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A RE-EXAMINATION OF THE EXCHANGE RATE OVERSHOOTING HYPOTHESIS: EVIDENCE FROM ZAMBIA

By

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A research report submitted in partial fulfillment of the requirements for the degree of

MASTERS OF MANAGEMENT IN FINANCE AND INVESTMENTS

WITS BUSINESS SCHOOL

at the

UNIVERSITY OF THE WITWATERSRAND

SUPERVISOR: PROF. SCHALING

Date of submission: 24th February 2014

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ABSTRACT

Dornbusch's exchange rate overshooting hypothesis has guided monetary policy conduct for many years though 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 if there is a long-run equilibrium relationship between the USD-ZMK exchange rate and the macroeconomic fundamentals (money supply, real Gross Domestic Product (GDP), interest rates and inflation rates). The study uses 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 result 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: C13, C22, F31, F41

ACKNOWLEDGEMENTS

I give glory to God for the gift of life without which this study could not have come to fruition. I am highly and will remain forever indebted to my wife, Dr. Chitalu Chama-Chiliba, for being a true model and whose research work fuelled my interest in economics research and for the financial contribution which made it possible for me to enroll at Wits Business School. This investment is not in vain. A million thanks and sincere gratitude to my supervisor, Professor Schaling, for his guidance, thought provoking questions and patience. I would like to extend my appreciation and acknowledgement to the faculty members of Wits Business School especially Prof. Ojah, Prof Alagidede and Dr. Mokoteli for the exciting and interactive learning; my family for always being there for me; my sister, Doreen, for holding fort during my absence; my friends and relatives I thank you all for your support.

DEDICATION

I dedicate this thesis to my beloved wife Chitalu, who knows this work much more than I do, but who had the patience to observe and listen and to Ethan, mum's boy, for giving me more time as you 'stuck' to your mother. This is for you guys.

LIST OF ACRONYMS

ADF	Augmented Dickey Fuller
AIC	Akaike Information Criteria
ARDL	Autoregressive Distributed Lag
BLUE	Best Linear Unbiased Estimators
BIC	Bayesian Information Criteria
CUSUM	Cumulative SUM
DF-GLS	Dickey Fuller Generalised Least Squares
ECM	Error Correction Mechanism
FRED	Federal Reserve Bank of St. Louis's Database
GDP	Gross Domestic Product
HQIC	Hannan-Quinn Information Criterion
IFEM	Foreign Exchange Market
OLS	Ordinary Least Squares
SIC	Schwartz Information Criterion
UIP	Uncovered Interest rate Parity
USD	United States Dollar
VAR	Vector Autoregressive
ZMK	Zambian Kwacha

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CHAPTER ONE: INTRODUCTION

1.1 Overview

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 behavior of exchange rates. This is due to the difficulty in 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 the money market equilibrium, purchasing power parity and uncovered interest rate parity (Rogoff, 2002; de Bruyn, Gupta and 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 later assumes that purchasing power parity only holds in the long-run (Pilbeam, 2006). 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 given an unanticipated monetary expansion the exchange rate will, in the short run, depreciate to a higher level than its long run equilibrium. The overshooting occurs due to difference of the speed of adjustments between the goods and the financial markets.

However, there is a discrepancy between empirical evidence and theoretical monetary models of exchange rate determination, which has been a source of debate and attracted

considerable research interest. Empirical research on exchange rate overshooting has produced mixed results. For instance, Frankel (1979), Driskill (1981), Rogoff (2002), Dornbusch (2004) and Nieh and Wang (2005) 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 overshooting model.

As most of the research on exchange rates in general has focused on developed economies, developing countries particularly sub-Saharan countries, have received little attention. However, with availability of data this gap is being filled (Sichei, Gebreselasie and Akanbi, 2005; Oduor, 2008; Chipili, 2009; Oduor, 2009; Enekwe, Ordu and Nwoha, 2013; Mbululu, Auret and Chiliba, 2013).

This paper attempts to re-examine the validity of Dornbusch's (1976) 'overshooting' hypothesis on the United States Dollar-Zambian Kwacha (USD-ZMK) exchange rate. This paper adopts the methodology in Nieh and Wang (2005) and Bahmani-Oskooee and Kara (2000) who studies the overshooting hypothesis by applying the monetary model of exchange rates and cointegration tests. It fills the gap in the literature on frontier economies and developing countries. The next section presents a summary of the historical background of the foreign exchange market in Zambia, a detailed discussion is available in Mbululu, Auret and Chiliba (2013)

1.2 Historical background on the Zambian foreign exchange market

The exchange rate mechanism in Zambia has seen a combination of both fixed and floating exchange system. The fixed exchange rate system was adopted for the period 1964-1982 and 1987-1991. The authorities sustained this mechanism through a combination of adjustments and issuance of import licences (Mkenda, 2001). During the period 1983-1985, 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 the 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 a broader participation in the exchange rate market by the commercial banks, the monetary authorities introduced a freely floating exchange rate system. The system allowed the commercial banks to trade foreign currency with the central bank at a frequency of three times a week and to improve liquidity on the market, the frequency of trading was increased to daily. Owing to the depressed economic conditions and the 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 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, licenced 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 with limited restrictions. Figure 1 shows the trend of the USD/ZMK exchange rate with high depreciation between 2008 and 2009 during the global financial crisis. 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 (Rogoff, 2002). Rogoff (2009) and Bjørnland (2009) both argue that exchange rate overshooting is a valid hypothesis in international macroeconomics.

Figure 1: Trends in USD/ZMK exchange rate

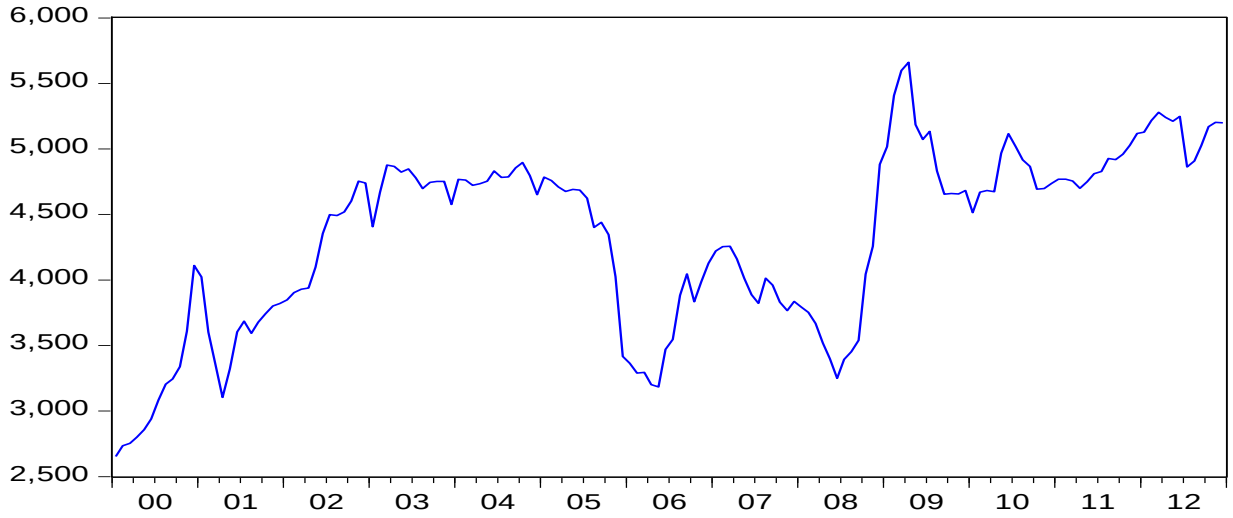
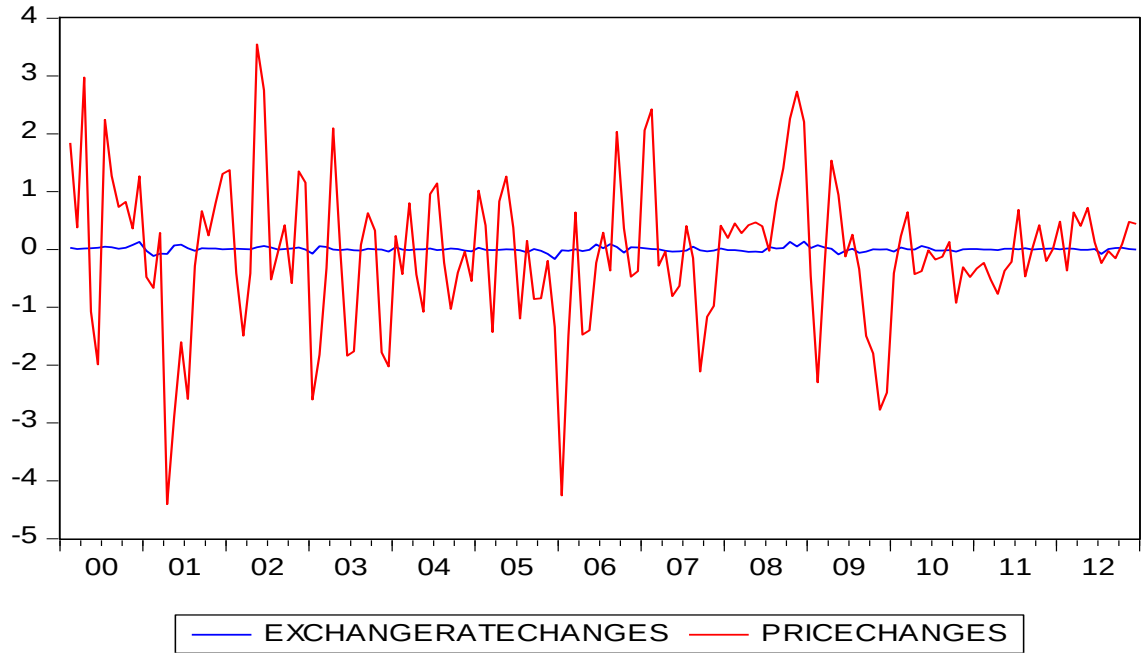


Figure 2: USD/ZMK exchange rates returns against price changes



1.3 Objectives of the study

It is imperative to understand exchange rate behaviour as it affects macroeconomic stability in an economy. High exchange rates volatility hampers decision making in terms of planning and forecasting. Apart from its impact on monetary policy formulation, exchange rate behaviour is of

keen interest to other markets participants like foreign exchange traders, brokers, importers and exporters and investors and financial institutions.

This paper conducts an empirical re-examination of the overshooting hypothesis using the USD-ZMK exchange rate, one of the highly volatile exchange rates. Specifically, the study will investigate whether the overshooting hypothesis holds for the USD-ZMK exchange rate. In addition, the study will attempt to test if there is a long-run equilibrium relationship between the USD-ZMK exchange rate and the macroeconomic fundamentals (money supply, real Gross Domestic Product (GDP), interest rates and inflation rates).

1.4 Importance of the study

The importance of this study is that it will help to understand the pattern and behavior of exchange rates in Zambia in the context of overshooting. With the recent adoption of inflation targeting in Zambia, it is imperative to understand the nature of exchange rate overshooting, if any, to inform the conduct of monetary policy and its transmission.

In most cases, overshooting predicts that the forward and spot rates will not move one for one (Flood, 1981). Contrary to the forward rate unbiased hypothesis, Rogoff (2002) argues that in the presence of exchange rates overshooting, the spot rate would move by more than the predicted forward rate. It is therefore important to understand the behaviour of exchange rates as this has a direct impact on both spot and forward rates, which are key inputs in pricing exchange rates in financial markets. Moreover, investigating the presence of exchange rate overshooting could help explain exchange rate volatility in Zambia (Pierdzioch, 2004).

1.5 Organisation of the study

The study is organised as follows: Chapter two reviews both the theoretical and the empirical literature on exchange rate overshooting model. Chapter three describes the data and econometric

methodology to be used in this study. Chapter four presents the empirical results and discussions. The conclusion, limitations and suggestions for further study are presented in chapter five.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter reviews both the theoretical and the empirical literature on exchange rate overshooting model. It starts with theoretical explanation of the monetary model of exchange rate and Dornbusch's (1976) sticky price version on which the overshooting model is based. This is then followed by a review of the empirical literature.

2.2 Theoretical background

The overshooting model is characterized by two core equations namely the money demand and the uncovered interest parity (Rogoff, 2002). The uncovered interest rate parity (UIP) states that the interest rate differential between two countries is equal to the expected change in the spot exchange rate and is defined as,

$$r_{t+1} = r^* + E_t(e_{t+1} - e_t) \quad (1)$$

where *r* and *r** refers to home and foreign interest rates, the last term on the right hand side of the equation represents the expected rate of change of the exchange rate and *e* is the logarithm of the exchange rate. The overshooting model assumes that the UIP holds at all times. UIP assumes perfect capital mobility, risk neutral investors and perfect substitutability between domestic and foreign assets. The UIP model further assumes rational expectations and that capital markets quickly respond to any shocks. However, there is lack of empirical evidence supporting the UIP model, (Rogoff, 2002). The money demand equation is shown as,

$$m - p = \eta y - \delta r \quad (2)$$

where *m* is the log of domestic money supply, *p* is log of domestic price level, *y* is the log of domestic real income and *r* is the nominal domestic interest rate, η and δ are both positive parameters that

measure the income elasticity of supply for money and interest elasticity of demand for money respectively. Higher interest rates results into lower demand for money because of the increased opportunity cost of holding money as economic agents would prefer to earn the higher interest rates than hold money. This can be further interpreted that an increase in national income leads to a higher transactive demand for money balances because the increased income level, holding other things constant, leads to an increase in economic activity and subsequent an increase to transactive demand for money as economic agents prefers to hold more money for transactive purposes. It can therefore be said that interest rates levels affect the demand and supply of money in the economy. Therefore, equilibrium in the money market is restored when money supply (*Ms)* is equal to money demand.

$$M_s = L(Y_t, r_t)P_t \tag{3}$$

where money demand is positively related to output (Y_t) and inversely related to the interest rate level (r_t).

Another important relationship in understanding the overshooting hypothesis is the purchasing power parity (PPP). The PPP theory states that when expressed in a common currency, a basket of goods should have the same cost across countries. According to Pilbeam (2006), the PPP states that the real exchange rate is defined by,

$$Q_t = S_t P_t^* / P_t \tag{4}$$

where S_t is the spot rate, P_t is the domestic price level and P_t^* is the foreign price level at time t. In the overshooting model, deviations from the PPP exist in the short-run. Having stated the key equations, we can now explain how the overshooting occurs in this model. We assume neutrality of

money in the long run and that the price level *p* is sticky, that is, it does not respond instantaneously to monetary shocks.

Combining equations (1) and (2) and assuming an unanticipated permanent increase in the money supply, *m*, in the presence of a sticky price level, the supply of real money balances, *m-p*, must also rise due to the increase in the money supply. As a result, the demand for real money balances must also rise in order to maintain equilibrium. Demand for real money balances will only rise if the domestic interest rate, *r,* declines. According to equation (1), the interest rate will decline only if the domestic currency is expected to appreciate. The long run impact of the shock is supposed to lead to a depreciation of the local currency. However, the initial momentary depreciation on impact 'overshoots' its long run depreciation. This initial 'overshooting' then leads to subsequent appreciation of the currency to restore equilibrium in the goods and financial markets (Rogoff, 2002). It can clearly be seen from the equations above that the validity of this model depends on the Keynesian model's assumption of nominal sticky prices in the short run (Romer, 2006).

2.3 Monetary model of exchange rates

The foundations of the monetary model of exchange rates is firmly grounded on the PPP and the quantity theory of money (Bahmani-Oskooee and Kara, 2000; de Bruyn, Gupta and Stander, 2013). The absolute version of the PPP is stated as,

$$S = P_Z / P_{USA} \tag{5}$$

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 we are using the USD/ZMK exchange rate 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,

$$MV = PT \tag{6}$$

where M is the money supply, V is the velocity of money circulation, P is the price level and T is the transaction or output level in the economy. Mishkin (2005) states that the quantity theory of money explains how the nominal value of aggregate income is determined. Extending this to the two economies, we have,

$$M_Z V_Z = P_Z T_Z \tag{7}$$

$$M_{US} V_{US} = P_{US} T_{US} \tag{8}$$

as the quantity theory of money for Zambia equation (7) and for the United States of America equation (8). Solving equations (7) and (8) for P_Z and P_{US} then substituting into equation (5) and making E, the exchange rate, the subject of the formula, we get,

$$E = \left(\frac{M_Z}{M_{US}}\right)\left(\frac{V_Z}{V_{US}}\right)\left(\frac{T_{US}}{T_Z}\right) \tag{9}$$

Equation (9) states that the exchange rate is determined by the relative money supply, the relative velocity and the relative transaction or output level. By adopting the approach in Bahmani-Oskooee and Kara (2000) in which the velocity of money is dependent on the interest rates and inflation rates, we can rewrite the relative velocities of money as,

$$\left(\frac{V_Z}{V_{US}}\right) = \left(\frac{r_Z}{r_{US}}\right) + \left(\frac{\inf_Z}{\inf_{US}}\right) \tag{10}$$

where r and inf is the interest and inflation rates respectively. By substituting $\left(\frac{V_Z}{V_{US}}\right)$ for $\left(\frac{r_Z}{r_{US}}\right)+\left(\frac{\inf_Z}{\inf_{US}}\right)$ into equation (9), replacing T by Y and taking logs of both sides, we arrive at the monetary model of exchange rates. This is represented as,

$$LogE = \log(M_Z - M_{US}) + \log(Y_{US} - Y_Z) + \log(r_Z - r_{US}) + \log(\inf_Z - \inf_{US}) \quad (11)$$

This study estimates the monetary model of exchange rates as shown in equation (11). In our model, we do not take logs of the interest rates and inflation rates. This will not change our model but the interpretation of the results will not be same as those of the logged coefficients. Having explained the model to be estimated, we now turn to the empirical literature on Dornbusch's (1976) 'overshooting' model.

2.4 Empirical literature

There is a plethora of literature on the overshooting hypothesis from different schools of thought. In this section, we start with a review of the empirical literature in support of Dornbusch's (1976) overshooting model. This will be followed by a review of the literature against this model. We end this section with presentation of review of literature on earlier studies on the Zambian economy.

Dornbusch (1976) introduced the sticky-price model to explain the fluctuations in the exchange rate and contains an 'overshooting' hypothesis. Dornbusch's (1976) model, therefore, can be said to focus on the short-run overshooting of the exchange rate due to differing speeds of adjustments between the goods market and the capital market. The exchange rate overshooting hypothesis has influenced a great deal of research in international economics. In an all-sided discussion, Tu and Feng (2009) provide a review and an appraisal of the merits and otherwise of this model and argue that it is important to understand this hypothesis as it is key consideration in the formulation of

monetary and exchange rate policies. Tu and Feng (2009) conclude that overshooting is not an inherent characteristic of foreign exchange rate market and that it depends on a set of assumptions such as the interest elasticity of money and capital mobility.

Various scholars have studied the overshooting phenomenon and provide evidence in support of Dornbusch's (1976) model. These include Frankel (1979), Driskill (1981), Papell (1984), Bhandari (1985), Papell (1988), Akiba (1996), Park (1997), Bahmani-Oskooee and Kara (2000), Goldfajn and Gupta (2001), Rogoff (2002), Dornbusch (2004) and Nieh and Wang (2005).

Frankel's (1979) model based on real interest differential found evidence in support of the overshooting phenomenon and concluded that the observed overshooting was proportional to the real interest differential between the currency pair. However, given that there are many factors which determine the exchange rate, it is too simplistic to base the overshooting solely on the interest differential. Nevertheless, it provides evidence of the overshooting hypothesis.

Driskill (1981) estimates a reduced-form exchange-rate equation using Swiss-USA data for the period 1973-79 using quarterly average data and finds evidence of short-run exchange-rate overshooting by a factor of about two following a monetary shock and that adjustments to stability takes longer than twenty-four months. Papell (1984) uses constrained maximum likelihood method estimation for the Mark/USD exchange rates and finds strong evidence for exchange rate overshooting and that an accommodative monetary policy can potentially cause the economy to switch from exchange rate overshooting to undershooting. Bhandari (1985) examines the exchange rate overshooting on a two-tier dual float exchange rate system and finds evidence in support of the overshooting hypothesis on the financial exchange rate. Papell (1988) estimated a discrete time version of the Dornbusch's (1976) overshooting model using quarterly data from 1973 (Q2) to 1984 (Q4) for Germany, Japan, the United Kingdom and the United States and finds evidence in favour of the overshooting model.

Clarida and Gali (1994) use a structured Vector Autoregressive (VAR) model to investigate the effects of shocks on various exchange rate pairs (U.S.-Canadian Dollar, U.S. Dollar-British Pound, U.S. Dollar-Deutschmark and U.S. Dollar-Yen nominal exchange rates) and find evidence of monetary shocks causing exchange rate overshooting "with maximum overshoot occurring approximately three months after the shock". Akiba (1996) investigates the overshooting hypothesis through the exchange rate sensitivity of the demand for money and finds evidence of a reduction in the exchange rate overshooting and the volatility of the exchange rate. Park (1997) estimated an asset based model and found evidence of overshooting and that the degree of overshooting is based on the price stickiness.

Pratomo (2005) uses ordinary least squares method and cointegration techniques and attempts to analyse whether Indonesian Rupiah overshot its long-run equilibrium when the crisis hit Indonesia in mid of 1998 and whether the fundamental macroeconomic factors influence exchange rate in Indonesia and finds evidence of exchange rate overshooting, a cointegration relationship between the exchange rate and macro fundamentals and further finds evidence showing a structural change in the exchange rate after the 1998 crisis.

Whilst the origin of the overshooting model is in the short-run nature, Bahmani-Oskooee and Kara (2000) used autoregressive distributed lag (ARDL) procedure on the Turkish Lira/USD exchange rate and provide evidence for the long-term overshooting phenomena. Nieh and Wang (2005) used the conventional Johansen's cointegration approach and ARDL procedure on the bilateral Taiwan USA exchange rate and found evidence of overshooting.

In spite of this empirical evidence and the elegance of the overshooting model (Rogoff, 2002),there is still empirical literature which refutes the existence of overshooting hypothesis. Many studies provide evidence against overshooting. Hacche and Townsend (1981), Backus (1984), Sims (1992), Eichenbaum and Evans (1995), Flood and Taylor (1996) and Kim and Roubini (2000) all do

not find evidence in support of the overshooting model while other scholars such as Meese and Rogoff (1983) argue that exchange rate models cannot explain the trend of exchange rates owing to the nature of estimation approach.

Hacche and Townend (1981) studied the effect of monetary influences on exchange rate behaviour for the United Kingdom following the abandonment of the fixed parity against the dollar in 1972 and found evidence against the exchange rate overshooting its long-run equilibrium level. Using Canadian and USA data over the 1970s, Backus (1984) did not find evidence in support of the overshooting hypothesis but that monetary fundamentals had a weak explanatory power for exchange rate changes. Eichenbaum and Evans (1995) used a value at risk identification approach to study the effect of shocks to the USA monetary policy on exchange rate over the period 1974-90 and found that the exchange rate continued to appreciate instead of the instantaneous jump as predicted by the overshooting model. Using data on twenty one industrialised countries during the floating rate period, Flood and Taylor (1996) provide evidence against the overshooting hypothesis.

Kim and Roubini (2000) use a 'structural VAR' approach with non-recursive contemporaneous restrictions and find evidence in favour of a delayed overshooting and reject Dornbusch's overshooting hypothesis. Kustra (2005) uses a VAR of a four exchange rate pairs data from 1975 to 2004 rejects the Dornbusch overshooting hypothesis as evidence supports delayed overshooting.

Bahmani-Oskooee and Panthamit (2006) examine the exchange rate overshooting hypothesis in in a multi-country context using data from Thailand, Korea, Indonesia, Malaysia and the Philippines. They find evidence in favour of a short-run overshooting phenomenon and that in the long-run, money is neutral. This renders support to the money neutrality paradigm. If money is indeed neutral in the long-run, it should not be important in explaining the exchange rate. In this case, money supply should not be a significant variable in explaining exchange rate in the long-run.

Heinlein and Krolzig (2011) studied the determination of the Pound/Dollar exchange rate in a small macroeconomic model using the macroeconomic differentials and found evidence of deviation from the UIP and that jumps in exchange rate following short-term interest variations were only significant at ten percent pointing to lack of support for the overshooting hypothesis.

The degree of capital mobility plays a bigger role in determining whether exchange rates overshoot or not. Frenkel and Rodriguez (1982) estimate a modified Dornbusch model and allows for a finite speed of adjustment in money markets. Evidence shows that in this case, the short-run effects of a monetary expansion are driven by the degree of capital mobility. Therefore in cases of higher capital mobility the exchange rate overshoots its long-run equilibrium value but undershoots the long-run value in case of relatively immobile capital. The Zambian economy records high capital mobility with little restrictions. Therefore, we expect the USD/ZMK to respond according to Frenkel and Rodriquez (1982) owing to the higher degree of capital mobility.

To the author's best knowledge, studies on the 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. Mkenda (2001) using annual data from 1965 to 1996 and cointegrating analysis finds 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 impacts the real exchange rate for exports in the long run. One of the limitations of Mkenda's study is the utilisation of data at low frequency.

Mungule (2004) using vector error correction models on quarterly time series data between 1973 and 1997 studied the determinants of the real effective exchange rates in Zambia. Results indicate that the real effective exchange rate depends on the prevailing real fundamentals, price differentials and real shocks. Similar to Mkenda (2001), Mungule's (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 have used various methodologies, in some cases, 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 the more recent papers in the literature, this study employs the ARDL model, which allow 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, we use monthly data from 2000 to 2012. In contrast to Mungule (2004) and Mkenda (2001), the exchange rates to be 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.

CHAPTER THREE: DATA AND METHODOLOGY

3.1 Introduction

This chapter contains a description of the data and the analytical framework to be used. The study relies on the monetary model of exchange rates, as such, monetary aggregates will be used in the analysis. These are exchange rates, money supply, inflation rates, real gross domestic product and interest rates. The next section provides a description of the data and the subsequent section explains the methodology to be used in this study.

3.2 Data

Empirical studies on investigating the exchange rate overshooting under the ARDL methodology have used monetary aggregates (for instance, Nieh and Wang, 2005; Bahmani-Oskooee and Kara, 2000). Similarly, this study uses the following variables; nominal exchange rates (e), money supply (m), real GDP (y), interest rates (r, monthly nominal) and inflation rates (inf). The data spans a thirteen year period from January 2000 to December 2012. Real GDP data for both the USA and Zambia were sourced from the International Financial Statistics (IFS). The other data for each country were sourced from the Federal Reserve Bank of St. Louis's data base (FRED) for USA data and the Bank of Zambia for Zambian data. All the exchange rate data were 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, number of ZMK per unit of US Dollar and it is the end of period nominal exchange rate. The variables are defined as follows:

$$e=\log(E) \tag{12}$$

$$m=\log(M) - \log(M^*) \tag{13}$$

$$y=\log(Y) - \log(Y^*) \tag{14}$$

$$r = R - R^* \quad (15)$$

$$\Pi = I - I^* \quad (16)$$

Where, E is the nominal exchange rate and M, Y, R and Π are respectively broad money supply (m2), real GDP, Interest rates (%) and Inflation (%). Variables with (*) relate to the United States of America while those without relate to Zambia.

3.3 Methodology

The study uses the Autoregressive Distributed Lag (ARDL) bounds test procedure, jointly developed by Pesaran, Shin and Smith (2001), to test if the overshooting hypothesis holds for the USD-ZMK exchange rates and to investigate if there is a long-run equilibrium between the USD-ZMK exchange rate and the monetary fundamentals. This paper adopts the ARDL methodology as developed by Nieh and Wang (2005) in re-examining Dornbusch's overshooting hypothesis. The ARDL has been 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. The ARDL bounds testing procedure can be applied to variables using Ordinary Lest 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). It has the 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). Thus, the ARDL model has gained popularity and is widely used in literature to examine cointegration relationships among economic variables (see Srinivasan and Kalaivani (2013), Tiwari, Shahbaz and Islam (2013), Sakyi (2011), Bahmani-Oskooee

and Hajilee (2010), Karim and Majid (2010), Shahbaz (2010), Bahmani-Oskooee and Gelan (2009), Majid and Yusof (2009), Wong and Tang (2008), Dube (2008), Nieh and Wang (2005), Ghatak and 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 test yield different results (Bahmani-Oskooee, 1998). Therefore, this paper utilises a battery of unit root tests.

3.3.1 Unit root tests

It is important to ensure that variables in a regression model are non-stationary to avoid spurious regressions (Granger and 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 must 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 and Kayikci, 2012). To avoid the use of $I(2)$ variables, we carry out unit roots tests to verify whether all our variables are $I(0)$ and $I(1)$. Owing to the different powers of unit roots tests, different tests give varying results especially for macroeconomic variables. Therefore, we use a battery of unit roots tests namely Augmented Dickey Fuller or ADF (Dickey and Fuller, 1981), PP (Phillips and Perron, 1988), KPSS (Kwiatkowski, Phillips, Schmidt and Shin, 1992), DF-GLS (Elliott, Rothenberg and Stock, 1996) and NP (Ng and Perron, 2001).

The ADF model, as presented by Dickey and Fuller (1981), is as follows:

$$\Delta y_t = c_0 + \delta_{t-1} \sum_{i=1}^{p} \Delta y_{t-1} + u_t \qquad (19)$$

$$\Delta y_t = c_0 + c_1 t + \delta y_{t-1} + \beta \sum_{i=1}^{p} \Delta y_{t-1} + u_t \quad (20)$$

where c_0 is the constant term and c_1 is a trend term, p is the number of lagged terms and u_t is white noise. Equation (19) refers to the case with intercept only while equation (20) refers to the case with both an intercept and a trend. The DF-GLS (Elliott, Rothenberg and Stock, 1996) is modelled as an OLS regression as follows:

$$d(y_t / \alpha) = d(z_t / \alpha)' \delta(\alpha) + \eta_t \quad (21)$$

where z_t contains either a constant only or both a constant and a trend. The DF-GLS (Elliott, Rothenberg and Stock, 1996) statistic is computed from,

$$\Delta y_t = \alpha y_{t-1} + \beta_1 \Delta y_{t-1} + ... + \beta_p \Delta y_{t-p} + \upsilon_t \quad (22)$$

where y and y_{t-1} are detrended terms. The PP (Phillips and Perron, 1988) is a non-parametric methodology. It has the further advantage of controlling for serial correlation in unit root test by modifying the t-ratio of the estimated coefficient and the test statistic is modelled as,

$$\tilde{t}_\alpha = t_\alpha \left(\frac{\gamma_0}{f_0} \right)^{1/2} - T \left(\frac{(f_0 - \gamma_0)(se(\hat{\alpha}))}{2 f_0^{1/2} s} \right) \quad (23)$$

where γ is the error variance estimate and t_α is the t-ratio of α, $\hat{\alpha}$ is the estimate coefficient, se is the standard error of the coefficient, f is residual and s is the standard error of the test regression. The KPSS (Kwiatkowski, Phillips, Schmidt and Shin, 1992) is a residual based test from OLS regression of y_t on an exogenous variable x_t hence,

$$y_t = x_t' \delta + u_t \quad (24)$$

with a lagrange multiplier based test statistic which is defined as,

$$LM = \sum_T \frac{s(t)^2}{T^2 f_0} \quad (25)$$

where the cumulative residual function is represented by $s(t)$ and f_0 is the residual. The unit root tests used in the study have different null hypotheses. For the ADF, DF-GLS, PP and NP the null hypothesis is that the series is non-stationary, that is, the series contains a unit root. The null for the KPSS tests for stationarity. It is important to note that the different results from unit roots tests on the integration orders of the variables could result in false results from the conventional cointegration results (Nieh and Wang, 2005).

3.3.2 The Auto regressive Distributed Lag (ARDL) Model

When variables in a regression are of different integration order, the usual OLS regression will not give reliable estimates. Pesaran et al. (1996, 2001) have developed a method of testing for cointegration when the variables are of different integrating orders. This is the ARDL or bounds test approach. However, for variables that are *I*(2), the computed F-statistic will give misleading results (Pesaran *et al.*, 2001) hence the importance of carrying out the unit root tests to eliminate any doubts. The ARDL model to be estimated takes the following form:

$$e_t = a_1 + a_2 m_t + a_3 y_t + a_4 r_t + a_5 i + u_t \qquad (17)$$

where e=log (E), m=log(M) - log(M*), y=log(Y) - log(Y*), r=R – R* and i=I – I*. Variables without (*) relate to the domestic economy (Zambia) and those with (*) relate to the foreign economy (USA). The expected coefficient signs are as follows: a_2 is greater than zero, which implies that a higher growth of money supply in Zambia over that of the United States will depreciate the Zambian Kwacha; a_3 is expected to be negative indicating an appreciation of the Zambian Kwacha due to an increase in Zambian income relative to that of the United States. Based on economic theory, an increase in income, holding other things constant, leads to an increase in the demand for money, leading to an increase in the local interest rate level and subsequent appreciation of the currency. Given an increase in the interest rates in Zambia, the currency is expected to appreciate,

which entails that a_4 will be negative. a_5 will be negative, indicating a depreciation of the local currency given an increase in the inflation rate. The overshooting hypothesis is a short-run phenomenon and to test for it, we use cointegration and error correction methods. The error correction ARDL approach relating to variables in equation (17) that is used in this study is given as,

$$\Delta e_t = a_0 + \sum_{j=1}^{n} a_{2j}\Delta e_{t-j} + \sum_{j=1}^{n} a_3 \Delta m_{t-j} + \sum_{j=1}^{n} a_4 \Delta y_{t-j} + \sum_{j=1}^{n} a_5 \Delta r_{t-j} + \sum_{j=1}^{n} a_6 \Delta i_{t-j} + \delta_1 e_{t-1} + \delta_2 m_{t-1} + \delta_3 y_{t-1} + \delta_4 r_{t-1} + \delta_5 i_{t-1} + \varepsilon_t \quad (18)$$

The ARDL approach for error correction mechanism (ECM) tests for the existence of a long-run relationship among 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 by $H_0 : \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5$ 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. Therefore, we use the bounds (upper and lower bands) tests critical values as developed by Pesaran *et al.* (1996, 2001). Pesaran *et al.,* (2001) have 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 based on Akaike Information Criteria (AIC) and this controls for the autocorrelation problem inherent in time series data.

3.4 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 test and parameter stability using recursive tests,that is, the cumulative sum (CUSUM) and CUSUM of squares tests.

3.4.1 Serial correlation test

It is possible in Ordinary Least Squares (OLS) regression for time series residuals to be serially correlated with their own lagged values. The EViews User's Guide (p273), states that in the presence of serial correlation, we have (i) OLS estimates are biased and inconsistent if a lagged dependent variable is used as an explanatory variable (ii) standard errors are incorrect and generally overstated and (iii) OLS is no longer an efficient linear estimator. 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.

3.4.2 Heteroskedasticity test

In the presence of heretoskedasticity, the OLS estimators are still linear and unbiased but no longer efficient and do not possess the minimum variance, that is, they are no longer Best Linear Unbiased Estimators (BLUE) hence the t and F tests based on these are misleading resulting in possible erroneous conclusions (Gujarati, 2003). The null of the White (1980) test is that the variance of the disturbance term is homoskedastic and the alternative is that the variance of the disturbance term is heteroskedastic.

3.4.3 Recursive tests

Recursive tests are carried out to test for parameter stability in the recursive residuals. Recursive tests shows a plot of the residuals in relation to the zero line. Parameter stability is shown by residuals

within the standard error bands. Residuals outside the given error bands indicate the presence of parameter instability of the equation. We estimate two tests here namely CUSUM test and CUSUM of squares test.

The CUSUM test, attributed to Brown, Durbin and Evans (1975), is derived through cumulative summing of the recursive residuals. The residuals are then plotted alongside the 5% critical values lines. In the presence of parameter instability, the cumulative recursive sum goes out of the error bands, that is, the two critical values. The test statistic of the CUSUM test is,

$$W_t = \sum_{r=k+1}^{t} w_r / s \tag{19}$$

where t=k+1, w is the recursive residual, s is the standard deviation of recursive residuals. Parameter instability results from the movement of W_t outside the two critical values.

The CUSUM of squares test, also attributed to Brown, Durbin and Evans (1975), is derived through summing the cumulative recursive residuals and the tests statistic is given as,

$$S_t = \left(\sum_{r=k+1}^{t} w_r^2 \right) \Big/ \left(\sum_{r=k+1}^{T} w_r^2 \right) \tag{20}$$

where w is the recursive residual and the mean of S_t is given as,

$$E(S_t) = (T-K)/(t-K) \tag{21}$$

Movement outside the critical lines points to parameter instability.

In this Chapter we explained the data sources and characteristics of the observations used in this paper. We also explained the methodology to be used in this paper, the autoregressive distributed lag procedure as developed by Pesaran *et al.* (1996, 2001) and described how we derived

the monetary differentials used in the empirical analysis. We also described the diagnostic checks that are done on the model. In the next Chapter, we present the empirical results.

CHAPTER FOUR: EMPIRICAL RESULTS

4.1 Introduction

This chapter presents empirical results from the analysis. In the next section, 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.

4.2 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. 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.

Table 1: Descriptive statistics of variables

Variable	Mean	Median	Max	Min	Standard Deviation	Skewness	Kurtosis	J-B Test (prob)
e	8.358	8.442	8.64	7.88	0.169	-0.796	2.777	16.785 (0.0002)*
m	-0.048	-0.126	0.871	-1.248	0.574	-0.121	1.924	7.914 (0.0191)*
y	-1.323	-1.377	-1.019	-1.522	0.154	0.535	1.864	15.833 (0.0004)*
r	15.526	10.259	48.941	0.303	12.730	0.984	2.702	25.734 (0.0000)*
Π	12.445	14.043	26.745	2.546	6.807	0.230	1.842	10.089 (0.0064)*

p-value.

4.3 Unit root test results

A summary of the results is presented in Table 2. The top panel (a) presents results based on a model including the intercept only and the bottom panel (b) presents 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: 1) intercept only; 2) the intercept and trend only.

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 significant at 1% and 5% levels respectively.
2. The null of the ADF, DF-GLS, PP and NP tests for unit root while that of the KPSS tests for stationarity.
3. Lvls refer to levels while Diff refers to differences.
4. *e, m, y, r* and π refers to logarithm of exchange rates, logarithm of money supply differential, logarithm of real GDP differential, short-term interest (91 day T-Bill) differential and inflation rate differential respectively.
5. The appropriate lag length for ADF, DF-GLS and NP are shown in the parentheses and selected based on AIC (Akaike information criterion). For PP and KPSS, the optimal bandwidths are selected by Bartlett kernel of Newey and West (1994).
6. The appropriate models for both levels and differences are intercept only (*m, r* and π) and intercept and trend (*e* and *y*).

However, 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 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 5% level of significance and non-stationary in both levels and differences. Due 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 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 money supply and real GDP differentials are stationary in levels at 1% level of significance in the intercept only case.

These results confirm our earlier expectation that different unit root tests will give different results due to the level of power of the tests. Based on the ADF, PP and KPSS unit roots 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 give spurious regression results.

4. 4 Results from the ARDL model

The lag structure of an ARDL model is very important for the results to be valid. The optimal lag lengths were selected based on the Akaike Information Criteria (AIC). However both Hannan-Quinn Information Criteria (HQIC) and the Schwartz Information Criteria (SIC) give 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.* (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 includes 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 and Pesaran (1997) p. 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, results from this study differ from the 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, Meese and Rogoff (1983) who found that structural models performed poorly in predicting exchange rate movements which 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 United States

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 statistics.

dollars exchange rate and macroeconomic fundamentals but rather that *'movement 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 random walk but that movement is influenced by order flows and noise-trader activities with minimal role for fundamentals. Given that our model utilises variables of different integration orders following application of various unit root testing, it this possible that results of earlier studies, such as Mungule (2004) could be biased due to 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.

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%.**

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 important in explaining the exchange rate using the general to specific approach. The general to specific approach is carried out 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 till we arrive at a model with only significant variables. The parsimonious model is shown in Table 7. The results from the general to specific ARDL model, shows that the expansionary monetary policy is not significant in explaining the exchange rate (the money supply variable is not included as 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, 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 Meese and Rogoff (1983) who argue that exchange rate models cannot explain the trend of exchange rates. Therefore, we 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.

4.5 Results of the diagnostic checks

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

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

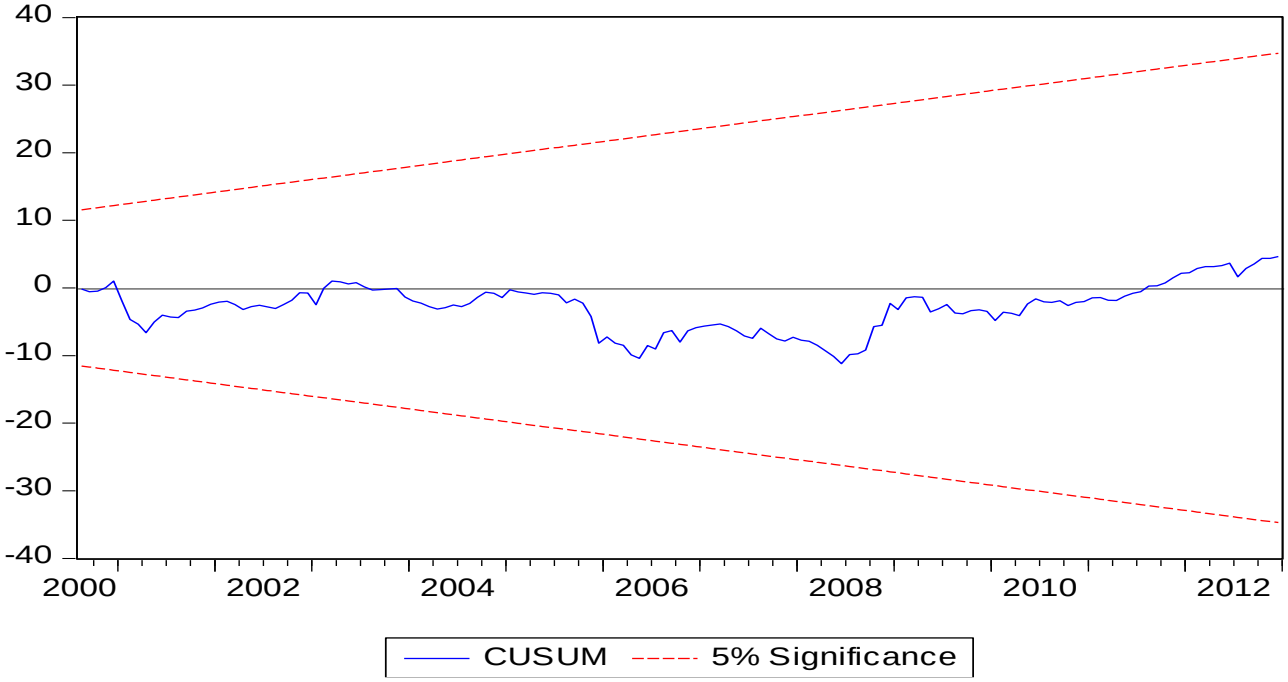
Table 9: White's Hetereskedasticity Test

F-statistic	**1.537132**	**Pro.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 of the White test is that the variance of the disturbance term is homoskedastic

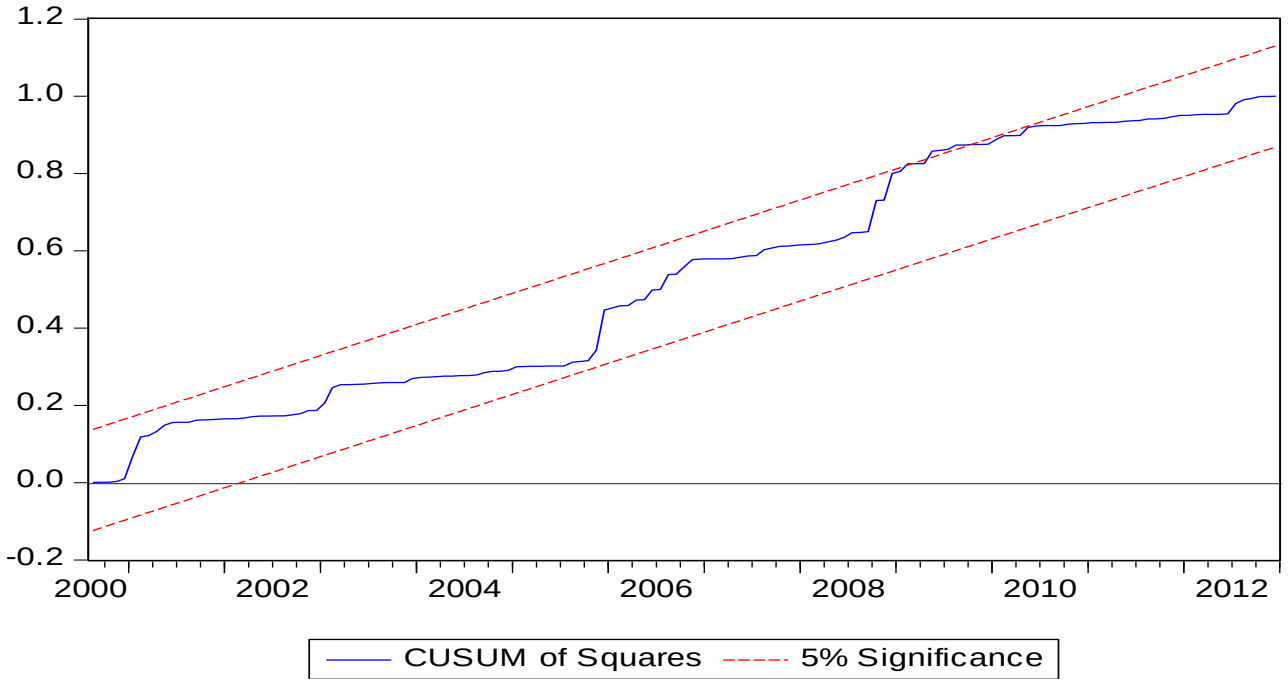
To test for parameter stability in recursive residuals, we used the CUSUM test and CUSUM of squares test. Figure 3 shows the CUSUM test results for the ARDL specification and Figure 4 shows the results of the CUSUM of squares test, both figures show that there is no parameter instability in the model**.** 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 Chapter, 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 carried out tests for serial correlation and heteroskedasticity. Both tests confirm that the model is appropriate. Finally, the CUSUM and CUSUM of squares tests have shown that the parameters of this model are stable. Having established the veracity of our model, we conclude the paper in the next Chapter.

CHAPTER FIVE: CONCLUSION

This paper conducts 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 investigates whether the overshooting hypothesis holds for the USD-ZMK exchange rate. In addition, the study tests if there is a long-run equilibrium relationship between the USD-ZMK exchange rate and the macroeconomic fundamentals (money supply, real Gross Domestic Product (GDP), interest rates and inflation rates). The study utilises a data set that spans a thirteen year period from January 2000 to December 2012.

This paper adopts the ARDL methodology as developed by Nieh and Wang (2005) 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 (Pesaran *et al.,* 2001). It has the 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). Thus, the ARDL model has gained popularity and is widely used in literature to examine cointegration relationships among economic variables.

Based on the results of the test statistics, the study finds no evidence of exchange rate overshooting. The result further shows that there is no evidence of 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.

The absence of long run equilibrium relationship supports one of the most significant studies in exchange rate determination, that is, Meese and Rogoff (1983) who find that structural models performed poorly in predicting exchange rate movements which 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 United States Dollars exchange rate and macroeconomic fundamentals but rather that *'movement 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 random walk but that movement is influenced by order flows and noise-trader activities with minimal role for fundamentals. To ensure that our model is robust, tests for serial correlation and heteroskedasticity confirm that the model is appropriate. In addition, the CUSUM and CUSUM of squares tests have shown that the parameters of this model are stable.

The Zambian foreign exchange market is relatively less developed (Mbululu *et al*, 2013). Therefore it is important to take this fact into consideration when interpreting results from this study. The United States 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 give a better reflection of the price of one currency in terms of the other.

To get a better appreciation of the long-run equilibrium relationship between the exchange rate and the macroeconomic fundamentals, the recommendation is that studies utilizing the ZAR/ZMK exchange rate should be considered. This is due to the mentioned trade flows and proximity between South Africa and Zambia. Whilst the USD/ZMK exchange rate has been utilised here, it must be pointed out that the trade flows between the United States and Zambia are less than between South Africa and Zambia. However, the fact that the United States dollar is a vehicle currency lends credence to the choice of the exchange rate pair utilised in this study.

REFERENCES

African Development Bank. (2007). *African Fixed Income Guidebook*. Retrieved from: http://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/24108323-EN-ADB-GUIDEBOOK.PDF Accessed: 30 March 2013.

Akiba, H. (1996). Exchange-rate sensitive demand for money and overshooting. *International Economic Journal,* **10**, 119–129.

Backus, D. (1984). Empirical models of the exchange rate: separating the wheat from the chaff. *Canadian Journal of Economics*, **17**, 824–846.

Bahmani-Oskooee, M. (1998). Do exchange rates follow a random walk process in Middle Eastern countries? *Economics Letters*, **58**, 339–344.

Bahmani-Oskooee, M. & Gelan, A. (2009). How stable is the demand for money in African countries? *Journal of economic studies*, **36**(3), 216 – 235.

Bahmani-Oskooee, M. & Hajilee, M. (2010). On the relation between currency depreciation and domestic investment, *Journal of post Keynesian economics*, **32**(4), 645-660.

Bahmani-Oskooee, M. & Kara, O. (2000). Exchange rate overshooting in Turkey. *Economics Letters,* **68**, 89–93.

Bahmani-Oskooee, M. & Panthamit, N. (2006). Exchange rate overshooting in East Asian countries. *Emerging Markets Finance and Trade,* **42**(4), 5-18.

Bhandari, J. S. (1985). A look at 'Overshooting' in a two-tier float exchange rate system. *Economics Letters,* **19**, 57–61.

Bildirici, M.E. & Kayikci, F. (2012). Economic growth and electricity consumption in emerging countries of Europa: An ARDL analysis. *Economic Research*, **25**(3), 538-558.

Bjørnland, H.C. (2009). Monetary policy and exchange rate overshooting: Dornbusch was right after all. *Journal of International Economics*, **79**(1), 64–77.

Brown, R. L., Durbin, J. & Evans, J. M. (1975). Techniques for testing the constancy of regression relationships over time, *Journal of the Royal Statistical Society, Series B*, **37**, 149-192.

Chipili, J.M. (2009). *Modelling exchange rate volatility in Zambia.* Retrieved from http://www.csae.ox.ac.uk/conferences/2009-EDiA/papers/377-Chipili.pdf Accessed: 30 March 2013.

Clarida, R. & Gali, J. (1994). Sources of real exchange rate fluctuations: How important are nominal shocks? *Carnegie-Rochester Conference Series on Public Policy*, **41**, 1-56.

de Bruyn, R., Gupta, R. & Stander, L. (2013). Testing the monetary model for exchange rate determination in South Africa: Evidence from 101 years of data, *Contemporary Economics,* **7**(1): 5-18.

Dickey, D. A. & Fuller, W. A. (1981). Likelihood ratio statistics for autoregressive time series with a unit root. *Econometrica,* **49**(4), 1057-1072.

Dornbusch, R. (1976). Expectations and exchange rate dynamics. *Journal of Political Economy*, **84**, 1161–1176.

Dornbusch, R. (2004). Monetary policy under exchange rate flexibility. Massachusetts Institute of Technology (MIT), *Working Paper.*

Driskill, R.A. (1981). Exchange rate dynamics: an empirical investigation. *Journal of Political Economy*, **89**, 357–371.

Dube, S. (2008). Stock prices and the exchange rate in a monetary model: A ARDL bounds testing approach using South African data. *African Finance Journal,* **10**(1), 1-27.

Eichenbaum, M. & Evans, C. (1995). Some empirical evidence on the effects of shocks to monetary policy on exchange rates, *Quarterly Journal of Economics,* **110**, 975-1010.

Elliott, G., Rothenberg, T. J. & Stock, J. H. (1996). Efficient tests for an autoregressive unit root. *Econometrica,* **64**(4), 813-836.

Enekwe, C. I., Ordu, M, M. & Nwoha, C. (2013). Effect of exchange rate fluctuations on manufacturing sector in Nigeria. *European Journal of Business and Management,* **5**(22) 67-73

Flood, R. P. (1981). Explanations of exchange rate volatility and other empirical regularities in some popular models of the foreign exchange market, *National Bureau of Economic Research Working paper number 625*. Retrieved from: http://www.nber.org/papers/w0625.pdf Accessed: 30 March 2013.

Flood, R.P. & Taylor, M.P. (1996). Exchange rate economics: what is wrong with the conventional macro approach? In: Frankel, J.A., Galli, G. & Giovannini, A. (Eds.), *Micro Structure of Foreign Exchange Markets*, The University of Chicago Press.

Frankel, J.A. (1979). On the mark: A theory of floating exchange rate based on real interest differentials. *American Economic Review*, **69**, 610–627.

Frenkel, J. & Rodriguez, C.A. (1982). Exchange rate dynamics and the overshooting hypothesis, *IMF Staff Papers,* **29**, 1-29.

Fuinhas, J. A. & Marques, A .C. (2012). Energy consumption and economic growth nexus in Portugal, Italy, Greece, Spain and Turkey: an ARDL bounds test approach (1965–2009). *Energy Economics*, **34**, 511-517.

Ghatak, S. & Siddiki, J. U. (2001). The use of the ARDL approach in estimating virtual exchange rates in India, *Journal of Applied Statistics*, **28**(5), 573-583.

Goldfajn, I. & Gupta, P. (2001). Overshootings and Reversals: The role of monetary policy. *Central Bank of Chile working paper*, **126,** 279–302. Retrieved from: http://www.comisiondistorsionesdeprecios.cl/eng/studies/working-papers/pdf/dtbc126.pdf. Accessed: 30 March 2013.

Granger, C. W. J. & Newbold, P. (1974). Spurious regressions in econometrics. *Journal of Econometrics,* **22**(2), 111-120.

Gujarati, D. N. (2003). *Basic Econometrics*, 4th ed., New York: McGraw-Hill.

Hacche, G. & Townend, J. (1981). Exchange rates and monetary policy: modeling Sterling's effective exchange rate, 1972–1980. In: Ellis, W.A. & Sinclair, D.J.N. (Eds.), *The Money Supply and Exchange Rate*, Oxford University Press, Oxford.

Heinlein, R. & Krolzig, H. (2011). Effects of monetary policy on the $/£ exchange rate. Is there a 'delayed overshooting puzzle'? School of Economics, University of Kent, Canterbury. [Online] Retrieved from http://www.eui.eu/Documents/DepartmentsCentres/Economics/Researchandteaching/Conferences/TSEConference-NewDevelopmentsinTimeSeries/Krolzig.pdf. Accessed: 20 August 2013.

Karim, B. A. & Majid, M. S. A. (2010). Does trade matter for stock market integration? *Studies in Economics and Finance,* **27**(1), 47 – 66.

Kim, S. & Roubini, N. (2000). Exchange rate anomalies in the industrial countries: A solution with a structural VAR approach, *Journal of Monetary Economics*, **45**, 561-586.

Kodongo, O. & Ojah, K. (2012). The dynamic relation between foreign exchange rates and international portfolio flows: Evidence from Africa's capital markets, *International Review of Economics and Finance*, **24**: 71-87.

Kustra, T. (2005). *Overshooting and the Canadian exchange rate.* Retrieved from http://qed.econ.queensu.ca/pub/students/rodrigue/826/kustra8262.pdf Accessed: 30 September 2013.

Kwiatkowski, D., Phillips, P., Schmidt, P. & Shin, Y. (1992). Testing the null hypothesis of stationary against the alternative of a unit root. *Journal of Econometrics,* **54**, 159-178.

Majid, M, S, A. & Yusof, R. M. (2009). Long-run relationship between Islamic stock returns and macroeconomic variables: An application of the autoregressive distributed lag model", *Humanomics,* **25**(2), 127 – 141.

Mbululu, D., Auret, C. & Chiliba, L. (2013). Do exchange rates follow random walks? A variance ratio test of the Zambian foreign exchange market. *Southern Africa Business Review Journal*, **17** (2), 45-66.

Meese, R. A. & Rogoff, K. (1983). Empirical exchange rate models of the seventies: Are any fit to survive? *Journal of International Economics,* **14**, 3-24.

Mishkin, F. (2006). *The Economics of Money, Banking and Financial Markets*. Seventh Ed. Boston: Pearson Addison Wesley.

Mkenda, B. K. (2001). Long-run and short-run determinants of the real exchange rate in Zambia. *Working Papers in Economics*, *40*, Department of Economics, Goteborg University.

Mungule, K. O. (2004). The determinants of the real exchange rate in Zambia, *AERC Research Paper,* **146.**

Newey, W. K. & West, K. D. (1994). Automatic Lag Selection in Covariance Matrix Estimation. *Review of Economic Studies*, **61**(4), 631-53.

Ng, S. & Perron, P. (2001). Lag length selection and the construction of unit root tests with good size and power. *Econometrica,* **69**(6), 1519-1554.

Oduor, J. (2009). *Exchange rate overshooting and its transmission through the monetary policy in Kenya*. Aachen: Shaker Verlag.

Oduor, J. (2008). *Impacts of the real exchange rate misalignments on trade creation and diversion within regional trading blocs*: The case of COMESA. Aachen: Shaker Verlag.

Papell, D. H. (1984). Activist monetary policy and exchange rate overshooting: The Deutsche Mark/Dollar Rate, *National Bureau of Economic Research Working paper,* **1195**. Retrieved from: http://www.nber.org/papers/w1195.pdf? Accessed: 30 March 2013

Papell, D.H. (1988). Expectations and exchange rate dynamics after a decade of floating. *Journal of International Economics*, **25**, 303–317.

Park, G. (1997). Short run and long run dynamics of exchange rates with sticky prices. *Review of International Economics*, **5**, 478–481.

Pesaran, M. H. & Pesaran, B. (1997). *Working with Microfit 4.0: interactive econometric analysis*. Oxford University Press.

Pesaran, M. H., Shin, Y & Smith, R. J. (1996). Testing for the existence of a long-run relationship. University of Cambridge, department of applied economics. *DAE working paper*, **9622**.

Pesaran, M. H., Shin, Y & Smith, R.J. (2001). Bounds testing approaches to the analysis of long-run relationship. *Journal of Applied Econometrics,* **16**, 289–326.

Phillips, P. C. B. & Perron. P. (1988). Testing for a unit root in time series regression. *Biometrika,* **75**(2), 335-346.

Pierdzioch, C. (2004). Productivity shocks and delayed exchange-rate overshooting. Kiel Institute for World Economics, *Kiel working paper,* **1199**.

Pilbeam, K. (2006). *International Finance*. Third Ed. Hampshire: Palgrave MacMillan.

Pippenger, J. (2009). Dornbusch was wrong: There is no convincing evidence of overshooting, delayed or otherwise. *Departmental Working Papers,* Department of Economics, University of California Santa Barbara.

Pippenger, J. (2008). Freely floating exchange rates do not systematically overshoot, *Journal of International Finance and Economics*, **8**(4), 37-56.

Pratomo, W. A. (2005). Exchange Rate of Indonesia: Does Rupiah Overshoot? Retrieved from http://mpra.ub.uni-muenchen.de/7381/ Accessed: 30 September 2013.

Quantitative Micro Software, LLC. (2009). *EViews illustrated for version 8*. Retrieved from http://www.eviews.com/illustrated/EViews_Illustrated.pdf Accessed: 30 September 2013.

Rogoff, K. (2002). Dornbusch's overshooting model after twenty-five years. Unpublished paper, *Washington: IMF Working Paper*.

Romer, D. (2006). *Advanced Macroeconomics*, Third Ed. New York: McGraw-Hill Irwin.

Sakyi, D. (2011). Trade openness, foreign aid and economic growth in post-liberalisation Ghana: An application of ARDL bounds test. *Journal of Economics and International Finance*, **3**(3), 146-156.

Shahbaz, M. (2010). Income inequality-economic growth and non-linearity: A case of Pakistan, *International Journal of Social Economics,* **37**(8), 613 – 636.

Sichei, M.M., Gebreselasie, T. G. & Akanbi, O. A. (2005). An econometric model of the Rand-US dollar nominal exchange rate. University of Pretoria, *Department of Economics Working Paper: 2005-14*.

Simwaka, K. (2004). Monetary model of exchange rate: Empirical evidence from Malawi. Reserve Bank of Malawi, *Working Paper Series*.

Sims, C. A. (1992). Interpreting the macroeconomic time series facts: The effects of monetary policy, *European Economic Review*, **36**, 975-1011.

Srinivasan, P. & Kalaivani, M. (2013). Exchange rate volatility and export growth in India: An ARDL bounds testing approach. *Decision Science Letters,* **2**(3), 191-202.

Tiwari, A.K., Shahbaz, M. & Islam,F. (2013). Does financial development increase rural-urban income inequality? Cointegration analysis in the case of Indian economy, *International Journal of Social Economics*, **40**(2), 151 – 168.

Tu, W. & Feng, J. (2009). An overview study on Dornbusch's overshooting hypothesis. *International Journal of Economics and Finance,* **1**(1), 110-116.

White, Halbert (1980).A heteroskedasticity-consistent covariance matrix and a direct test for heteroskedasticity, *Econometrica*, **48**, 817-838.

Wong, K. N. & Tang, T.C. (2008). The effects of exchange rate variability on Malaysia's disaggregated electrical exports. *Journal of Economic Studies,* **35**(2), 154 – 169.