth. Reserve money has significantly larger impact on the exchange rate than broad money.

Long run Parameters

LOG(NPER(-1))	-0.17921	
LOG(M3ZZZW(-1))	0.10675	0.595687
LOG(RMZZW(-1))	0.135105	0.753913
		1.3496

International Journal of Economic Policy
ISSN: 2788-6352 (Online)
Vol. 5, Issue No. 4, pp 1 - 21, 2025
www.carijournals.org

In the long run, a 1% increase in broad money leads to a **59.5%** depreciation in the exchange rate, while a 1% increase in reserve money leads to a **75.4%** exchange rate depreciation. In the long run, a 1% increase in both reserve money and broad money leads to a **1.35%** depreciation in the exchange rate.

Short run dynamics and inflation expectations

The exchange rate evolution is dominated by price level dynamics, which are significant and contemporaneous. This shows the impact of the nexus of inflation expectations, and expectations of exchange rate depreciation. Inflation expectations are mainly driven by the parallel market premium. The parallel market evolved in response to excessive monetary growth against a fixed or crawling peg exchange rate mechanism.

In June 2020, Authorities introduced a Dutch Foreign Currency Auction system, which immediately collapsed the parallel market premium from 200% to levels below 15%. However, since November/December 2020, Authorities reverted back to an unofficial crawling peg and the parallel market premium drift gained momentum from the beginning of 2021, peaking at 135% in April 2022.

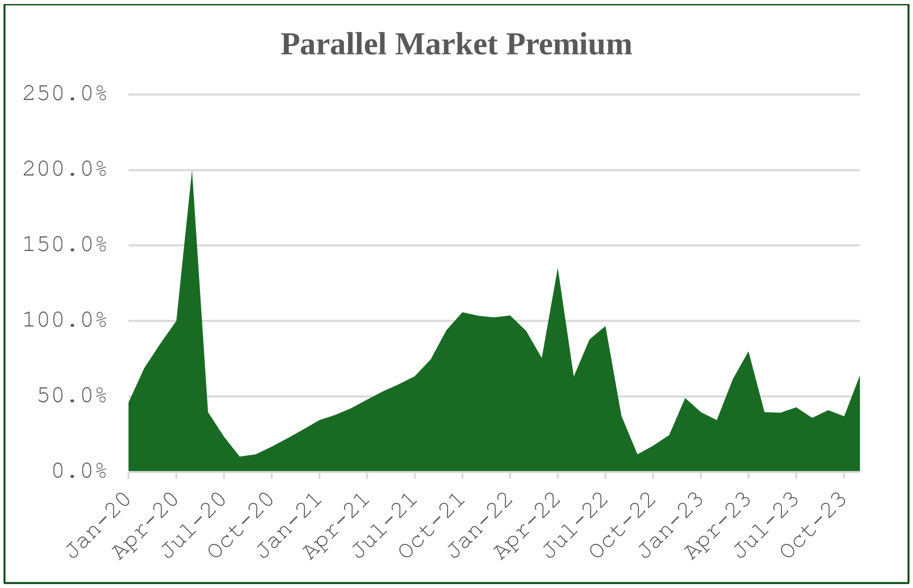

Figure 1: Parallel Market Premium

Single Period Shock to Reserve Money and Broad Money

Substituted Coefficients:

DLOG(NPER) = -0.179204507554*LOG(NPER(-1)) + 0.106749637474*LOG(M3ZZZW(-1)) + 0.135104971416*LOG(RMZZW(-1)) - 3.34254310629 + 0.873183234211*DLOG(CPI) + 0.603370144079*DUM23M5 + 0.851908263997*DUM23M6 + 0.340343368654*DUM20M5

Applying a single period shock to the model above gives rise to monetary shocks propagation as shown below:

Table 2: Monetary shocks propagation and the exchange rate

	1% increase in reserve money and broad money (M3)	Exchange rate response	Pass through	Months
2019M01	0	0	0	
2019M02	0.999995	0.240937	17.8%	1
2019M03	1.000002	0.43915	32.5%	2
2019M04	0.999994	0.602113	44.6%	3
2019M05	1.000001	0.736073	54.5%	4
2019M06	1.000004	0.84617	62.7%	5
2019M07	1.000001	0.936595	69.3%	6
2019M08	**0.999998**	**1.010922**	**74.9%**	**7**
2019M09	0.999997	1.071985	79.4%	8
2019M10	1.000026	1.122112	83.1%	9
2019M11	1.000036	1.16323	86.1%	10
2019M12	1.000029	1.197034	88.6%	11
2020M01	**1.000021**	**1.224784**	**90.7%**	**12**
2020M02	1	1.247572	92.4%	13
2020M03	0.999985	1.266253	93.8%	14
2020M04	0.999985	1.28161	94.9%	15
2020M05	1.000022	1.294219	95.8%	16
2020M06	0.999984	1.30455	96.6%	17
2020M07	**0.999994**	**1.313051**	**97.2%**	**18**
2020M08	0.999993	1.320019	97.7%	19
2020M09	0.999998	1.325735	98.2%	20
2020M10	1.000002	1.330439	98.5%	21
2020M11	0.999992	1.334298	98.8%	22
2020M12	0.999997	1.337462	99.0%	23
2021M01	**0.999998**	**1.340068**	**99.2%**	24
2021M02	0.999995	1.342138	99.4%	25
2021M03	0.999974	1.343936	99.5%	26
2021M04	0.999984	1.345386	99.6%	27
2021M05	1.000013	1.346589	99.7%	28
2021M06	1.000009	1.347538	99.8%	29
2021M07	**1.000016**	**1.348337**	**99.8%**	**30**
2021M08	1.000015	1.348994	99.9%	31

2021M09	1.000008	1.34947	99.9%	32
2021M10	0.999982	1.349939	100.0%	33
2021M11	0.999987	1.350329	100.0%	34
2021M12	0.999992	1.350572	100.0%	35
2022M01	**0.999983**	**1.350824**	**100.0%**	**36**

A **1%** shock to reserve money and broad money leads to shocks propagation over 36 months, with the long run impact of **1.35%** on the exchange rate.

i. 74.9% of the shock occurs after 7 months;
ii. 90.7% of the shock occurs after 12 months;
iii. 97.2% of the shock occurs after 18 months;
iv. 99.2% of the shock occurs after 24 months

The graph below shows the adjustment to long run, following a single period shock.

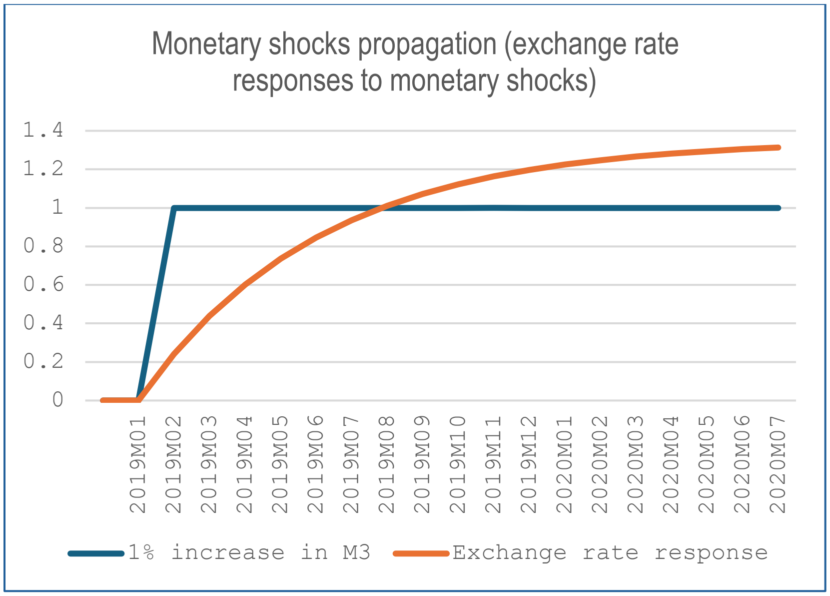

Figure 3: A 1% increase in reserve money, impact on the exchange rate

Specification and Diagnostic Tests

The Specification and Diagnostic Tests are necessary to ensure that the model does not suffer from serial correlation, heteroscedasticity, non-normality and parameter instability.

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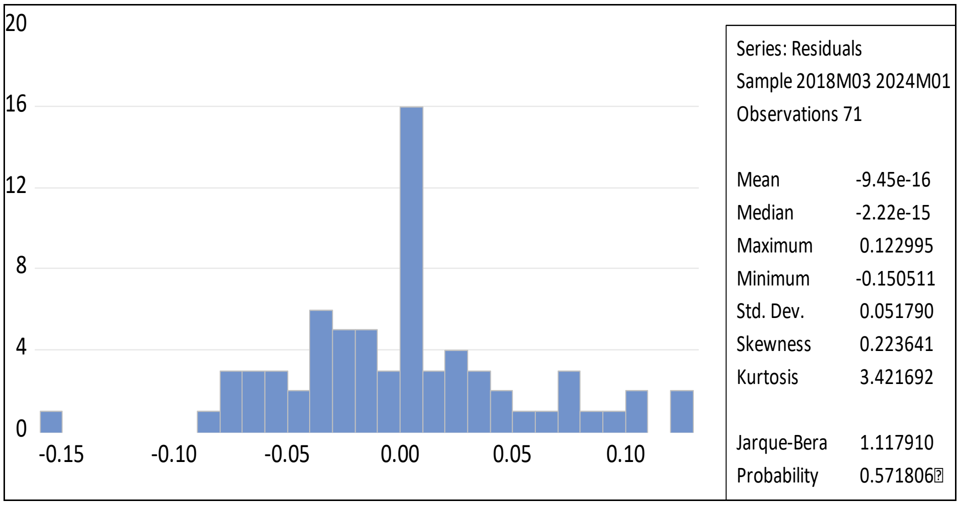
Histogram and Normality Tests



H0: The residuals are normally distributed

H1: Residuals are not normally distributed

The JB joint test for normality shows that the residuals are normally distributed.

LM Serial Correlation Test

Breusch-Godfrey Serial Correlation LM Test:			
Null hypothesis: No serial correlation at up to 2 lags			
F-statistic	0.314099	Prob. F(2,60)	0.7316
Obs*R-squared	0.735665	Prob. Chi-Square(2)	0.6922

H0: The residuals have no serial correlation

H1: The residuals have serial correlation

The BG test results show that the residuals have no serial correlation.

Heteroscedasticity Tests

Heteroskedasticity Test: Breusch-Pagan-Godfrey			
Null hypothesis: Homoskedasticity			
F-statistic	0.396772	Prob. F(8,62)	0.9182
Obs*R-squared	3.457909	Prob. Chi-Square(8)	0.9024
Scaled explained SS	7.372188	Prob. Chi-Square(8)	0.4971

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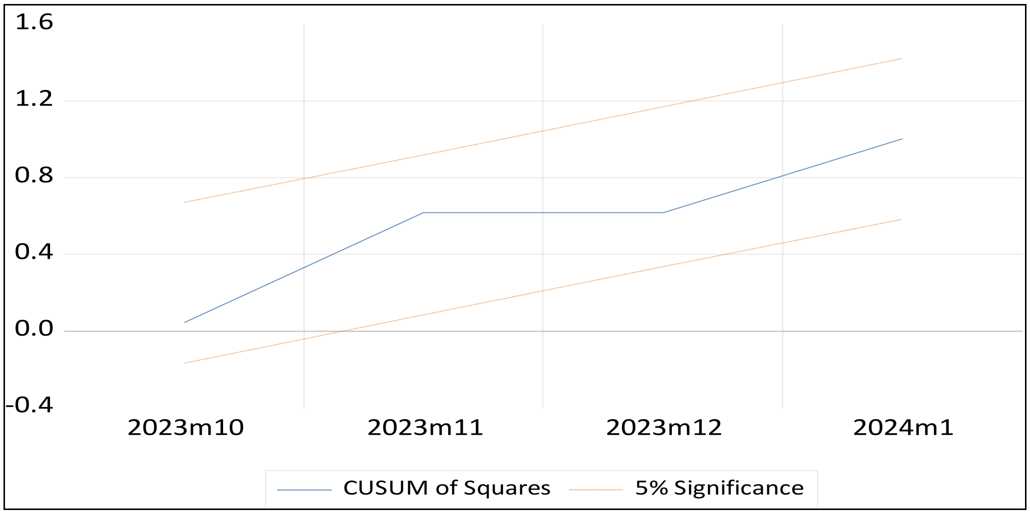
H0: The residuals are homoscedastic (uniform variance)

H1: The residuals have no uniform variance

Stability Tests

Cusum of Squares



Ho: Parameters are stable overtime

H1: The model is unstable

The Cusum of squares test shows that the model is stable over the entire horizon

Dynamic Multipliers

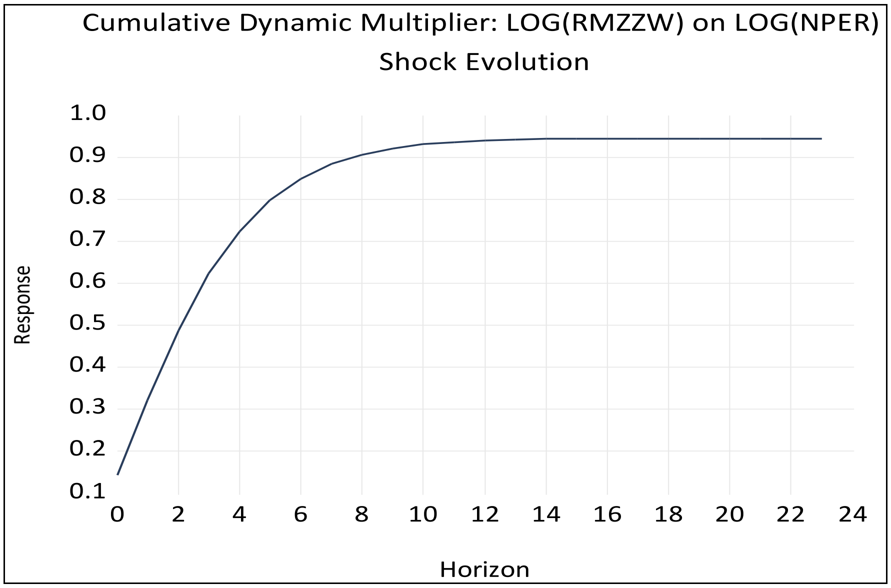


Figure 4: Dynamic Multipliers

Interpretation:

Impact of reserve money shock on the exchange rate

The impact of a single period reserve money shock on the exchange rate has instant and progressing impact on the exchange rate. A 1% increase in reserve money generates instant short run dynamics (same month) leading to long run steady state impact of 0.94% after 14 months. This implies almost a 1:1 relationship between reserve money growth and exchange rate depreciation.

The policy implications is that, achieving exchange rate stability requires control of reserve money growth and collapsing inflation expectations. Adverse expectations are largely generated by widening deviation between the official and the parallel market exchange rate.

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