A re-examination of the exchange rate overshooting hypothesis: Evidence from Zambia

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ABSTRACT

Dornbusch's exchange rate overshooting hypothesis has guided monetary policy conduct for many years, despite the fact that empirical evidence on its validity is mixed. This study re-examines the validity of the overshooting hypothesis by using the autoregressive distributed lag (ARDL) procedure. Specifically, the study investigates whether the overshooting hypothesis holds for the United States dollar/Zambian kwacha (USD-ZMK) exchange rate. In addition, the study tests whether there is a long-run equilibrium relationship between the USD-ZMK exchange rate and relevant macroeconomic fundamentals. Using monthly nominal USD/ZMK exchange rates and monetary fundamentals data from January 2000 to December 2012, the study finds no evidence of exchange rate overshooting. The results also show that there is no long-run equilibrium relationship between the exchange rate and the differentials of macroeconomic fundamentals. The implication is that macroeconomic fundamentals are insignificant in determining the exchange rate fluctuations in the long run. This finding is inconsistent with the monetary model of exchange rate determination, which asserts that there is a long-run relationship between the exchange rate and macroeconomic fundamentals.

Key words: Exchange rates, monetary model, autoregressive distributed lag, cointegration, exchange rate overshooting

JEL codes: C13, C22, F31, F41

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Introduction

Exchange rate determination continues to be one of the core areas of research in international finance and financial economics. Although several exchange rate determination models have been developed and subsequently modified, there is no consensus among economists and other researchers on which model best describes the behaviour of exchange rates. The reason for this is the difficulty of explaining and forecasting exchange rates based on macroeconomic fundamentals. Empirical tests of the models are often ambiguous and sometimes even contradictory (Simwaka 2004). The monetary model of exchange rates attempts to explain the exchange rate through macroeconomics fundamentals. This model is based on three main pillars, namely money market equilibrium, purchasing power parity and uncovered interest rate parity (Rogoff 2002; De Bruyn, Gupta & Stander 2013).

Two of the earliest forms of monetary models of exchange rate determination are the flexible and sticky price versions. A key difference between the flexible and the sticky-price model is that the latter assumes that purchasing power parity only holds in the long-run.

Dornbusch's (1976) sticky-price model explains the fluctuations in the exchange rate and contains an "overshooting" hypothesis.

In general, exchange rate overshooting explains the mechanism whereby the short-run response of the exchange rate to a shock exceeds its long-run response. Specifically, if there is an unanticipated monetary expansion, the exchange rate will, in the short run, depreciate to a higher level than its long-run equilibrium. The reason for the overshooting is the speed of adjustments between the goods and the financial markets.

However, there is a discrepancy between empirical evidence and the theoretical monetary models of exchange rate determination, which has been a source of debate and attracted considerable interest. Empirical research on exchange rate overshooting has produced mixed results. For instance, Frankel (1979), Driskill (1981), Rogoff (2002) and Dornbusch (2004) provide support for the overshooting model, while the findings of Backus (1984), Sims (1992), Eichenbaum and Evans (1995), Flood and Taylor (1996) and Kim and Roubini (2000) contradict the model.

Since most of the research on exchange rates has generally focused on developed economies, developing countries, particularly sub-Saharan countries, have received little attention. However, with the availability of data, this gap is being filled (Sichei, Gebreselasie & Akanbi 2005; Oduor 2008, 2009; Chipili 2009; Enekwe, Ordu & Nwoha, 2013; Mbululu, Auret & Chiliba 2013). The economics of exchange rates have recently become a topical issue in Zambia owing to the relatively small but open economy, which relies heavily on imports of the most basic household goods, medicines,

machinery, petroleum products and many other inputs used in manufacture of other essential goods. Understanding the nature and behaviour of exchange rates has since become important to all economic agents in the Zambian economy. The aim of this paper is to contribute to the understanding of this phenomenon.

Studies on exchange rate overshooting on the Zambian foreign exchange rate market are non-existent. Some studies have analysed the main determinants of the real exchange rate in Zambia. Using annual data from 1965 to 1996 and cointegrating analysis, Mkenda (2001) found that terms of trade, government consumption and investment are key influences on real exchange rate for imports, while terms of trade, foreign reserves and trade taxes impact on the real exchange rate for exports in the long run. One of the limitations of Mkenda (2001)'s study was the utilisation of low frequency data.

Mungule (2004) used vector error correction models on quarterly time series data between 1973 and 1997, and studied the determinants of the real effective exchange rates in Zambia. The results indicated that the real effective exchange rate depends on the prevailing real fundamentals, price differentials and real shocks. Similar to Mkenda (2001), Mungule (2004) does not differentiate between the official and the parallel market rates. For the period covered by Mungule (2004), exchange rates were, by then, not determined by a fully-fledged market mechanism, which came into existence in mid-2003.

From the foregoing, there is no consensus in the empirical literature on the relationship between the exchange rate and macro fundamentals. The studies reviewed used various methodologies, and in some instances, the variables used in the models could be integrated of different orders, but the power of the unit root tests could not detect this. Similar to more recent papers in the literature, this study employed the ARDL model, which allows for variables of different integration orders to be examined in the same model. Moreover, the study extends the previous analysis by using higher frequency of monthly observations, that is, monthly data from 2000 to 2012 was used. In contrast to the research of Mungule (2004) and Mkenda (2001), the exchange rates used in this paper reflect a true market determined rate following the introduction of the broad-based interbank foreign exchange rate system in Zambia in 2003. Based on the argument by Tu and Feng (2009), the study incorporates the assumptions, such as the interest elasticity of money, in deriving the monetary model of exchange rate determination. Also, this research contributes to the existing debate on exchange rate overshooting by conducting the analysis in a fully liberalised small economy.

More specifically, the validity of Dornbusch's (1976) overshooting hypothesis for the US dollar-Zambian Kwacha (USD-ZMK) exchange rate is re-examined. Given

that the overshooting hypothesis is a short-run phenomenon, we test for it, using the autoregressive distributed lag (ARDL) bounds test procedure, jointly developed by Pesaran, Shin and Smith (2001). Furthermore, the study also tests whether there is a long-run equilibrium relationship between the USD-ZMK exchange rate and relevant macroeconomic fundamentals (money supply, real gross domestic product [GDP], interest rates and inflation rates). The paper is closely related to the research of Nieh and Wang (2005) and Bahmani-Oskooee and Kara (2000), who studied the overshooting hypothesis for Taiwan and Turkey, respectively. This study should fill the gap in the literature on frontier economies and developing countries. Moreover, investigating the presence of exchange rate overshooting could help explain exchange rate volatility in Zambia.

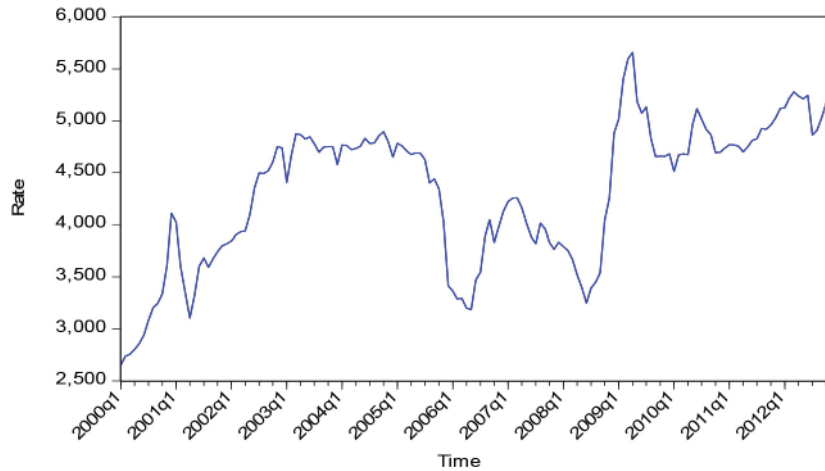
The layout of the study is as follows: Section 2 presents a summary of the historical background on the foreign exchange market in Zambia.[1] Section 3 deals with the theoretical model. Section 4 describes the data and econometric methodology used in the study. Section 5 presents and discusses the empirical results, while the conclusions, limitations and suggestions for further study are presented in Section 6.

Historical background on the Zambian foreign exchange market

The exchange rate mechanism in Zambia has seen a combination of both a fixed and floating exchange system. A fixed exchange rate system was adopted for the periods 1964 to 1982 and 1987 to 1991. The authorities sustained this mechanism through a combination of adjustments and issuance of import licences (Mkenda 2001). During the period from 1983 to 1985, the Zambia kwacha was pegged to a basket of major trading partners' currencies with a one percent crawl mechanism, which was subsequently revised upwards to one and a half percent, as economic conditions worsened. At the end of 1985, the monetary authorities introduced a floating exchange rate regime in which the Bank of Zambia auctioned off foreign currency (Chipili 2009).

To allow broader participation in the exchange rate market by commercial banks, the monetary authorities introduced a freely floating exchange rate system. The system allowed commercial banks to trade foreign currency with the central bank at a frequency of three times a week, and to improve liquidity in the market, the frequency of trading was increased to daily. Owing to depressed economic conditions and high exchange rate volatility, the Zambian monetary authorities introduced a broad-based interbank foreign-exchange market (IFEM) to promote efficiency and improve liquidity through a market determined exchange rate system (Chipili 2009).

The African Development Bank (2007) commended the introduction of IFEM as it considered this to be an important step in improving efficiency in the market (Mbululu et al. 2013). With the introduction of the IFEM, commercial banks were able to allocate counterpart limits to each other and trade foreign currencies on the interbank market, settle all local currency obligations through the central bank and trade foreign exchange with corporates and the general public. In addition, licensed agents were allowed to bid and offer foreign exchange to the general public. Currently, the Zambian foreign exchange rate market is one of the most fully liberalised markets in the developing world. Figure 1 shows the USD/ZMK exchange rate and its high depreciation between 2008 and 2009 during the great recession. Figure 2 shows the volatility of the exchange rate against the relative price changes between the two economies. From the two figures, it is evident that the Zambian kwacha is highly volatile. Exchange rate overshooting is said to be a cause of high currency volatility (Pierdzioch 2004). Although there is considerable empirical evidence against the overshooting model, it still remains one of the core models in international finance, and Rogoff (2002) and Bjørnland (2009) both argue that exchange rate overshooting is a valid hypothesis in international macroeconomics.



Source: Author's calculations

Figure 1: Trends in the USD/ZMK exchange rate

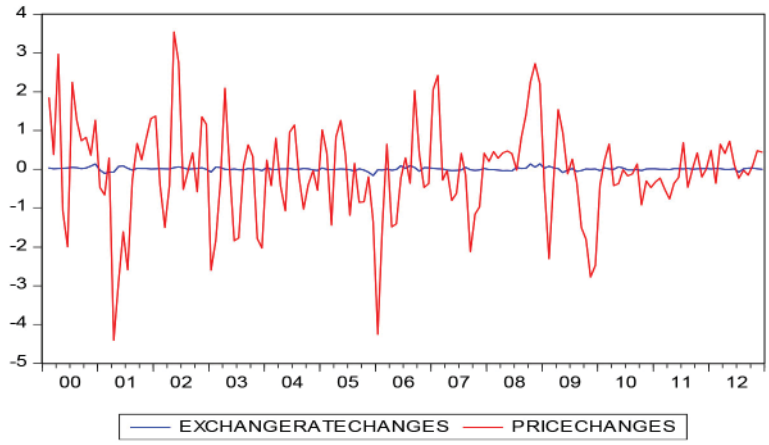


Figure 2: FUSD/ZMK exchange rates returns against price changes

The model

The foundations of the monetary model of exchange rates are firmly grounded on PPP and the quantity theory of money (Bahmani-Oskooee & Kara 2000; De Bruyn et al. 2013). The absolute version of PPP is stated as

$$S = P_Z / P_{USA} \tag{1}$$

where S, the exchange rate, is the number of units of domestic currency per foreign currency, P_Z is the domestic price level and P_{USA} is the foreign price level. Since the USD/ZMK exchange rate is used in this study, the domestic currency relates to Zambia (ZMK) and the US dollar is the foreign currency. The quantity theory of money is stated as

$$MV = YP \tag{2}$$

where M is the money supply, V is the velocity of money circulation, P is the price level and Y is the transaction or output level in the economy. Extending this to the two economies, yields

$$M_Z V_Z = P_Z Y_Z \tag{3}$$

$$M_{US} V_{US} = P_{US} Y_{US} \tag{4}$$

as the quantity theory of money for the Zambia equation **(3)** and for the US equation **(4)**. Solving equations **(3)** and **(4)** for P_Z and P_{US} then substituting into equation **(1)** and rearranging, we obtain

$$E = \left(\frac{M_Z}{M_{US}}\right)\left(\frac{V_Z}{V_{US}}\right)\left(\frac{Y_{US}}{Y_Z}\right) \tag{5}$$

Equation **(5)** indicates that the relative money supply, relative velocity and relative income are the determinants of the exchange rate. Taking logs on both sides of **(5)** yields

$$\log E = (\log M_Z - \log M_{US}) + (\log Y_{US} - \log Y_Z) + (\log V_Z - \log V_{US}) \tag{6}$$

The last step in arriving at the monetary model is to identify the determinants of velocity in the two countries. Following Bahsmani-Oskooe and Kara (2000) (hereafter BOK) we shall assume that the nominal interest rate and the inflation rate in the two countries are the main determinants of velocities. Thus, denoting the nominal interest rates by r_Z and r_{US} and the inflation rates by π_Z and π_{US}, the monetary model that we plan to estimate takes the following form:

$$e_t = a_1 + a_2 m_t + a_3 y_t + a_4 r_t + a_5 \pi_t + u_t \tag{7}$$

where $e = \log E$; $m = \log M_Z - \log M_{US}$; $y = \log Y_Z - \log Y_{US}$; $r = r_z - r_{US}$; ; $\pi = \pi_Z - \pi_{US}$ and u is an error term.

It is expected that the estimate of $a_2 > 0$ indicating that a faster growth of the money supply in Zambia over that of the USA will depreciate the kwacha.[2]

Following the monetarist prediction, the estimate of a_3 is expected to be negative, indicating an appreciation of the kwacha relative to an increase in Zambian income relative to that of the USA. Estimates of a_4 and a_5 are expected to be positive, indicating a depreciation of the kwacha due to an increase in the Zambian interest rate and inflation rate respectively.

Data and methodology

Data

Empirical studies investigating the exchange rate overshooting under the ARDL methodology have used monetary aggregates (e.g. Nieh & Wang 2005; Bahmani-

Oskooee & Kara 2000). Similarly, this study uses the following variables: the nominal exchange rate (e), home and foreign money supplies (m), home and foreign real GDP (y), interest rates (r, monthly nominal 91-day T-Bill differential) and inflation rates (π). The data spans a 13-year period from January 2000 to December 2012. Real GDP data for both the USA and Zambia was sourced from the International Financial Statistics (IFS). The other data for each country was sourced from the Federal Reserve Bank of St Louis's data base (FRED) for US data, and the Bank of Zambia for Zambian data. All the exchange rate data was sourced from the Bank of Zambia. Real GDP data is quarterly and was transformed into monthly rates by adopting the procedure in Kodongo and Ojah (2012), that is, monthly real GDP is calculated on the assumption that quarterly real GDP is evenly spread during the quarter. The nominal exchange rate, e, is defined as the number of local currency units per one US dollar, that is, the number of ZMK per unit of US dollar, and it is the end-of-period nominal exchange rate.

Methodology

The study uses the ARDL bounds test procedure, jointly developed by Pesaran et al. (2001), to test if the overshooting hypothesis holds for the USD-ZMK exchange rates and to investigate whether there is long-run equilibrium between the USD-ZMK exchange rate and monetary fundamentals.

An ARDL is utilised here mainly because it allows for variables integrated of order zero and order one , *I (0)* and *I(1)* respectively, to be utilised in the same model without the risk of generating spurious regressions. This is important as we have variables in levels (e.g. e, m and y) and others in terms of a rate of change (e.g. π). The ARDL bounds testing procedure can be applied to variables using ordinary least squares (OLS) even if they are integrated of different orders and the technique is suitable for small or finite sample size (Pesaran et al, 2001). Furthermore, it is more likely to be efficient since it requires estimating few parameters using a single equation, in contrast to the Johansen co-integration approach, which is more data intensive and requires an estimation of a vector autoregressive system of equations and could thus lead to a substantial loss of degrees of freedom. The ARDL bounds test is robust for finite samples, even in the presence of phenomena of shocks and regime shifts (Fuinhas & Marques 2012). Thus, the ARDL model has gained popularity and is widely used in the literature to examine co-integration relationships between economic variables (see Srinivasan & Kalaivani 2013; Tiwari, Shahbaz & Islam 2013; Sakyi 2011; Bahmani-Oskooee & Hajilee 2010; Karim & Majid 2010; Shahbaz 2010;

Bahmani-Oskooee & Gelan 2009; Majid & Yusof 2009; Wong & Tang 2008; Dube 2008; Nieh & Wang 2005; Ghatak & Siddiki 2001).

Given that the overshooting hypothesis is a short-run phenomenon, we test for it, using cointegration and error correction methods. These methods have been used in various studies and will enable us to make comparisons with earlier research. Traditionally, to test for cointegration and error correction, the first stage is to test for the cointegration order of the variables. Owing to the power of the unit root tests, different tests yield different results (Bahmani-Oskooee, 1998). Hence this paper utilises a battery of unit root tests.

Unit root tests

It is important to ensure that variables in a regression model are non-stationary to avoid spurious regressions (Granger & Newbold 1974). One of the benefits of the ARDL approach is that it allows for variables of different integration orders to be applied in the same model. However, it should be mentioned that this methodology is valid only if $I(0)$ and $I(1)$ variables are included in a particular model. Inclusion of $I(2)$ leads to spurious regression (Bildirici & Kayikci 2012). To avoid the use of $I(2)$ variables, we conduct unit root tests to verify whether all our variables are $I(0)$ and $I(1)$. Owing to the different powers of unit root tests, different tests give varying results, especially for macroeconomic variables. We thus use a battery of unit root tests, namely the augmented Dickey Fuller or ADF (Dickey & Fuller 1981), PP (Phillips & Perron 1988), KPSS (Kwiatkowski, Phillips, Schmidt & Shin 1992), DF-GLS (Elliott, Rothenberg & Stock 1996) and NP (Ng & Perron 2001).

It is important to note that the different results from unit root tests on the integration orders of the variables could result in false results from the conventional cointegration results (Nieh & Wang 2005).

The ARDL model

The error correction ARDL approach relating to the variables in equation **(7)** that is used in this study is given as

$$\begin{aligned}\Delta e_t &= a_0 + \sum_{j=1}^{n} a_{2j}\Delta e_{t-j} + \sum_{j=0}^{n} a_3\Delta m_{t-j} + \sum_{j=0}^{n} a_4\Delta y_{t-j} + \\ &\sum_{j=0}^{n} a_5\Delta r_{t-j} + \sum_{j=0}^{n} a_6\Delta i_{t-j} + \delta_1 e_{t-1} + \delta_2 m_{t-1} + \delta_3 y_{t-1} + \delta_4 r_{t-1} + \delta_5 \pi_{t-1} + \varepsilon_t\end{aligned} \tag{8}$$

The ARDL approach for the error correction mechanism (ECM) tests for the existence of a long-run relationship between the variables. This is done by conducting an F-test for the joint significance of the coefficients of the lagged levels of the variables. To run

the ARDL test, the null of no cointegration, defined as $H_0 : \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5$, is tested against the alternative of $H_1 : \delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq \delta_5$. The ECM is adopted to check for cointegration between the macro fundamentals and the exchange rate. We use the F-test procedure here in line with the ARDL approach. However, the asymptotic distribution of this F-statistic is non-standard. We therefore use the bounds (upper and lower bands) test's critical values as developed by Pesaran et al. (1996, 2001). Pesaran et al. (2001) developed two sets of critical values for a given significance level. The first band is calculated on the assumption that all variables included in the ARDL model are $I(0)$, while the second one is calculated on the assumption that the variables are $I(1)$. If the calculated F-statistic lies above the upper level of the band, the null of no cointegration is rejected, indicating the presence of cointegration. However, if the calculated F-statistic falls below the lower level of the band, the null of no cointegration cannot be rejected, supporting evidence of lack of cointegration. If it falls within the band, the result is inconclusive. The optimal number of lags in the short-run specification of the ARDL model is chosen on the basis of Akaike information criteria (AIC), and this controls for the autocorrelation problem inherent in time series data.

Diagnostic checks

In addition, we conduct appropriate diagnostic checks to ensure that the results from the analysis are robust. These include tests for serial correlation using the Breusch-Godfrey test, heteroscedasticity using the White (1980) test and parameter stability using recursive tests, that is, the cumulative sum (CUSUM) and CUSUM of squares tests. We test for serial correlation using the Breusch-Godfrey test. The results are presented in Table 8. We fail to reject the null hypothesis of no serial correlation and conclude that our model is robust to serial correlation. Recursive tests are conducted to test for parameter stability in the recursive residuals. We use two tests here, namely the CUSUM test and CUSUM of squares test (Brown, Durbin & Evans 1975). A regression specification error test (RESET) is also included to check the functional form and provide evidence for elimination of the insignificant variables from the model.

Empirical results

This section presents the empirical results of the analysis. We present the descriptive statistics and results from the unit root tests. This is followed by a detailed discussion of the ARDL and error correction tests.

Descriptive statistics

Table 1 shows the descriptive statistics of the variables used in the analysis. Skewness is positive for all variables except the nominal exchange rate (e) and money supply (m). It is therefore inferred that most observations are below the expected value of the series except for nominal exchange rates and money supply. The kurtosis is less than three for all the variables implying that the observations are all platykurtic – that is, flat relative to the normal distribution.

Table 1: Descriptive statistics of variables

Variable	Mean	Median	Max	Min	Standard deviation	Skewness	Kurtosis	J-B test
e	8.358	8.442	8.64	7.88	0.169	-0.796	2.777	16.785 ***
m	-0.048	-0.126	0.871	-1.248	0.574	-0.121	1.924	7.914 *
y	-1.323	-1.377	-1.019	-1.522	0.154	0.535	1.864	15.833 ***
r	15.526	10.259	48.941	0.303	12.730	0.984	2.702	25.734 ***
π	12.445	14.043	26.745	2.546	6.807	0.230	1.842	10.089 ***

Notes: ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively. J-B is the Jarque and Berra test for normality.

The J-B test further shows that the variables are not normally distributed except for the money supply differential which is significant at five percent. The exchange rate, money supply and output are far less volatile than the interest rate and inflation, as shown in Table 1.

Table 2: Unit root tests results

(a)	e	m	y	r	π
INTERCEPT ONLY					
ADF					
Lvls	(1) -2.88*	(0) -1.495	(4) 1.022	(1) -1.682	(12) -1.437
Diff	(0) -8.484***	(0) -13.603***	(3) 3.096**	(0) -8.988***	(11) -5.641***
DF-GLS					
Lvls	(1) -0.459	(0) 2.562**	(4) 1.157	(1) -0.971	(12) -0.363
Diff	(1) -6.003***	(12) -1.253	(3) 2.687***	(0) -8.942***	(12) -1.308
PP					
Lvls	(5) -2.820*	(12) -1.867	(8) 2.791*	(5) -1.620	(5) -1.462
Diff	(0) -8.484***	(9) -14.179***	(8) -3.491***	(3) -8.959***	(3) -8.062***
KPSS					
Lvls	(10) 0.585**	(10) 1.523	(10) 1.459	(10) 1.045	(10) 1.192
Diff	(5) 0.111***	(11) 0.219***	(9) 0.782**	(5) 0.069***	(4) 0.046***
NP					
Lvls	(1) -0.459	(0) 2.702***	(1) 2.880***	(1) -0.978	(3) -1.145
Diff	(0) -5.461***	(0) -6.204***	(0) -3.094***	(0) -5.891***	(2) -2.569**
(b)					
INTERCEPT AND TREND					
ADF					
Lvls	(1) -3.064	(0) -4.675***	(4) -1.042	(0) -4.674***	(12) -2.186
Diff	(0) -8.484***	(0) -13.644***	(3) -3.342*	(0) -13.644***	(11) -5.652***
DF-GLS					
Lvls	(1) -1.981	(0) -2.274	(4) -0.837	(1) -2.322	(12) -2.234
Diff	(0) -8.303***	(0) -13.523***	(3) -3.433	(0) -9.019***	(11) -2.791*
PP					
Lvls	(5) -2.909	(5) -4.589***	(8) -1.265	(5) -2.142	5) -2.979
Diff	(1) -8.504***	(11) -14.895***	(6) -4.236***	(3) -8.938***	(3) -8.028***
KPSS					
Lvls	(9) 0.139*	(8) 0.097***	(10) 0.367	(10) 0.218	(9) 0.093***
Diff	(4) 0.076***	(12) 0.074***	(8) 0.100***	(5) 0.050***	(4) 0.046***
NP					
Lvls	(1) -1.991	(0) -2.172	(1) -0.947	(1) -2.341	(3) -3.064**
Diff	(0) -5.742***	(0) -6.178***	(0) -3.726	(0) -5.908***	(2) -3.743***

Notes:

1. *** and ** denote significance at the 1% and 5% levels respectively.
2. The null of the ADF, DF-GLS, PP and NP tests for the unit root, while that of the KPSS tests for stationarity.
3. Lvls refer to levels, while Diff refers to differences.
4. The appropriate lag length for ADF, DF-GLS and NP is shown in parentheses and selected on the basis of AIC (Akaike information criteria). For PP and KPSS, the optimal bandwidths are selected by the Bartlett kernel of Newey and West (1994).
5. The appropriate models for both levels and differences are the intercept only (*m, r* and *π*) and the intercept and trend (e and y).

Unit root test results

A summary of the results is presented in Table 2. The top panel (a) presents the results based on a model, including the intercept only, while the bottom panel (b) presents the results based on a model with both intercept and trend. For the ADF and PP tests, all the variables are difference stationary for two cases, namely (1) the intercept only; and (2) the intercept and trend only.

However, the money supply differential is stationary under the ADF and PP, while the interest differential is stationary under ADF. We conclude that all variables are difference stationary under the ADF and PP tests. Owing to the different power of each unit root methodology, we also conduct the DF-GLS unit root test. For the DF-GLS, all variables are difference stationary in both the intercept only and intercept and trend cases except the money supply and inflation differentials, which are found to be stationary in levels at a 5% level of significance and non-stationary in both levels and differences. Owing to the low power of the DF-GLS unit root test, we conclude that the inflation rate differential is difference stationary, based on the results from the ADF and PP tests. The KPSS test shows that all the variables, with the exception of the logarithm of exchange rates, are difference stationary in both the intercept only and intercept and trend cases. The logarithm of the exchange rate is found to be stationary in levels at 10% level of significance. The NP test confirms the results of the ADF, PP and KPSS tests. However, in this case, the logarithm of the money supply and real GDP differentials are stationary in levels at a 1% level of significance in the intercept only case. These results confirm our earlier expectation that different unit root tests will yield different results because of the level of power of the tests. Based on the ADF, PP and KPSS unit root test results, we can conclude that all our variables are integrated of order zero, I(0) or one I(1). Since all the variables are a combination of I(0) or I(1) and no variable is $I(2)$, we are certain that the analysis using ARDL model will not yield spurious regression results.

Results from the ARDL model

The lag structure of an ARDL model is crucial for the results to be valid. The optimal lag lengths were selected on the basis of the AIC. However, both the Hannan-Quinn information criteria (HQIC) and the Schwartz information criteria (SIC) provide similar results.

Table 3: Lag selection criteria

Lag	AIC	HQIC	BIC
0	8.35038	8.39078	8.44985
1	-9.52011	-9.27766	-8.92329
2	**-10.8358#**	**-10.3913#**	**-9.74161#**
3	-10.7262	-10.0797	-9.13468
4	-10.7222	-9.87362	-8.63332

Refers to optimal lag length.

The results from Table 3, which summarises the optimal lag length selection criteria, shows that the information criteria suggest that the optimal lag length is two. We therefore estimate an ARDL (2, 2, 2, 2, 2).

Having determined the appropriate lag length, we conduct the cointegration test using the F-test following Pesaran et al.'s (1997) bounds-based critical values. The F-statistic is derived from the Wald test for coefficient restrictions by eliminating both the first and second lags of the dependent variable, which are found to be insignificant. The calculated F-statistic from the Wald test is summarised in Table 4.

Table 4: Wald test

Test statistic	Value	df	Probability
F-statistic	2.374	(5, 143)	0.0420
Chi-square	11.87047	5	0.0366

The F-statistic of 2.374 from the Wald test is compared to the bounds critical value by Pesaran and Pesaran (1997). The Pesaran and Pesaran (1997) bounds critical values, which include the intercept but without trend, are shown in Table 5.

Table 5: ARDL bounds testing critical values (CASE II: intercept and no trend)

Significance level	Lower bound	Upper bound
5%	2.425	3.574

Source: Pesaran & Pesaran (1997:478), appendices)

Since the computed F-statistic of 2.374 is lower than the lower bound critical value of 2.425, the null of no cointegration cannot be rejected. This means that there is no long-run equilibrium relationship between the exchange rate and the differentials of macroeconomic fundamentals. The implication is that macroeconomic fundamentals are insignificant in determining the exchange rate fluctuations in the long run. This finding is inconsistent with the monetary model of exchange

rate determination, which asserts that there is a long-run relationship between the exchange rate and macroeconomic fundamentals. Furthermore, the results from this study differ from those of earlier empirical studies on the USD/ZMK exchange rates. Specifically, Mungule (2004) found evidence in support of the long-run equilibrium relationship between the exchange rate and the macroeconomic fundamentals. Notably, the absence of long-run equilibrium relationship supports one of the most significant studies in exchange rate determination, that is, the study of Meese and Rogoff (1983), who found that structural models performed poorly in predicting exchange rate movements that follow a random walk pattern.

Table 6: Full ARDL estimation model

Variable	Coefficient
e_{t-1}	-0.071145 (-2.372583)
m_{t-1}	-0.003327 (-0.097449)
y_{t-1}	0.062490 (0.763603)
r_{t-1}	0.000172 (0.389308)
π_{t-1}	0.000516 (0.472269)
Δe_{t-1}	0.313393 (3.702291)
Δm_{t-1}	0.097243 (1.204980)
Δy_{t-1}	2.215242 (1.370062)
Δr_{t-1}	-0.004556 (-3.372426)
$\Delta \pi_{t-1}$	-0.000915 (-0.368348)

The figures in parenthesis are the t-statistics.

Moreover, consistent with this hypothesis, Nieh and Wang (2005) did not find statistical evidence of a long-run equilibrium relationship between the Taiwanese and US dollars' exchange rate and macroeconomic fundamentals, but rather that *'movemenst in exchange rates are determined by speculative bubbles in the marke'*. This view is further supported by Mbululu et al. (2013) in an empirical analysis of

exchange rates in Zambia, who found that the USD/ZMK exchange rate does not follow a random walk pattern, but that movement is influenced by order flows and noise-trader activities with a minimal role for fundamentals. Given that our model utilises variables of different integration orders following application of various unit root tests, it is possible that the results of earlier studies, such as that of Mungule (2004), could be biased because of the weaker exposure of variables to different types of unit root tests. Having established that there is no long-run equilibrium relationship, we estimate the ARDL model to show the short-run relationship between the exchange rate and the macro fundamentals. In the ARDL general to specific model, the procedure is to start with the full model specification, as shown in Table 6. The model shows that there is a negative relationship between the lagged money supply differential variable and exchange rate. However, this relationship is not significant. The lagged exchange rate variable is significant and negatively related to the exchange rate. This shows that a decrease in the previous exchange rate will lead to an increase in the current exchange rate, and vice versa. The results suggest that there is no evidence of exchange rate overshooting in the Zambian foreign exchange market. Having found no evidence of exchange rate overshooting, we turn our attention to test if the macro fundamental differentials are significant in explaining the exchange rate using the general to specific approach. The general to specific approach is conducted as follows. Starting from the initial model shown in Table 6, we eliminate the non-significant variables and re-estimate the model. We follow this procedure of elimination until we arrive at a model with only significant variables. The parsimonious model is shown in Table 7.

Table 7: Final ARDL specification model

Variable	Coefficient	t-statistic	Prob
e_{t-1}	-0.057814	-3.274115	0.0013***
Δe_{t-1}	0.335982	4.648904	0.0000***
Δy_{t-1}	2.332640	1.907780	0.0583*
Δr_{t-1}	-0.004712	-3.665655	0.0003***
Constant	0.477941	3.254123	0.0014***

* = significant at 10%, *** = significant at 1%.

The results from the general to specific ARDL model show that expansionary monetary policy is not significant in explaining the exchange rate (the money supply

variable is not included because it is not significant). This result supports empirical evidence by Mbululu et al. (2013), who argue that monetary aggregates do not influence exchange rate movements in the Zambian foreign exchange market. In addition, the results show that there is a negative relationship between the current and lagged exchange rate terms. The model further shows that differenced lagged terms of the exchange rate, real GDP and interest rates are important in explaining exchange rates movement in Zambia. However, we are cautious to conclude that the macro fundamentals are jointly not significant in explaining the exchange rate movements. This is consistent with the results of Meese and Rogoff (1983), who argue that exchange rate models cannot explain the trend of exchange rates. We therefore conclude that by using the exchange rate and the differentials of money supply, real GDP, interest and inflation rates, we find no evidence of exchange rate overshooting in the Zambian foreign exchange market.

Results of diagnostic checks

In an econometric study of this nature, care should be taken to ensure that the results from the model are robust. To ensure this, we conduct diagnostic tests to verify that our model is indeed statistically valid and that we can interpret our results with confidence. We perform a serial correlation test for autocorrelation, a heterescedasticity test, a test for recursive parameter stability using the cumulative sum (CUSUM) test and CUSUM of squares test and the Ramsey RESET test to check the functional form.

The results of the test for serial correlation using the Breusch-Godfrey test are presented in Table 8. The null hypothesis of no serial correlation is not rejected. We can therefore conclude that our model is robust to serial correlation.

Table 8: Breusch-Godfrey serial correlation LM test

F-statistic	**0.133629**	**Prob. F(2,147)**	**0.8750**
Obs*R-squared	0.279477	Prob. Chi-Square(2)	0.8696

The null hypothesis of the Breusch-Godfrey test is that there is no serial correlation.

To detect heteroscedasticity, we conduct the White (1980) test. From the results in Table 9, we fail to reject the null hypothesis of homoscedasticity, an indication that the model does not suffer from heteroscedasticity.

Table 9: White's Heteroscedasticity test

F-statistic	**1.537132**	**Prob. F (14,139)**	**0.1054**
Obs*R-squared	20.64577	Prob. Chi-Square (14)	0.1111
Scaled explained SS	42.99947	Prob. Chi-Square (14)	0.0001

The null hypothesis of the White test is that the variance of the disturbance term is homoscedastic.

To test for parameter stability in recursive residuals, we used the CUSUM test and CUSUM of squares test. Figure 3 shows the CUSUM test results for the ARDL specification and Figure 4 the results of the CUSUM of squares test. Both figures indicate that there is no parameter instability in the model. We can therefore conclude that this model is well specified as it passes both the residual and stability diagnostic tests.

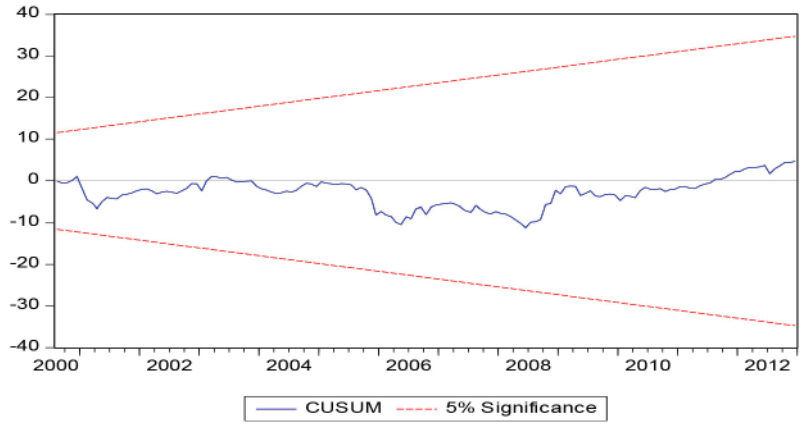


Figure 3: CUSUM test of parameter stability

In this section, we presented results from the unit root tests, the ARDL specification model and the residual and parameter stability tests. The unit root tests results have shown that we have a combination of variables of different integration orders.

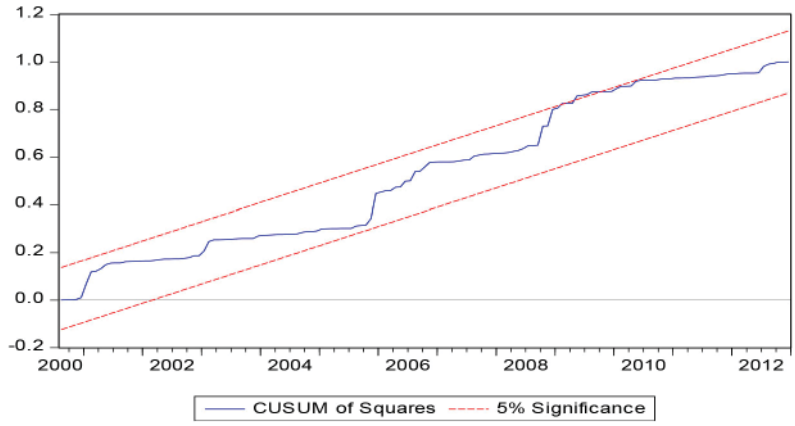


Figure 4: CUSUM of squares test of parameter stability

We have used the ARDL model, which is the most appropriate model, given the variables of different integration orders. To ensure that our model is robust, we performed tests for serial correlation and heteroscedasticity. Both tests confirm that the model is appropriate. The Ramsey RESET test for functional form, as presented in Table 10, indicates that the model is correctly specified. Finally, the CUSUM and CUSUM of squares tests have shown that the parameters of this model are stable.

Conclusion

This paper conducted an empirical re-examination of the overshooting hypothesis using the USD-ZMK exchange rate, one of the most volatile exchange rates using the autoregressive distributed lag (ARDL) procedure. Specifically, the study investigated whether the overshooting hypothesis holds for the USD-ZMK exchange rate. In addition, the study tested whether there is a long-run equilibrium relationship between the USD-ZMK exchange rate and the macroeconomic fundamentals (money supply, real GDP, interest rates and inflation rates). The study utilised a data set spanning a 13-year period from January 2000 to December 2012.

This paper adopted the ARDL methodology as developed by Pesaran et al. (2001) in re-examining Dornbusch's overshooting hypothesis. The ARDL bounds testing procedure can be applied to variables using OLS even if they are integrated of different orders and the technique is suitable for small or finite sample size. It has an advantage in that variables of different integration orders can be utilised in the same model. Furthermore, it is more likely to be efficient since it requires estimating few parameters using a single equation, unlike the Johansen cointegration approach,

which is more data intensive and requires estimation of a vector autoregressive system of equations and could thus lead to a substantial loss of degrees of freedom. The ARDL bounds test is robust for finite samples, even in the presence of phenomena of shocks and regime shifts (Fuinhas & Marques 2012). The ARDL model has thus gained popularity and is widely used in the literature to examine cointegration relationships between economic variables.

Based on the results of the test statistics, the study found no evidence of exchange rate overshooting. The result further showed that there was no evidence of a long-run equilibrium relationship between the exchange rate and the differentials of macroeconomic fundamentals. The implication is that in the case of Zambia, macroeconomic fundamentals are insignificant in determining exchange rate fluctuations against the USD in the long run. This finding is inconsistent with the monetary model of exchange rate determination, which asserts that there is a long-run relationship between the exchange rate and macroeconomic fundamentals.

The absence of a long-run equilibrium relationship supports one of the most significant studies in exchange rate determination, that is, the study of Meese and Rogoff (1983), who found that structural models performed poorly in predicting exchange rate movements that follow a random walk pattern. Moreover, consistent with this hypothesis, Nieh and Wang (2005) did not find statistical evidence of a long-run equilibrium relationship between the Taiwanese and US dollars' exchange rate and macroeconomic fundamentals but rather that *'movements in exchange rates are determined by speculative bubbles in the market'*. This view is further supported by Mbululu et al. (2013) in an empirical analysis of exchange rates in Zambia, who found that the USD/ZMK exchange rate does not follow a random walk pattern, but that movement is influenced by order flows and noise-trader activities with a minimal role for fundamentals. To ensure that our model was robust, tests for serial correlation and heteroscedasticity confirmed that the model was indeed appropriate. In addition, the Ramsey RESET Test, the CUSUM and CUSUM of squares tests all indicated that the parameters of the model were stable.

The Zambian foreign exchange market is relatively less developed (Mbululu et al. 2013). It is thus imperative to take this fact into consideration when interpreting the results of this study. The US dollar is the dominant currency on the interbank foreign exchange market in Zambia. However, the South African rand has become more important in recent years owing to the huge trade flows between South Africa and Zambia. Future studies in this area would add more value by re-examining the exchange rate overshooting hypothesis on the South Africa rand/Zambian kwacha (ZAR/ZMK) exchange rate, as it is assumed that the huge trade flows between the

two countries would provide a better picture of the price of one currency in terms of the other.

To foster a better appreciation of the long-run equilibrium relationship between the exchange rate and the macroeconomic fundamentals, the recommendation is that studies utilising the ZAR/ZMK exchange rate should be considered. This is because of the above-mentioned trade flows and proximity between South Africa and Zambia. While the USD/ZMK exchange rate was utilised here, it should be pointed out that the trade flows between the USA and Zambia are less than those between South Africa and Zambia. However, the fact that the US dollar is a vehicle currency lends credence to the choice of the exchange rate pair utilised in this study.

Endnotes

1. A detailed discussion is available in Mbululu et al. (2013).
2. As pointed out by BOK, monetarists would predict an estimate of $a_3 = 1$.

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