

**The relationship between commodity price volatility and  
exchange rate stability in a single commodity dependent  
economy: The case of Zambia**

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## **Abstract**

This study examines the empirical relationship between monthly spot copper price movements and monthly Zambian Kwacha / US Dollar spot exchange rates, for the period January 2005 to February 2015. The ARDL bounds short-run estimate reveals there is both positive and negative coefficient interaction of copper price movements on the exchange rates in the short-run. However, the overall impact of copper prices on the exchange rate, is not significant in the short-run. The ARDL bounds test also confirms the presence of a long-run relationship between copper prices and the exchange rate. The coefficient estimates reveal that both the consumer price index and the terms-of-trade have a statistical weak impact on the exchange rate in both the short and long run. The study finds that Zambia's GDP has a negative impact on the exchange rate in the short-run, but has a statistically significant positive long-run effect. China's GDP, used as a proxy to capture foreign demand for copper, has both a positive and negative interaction on the exchange rate in the short-run and a negative effect in the long-run.

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## List of acronyms

ARDL	Autoregressive Distributed Lag
BOZ	Bank of Zambia
CPI	Consumer Price Index
CUSUM	Cumulative Sum
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
KCM	Konkola Copper Mines
LME	London Metal Exchange
OECD	Organisation for Economic Cooperation & Development
OLS	Ordinary Least Squares
REER	Real exchange rate
SI	Statutory Instrument
TOT	Terms-of-trade
USD/ \$	United States Dollar
ZAR	South African Rand
ZMW	Zambian Kwacha

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## 1.0 Introduction

In recent decades, exchange rate regimes have been at the centre of policy debates in developed and developing economies, as countries abandoned fixed exchange rates and globalised (Edwards *et al.*, 1999). A flexible exchange rate regime allows a country to have an independent monetary policy, providing the economy with the flexibility to accommodate domestic and foreign shocks, including changes in external terms of trade and interest rates (*ibid*). Within the context of emerging economies, floating exchange rates are associated with higher variability than fixed exchange rates (Flood *et al.*, 1995). McKinnon (1988), reports that exchange rate stability is an important factor in building investor confidence, promoting trade and providing a measure of predictability that is essential for commerce to flourish. However, many developing countries suffer from weakly developed financial markets and institutions, and the absence of deep foreign exchange markets, consequently adopting free floating exchange rates is problematic (Masson, 2001). Compounding this dilemma is the inconclusive relationship between economic fundamentals and exchange rates evidenced by numerous and continual theoretical and empirical literature on the subject and thus, exchange rates have been one of the most widely debated topics in international finance, manifesting in numerous empirical puzzles such as the Meese and Rogoff (1983) forecasting puzzle, and the purchasing power parity puzzle (Chen *et al.*, 2003). It has also been argued that the only sustainable regime is a ‘free floating’ exchange rate or monetary unification. This is because contingent policy rules to reach explicit exchange rate targets are no longer viable, and countries are forced to choose between floating exchange rates on the one hand and monetary unification on the other (Masson, 2001). This is part of Mundell Flemings trilemma or impossible trinity, which suggests that it is impossible to have a fixed foreign exchange rate, free capital movement, and an independent monetary policy, all at the same time. Rather if a country chooses a fixed exchange rate and free capital movement, it would certainly have to forego, an independent monetary policy. Purely floating and fixed exchange rate systems are only two of a range of possible exchange rate regimes. Hence, the profusion of exchange rate systems and the blurred boundaries between many of them makes any attempt to empirically determine the merits of alternative regimes difficult (Edwards *et al.*, 1999).

Achieving and maintaining exchange rate stability is a daunting task for monetary authorities, and this can be further complicated by having a commodity-based export sector, coupled with a limited or underdeveloped industrial and commercial sector (Allen *et al.*, 2005). This is because commodity exporters tend to be price takers (Chen *et al.*, 2003); and consequently, policy makers are plagued with questions regarding the determinants of commodity price trends and variability (Deaton, 1999). McKinnon (1988), also states that exchange rate stability is necessary in avoiding dissatisfaction with fluctuating relative currency values, which in extreme cases, could necessitate

the introduction of protectionist policies. However, such measures often create a bias against tradables, especially exports and ultimately prevent the achievement of attainable growth rates (Yeats *et al.*, 1991). From a policy stand point, the evidence of exchange rate uncertainty adversely affecting trade flows especially in developing countries, may compel governments to intervene in foreign currency markets, to stabilise exchange rates as severe fluctuations have the potential to affect the design of appropriate macroeconomic policies (Chipili, 2013). Schinasi (2003), notes that monetary authorities have a natural role to play in ensuring financial stability and the key choice is deciding the extent to which they can intervene to ensure financial and monetary stability.

Allen *et al.* (2005), advise that determining the extent of intervention is largely guided by monetary policy. In the case of ‘commodity currencies’, formulating the right monetary policy can be achieved by understanding the long-run and short-run relationship between commodity price volatility and exchange rates (Lee, 2012). Many developing countries depend on primary commodities for a significant share of their export earnings and thus, the wild fluctuations of global commodity prices are likely to account for a large share of these countries’ terms-of-trade shocks and may have a critical influence on the value of their currencies (*ibid*). Moreover, emerging countries with production and trade structures concentrated on commodities are vulnerable to price swings, and the issue of rising commodity price volatility is policy relevant (Calvo-Gonzalez *et al.*, 2010). Therefore, a deeper understanding of exchange rate responses to world commodity prices is crucial for countries that rely heavily on commodity exports, as it may contribute to monetary policy decisions and strategies for globalization (Lee, 2012).

The currency of a country is termed a ‘commodity currency’ when its value moves in sympathy to commodity price cycles and when its exports are largely commodity-based (Chen *et al.*, 2003; Clements *et al.*, 2008). By this definition, it can be inferred that the Zambian Kwacha, is a ‘commodity currency’. This is attributed to the fact that over ninety percent of exports are commodities of which over seventy percent is copper, with copper mining and other mining related activities accounting for 10% of Zambia’s GDP (Chipili, 2015). While the exchange rate has exhibited, a rising trend with considerable fluctuations, the value of trade has been on a rising trend (Chipili, 2013). Zambia, adopted a ‘free floating’ exchange rate regime in 1992 but the country’s foreign exchange market is largely underdeveloped and virtually non-existent hedging instruments (Chipili, 2013). In addition, Zambian exporters are unable to influence the price in the export markets, and most exporters have long-term contractual commitments which cannot be reneged upon without facing severe financial consequences (*ibid*). Hence, the country’s over-reliance on commodity exports heightens the risk of exchange rate instability “Dutch Disease”.

## 2.0 Problem definition

Sub-Saharan Africa has two primary challenges; first, dependence on relatively few export products; and second, declining market share and volatility of commodity prices (Combes *et al.*, 2002). This dependency is accompanied by general economic instability evidenced by exchange rate volatility, reflecting the intuition that if volatility matters, it should do so in countries most dependent on primary products (Bleaney, 2001). Deaton (1999), reports economic instability not only derails the economic progress of commodity exporting countries, but also shifts the attention of policy and monetary authorities to short term interventions meant to address exchange rate instability. However, policy interventions may not always succeed and in some cases, may increase exchange rate volatility, particularly when central banks intervene without notifying the public (Dominguez, 1998).

With regards to Zambia, the ineffectiveness of policy intervention to curb exchange rate volatility has been evidenced by the number of monetary statutory instruments that have been implemented and revoked in the last five years, as well as the apparent instability and excessive variability of the exchange rate prior, during and after intervention (Shula, 2015). There may be several reasons why policy intervention has not ‘cured’ exchange rate instability in Zambia, but the primary two are the country’s dependence on a limited basket of commodity exports, mainly copper; and because the country is a price taker on the global commodity market (Chen *et al.*, 2003). Emerging economies that are dependent on commodity exports, such as Zambia, require local and foreign direct investment to develop, industrialize and move away from resource dependency (Bwalya, 2006). One of the most pronounced reasons for providing fiscal incentives to attract foreign direct investment (FDI), is because this form of investment is a particularly effective conduit for technology and skills transfer through technology spill-overs to domestically owned firms in the host country, FDI is thought of as a composite bundle of capital stocks, know-how, and technology (Mello, 1997). However, FDI is negatively affected by exchange rate instability (Bleaney, 2001). Existing empirical evidence suggests that commodity export prices have a strong bearing on the real exchange rates, particularly flexible exchange rates (Chipili, 2015). Taggart *et al.* (1998), state that instability has implications on investor confidence, trade levels, competitiveness, and the balance of payments.

Since the 1970’s, the Zambian Government has formulated and implemented various diversification strategies, but despite a good performance in non-traditional exports over this past decade, copper still accounts for 70% of Zambia’s exports (Shula, 2015). The dependency on copper mining in Zambia, compounded by falling world copper prices and the possible withdrawal of investment from the mining sector, may seriously threaten long term economic growth and

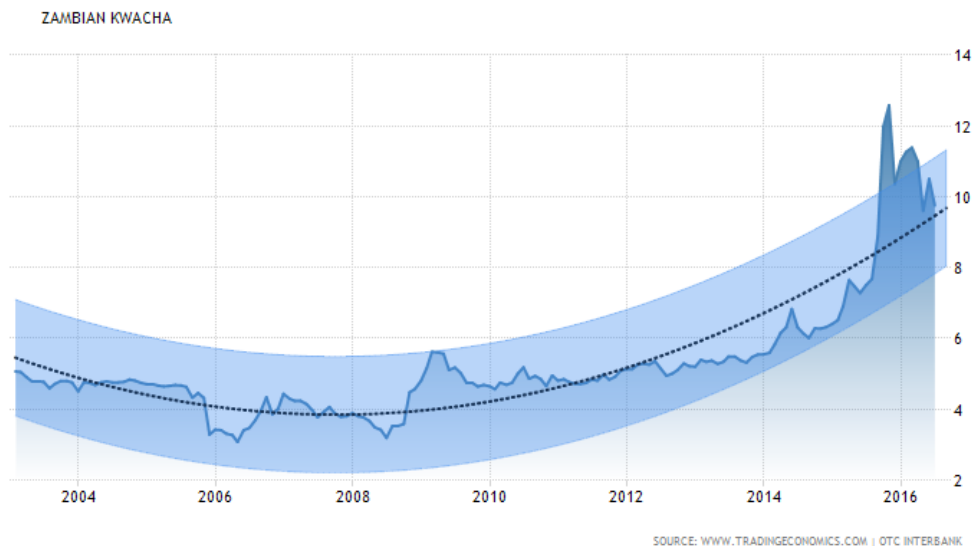
stability (Lofgren *et al.*, 2003; Central Statistics Office, 2015). In addition, the country has been negatively affected by the sharp reduction in the price of important agriculture commodities such as cotton and tobacco (Shula, 2015). In 2014, the Bank of Zambia current account registered a deficit of US \$431 million, compared to a deficit of US \$284 million in 2013, and over the same period the decline in export earnings is attributed to a contraction of 7.8% in copper earnings, preceded by declining export volumes and averaged realized copper prices (*ibid*). Furthermore, the projected slow-down in China’s economy beyond 2015, will negatively affect the country’s copper exports and will result in adverse negative effects on the exchange rate and inflation (Ademola *et al.*, 2009).

Table 1: Zambia’s metal exports & non-traditional exports

Group	January 2005		June 2016	
	Value	Percentage	Value	Percentage
	K’ million	share %	K’ million	share %
Traditional exports - metals	479.9	84	3,614.8	69.5
Non-traditional exports	93.3	16	1,584.3	30.5
Total exports	573.2	100	5,199.1	100

Source: Central statistics office: <http://www.zamstats.gov.zm/gen/monthly.php>

Figure 1 below represents ZMW/USD exchange rate over the period of January 2005 to June 2006 and Figure 2 shows the trend of copper prices during the same period. Figure 2 shows a general downward trend in copper prices accompanied by frequent levels of volatility, whereas figure 1 shows a general upward trend or increase in the bilateral exchange rate of the ZMW/USD currency pairing, characterised by levels of volatility. The graphs suggest that while copper prices are trending downwards, the exchange rate of the Zambian Kwacha against the United States Dollar is increasing i.e. reduction in copper prices is accompanied by depreciation of the ZMW. This observed trend between the two variables, copper prices and ZMW/USD exchange rate, suggests a relationship that warrants an empirical investigation, further necessitated by the country’s dependency on copper exports.



**Figure 1:** Trends in ZMW/USD exchange rate, 2005 - 2016



**Figure 2:** Trends in copper spot prices USD/ per tonne, 2005 - 2016

Evidently, Zambia is dependent on copper export for economic growth and considering this in conjunction with the country's free floating exchange rate regime and open economy, it can be assumed, that the dependency on copper export represents a risk of exchange rate instability. This research thus seeks to establish if there exists a relationship between the spot price of copper and the ZMW/USD spot real exchange rate, and to determine the nature of this relationship. The results of this study may be used to design appropriate policy responses that will ensure that impulses to copper prices do not negatively undermine the overall competitiveness of the Zambian economy (Chipili, 2015).

### **3.0 Statement of research questions**

#### 3.1 Research questions

##### 3.1.1 Primary research questions

The primary research questions that this research seeks to investigate is:

*What is the empirical relationship between monthly spot copper price movements and the monthly Zambian Kwacha / US Dollar spot exchange rate over the period of January 2005 – February 2015?*

##### 3.1.2 Secondary research questions

To further explore the primary research question, the study will also examine the following sub-questions:

1. Do copper price movements have a long-run or short-run effect on exchange rate stability in Zambia?
2. Do copper price movements have a significantly positive or negative effect on the exchange rate in Zambia?

## 4.0 Justification of the study

### 4.1 Motivation for the study

Many emerging countries remain overwhelmingly dependent on income from commodity exports, and for commodity dependent economies the fundamental determinant of their real exchange rate are real commodity prices (Cashin *et al.*, 2004). To counter exchange rate instability, the Bank of Zambia has instituted several policy directives to stabilise the exchange rate. These policies have largely been unsuccessful and some have been revoked. For example, to curb the demand of the United States dollar, and in turn arrest the rising exchange rate, statutory instrument number 33 of 2012 was enacted to prohibit quoting and paying of goods and services in foreign exchange (Bank of Zambia, 2015). Though well intentioned, this policy has only been partially successful because merchants simply quote prices in local currency referenced to the prevailing ZMW/USD exchange rate. Statutory instrument number 32 of 2013, was then enacted to further reduce the pressure of foreign exchange and exchange rate instability, it was mainly directed at mining companies which are Zambia's main foreign exchange earners, with the aim of compelling companies to register all foreign loans, provide scheduled repayments in advance, and notify the central bank of any dividends, royalties, management fees and other foreign obligations (Bank of Zambia, 2015). In addition, SI 32 required all companies to make import and export declarations to enable the central bank take note of all foreign exchange proceeds, and for commercial banks to monitor these transactions and conduct further due diligence on importing and exporting companies. However, Statutory instrument number 32 was revoked within a few months (through the enactment of SI number 55), due to the complexity of implementation and the challenges experienced by all stakeholders with regards to monitoring imports and exports and matching foreign exchange inflows with exports (Bank of Zambia, 2015). These policies and policy revocations have had a negative impact on investor confidence and FDI in mining and mining related activities, as well as in agriculture and commercial sectors. It is also important to note that in economies like Zambia, with free floating exchange rates and inflation targeting monetary policies, the reversal in trade balances aggravated by capital outflows, leads to currency depreciation (Bova, 2012).<sup>1</sup>

These examples highlight the importance of understanding the impact and consequences of the developing countries' exchange rate vulnerability to the volatility of commodity prices (Combes *et al.*, 2002). Foreign exchange policy shocks are found to be a more important source of the exchange rate fluctuation than conventional monetary policy shocks and controlling for inflationary pressure should be important, since monetary policy shocks may reflect some inflationary pressure that also leads to the exchange rate depreciation (Kim, 2003). Therefore, understanding the impact of commodity price volatility on exchange rates is relevant for Zambia and may lead to the formulation of effective and adaptive sterilization policies.



## 4.2 Relevance of the study

Chen *et al.* (2003), advise that the effects of commodity price shocks on exchange rates are of considerable interest to commodity exporting countries. Combes *et al.* (2002), note that the persistent volatility of commodity prices is seen by many as a source of vulnerability for commodity export countries and this vulnerability can impede growth. Deaton (1999), states that without understanding the nature of commodity prices it is difficult to construct good policy rules. The natural endowment of commodities is normally country specific and this warrants the need for country specific case studies to be undertaken. Although, there are several country-specific studies that have been conducted to understand the relationship between commodity price volatility and exchange rates, most of these studies have been done with regards to developed countries (Lee, 2012).

In contrast, this study is conducted from the perspective of a single commodity dependent Sub-Saharan economy, and will thus be relevant to single commodity export economies in developing countries. Furthermore, in contrast to some studies conducted within the context of African economies, this study examines the relationship of commodity price volatility and exchange rate stability from the perspective of hard and not soft commodities<sup>1</sup>. Although some commodities are important across several countries, such as cotton, coffee, diamonds, oil, and gold, the mix varies greatly from country to country, and some commodities are important only to one or two countries, such as uranium in Niger, phosphates in Togo, or iron ore in Mauritania (Deaton, 1999). Recognising the diversity of commodity exports in Africa is important because prices of different commodities do not move in parallel, and therefore, the use of commodity price indices is more relevant to industrialized importers than for exporters, whose individual experiences are different (*ibid*).

Moreover, there is less literature devoted to the link between exchange rates and world prices of commodities (Clements *et al.*, 2008). Since Zambia's exports are dominated by commodities, particularly copper, the volatility in global prices of copper and the influence copper price volatility has on the country's bilateral exchange rates should be of concern to monetary policy makers in Zambia. Exchange rate stability is an important factor in Zambia, which is a net importer of food and intermediate inputs for production and in the absence of effective hedging

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<sup>1</sup> The term "hard commodities" refer to minerals and metals e.g. iron ore, gold, silver and copper; whereas, the term "soft commodities" refer to agricultural products such as tea, coffee, cotton as well as livestock (Kaplinsky, 2005).

mechanisms, volatility can erode private sector balance sheets on both cash flows and asset values (Shula, 2015).

Commodity price volatility is affected by a range of determinants, in both the short-run and long-run, that includes real income, money supply, inflation, interest rates, terms of trade, and openness (Pindyck, 2001; Chipili, 2015). The persistent volatility of commodity prices is seen by many emerging countries as a serious source of vulnerability (Combes *et al.*, 2002). Consequently, the term ‘resource curse’ is attributed to the volatility in commodity prices as opposed to the abundance of the resource itself (Cavalcanti *et al.*, 2015). Hence, the volatility of commodity terms of trade is particularly important for primary commodity export countries, where resource revenues are highly volatile due to their exposure to global commodity market swings (*ibid*). Furthermore, the “commodity currency” literature highlights the robust exchange rate responses to fluctuations in world commodity prices (Lee, 2012). Exchange rate stability is often viewed as being favourable to trade and therefore enhances general welfare.

In the context of Zambia, the most recent and relevant study is Chipili (2015) who examines the relationship between copper prices and exchange rates for the period 1994 – 2012. However, this study differs from Chipili in several respects, methodology and variables used. Also, in line with recommendations by Tokarick (2008), the study makes use of the changes in terms of trade. Secondly, the study reveals whether copper price movements have a long-run or short-run effect on exchange rate stability in Zambia using the ARDL approach in contrast to Chipili, who uses the VECM methodology. Thirdly, this study focuses on the period post introduction of the broad interbank foreign exchange market mechanism introduced in 2003 by Bank of Zambia.<sup>2</sup> It is envisaged that the results of this study will lead to a deeper understanding of the short-run and long-run associations between exchange rate instability and copper-price volatility within the context of Zambia.

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<sup>2</sup> Prior to this period, the market had experimented with several exchange rate trading mechanisms but these were hindered by inefficiencies (Shula, 2015).

## **5.0 Literature review**

This literature review discusses the theoretical and empirical studies that explore the relationship between commodity prices and exchange rates. The review is divided into three sub-sections that discuss cross-country studies, emerging country studies, and empirical studies on Zambia. Each sub-section is concluded with a summary, and this is supplemented with a conclusion of the literature review at the end of this chapter.

### **5.1 Theoretical studies on commodity price volatility and exchange rates**

The theoretical studies highlight and examine the relationship between commodity prices and exchange rates by reviewing contemporary theoretical strands on the subject and discussing their hypothesis. An attempt is made to show how studies link or relate to one another.

Taggart *et al.* (1998) explores the relationship between stability of the exchange rate and competitiveness by considering two hypotheses: first, that a stable currency is good for businesses; and second, that a stable exchange rate reinforces anti-inflationary policy. According to Taggart *et al.*, the concept of a 'balance' in competitiveness advocates and asserts that a stable currency exchange rate is good for business competitiveness because firms operating under exchange rate stability will have a competitive advantage over companies operating in economic environments characterised by exchange rate instability. Furthermore, exchange rate stability will encourage internationally trading firms to focus their competitive ability on the development of new products. Taggart *et al.*, conclude that exchange rate stability is essential for exporting firms to attain and maintain performance competitiveness relative to peer exporters in other economies, which accords with Bova (2012) and Chipili (2013).

McKinnon (1998) proposes and evaluates several monetary and exchange rate policies that may be adopted to foster international financial stability. According to McKinnon, the purchasing power parity (PPP) can be a theoretical guide for central banks to promote or maintain monetary and exchange rate stability. The idea behind PPP is to calculate nominal exchange rates that would align national price level of internationally tradeable goods as approximately measured by their respective producer or wholesale price indexes (*ibid*). McKinnon concludes that unexpected exchange rate changes can impose either more inflation or deflation depending on a country's monetary and exchange rate policies. Furthermore, when exchange rates and portfolio preferences are stabilised internationally, monetary expansion or contraction at common price levels becomes more predictable. The implication is that once exchange rates are aligned to the purchasing power parity, and representatives of monetary institutions continually monitor the common price level in

international tradeable goods, then the collective monetary expansion can be tailored upward or downward, referenced to inflationary or deflationary trends at the common price level.

Edwards *et al.* (1999) assesses the relationship between exchange rate volatility and growth in emerging economies. They, argue that the optimal exchange rate regime in emerging countries has been hampered by the lack of genuine experiences with floating exchange rates; and that most exchange rate regimes classified as “floating” correspond to variations of managed systems instead. The study focusses on three aspects: first, the merits of alternative exchange rate regimes; second, the extent to which purchasing power parity (PPP) holds in the long run; and third, the implications of real exchange rate (RER) misalignment (where misalignment refers to instances when a countries’ RER is not in equilibrium with the other macro and microeconomic indicators). According to Edwards *et al.*, a country with a low inflation rate is associated with a higher currency value and its purchasing power parity is higher relative to other currencies. Furthermore, currencies with a fixed exchange rate system experiences lower average rates of inflation, and in some countries, a fixed exchange rate has been associated with a lower rate of inflation, while in other countries it has not been an effective nominal anchor. The study thus concludes that most exchange rate regimes classified as “floating” in emerging markets correspond to some form of managed system and there are still major gaps in understanding the long-run behaviour of real exchange rates in the emerging countries. The objective of assessing the extent to which PPP holds in the long-run is hampered because the time series available for the emerging countries are relatively short and, in many cases, the quality of the data is questionable. Also, alternative methods for assessing real exchange rate misalignment in developing countries are required as existing models are still subject to several limitations such as the lack of a general equilibrium connection between the equilibrium real exchange rate and the current account position of a country.

Deaton (1999) identifies and evaluates the leading explanations for the behaviour of primary commodity prices to improve the ability to forecast commodity prices so that policy makers may construct good policy rules. Deaton, states that the reasons why commodity prices behave as they do and what determines their trends and variability are central questions for policy makers in Africa. Also, although there has been progress in understanding commodity prices, the technical ability to forecast commodity prices remains inadequate. In addition, without an adequate understanding of the nature of commodity prices, it is difficult to construct good policy rules. Deaton observes that, income from commodity price booms helps the economies of African producing countries, just as they are hurt by the loss of income during slumps. Deaton thus posits that sensible development and macroeconomic policy rules for commodity exporting countries

must be grounded in an understanding of the behaviour of commodity prices. The theoretical explanation is that the impact of commodity price volatility on an exporting countries economy is said to be an exogenous factor and this is partly attributed to the fact that, developing countries export primary commodities mostly and most do not have a diversified export base. Furthermore, income elasticities for primary commodities are lower than those of manufactured items, and thus the demand for manufactured products grows more rapidly than commodities. Hence, manufacturing industries in developed countries at the 'centre' have market power that enable them to exploit commodity exporting countries at the 'periphery'. Deaton concludes that there are various accounts and interpretations of African countries' political and economic responses to commodity price fluctuations. In addition, there is a close relationship between commodity price movements and growth. However, this evidence is not exculpatory for all African governments, some which are guilty of egregiously inappropriate policies, but it is apparent that the root of Africa's slow growth also lies in both poor investment appraisal and quality government and policy.

Cashin *et al.* (2000) examine the duration of terms of trade shocks in sub-Saharan Africa. They note that a common characteristic among the commodity exporting countries of sub Saharan Africa is that movement in their terms of trade is a key determinant of macroeconomic performance, which in turn has a significant impact on real national incomes. Cashin *et al.*, posit that changes in the terms of trade have a strong impact on the macroeconomic performance and incomes of commodity exporting emerging countries. The underlying theory is that the ratio of the prices of a country's exports to the prices of its imports defines the net barter terms of trade, which measures the number of units of imports that can be exchanged for a unit of exports. They note that exports of sub Saharan African countries are dominated by primary commodities which are prone to cyclical and fundamental demand and supply shocks that lead to terms of trade shocks. The study reveals that the difficulty of predicting the likely duration of commodity price shocks limits the ability of African policymakers to manage commodity 'booms' and 'slumps'. Also, the persistence of terms of trade shocks varies widely, for half the sub Saharan African countries, shocks are short lived and for one-third of the countries such shocks are long lived. The study concludes that countries whose exports are highly concentrated in commodities are subject to long commodity price shocks that impact their real national incomes in accordance with Deaton (1999), Edwards *et al.* (1999) and Combes *et al.* (2002). Cashin *et al.*, recommend that in response to terms of trade shocks, African policymakers should make decisions that influence domestic saving rates, with the goal of smoothing the path of national consumption. This is particularly important in the case of temporary positive shocks, because increased domestic saving during a temporary

windfall can raise current and future output. Furthermore, measures of average shock duration and their associated variability can also be useful in informing domestic saving decisions.

Pindyck (2001) investigates commodity volatility and price dynamics because volatility has the potential to affect market variables by directly affecting the marginal value of storage, and by affecting a component of the total marginal cost of production. Which is the opportunity cost of exercising the option to produce the commodity at present rather than wait for additional price information. The study posits that commodity prices tend to be volatile, and volatility itself varies over time. According to Pindyck, volatility is a determinant of commodity market dynamics. The study concludes that volatility should affect market variables through the marginal value of storage and through the opportunity cost component of marginal cost. Also, market variables do little to explain volatility. Furthermore, volatility can be forecasted but is largely dependent on its own past values, which accords with Calvo-Gonzalez *et al.* (2010).

Combes *et al.* (2002), examines the consequences for developing countries' vulnerability to the volatility of commodity prices by defining and measuring a country's shocks and exposure arising from commodity price volatility. This is done to identify and define structural vulnerability distinct from policy vulnerability and present the main channels through which commodity price vulnerability influences economic growth. Combes *et al.*, advise that while structural vulnerability is bad for growth, a policy of openness contributes to resilience regarding the level of vulnerability to commodity volatility and development aid can play an important growth enhancing and poverty reduction. In addition, the study outlines the policy implications for development aid, its allocation and design that could lead to growth. Combes *et al.*, hypothesise that in general, smaller countries are more exposed to sentiments in global commodity markets and thus more vulnerable to commodity price shocks. Combes *et al.*, state that the theoretical explanation for this is that commodity exporting countries resilience to exogenous factors will essentially depend on the policies followed, and the risk that a country will be affected by commodity price volatility, is broken down into size of the shock, exposure and capacity to be resilient. The vulnerability of a commodity exporting country depends on fluctuations in world prices for its commodity exports as reflected in the instability of its terms of trade and its exposure to these fluctuations, and this is represented by the ratio of its exports to GDP i.e. its trade dependency as well as its resilience and its capacity to manage shocks effectively as they occur. The study concludes commodity price volatility have implications both for the allocation of aid among target countries, and thus structural vulnerability should be considered in allocating aid. Hence, aid will have a greater capacity for poverty reduction, if it is allocated in line with the vulnerability of a country to export price volatility. This study accords with Deaton (1999).

Clements *et al.* (2008) analyses the interactions between ‘commodity currencies’ and ‘currency-based commodities’ where a commodity currency is defined as a currency whose value moves in sympathy with world commodity prices while a currency-based commodity is defined as commodities whose prices are substantially affected by currency fluctuations. Countries that are commonly thought to have ‘commodity currencies’ include Australia, Canada, and New Zealand, as well as many developing countries that are rich in natural resources. Few studies consider the opposite case of ‘currency commodities’, whereby the value of an exchange rate of a commodity-exporting country can have an impact on commodity prices. This is commonly because commodity producers are typically price takers not price makers. Clements *et al.*, argue that when the value of the currency of a commodity exporting country moves in sympathy with world commodity prices then it is deemed to be a ‘commodity currency’. Clements *et al.*, report that a surge in resource exports leads to a real appreciation of the country’s exchange rate and vice versa, and when there is a commodity boom, the appreciation of the commodity currency benefits domestic consumers in the form of lower priced imports. In addition, a country that is a dominant exporter of a certain commodity, and whose large volumes of exports typically place downward pressure on world prices and vice versa, is considered a price maker or has market power. According to Clements *et al.*, the role of the terms of trade is probably an important element in linking the endogenous determination of both exchange rates and commodity prices, which accords with Tokarick (2008).

Rickne (2009) reviews oil price and exchange rate movements and the role of domestic legal and political institutions. According to Rickne, oil exporting countries with high bureaucratic quality and strong and impartial legal systems have real exchange rates that co-move less with the oil price movements. The study notes that empirical studies on the growth rates of countries endowed with natural resources have shown that the greater the resource endowment, the lower the level of economic growth (commonly known as “Dutch Disease”). One theoretical explanation for this paradoxical phenomenon is that the resource exporter’s real exchange rate co-moves with highly volatile commodity prices, thus when commodity prices increase, the real exchange rate appreciates and undercuts the competitiveness of the domestic industry. In turn the domestic non-resource industry base may fail to recover if the commodity price continues to decline over several price cycles. Rickne further shows that the effect of oil price movements on the real exchange rate of an oil-exporting economy depends on the degree of myopia in government spending. He thus concludes that the co-variation between the oil price and the real exchange rates of the sampled oil exporters is conditional on political and legal institutions.

In summary, the theoretical literature highlights the significance of commodity exports to emerging countries. The literature also discusses the vulnerability and the negative impact of commodity price volatility on the exchange rates of commodity exporting countries. McKinnon (1998) and Edwards *et al.* (1999) concur that commodity price volatility has implications for the economic growth prospects of developing countries. Combes *et al.* (2002) investigates the implications for vulnerability and complimented by Clements *et al.* (2008), identifies that there is a significant difference between ‘commodity currencies’ and ‘currency-based commodities’. The ability of commodity exporting countries to withstand and manage economic shocks arising from commodity volatility seems to lie within the capacity of their institutional frameworks as illustrated in the study by Rickne (2009).

## **5.2 Empirical studies on commodity price volatility and exchange rates**

This section has been divided into three segments, the first segment covers empirical cross-country studies, followed by emerging country studies, and the third segment highlights a review of an empirical study on Zambia regarding copper prices and exchange rate dynamics.

### **5.2.1 Cross – country studies**

This section discusses several empirical cross country studies that have been undertaken to investigate the relationship between commodity prices and exchange rates. The studies highlight the subject, objectives, data, as well as the methodology used. The studies also demonstrate how they relate to previous studies.

Brunetti *et al.* (1995) evaluate the view that metal’s price volatility has tended to rise over time. The study uses daily price quotations from the London Metal Exchange (LME) from a 24-year period 1972 to 1995 for copper, aluminium, nickel, lead, tin and zinc, to develop a model which relates metals volatility to the metals balance and the stock consumption ratio. Brunetti *et al.* report that the results reveal that metal price volatility is highly variable and that short-term fluctuations are impacted by speculative movements. Brunetti *et al.*, state that the results also indicate that much of the medium-term variability in the volatility of non-ferrous metals prices on the LME may be explained by physical or fundamental factors. However, this does not imply that informational factors and speculative pressure are absent from these markets, but they appear to only have short-term impacts. Brunetti *et al.*, report that despite high volatility in individual months, metals volatility was in general slightly beneath its long-term average levels in 1994-95. There is therefore no basis for the view that metals volatility is either high or that it is increasing. Thus, Brunetti *et al.*, concludes that contrary to Slate’s (1991) contention that the variability of exchange prices has increased overtime, excessive volatility is only associated with periods of



tight demands, most clearly is during the periods of 1973 to 74 (oil crisis) and 1987 to 1990 (financial crisis).

Cuddington *et al.* (1998) examines commodity price volatility across several exchange rate regimes for the period from 1880 to 1996. The objective for the study is to establish the short and long-term impacts that the fluctuations in primary commodity prices have on the world economy. The study makes use of alternative data sets on commodities collected by Grilli and Yang (1988), James Boughton (1992) and IMF's International Financial Statistics (IFS) to examine various commodity price movements during the gold standard period of 1880 to 1913; the interwar years from 1927 to 1931; and the Bretton Woods system from 1946 - 1971. The findings suggest that exchange arrangement may produce an important source of systematic risk to world commodity trade. Also, the results indicate that there is significant evidence that flexible exchange periods have been associated with higher real commodity price volatility than the fixed exchange periods. Thus, Cuddington *et al.*, concludes that exchange arrangements may derive an important source of systematic risk to world commodity trade and regime shifts play a nontrivial role in determining volatility persistence.

Chen *et al.* (2003) examines the relationship between exchange rates and commodity prices to contribute to the knowledge gap between economic fundamentals and exchange rates. They focus on three OECD economies, namely Australia, Canada, and New Zealand, where primary commodities constitute a significant share of the country's exports. The study notes that US dollar price of their commodity exports, generally exogenous to these small economies, has a strong and stable influence on their floating real rates. Using the standard Balassa–Samuelson model, they find that bilateral exchange rates exhibit significant co-movement with world commodity prices. Chen *et al.*, argue that the presence of sluggish nominal price adjustments and incomplete pass-through typically make proper identification quite impossible when the standard measures of terms of trade are used in the determination of real exchange rate rather than the exogenous commodity prices. World relative commodity prices are likely to be better at capturing the exogenous component of terms of trade shocks than standard terms of trade measures. Chen *et al.*, thus conclude that the world prices of commodity exports, measured in real US dollars, appear to have a strong and stable influence on the real exchange rates of New Zealand and Australia. However, for Canada, the relationship is somewhat less robust.

Chen *et al.* (2008), investigate whether exchange rates can forecast commodity prices by examining the predictive nature of the 'commodity currencies' of Australia, Canada, and New Zealand, South African and Chile. The methodology involves the test of present value models of

exchange rate determination by running a reverse regression. The study demonstrates that "commodity currency" exchange rates have a remarkably robust power in predicting global commodity prices, for both in-sample and out-of-sample data, and against a variety of alternative benchmarks. In-sample granger causality finds that exchange rates are predictable by their country specific commodity price indices, suggesting that exchange rates of commodity exporters can be predicted from commodity price movements.

Ploeg *et al.* (2009) examine the impact of commodity price volatility on economic growth across regions and continents for the period 1970 to 2003. The objective is to determine the impact of natural resource price volatility on economic growth measured by GDP. They group the countries as follows: North America, Western Europe, Eastern Europe and Central Asia, South Asia, Latin America and the Caribbean's, East Asia and Pacific, Middle East and North Africa and Sub Saharan Africa. The natural resources across the regions are then grouped in two categories first is fuels, and ores and metals; and the second is agriculture, raw materials and food. Using multivariate econometric analysis, the results demonstrate that countries that are natural resource dependent are more volatile. With regards to the regions, Sub-Saharan Africa and the Middle East and North Africa experience the highest volatility in commodity prices and the most significant adverse impact on economic growth. The key differentiator of this study is that the analysis also considers the degree of financial services development in each region. According to Ploeg *et al.*, Sub Saharan Africa is the most vulnerable to commodity price volatility as it is overly dependent on natural resources (the "Dutch Disease" effect), which may also induce real exchange rate volatility in accordance with Deaton (1999).

Tokarick (2008) explores the relationship between changes in the terms of trade of a commodity exporting country and the real exchange rate. The objective of the study is to determine whether the terms of trade of a commodity-exporting country could cause the relative price of nontraded goods to rise or fall, depending on the strength of income and substitution effects. Using an alternative model structure that could be used to capture how changes in the terms of trade affect the price of the nontraded good and the real exchange rate as proposed by Neary (1988). The results show a link in the relationship between changes in a country's terms of trade and its real exchange rate. Furthermore, a change in the terms of trade of a commodity exporting country could cause the relative price of nontraded to traded goods to rise or fall depending on the magnitude of substitution and income effects. Tokarick notes that some recent models, particularly those of CCS and Chen and Rogoff (2003), do not allow changes in real income to affect the price of nontraded goods. Tokarick advises that this is a significant omission because the literature on the "Dutch Disease" has emphasized the importance of changes in spending that results from an

improvement in a country's terms of trade that in turn influence the price of nontraded goods and the real exchange rate. Moreover, a rise in the price of a commodity export encourages greater production of that good as exporters seek to take advantage of attractive commodity prices. This tends to raise income and spending, which also tends to influence the price of the nontraded good, thus pushing up its price and leading to an appreciation of real exchange rate. This is referred to as the 'spending effect' in models of the "Dutch Disease".

Browne *et al.* (2010) examines the relationship between commodity prices, money and inflation using a VECM model with quarterly data covering the period of Q1 1959 to Q4 2008 for 22 basic commodities whose markets are particularly sensitive to changes in economic conditions. The study is motivated largely by recent experiences of rapid commodity price increases and the objective is to prove that a long-run dynamic relationship exists between commodity prices, consumer prices and money supply. Browne *et al.*, also argue that there has been resurgent interest in the argument that monetary conditions account for changes in commodity prices and seeks to demonstrate that monetary conditions account for changes in commodity prices. The results show that an equilibrium relationship exists whereby both commodity and consumer prices are proportional to the money supply in the long run, with causality running from commodities to inflation. Also, there exists long-run proportionality between money and consumer prices and between money and commodity prices, but commodity prices react relatively quickly following a money shock and tend to overshoot their new equilibrium values compared to the other factors. Browne *et al.*, thus conclude that it is important that monetary aggregates are brought into the analyses of the commodity price-consumer price relationship.

Groen *et al.* (2010) study commodity prices, commodity currencies and global economic developments to forecast commodity price movements. The study uses different types of factor-augmented models that use information from a large data set containing a variety of indicators of supply and demand conditions across major developed and developing countries. The results show that exchange rate fluctuations of commodity exporting countries with market based floating exchange rates (such as Canada, Australia, New Zealand, Chile and South Africa) have remarkable robust power in predicting future global commodity prices. However, while the results corroborate the notion that commodity currencies are somewhat privileged variables in terms of their predictive power, the results obtained are unable to obtain robust validation of this notion across commodity indices and across forecasting horizons. The results thus question the predictive nature of "commodity currencies" and "currency commodities".as reported by Chen *et al.* (2008) and Clements *et al.* (2008).

Calvo-Gonzalez *et al.* (2010) investigate whether commodity prices have been more volatile in the last thirty years leading up to 2009, than in periods prior to this. The study focuses on trends in commodity prices rather than their volatility characteristics, motivated by the pattern of volatility across commodities over time. The data set examines commodity price volatility for 45 commodity prices from 1789 to 2009. They use the methodology in Eichengreen (1994) to identify exchange rates regimes and a GARCH model to examine volatility. The results find heterogeneity across individual commodities, even in periods where volatility breaks are more common i.e. all commodities do not experience the same level of variation. Their analysis further shows that there are periods when structural breaks in volatility are more common such as the two world wars and the collapse of the Bretton-Woods system. Calvo-Gonzalez *et al.*, conclude that the volatility trend has been rising since the 1970's and this would have implications for welfare and the design of public policy interventions. Also, poor countries with production and trade structures concentrated in commodities are vulnerable to price swings, and that the timing and number of breaks in volatility vary considerably across individual commodities.

Ciner (2011) examines the relationship between commodity prices and inflation by using a frequency dependent regression model in which the coefficient is permitted to vary over time. The data comprises Thomson Reuter/Jeffries CRB commodity futures index to represent commodity prices and the consumer price index (CPI) to measure inflation. The frequency of the series is monthly and the data cover the period between February of 1983 and April of 2010. According to Ciner, the connection between commodity price and inflation is important for at least two reasons: firstly, commodities are frequently touted as inflation hedges, which can be used to motivate commodity investments; and secondly, if commodity prices precede general inflation in the economy they can be utilized by monetary authorities in policy decisions. The results find evidence that commodity prices are likely to contain information on expected changes in about inflation. However, in contrast to Rickne (2009) and Browne *et al.* (2010), Ciner (2011) finds no significant reverse causality from inflation to commodity prices.

Will *et al.* (2011) study the fundamental drivers of recent price trends and considers the role played by financial speculation in commodity price formation. Will *et al.*, compare similar levels of nominal price volatility that have been observed at various times since the post-war period. They note that high and volatile commodity prices have returned as a significant global issue, with the prices of many commodities returning to around their mid-2008 peaks. Will *et al.*, observes that a series of unexpected demand shocks explains most of the variation in commodity prices over recent years and while it is empirically difficult to completely rule out a causal link between speculation in commodity derivatives markets and short lived volatility in commodity prices, there

are strong grounds to conclude that speculation has not had a systematic impact on recent commodity price dynamics. The results thus imply that price volatility is an inherent characteristic of primary commodities, and it is therefore essential that policy makers in emerging countries explore manufacturing and industrialisation to diversify and insulate against commodity price shocks.

Jacks *et al.* (2011) undertake an empirical review commodity price volatility and world market integration since 1600. The objective is to demonstrate that commodity price volatility has not increased over time and that commodities have always shown greater price volatility than manufactures, and to also show that world market integration breeds less commodity price volatility. They review comparative terms of trade volatility by region, and compare trade volatility of the regions of East Asia and Pacific, Latin America and the Caribbean, Middle East and North Africa, South Asia and Sub Saharan Africa to the industrialised countries. Jacks *et al.*, calculate the terms-of-trade volatility as the standard deviation of the logarithmic change in terms of trade over each of the four decades 1960–2000. The study also incorporates the use of GARCH (1,1) model to model commodity price changes. The results reveal that there are comparatively higher terms of trade volatility in the emerging economies than the industrialised countries. Also, globalisation and market integration has led to less volatility. Jacks *et al.*, report that the impact of supply shocks in commodity-exporting countries is diminished by the integration of small local markets with large world markets; but on the other hand, by their integration into world markets, commodity-exporting countries expose themselves to world demand instability generated by cyclical booms and busts in the industrial countries. Jacks *et al.*, conclude that globalization has been good for growth in poor countries as it has reduced commodity price volatility.

Chen *et al.* (2012) investigates the predictive nature of commodity prices on real exchange rates using Bayesian model. The study uses quarterly data for Australia (from 1984:1 to 2008:1), Canada (from 1973: Q1 to 2008: Q1), Chile (from 1989: Q3 to 2008: Q1), New Zealand (from 1987: Q1 to 2008: Q1), and South Africa (from 1994: Q1 to 2008: Q1). The study uses Bayesian model averaging and least angle regression. Their results show that in accordance with Chen *et al.* (2003), the world price of primary commodity exports for commodity exporters with market based exchange rates is an important and robust determinant of their real exchange rates. According to Chen *et al.*, results show that while various combinations of macroeconomic fundamentals, including commodity prices may at times, assist to predict quarterly exchange rate changes, no single specification emerges as the clear dominant combination. Also, despite inducing strong contemporaneous currency responses, commodity prices reveal little about subsequent exchange rate movements a quarter ahead. The results confirm the impact of commodity price volatility on

exchange rates but raises questions on the long run relationship and long run predictive nature of commodity prices on exchange rates. The study concludes that commodity price shocks appear to have little lasting influence on exchange rate dynamics. Also, macroeconomic fundamentals do assist in predicting future exchange rate changes; however, no single equation stands out as the dominant specification. Chen *et al.*, posit that if commodity prices can indeed be shown to be a consistent and empirically reliable factor in empirical exchange rate equations, the finding would have important implications across a variety of policy issues, not least concerning issues such as how to implement inflation-targeting in developing countries, which accords with Ciner (2011).

Lee (2012) investigates what determines a “commodity currency” and highlights the robust exchange rate response to fluctuations in world commodity prices that occurs for major commodity exporters. The study uses OLS and quarterly panel data from 1980 to 2010 for 63 major commodity exporters at different stages of development and in various economic stages. According to Lee, the three factors that affect the long-run relationship between the real exchange rate and commodity prices are a country’s export market structure, monetary policy choices, and degree of trade and financial openness. He further observes that the commodity price exchange rate connection is much weaker in the short-run than has generally been observed in prior literature based on a small set of developed countries. In addition, an increase in world prices of primary commodities brings about higher export revenue for commodity exporters and the world price of a commodity depends on the supply of the world leading producer(s). According to Lee, in theory, a country adopting inflation targeting would experience low and stable domestic inflation but at the same time may also need to float its currency, this will entail that the response of the real exchange rate to a commodity price shock will depend on the degree of commodity price transmission into the country’s exchange rate.

Kohlscheen *et al.* (2016), investigate the relationship between commodity prices and exchange rates using the granular 3-digit UN Comtrade data as well as market price information of 83 associated proxy commodities to construct country specific commodity export price indices (CXPIs) at daily frequency for the period January 2004 to February 2015 for 11 primary commodities exporting countries. The results show that commodity prices predict exchange rate movements of 11 commodities exporting countries in an in-sample panel, up to two months. Furthermore, commodity-related drivers of exchange rates suggest that currency movements are not purely random as there is a factor related to commodities that explains movements in exchange rates beyond the information embedded in carry trade, global uncertainty and risk appetite. The study thus concludes that the link between commodity prices and exchange rates is economically and statistically significant at high frequency. Further, the commodity price exchange rate

connection is largely unaffected when changes in uncertainty and global risk appetite are considered. Models incorporating commodity prices explain the component of exchange rate variations that is purely orthogonal to changes in risk and risk appetite.

Cavalcanti *et al.* (2015) study the impact of the volatility of commodity terms of trade on economic growth, total factor productivity, physical capital accumulation and human capital acquisition by examining commodity dependence and volatility impact. The study uses annual data between 1970 and 2007 and construct a panel dataset of 118 countries. The analytical process involves splitting the sample into two sets, 62 primary commodity exporters; and 56 other countries which have a more diversified export basket. The study uses the dynamic common correlated effects pooled mean group (CCEPMG) methodology. They determine that commodity price volatility has a negative effect on economic growth of primary commodity exporting countries, which has been intrinsic in commodity markets and has been rising in recent years. Cavalcanti *et al.*, recommend that good policy rules are essential for a country to successfully manage its income from commodity export windfalls and at the same time insulate itself against external shocks. Cavalcanti *et al.*, report that the persistent volatility of commodity prices is seen by many as a serious source of vulnerability and the volatility of commodity prices remains one of the main factors behind the vulnerability of low income countries, evidenced by structural vulnerability, poverty and apparent limitations for growth. Cavalcanti *et al.*, advise that the creation of commodity stabilization funds, or sovereign wealth funds, might be one of the options to offset the negative effects of commodity ‘booms and slumps’, and note that further research is needed in this area, as more resource rich economies prioritize and pursue this as a policy agenda.

Coudert *et al.* (2015) study the relationship between terms of trade and real exchange rates in commodity-producing countries on both the short and the long run. The study uses a panel of 68 commodity exporters, split in sub-samples of advanced, intermediate and low-income countries. Specifically, it includes (i) a group of five advanced countries (Australia, Canada, Iceland, New Zealand, Norway); (ii) a set of 37 intermediate income countries, either emerging or developing; and (iii) 26 low-income countries. Using a panel smooth transition regression (PSTR) model, the results confirm the existence of a positive relationship between the real exchange rate and the country’s terms of trade for a whole panel of commodity exporters, be they advanced, intermediate or low-income countries thus confirming Cashin *et al.* (2004). However, in regards to the short run, this relationship is only evident for the advanced economies, which is attributed to the stabilized currencies attained by developed industrialised countries that mitigate the short-run response of their real exchange rate to terms of trade shocks. The study concludes that market

volatility exacerbates the response of the exchange rates to shocks in terms of trade and accelerates their return to fundamental values.

In summary, the cross-country empirical studies by Chen *et al.* (2003), Chen *et al.* (2008), Lee (2012) and Kohlscheen *et al.* (2016) provide broad and specific evidence of the relationship between commodity prices and exchange rates. These studies highlight the significance of the relationship as well as the implication at macro and microeconomic level. The study by Will *et al.* (2011), discusses the fundamental drivers of volatility and this gives context to the studies undertaken by Brunetti *et al.* (1995), Cuddington *et al.* (1998) and Jacks *et al.* (2011) that discuss trends in volatility as well as the impact and implications of volatility on commodity prices, exchange rates and economic growth. The other empirical studies in this section, are detailed studies specific to the relationship of commodity price volatility on exchange rates and other macro and monetary variables such as the terms of trade and inflation.

### ***5.2.2 Emerging country studies***

This section is dedicated to reviewing various empirical studies undertaken on emerging markets. The objective is to demonstrate the significance of the relationship between commodity prices and exchange rates within the context of emerging markets and highlight similarities and differences among the studies.

Ghura *et al.* (1992) investigates the relationship between the real exchange rate and macroeconomic performance in Sub Saharan Africa using pooled time series and cross sectional data for thirty-three Sub Saharan African countries, for the period 1977 to 1987. They categorise the countries into high, medium, low, and negative growth countries; and construct a model-based measure of REER misalignment and variability. The results confirm the negative relationship between the real exchange rate misalignment and economic performance, indicating that higher levels of misalignment are accompanied by higher levels of macro-economic instability. Ghura *et al.*, report that the results confirm the predictions of endogenous growth models in which economic mismanagement has deleterious effects on economic growth, which accords with Rickne (2009). Ghura *et al.*, conclude that macroeconomic instability slows growth and other indicators of performance. A contribution of this study is the explicit comparison of three alternative measures of the REER, in this study all three measures are empirically significant and cannot be rejected. Another contribution is that the variability of the REER has led to a negative effect on real income growth, exports, imports and investments.



Bleaney *et al.* (2001) examines the impact of terms of trade and real exchange rate volatility on investment and growth in 14 sub-Saharan African countries from 1980 to 1995. They estimate the volatility of both the terms of trade and the real exchange rate using a GARCH model. The results reveal that growth is negatively affected by terms of trade instability, and investment is limited by real exchange rate instability. Bleaney *et al.* thus conclude that there is a negative association between specialization in primary product for export and economic growth, which accords with McKinnon (1998); Edwards *et al.* (1999) and Deaton (1999). Bleaney *et al.*, concludes that there is a negative correlation between specialization in primary product exports and growth. Also, real exchange rate volatility has a significant negative impact on investment, and volatility in the terms-of-trade has a negative impact on growth which accords with William *et al.* (2005) and Cavalcanti *et al.* (2015).

Cashin *et al.* (2004) examines commodity currencies and the real exchange rate by focusing on whether the real exchange rates of commodity exporting countries and the real prices of their commodity exports move together over time among 58 commodity exporting countries in Africa, Asia, South America, Europe, Middle East and Australia over the period of 1980 – 2002. Using Engle and Granger (1987) cointegration analysis they find evidence of a long-run relationship between national real exchange rate and real commodity prices for about one-third of the commodity-exporting countries. However, the long-run real exchange rates of these ‘commodity currencies’ do not appear to be constant, as would be implied by purchasing power parity-based models, but instead is dependent on movements in the real price of commodity exports. Therefore, since primary commodities constitute a significant component of exports for these countries, world commodity price movements can thus explain a significant component of the terms of trade fluctuations. Cashin *et al.*, further finds that for most commodity currencies, causality runs from the real commodity prices to the real exchange rate.

Dungey (2004) investigates the effects of the terms of trade on real exchange rate movements on six Asian economies for the period 1967 to 1998. Using a GARCH model, the results indicate that the contribution of the terms of trade to real exchange rate volatility ranges from almost nothing in Pakistan and Sri Lanka to 24% in the Philippines. The association between the terms of trade and the common world factor shows a negative contribution to volatility on the East Asian exchange rates, indicating that terms of trade adjustments play a role in reducing the volatility of exchange rate fluctuations.

Medina (2010) undertakes an empirical investigation on the dynamic effects of commodity prices on the fiscal performance of eight Latin American countries for the period 1972 to 1987. He uses

quarterly data set which includes unique country specific commodity price indices and a comprehensive measure of public expenditures. The methodology incorporates the use of a vector auto regression approach. The results indicate that generally Latin American countries' fiscal positions react strongly to shocks to commodity prices, though there are marked differences across the countries under study. According to Medina, Venezuela displays the highest sensitivity to commodity price shocks, with expenditures reacting significantly more than revenues. Chile's expenditure reacts very little to commodity price fluctuations, and the dynamic responses of its fiscal indicators are similar to those seen in high income commodity exporting countries such as Australia, Canada and New Zealand. This observation may relate to institutional capacity and governance, which in some cases includes the efficient application of fiscal rules complemented by political commitment and high standards of transparency.

Bodart *et al.* (2015) investigates the relationship between real exchange rates, commodity prices and structural factors within the context of developing countries that specialise in the export of one main primary commodity, including 33 small developing countries over the period of 1980 to 2012. Using the block bootstrap version of LLC and IPS tests proposed by Choi and Chue (2007), the results reveal that the real exchange rate is positively related to world commodity prices, and that the relationship is subject to structural factors, namely; the degree of flexibility of the exchange rate, the degree of financial openness and degree of trade openness. Also, the commodity price elasticity of the real exchange rate remains unaffected by the type of the main commodity that is exported. However, commodity price elasticity of the real exchange rate is smaller for countries whose exports are weakly diversified. According to Bodart *et al.*, a possible explanation of this result is the low diversification of commodity exports. The results of the study lead to the conclusion that commodity prices are a key determinant of the real exchange rate for countries that produce and export primary commodities. The results of the study have policy significance on three levels. First, emerging countries concerned with the impact of commodity price volatility on competitiveness should adopt a floating exchange rate instead of a fixed exchange rate. Secondly, developing countries can reduce the dependence of their real exchange rate on world commodity prices by being more opened to international capital movements and to external trade. Thirdly, in contrast to recommendations made by other studies, Sub-Saharan African countries particularly oil producing countries, can isolate their real exchange rate from world commodity price shocks, by keeping their exports concentrated on a few primary commodities.

Hegerty (2016) undertakes an empirical study on commodity price volatility to assess its impact on the macro economies in nine emerging countries (Brazil, Chile, Indonesia, Malaysia, Mexico, Peru, the Philippines, Russia, and South Africa) covering the period from February 1980 to

January 2014. The analysis makes use of a multivariate GARCH method to determine impact of commodity prices and output, exchange rates, interest rates and inflation. The results show that Chile has a true “commodity currency” and can even be said to have a “commodity macro economy”. Also, not only are all variables linked to copper prices as evidenced in the GARCH coefficients, but copper prices are affected by Chile’s economy. Oil prices appear to have little effect on Russia, whilst on the other hand, gold prices are closely linked to South Africa’s exchange rate movements and inflation, but not overall economic output. Indonesia’s and Malaysia’s economies are clearly impacted by commodity price volatility, whilst this is less so in the case of the Philippines. The study concludes that policy makers in inflation targeting countries, should be wary of price increases “fuelled” by commodity price increases. Results also lead to the conclusion that each country behaves idiosyncratically, volatility evidenced in exchange rates and inflation are linked to commodity price fluctuations in more instances than economic output or national interest rates. According to Hegerty (2016), all economies under study must be wary of events in China, as socio-economic events in China tends to affect commodity prices globally. China’s role as an exporter of manufactured items, coupled with its dominance in global purchasing of commodities, may undermine the prices of many manufactured items. The varying country specific results obtained in the study illustrate the need for country specific studies to assist policy makers in emerging countries which accords Chen *et al.* (2008).

Emerging country studies provide context and background prior to a country specific emerging country study. From a generalised perspective Ghura *et al.* (1992), Medina (2010) and Hegerty (2016) provide an insight on the impact of commodity price volatility and/or REER volatility on the macroeconomic performance of emerging countries. The studies give a compelling reason for researchers to undertake country specific studies with a view of contributing to policy formulation that may counter or remedy the effects of volatility on emerging countries. Bleaney *et al.* (2001) and Dungey (2004) investigate the effects of the terms of trade on real exchange rate movement in the context of emerging countries. The results of these studies highlight the fact that it is imperative that emerging countries improve upon their terms of trade to counter the effects of commodity price volatility and limit the effects on the economy and other monetary variables i.e. the studies show a causal relationship between the fundamentals. The study by Cashin *et al.* (2004) investigates the causal relationship between commodity prices and exchange rates and their implications for policy makers in emerging countries.

### ***5.2.3 Empirical studies on Zambia***

In this section, we review empirical studies undertaken within the context of Zambia that contribute to the understanding between commodity price and exchange rate in Zambia.

Bova (2012) investigates the commodity currency link in Zambia for the period 2000 to 2008. The study uses IMF trade statistics for copper prices and exchange rate data, London Metal Exchange for copper prices and WB-CAS for capital flows. The objective of the study is to understand the extent to which the macroeconomic establishment in Zambia allowed for policy measures to counter the commodity shocks. The study further examines the scope for countercyclical policies in Zambia through an analysis of how shocks during the copper boom and the financial crisis were transmitted to the currency and through the currency, to the rest of the economy. The results show the negative impact the currency appreciation had on export competing sectors of the economy; the second was the limited amount of foreign exchange reserves that the central bank accumulated during the period, which posed problems during the subsequent depreciation of the currency. Also, the co-movements of the CPI and of the Kwacha suggest the existence of pass-through from the inflation rate to the exchange rate. Bova (2012) concludes that the dominance of the mining sector on the domestic foreign exchange market explains the close link between the Zambian Kwacha and the copper price; when the price of copper increases, the local currency tends to appreciate and vice versa. The study recommends improving the resilience to shocks for commodity dependent countries which in turn helps to foster economic diversification.

Chipili (2013) studies the impact of exchange rate volatility on trade flows in Zambia. Import and export demand equations capturing aggregate and sectoral data are estimated using the Johansen cointegration method. The results reveal the existence of a stable long-run equilibrium relationship between trade flows, income, relative price and exchange rate volatility. Exchange rate volatility tends to be more significant in the long-run while in the short-run, some of the trade flows, especially aggregate imports and exports, are affected by exchange rate volatility. While export commodities exhibit varied sensitivity to exchange rate volatility, the growth in value of export commodities in Zambia may suggest that these commodities are not necessarily deterred by exchange rate fluctuations. The positive influence of exchange rate volatility on some exports should, all else being equal, improve the trade balance. Chipili concludes that considering exchange rate volatility, is an essential part of exchange rate and trade policy formulation as it influences the allocation of resources between tradable and non-tradable sectors in Zambia. A stable exchange rate is essential for trade promotion in Zambia, which accords with Combes *et al.* (2002) and Cavalcanti *et al.* (2015).

Chipili (2015) examines copper prices and exchange rate dynamics in Zambia for the period 1994 and 2012. The study examines the impact of copper price shocks to the ZMW/USD exchange rate by examining real copper price and real USD/ ZMW exchange rates from 1994 to 2012. To

determine both the short-run and long-run copper price elasticities of the real Kwacha/US\$ exchange rate, a bivariate vector equilibrium correction model (VECM), similar to Cashin *et al.* (2002) is used, and the long-run causality or weak exogeneity is tested in the vector error correction (VEC) framework. Chipili notes that USD/ ZMW exchange rate has fluctuated widely with large changes attributed to the copper price booms and bursts due to the significant contribution of copper to the Zambian economy. Results of the study indicate the existence of a long-run equilibrium relationship between the real copper price and the real ZMW/USD and exchange rate. A positive shock to the copper price exerts a permanent negative impact on the exchange rate, driving it to a new equilibrium level. Results also show that copper prices have a weak short-run effect on the exchange rate. While the real copper price and real Kwacha/US\$ exchange rate move together in the long-run, in the short-term, results indicate that the real ZMW/USD exchange rate is driven by its own past values. This signifies weak short-run copper price effects on the Kwacha exchange rate. Also, exchange rate is preceded by overshooting behaviour, an overreaction in response to the impact of the copper price shock. Chipili notes that improvements in the external sector and positive news relating to debt relief in 2006 induced a real appreciation of the Kwacha while political uncertainty in 2008 depreciated the real Kwacha exchange rate. However, the supply shocks in 1995 had little statistical impact on the exchange rate. The study concludes that the empirical results establish the existence of a long-run equilibrium relationship between the real copper price and the real ZMW/USD exchange rate and confirms that the Zambian Kwacha is a commodity-currency. Also, a positive shock to copper price leads to a permanent appreciation of the real Kwacha exchange rate, pushing it to the new equilibrium level preceded by overshooting behaviour. Chipili recommends that shocks to the copper price should form an integral part of overall exchange rate management in Zambia, as the shocks entail an adjustment of the exchange rate to a new equilibrium. The empirical results signify the importance of closely monitoring underlying developments in copper prices to design appropriate policy response to ensure that impulses to the copper price do not undermine the external competitiveness of the economy which accords with Ghura *et al.* (1992), Edwards *et al.* (1999), Medina (2010). According to Chipili, the study signifies the important role of copper price in exchange rate dynamics in Zambia and that shocks to the copper price should form an integral part of overall exchange rate management in Zambia which accords with Chen *et al.* (2003). However, the study does not consider the changes in terms of trade as recommended by Tokarick (2008). Chipili reports that, the effects of terms of trade on the real exchange rate is ambiguous, depending on the relative strength of income and substitution effects.

In summary, the studies under review reveal a strong correlation between copper prices and the ZMW/USD exchange rate. The studies suggest that an improvement in copper prices translates to

an appreciation of the ZMW/USD exchange rate. The studies also highlight the adverse effects that exchange rate instability has on the economic growth of Zambia. However, the studies are inconclusive about the effects of the CPI on the commodity price / exchange rate relationship and the adjustment for the terms of trade appears to be absent in their consideration.

### 5.3 Conclusion of the literature review

The theoretical literature introduces concepts that relate to determinants and consequences of commodity price volatility on emerging economies. The section also highlights theories underpinning the relationship between commodity prices and exchange rates as well as the relationship between commodity prices and other macro and micro economic variables. Deaton (1999) advances leading explanations for the behaviour of commodity prices and their intrinsic nature to be volatile, while Cashin *et al.* (2000), Pindyck (2001) and Combes *et al.* (2002) examine the price dynamics and consequences of volatility on emerging economies. The section also introduces and discusses the important concepts of “commodity currencies” and “currency commodities” as derived by Clements *et al.* (2008), who define commodity currencies as a currency whose value moves in sympathy with world commodity prices. While currency commodities are defined as commodities whose prices are substantially affected by currency fluctuations.

The empirical literature section discusses the relationship between commodity prices and exchange rates, as well as the relationship between commodity prices and other macro and micro economic variables in more detail. The relationship dynamics are discussed at three levels, namely; cross-country, emerging economies and country study. To the best of the researcher’s knowledge, there are no other recent studies on the relationship between commodity prices and exchange rates within the context of Zambia other than Bova (2012) and Chipili (2015). The literature reviewed is in consensus regarding the need for country specific studies to be undertaken for policy makers to understand commodity price behaviour and formulate exchange rate sterilization policies. However, the literature is inconclusive with regards to the macro and/ or micro economic variables that need to be brought into the ‘fold’ when determining the relationship between commodity price volatility and exchange rates. In addition, there is lack of uniformity regarding the analytical framework or methodology, for the empirical determination of the relationship between commodity prices and exchange rates.

## 6.0 Research methodology

This chapter outlines the data to be used, the analytical framework selected to analyse the data as well as the diagnostic tests identified to validate the robustness of the model. Also, included, is a statement of the assumptions and anticipated limitations of the study.

This is an explanatory research design and strategy, aimed to empirically test the relationship between monthly copper price movements and the monthly Zambian Kwacha / US Dollar exchange rate for the period of January 2005 – February 2015. The methodology uses an econometric tool to analyse quantitative (numeric) secondary data and generate results for interpretation. The approach selected is suitable given that the objective of the study is to empirically determine the nature of the relationship between copper prices and exchange rates and offer an explanation regarding this relationship. This differs remarkably from a deductive research, which aims to test an underlying theory on a subject matter and an inductive research, whose objective would be to contribute to a theory or build on an existing theory regarding the subject matter (Burney, 2008). Among other objectives, the research design is aimed at determining whether a short or long run relationship exists between, monthly copper prices and exchange rates and to determine whether copper price movements have a significant positive or negative effect on the exchange rate in Zambia.

### 6.1 Research Data

The data used to conduct the empirical analysis comprises a dependent variable, one explanatory variable of significant interest, and four control factors. The month end mid-REER, herein referred to as the dependent variable, are obtained from Bank of Zambia, and the month-end spot copper prices i.e. explanatory variable, are obtained from the London Metal Exchange. With regards to the control variables; both the monthly CPI index and monthly changes in the terms-of trade are obtained from the Central Statistics Office of Zambia. The quarterly and annual real GDP growth rates for both China and Zambia are obtained from Bloomberg.

#### 6.1.1 Dependent variable

The dependent variable consists of the real exchange rates (REER), which are the monthly period-end exchange rates of the Zambian Kwacha (ZMW) to the United States dollar (USD) for the period January 2005 to February 2015. The month-end exchange rate is defined as the real effective exchange rate (REER). The REER is the foreign price of the domestic basket of consumption relative to the foreign price of the foreign basket of consumption. (Cashin *et al.*, 2004). Real exchange rates have been used instead of bilateral (nominal) exchange rates, as the effective real exchange rate measures the international competitiveness of a country against all its

trade partners, and this helps to avoid potential biases associated with the choice of base country in bilateral real exchange rate analysis (Cashin *et al.*, 2004).

### 6.1.2 Explanatory variables

The explanatory factor of interest are the month-end spot copper prices for the period January 2005 to February 2015 denoted in USD per tonne. The spot copper price is a common reference point for copper prices by copper mines in Zambia. Month-end spot copper prices is denoted as the explanatory variable in accordance with Chen *et al.*, 2003; Dungey, 2004; Calvo-Gonzalez *et al.*, 2010.

### 6.1.3 Control factors

In addition to the dependent and explanatory variables, the analysis also makes use of macroeconomic control variables, which have been selected in accordance with the related literature of Ghura *et al.* 1992; Browne *et al.* 2010; and Ciner, 2011. According to the vast literature on the determination of real exchange rates, numerous macroeconomic variables can serve as controls (Bodart *et al.*, 2015). However, in the case of small developing countries, a limited number of macroeconomic data is available in good quality (*ibid*). This study has included the following:

1. CPI Monthly Index which is included to control for the relationship between commodity prices and inflation in accordance with Ciner, 2011 and Ademola, 2009.
2. Zambia's real GDP is included to control for the possible negative association between specialization in primary product for export and economic growth in accordance with McKinnon, 1998; Edwards *et al.*, 1999; Deaton, 1999; and Cavalcanti *et al.*, 2015.
3. Changes in terms-of-trade is used to control for the relationship between changes in a country's (Zambia) terms-of-trade and its real exchange rate (REER). Tokarick (2008) reports that, income effects that arise from changes in commodity prices play a key role in influencing the price of nontraded goods and ultimately the real exchange rate, as in models of the "Dutch Disease". The terms of trade are an important element in linking the endogenous determination of both exchange rates and commodity prices, which accords with Bleaney *et al.*, 2001; Dungey, 2004; Tokarick, 2008; and Clements *et al.*, 2008; Cavalcanti *et al.*, 2015; and Coudert *et al.*, 2015.



4. China's real GDP is used as a proxy to capture foreign demand for copper. Bova (2012) notes that, due to China's increasing demand for metals, copper prices increased sharply between 2002 and 2008. In addition, Hegerty (2016) establishes that, China's economic slowdown is detrimental to copper exporters which accords with Kaplinsky, 2010 and Ademola, 2009.

#### 6.1.1 Sample period

The sample period used in this study runs from January 2005 to February 2016. The start date has been chosen to take account of the period post the introduction of the broad-based interbank foreign exchange market mechanism (IFEM), introduced in July 2003. The IFEM seeks to address the weaknesses of the previous foreign exchange rate system in which banks simply added a margin on rates published by BOZ. The introduction of IFEM was considered an important step in improving efficiency in the money market as this allowed commercial banks and other licensed agents to bid and offer foreign exchange on the interbank market. Hence, exchange rates are now determined by the market. It is against this background that the sample period has been selected to avoid potential biases with data prior to the introduction of IFEM when foreign exchange rates may not have been 'efficiently' determined by the market and other fundamentals such as copper prices.

#### 6.2 Analytical framework

The approach used to conduct the empirical analysis consists of the autoregressive distributed lag (ARDL) bounds test procedure developed by Pesaran and Shin, 1999 and Pesaran *et al.*, 2001. This empirical methodology is used to test if there exists a short-run or long-run relationship between month end spot copper prices and month end REER exchange rates in Zambia over the period of January 2005 to 2016. The analysis will be conducted using *EViews* software.

There are several reasons this research insists on an ARDL bounds test procedure as opposed to other statistical models.

1. The data is in time series format and therefore an ARDL bounds test procedure is suitable to observe for correlation and cointegration, and to establish if there is a short or long-run relationship between copper prices and ZMW/USD exchange rate.
2. The ARDL procedure generally provides unbiased estimates of the long-run model and generally produces valid statistics even when two step procedures are used (Odhiambo, 2009).

3. The use of the ARDL bounds test procedure will be in line with previous similar empirical studies on the subject (for example Chen *et al.*, 2003; Cashin, 2004; Saria *et al.*, 2010 and Arize *et al.*, 2012).
4. Cashin *et al.* (2004), recommend that the use of nonstationary exchange rates imply that cointegration methods i.e. ARDL model, should be used to examine long-run relationships between fundamentals and exchange rates.
5. The use of the ARDL test bound procedure will provide a level of consistency and to some degree serve as a basis for comparison, between this research and other empirical studies of a similar nature that have been undertaken using this analytical framework.
6. The ARDL / Bounds testing procedure developed by Pesaran and Shin, 1999 and Pesaran *et al.*, 2001 has comparative advantages in the modelling of non-stationary time-series data; this study notes the following key advantages; (a) Either  $I(0)$  or  $I(1)$  data can be used in the analysis, (b) the econometric model involves just one single equation and is simpler to implement and interpret, and (c) a set of variables can be assigned different lag lengths. The vector auto correction model (VECM) developed by Johansen (1988) and the ARDL / bounds procedure can both be used as analytical frameworks for this study. However, this study has opted for the ARDL bounds test procedure because a study by Iqbal *et al.*, (2013) which reveals that the ARDL has lowest forecast error in the short-run among the ECM based techniques i.e. Engle-Granger, Johansen and the ARDL. Furthermore, whereas for long-run forecasting horizon ECM based techniques generate better forecasts than co-integration based techniques i.e. unrestricted VAR and ARIMA, the advantage of VECM appears to be in the long-run, which accords with Hoffman and Rasche (1996).

The analytical process will undertake the following steps:

1. An appropriate lag structure for the model is determined and illustrated in the model specification i.e. lagged monthly as shown in the variables.
2. Unit root tests are conducted to ensure that none of the variables are non-stationary and thus to avoid spurious regression as accords with (Engel and Granger, 1987). One important reason is that a model whose coefficients are nonstationary will exhibit the unfortunate property that previous values of the error term will have a non-declining effect on the current value of the dependant variable as time progresses (Brooks, 2008).

3. An ARDL model is produced.
4. An error-correction model (ECM) derived from the ARDL model is then used to test for the existence of a long-run relationship among the variables and check for cointegration.
5. The stability of the model is verified by undertaking the diagnostic and stability tests.

### 6.2.1 Unit root tests

Unit root test, ADF model, postulated by Dickey and Fuller (1981) is used to ensure that variables the ARDL model are non-stationary and to avoid spurious regressions. The ADF model equation is specified as follows:

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

$$\Delta y_t = c_0 + c_1 t + \delta y_{t-1} + \beta \sum_{i=1}^p \Delta y_{t-1} + u_t \quad (2)$$

Where  $c_0$  is denoted as the constant,  $c_1$  is the trend,  $p$  denotes the number of lagged terms and  $u_t$  is the white noise. Equation (1) refers to the intercept only and equation (2) is for both the intercept and the trend.

The ordinary least squares regression is measured using the Phillips and Perron model (1988) (PP), as it has the additional advantage over the ADF model by incorporating an automatic correction for auto correlated residuals (Brooks, 2008), and accommodates models with a fitted drift as well as a time trend so that it can distinguish between unit root nonstationary and stationarity regarding a deterministic trend. The limiting distributions of the statistics are obtained under both the unit root null and a sequence of local alternatives.

$$\bar{t}_\alpha = t_\alpha \left( \frac{\gamma_o}{f_o} \right)^{1/2} - \left( \frac{(f_o - \gamma_o)(se(\hat{\alpha}))}{2f_o^{1/2} S} \right) \quad (3)$$

To ensure that the errors of this model are serially independent, the Lagrange multiplier based test statistic is used; it is denoted as:

$$LM = \sum_T \frac{S(t)^2}{T^2 f_0} \quad (4)$$

In cases where the ADF and PP tests produce contradictory results, the KPSS stationarity test (Kwiatkowski, Phillips, Schmidt and Shin, 1992) will be used to resolve any disparity. The KPSS test is a residual based test that estimates stationarity by regressing  $y_t$  on an exogenous variable  $x_t$  and is denoted as:

$$y_t = x'_t \delta + u_t \quad (5)$$

### 6.3 Model Specification

ARDL test bounds procedure:

1. The first test investigates the bivariate relationship between copper prices and the USD / ZMW exchange rate exchange rate over the period of January 2005 – February 2015.
2. The second step estimates the short–run and long-run relationship between copper prices and exchange rates with the inclusion of other variables i.e. control factors.

The model is specified as follows:

$$e_t = a_1 + a_2 m_t + a_3 y_t + a_4 r_t + a_5 i + a_6 g + u_t \quad (6)$$

$e = \log(E)$ ,  $m = \log(M) - \log(M^*)$ ,  $y = \log(Y) - \log(Y^*)$ ,  $r = R - R^*$ ,  $i = I - I^*$  and  $g = G - G^*$ .

Where (e) is the month end spot real exchange rate per 1 USD; (m) is the month end spot copper price per tonne in USD; (y) is the monthly CPI rate (%); (r) is the annual real GDP rate for Zambia (%); (i) is the annual change in terms-of-trade for Zambia (%); and (g) is China's real GDP rate. Variables with (\*) refer to the previous i.e. lagged variable.

#### 6.3.1 Cointegration test

The error correction mechanism (ECM) of the ARDL procedure tests for the existence of a long-run relationship among the variables represented by cointegration among the dependent and explanatory factors. The equation is given as follows:

$$\Delta e_t = a_0 + \sum_{j=1}^n a_{2j} \Delta e_{t-j} + \sum_{j=0}^n a_3 \Delta m_{t-j} + \sum_{j=0}^n a_4 \Delta y_{t-j} + \sum_{j=0}^n a_5 r_{t-j} + \sum_{j=0}^n a_6 \Delta i_{t-1} + \sum_{j=0}^n a_7 \Delta g_{t-1} + \lambda EC_t + \varepsilon_1 \quad (7)$$

The null hypothesis states that there is no cointegration and thus  $H_0 : \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6$  tested against the alternative hypothesis of  $H_1 : \delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq \delta_5 \neq \delta_6$ . In line with recommendations by Pesaran *et al.* (2001) the  $F$  test is used to estimate lower and upper bands. The first is calculated to ascertain if the variables in the model are  $I(0)$  and the second is calculated to establish if the variables are  $I(1)$ . If the calculated  $F$ -statistic lies above the upper level of the band, the null hypothesis of no cointegration is rejected, indicating the presence of cointegration. Should the  $F$ -statistic fall below the lower level of the band, the null hypothesis cannot be rejected, thus giving support for evidence of the absence of cointegration. If the  $F$ -statistic falls within the band, the test result is inconclusive.

#### 6.4 Diagnostic tests

A series of diagnostic tests will be employed to ensure that the ARDL model is correctly specified and stable. Zeileis *et al.* (2002) advises that, diagnostic tests are useful in econometrics because they assess the robustness of the empirical models. Diagnostic checks must not be seen simply as procedure but also as an explorative tool to extract information about the structure of the data, especially with regards to residual plots or other diagnostic plots.

##### 6.4.1 Serial correlation

The Breusch-Godfrey test (1978) for serial correlation will be used to test if the residuals are correlated with the lagged values in OLS regression. Godfrey *et al.* (2005) reports that, failure to detect serial correlation may lead to misleading inferences, thus it may be recommended to use the standard or modified Lagrange multiplier test in such circumstances.

##### 6.4.2 Heteroscedasticity

The White test (1980) for Heteroscedasticity will be conducted to determine if the variance of the errors is constant. Should heteroscedasticity characterise the data set for this study, the OLS estimators may not be significant for accurate inference to be made and inference based on  $t$  and  $F$  tests may be inaccurate (Gujarati, 2015). In the presence of seasonal or conditional heteroscedasticity the study may use the Lagrange multiplier test and/ or a Hausman-type test to improve performance by using a less variable estimate of the covariance. The tests use restricted residuals to calculate the heteroscedasticity-consistent covariance matrix estimates (HCCME) proposed by White (Godfrey *et al.*, 2005). It is recommended to use the Lagrange multiplier test which is safer and robust to heteroscedasticity of unspecified form, rather than the Hausman test (*ibid*).

### 6.4.3 Parameter stability

Recursive tests are undertaken to test for parameter instability, which is evident when there are residuals outside and not inside the standard error bands. This diagnostic check will involve the use of CUSUM and CUSUM of squares test attributed to Brown, Durbin and Evans (1975). The CUSUM statistic is based on a normalised scaled version of the cumulative sums of the residuals; in a perfect parameter stability, the null hypothesis of the CUSUM statistic is zero however many residuals are included in the sum because the expected value of a disturbance is always zero (Brooks, 2008). The test statistic for CUSUM is denoted as;

$$S_t = \left( \sum_{r=k+1}^t w_r^2 \right) / \left( \sum_{r=k+1}^T w_r^2 \right) \quad (8)$$

Where  $w$  is the recursive residual and  $S_t$  is denoted as  $E(S_t) = (T - K) / (T - K)$ . Parameter instability results in the movement of  $W_t$  outside critical values.

## 6.5 Statement of Limitations and assumptions

The research makes the following assumptions;

### 6.5.1 Data Assumptions

1. The data provided by the relevant authorities on their respective websites is accurate and is not preliminary data that is subject to further revisions or adjustments.
2. The study assumes that the monthly variables that constitute the sample period from January 2005 to February 2015 is adequate to draw meaningful conclusions on the subject within the context of Zambia.

### 6.1.1 Methodological assumptions

1. The methodology will involve the analysis regarding the relationship of several economic variables and thus it is assumed it will provide for cross examination of their interrelationships.
2. The methodology selected should be able to generate consistent results over time given similar conditions.
3. The ARDL test bound procedure opted for should provide a description and explanation regarding the relationship between copper prices, exchange rates and other control variables.

4. The findings derived from the methodology should be accurate and conclusive to the extent that they are sufficiently reliable to use for the basis of policy formulation.

#### 6.1.2 Data Limitations

1. The Zambian Kwacha was rebased on 2<sup>nd</sup> January 2013, therefore the month end local currency units per USD prior to 2013, require rebasing i.e. manual adjustment of the real exchange rate of ZMW per 1 USD, to achieve data uniformity and consistency for the entire sample period. Rebasing involves dividing the local currency units per 1USD by 1,000, and rounding off to the nearest two decimal places (Bank of Zambia, 2015). For example, ZMW 5,000.00 prior to 2<sup>nd</sup> January 2013 is now expressed as ZMW 5.00.
2. The month-end LME spot copper prices are obtained from Konkola Copper Mines marketing team. The primary reason for obtaining the information from a third party is attributed to the prohibitive cost associated with obtaining the data directly from the LME. Obtaining secondary data from a third party has been noted as a limitation given the possible likelihood of errors in the transference of data.
3. The monthly terms-of-trade are derived using monthly import and export data available from the Central statistics Office of Zambia. The monthly terms of trade index, are expressed as a percentage, and derived by dividing the gross value of exports by the gross value of imports.
4. The real GDP for both China and Zambia, are generated quarterly and annually respectively, by the relevant authorities. This is a limitation considering that this research analysis is based on monthly data. The quarterly real GDP data will be interpolated to monthly data using cubic spline, to match the data points for both the explanatory and dependant variables.

#### 6.1.3 Methodological limitations

1. The ARDL test bound procedure is not able to determine causality regarding the relationship between commodity prices and exchange rates. Therefore, another test would need to be undertaken such as the Granger test for causality, which is beyond the scope of this analysis.
2. The study assumes that the distribution of the test statistic is appropriate for the model.

This chapter discussed the composition, source, characteristics and sample period of the data accompanied by the relevant justifications. The econometric tool *EViews* as well as the analytical framework i.e. the ARDL test-bound procedure developed by Pesaran *et al.*, have been outlined,

including the model specifications and diagnostic tests to be performed. The chapter concludes with an overview of the limitations and assumptions as it pertains to the data and the methodology.



## 7.0 Research findings, analysis and discussion

In this chapter, the results of the data analysis are presented and discussed. The discussion of the results starts with the analysis on unit root and stationarity tests, followed by the ARDL test results, and the diagnostic test results which are undertaken to assess heteroscedasticity and model stability.

### 7.1 Descriptive statistics

Descriptive statistics for the set of dependent and explanatory variables are presented in Table 2 below. The standard deviation for all the variables appears to be significant, consistent with extreme variability associated with countries that are dependent on commodity exports as accords with Deaton (1999). It is also noted that the skewness is positive for all the variables other than month end spot copper prices and monthly volatility terms of trade. The skewness is likely to be attributed to frequent shocks in commodity markets that inevitably impacts the macroeconomy of commodity exporters as accords with Coudert *et al.* (2015). The positive skewness shows that prices tend to respond positively rather than negatively. The Jarque-Bera-Test results show that the variables are not normally distributed, with kurtosis averaging 2.9. Thus, the distribution of the data can be said to be characterised by tails; a caution for the possible presence of outliers.

The results reveal that during the ten-year period of January 2005 to February 2015, high copper spot prices have been mirrored by strong Zambian Kwacha / US Dollar spot exchange rates. This is evidenced by the mean copper spot price of USD 6,794.42 per tonne, and the mean REER of ZMW 4.78/ 1 USD. This observation accords with Bova (2012), who reports that due to China and India's increasing demand for metals, metal prices experienced an exceptional surge from 2003 to 2008, a period defined as the second commodity boom. Bova, further states that copper prices increased sharply from December 2002 to July 2008. In addition, the period seems to correspond to high growth rates for both China and Zambia, evidenced by the mean GDP of 10% and 6.8% per annum, respectively. This supports the assertion that copper prices and demand is largely attributed to China's economic growth. China accounts for 40% of the global demand for copper (Investing News, 2015). Furthermore, China's economic growth has given rise to production by mineral exporters as accords with Ademola (2009), Oyejide *et al.* (2009) and Hegerty (2016). The statistics further show that mean inflation rate is 10%, with a high of 19.5% and a positive mean terms-of-trade of 110%, which is expected considering that the period has generally been favourable to copper exporters as accords with (Bova, 2012). Generally, the results indicate that the period has largely been characterised by positive macro-economic growth trends for both China and Zambia, and a strong mean REER, despite global recessions that have plagued

the ten years under review (Edwards, 2015). This reinforces the findings by Ghura *et al.*, who states that a positive relationship exists between economic fundamentals and exchange rates.

Table 2: Descriptive statistics

Variable	USD/ ZMW rate	Copper Price	CPI	Zambia GDP	China GDP	TOT
Mean	4.775	6794.416	10.198	6.769	10.036	109.906
Median	4.779	7171.845	8.900	6.115	10.006	106.580
Maximum	6.861	9867.600	19.500	10.653	15.000	173.597
Minimum	3.084	3071.980	6.000	3.600	6.337	40.854
Std. Dev.	0.835	1660.592	3.633	1.675	2.349	23.971
Skewness	0.119	-0.741	1.151	0.833	0.311	-0.002
Kurtosis	2.693	2.835	3.262	2.761	1.958	3.629
Jarque-Bera – Test	0.768	11.298	27.299	14.399	7.493	2.012
P - value	0.681	0.004	0.000	0.0007	0.024	0.366

## 7.2 Unit root Stationarity tests

Unit root and stationarity tests are conducted prior to the ARDL estimation procedure. For each unit test procedure, the data is examined at two stages. The first test is undertaken on trend, and the second test at both trend and intercept. The unit root tests conducted comprise the Augmented Dickey-Fuller test (ADF), DF – GLS test, Phillips-Perron test (PP) and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test statistic for stationarity. The lag lengths for the ADF and DF-GLS are based on the Akaike information criterion with a maximum of four lags, while the estimation method for the KPSS test is based on Bartlett Kernel / Newey-West bandwidth. The unit root tests are used to determine if the data is  $I(0)$  and  $I(1)$ , and to ensure that none of the variables are  $I(2)$ . Results of the unit and stationarity tests are presented in table 3 below.

Table 3: Table 3: Unit root and stationarity test results

Variable	ADF		DF - GLS		PP		KPSS	
	Trend	T & I	Trend	T & I	Trend	T & I	Trend	T & I
REER	-1.467 ***	-1.412 ***	-1.466 ***	-2.603 ***	-1.133 ***	-3.229 **	1.010 ***	0.083
Copper price	-2.945 ***	-2.749 ***	-1.310 ***	-2.151 ***	-2.674 **	-2.390 ***	0.426 **	0.121 **
CPI rate	-2.605 **	-3.485 **	-0.653 ***	-2.691 ***	-2.321 ***	-2.528 ***	0.783 ***	0.068
Zambia GDP	-1.370 ***	-0.779 ***	-0.955 ***	-1.050 ***	-1.292 ***	-0.920 ***	0.290	0.268 **

TOT	-3.789	-2.991 ***	-1.794 **	-2.335 ***	-4.587	-4.539	0.164	0.158 **
China GDP	-2.594 ***	-4.833	-2.042 ***	-4.457	-1.502 ***	-2.599 ***	0.889 ***	0.054

T & I, refers to Trend and Intercept test.

\*\*\*, \*\*, and \*, represents significance at the 1%, 5%, and 10% levels respectively.

The results of the ADF test indicate that the null hypothesis for the presence of unit root is rejected at 5% confidence level, except for terms-of-trade at both trend and intercept, as well as the ADF trend test on copper price data. With regards to the DF–GLS test results, the null hypothesis for the presence of unit root is rejected at 5% confidence level, except for the trend and intercept test on China GDP data. The PP test statistic results reveal that the null hypothesis for the presence of unit roots is rejected at 5% confidence level, except for the terms-of-trade, where results fail to reject the null hypothesis. The KPSS test for the determination of stationarity around a deterministic trend, reveals that the null hypothesis for stationarity is not rejected at the 5% confidence level with regards to the REER rate, CPI rate and China GDP, for the trend test only. With regards to the trend and intercept test, the null hypothesis for stationarity is not rejected, at the 5% confidence level, for the variables, copper price, Zambia GDP and terms-of-trade; the variables exhibit different results in stationary at both the trend test and trend and intercept test. In summary, the variables REER, copper price, CPI rate, Zambia GDP and China GDP are deemed  $I(0)$  variables; whereas the terms-of-trade is deemed  $I(1)$ .

### 7.3 Lag selection criteria

Prior to determining the long run relationship between REER and the other explanatory variables the first step is to determine the appropriate lag criteria for the ARDL model. The selection of the lag length is illustrated in Table 4 below. The optimal lag length selection is based on the Akaike information criterion (AIC), and the appropriate lag length for the model is 4.

Table 4: Lag selection criteria

VAR Lag Order Selection Criteria: Endogenous variables - Log (REER rate) Log (Copper price) Log (CPI rate) Log (Zambia GDP) Log (Tot) Log (China GDP).

Lag	Log L	LR	FPE	AIC	SC	HQ
0	205.5879	NA	1.37e-09	-3.382846	-3.241964	-3.325644
1	1044.777	1578.814	1.68e-15	-16.99623	-16.01005	-16.59581
2	1358.232	557.8431	1.53e-17	-21.69885	-19.86738	-20.95522
3	1644.615	480.5413	2.22e-19	-25.94263	-23.26587	-24.85579
4	1741.409	152.5732*	8.09e-20*	-26.97303*	-23.45098*	-25.54297*

\* indicates lag order selected by the criterion: (each test at 5% level).

#### 7.4 Wald test

The next step is to produce the Wald Chi-squared test  $F$ -statistic to determine whether the explanatory variables in the model are significant. The results in Table 5 below show that the results fail to reject the null hypothesis of no explanatory power of the variables, indicating that there is evidence of a significant relationship between the time series variables.

Table 5: Wald test

Test Statistic	Value	DF	Probability
t-statistic	6.127	103	0.000
F-statistic	37.538	(1, 103)	0.000
Chi-square	37.538	1	0.000

Null Hypothesis:  $C(1) = 0$   
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C (1)	0.583	0.095

Restrictions are linear in coefficients.

#### 7.5 Bounds test procedure

The bounds test procedure is undertaken to test for the existence or absence of long-run relationships between the variables. This is accomplished by comparing the  $F$ -statistic computed to the critical values in the table. The results of the ARDL bounds test are presented in Table 6 below. The  $F$ -statistic of 5.31 exceeds the 1% critical value of 3.41 for  $I(0)$  variables and the critical value of 4.68 for  $I(1)$  variables. Thus, the null hypothesis of no long-run relationship is rejected. Hence, there is evidence of a significant long-run relationship between the variable. Furthermore, the  $F$ -statistic in the bounds test indicates that the variables have significant level relationships, with the exchange rate on the condition that the characteristics of the explanatory variables are held constant. By implication, should the inherent characteristics and fundamental dynamics in one or more explanatory variables change significantly, there is a possibility that the significance of the  $F$ -statistic could be altered, thereby leading to possible changes to the conclusion of the hypothesis.

Table 6: ARDL bounds test

Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	5.307322	5

Critical Values of the bounds test		
Significance	I (0) Bound	I (1) Bound
10%	2.26	3.35
5%	2.62	3.79
2.5%	2.96	4.18
1%	3.41	4.68

#### 7.6 ARDL estimation

Having examined the preconditions necessary to produce the ARDL model, the next step of the analysis is to use the ARDL test procedure to assess the bivariate relationship between copper prices and the REER for the period of January 2005 – February 2015. The results are presented in Table 7 below.

The coefficient of copper prices shows that in the short-run, a 1% increase in copper prices immediately impacts the REER negatively by -0.17% in the initial month. The regression coefficient of -0.063 implies that for every 1% increase in copper prices, the mean change in the REER is potentially -0.06% in the short-run. Therefore, during the period January 2005 to February 2015, copper price movements have a negative effect on the exchange rate in Zambia in the short-run, although not significantly. This result is consistent with Chipili (2015), who concludes that copper price movements have a weak short-run effect on the Kwacha exchange rate. Therefore, from a risk management and monetary policy perspective, copper price movements are not likely to affect the ZMW/USD real effective exchange rate in the short-run.

Table 7: ARDL Estimation

Bivariate relationship between exchange rates and copper prices

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LOG (REER RATE (-1))	0.969	0.024	39.824	0.000
LOG (COPPER PRICE)	-0.174	0.061	-2.862	0.005
LOG (COPPERPRICE (-1))	0.239	0.102	2.331	0.022
LOG (COPPER PRICE (-2))	-0.228	0.102	-2.226	0.028
LOG (COPPER PRICE (-3))	0.176	0.060	2.949	0.004
C	-0.063	0.148	-0.425	0.672

### 7.7 ARDL full estimation

After exploring the short-run ARDL dynamics, the next step involves the use of the ARDL test equation to estimate the relationship between copper prices and exchange rates, with the inclusion of all the other explanatory variables. The results are shown in Table 8 below and the coefficient of determination ( $R^2$ ) is 0.96 and is therefore an indication that a large proportion of factors that affect the variability of the REER are accounted for by proportional variations in the explanatory variables. In addition, the  $F$ -statistic is highly significant, indicating that there is a significant relationship between the set of explanatory variables in the model and dependant variable. Furthermore, the regression coefficient is positive and statistically significant at 1.05. Therefore, co-movements of the explanatory variables are likely to impact the conditional mean of the REER by 1.05 in the short-run holding all other factors constant.

The coefficient of the copper price is -0.15, which implies that for every 1% increase in copper prices the REER is negatively impacted by -0.15% in the month. The coefficient for the CPI is -0.032 and thus has an insignificant negative impact on the REER in the short-run. This finding does not support empirical evidence found by Bova (2012), who states that co-movements of the CPI and ZMW show the existence of a pass-through effect from the inflation rate to the exchange rate in the short-run. Zambia's GDP multiplier is quite significant at -0.08 (-0.047/0.583), implying that for every 1% growth in Zambia's GDP, the ZMW/USD exchange rate is negatively impacted by -0.08% in the short run.

The terms-of-trade coefficient is 0.05, thus for every 1% increase in the terms of trade it is expected that the REER will be impacted by 0.05% in the immediate and subsequent month. However, the terms-of-trade is statistically insignificant in the third month but positively impacts

the REER in the fourth month as the coefficient is 0.10. The significance of the terms-of-trade on the REER accords with Tokarick (2008), who reports that changes in spending that result from an improvement in a country's terms of trade, influence the price of nontraded goods and ultimately the real exchange rate. China's GDP is statistically significant at all levels and shows that changes in China's GDP, has both a positive and negative effect on the REER. 1% growth in China's GDP results in negative impact of -1.2% on the REER in the initial month, a positive impact of 0.18% in the second month and a negative impact of -0.77% in the third month, holding all other variables and conditions constant. The significance of China on Zambia's economy accords with studies undertaken by Kaplinsky (2005) reports that the entry of China into the global market has stimulated significant demand for 'hard commodities'. China's demand for base metals, such as copper, grew from 7% to 10% of global demand between 1993 and- 2003. Furthermore, China now accounts for approximately 40% of the global demand for copper (Investing News, 2015). Hence, Ademola *et al.* (2009) states that the projected slow-down in China's economy beyond 2015, could negatively affect Zambia's copper exports, and thus negatively affect the exchange rate and inflation rate. Hegerty (2016) also reports that China is a significant trading partner for emerging countries and exporters must be weary of events in China, as socio-economic events in China affect commodity prices. In addition, Chile currently produces 30% of global production, which translates to 5.7 million metric tonnes per annum (Investing News, 2015). Hence, it is probable that Zambia could be affected by both demand shocks from China and supply shocks from Chile. Therefore, from a risk management and monetary policy perspective, movements in copper prices, terms-of-trade and socio-economic events in China and Chile are likely to account for significant changes in the REER within the short term.

Table 8: ARDL full estimation

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LOG (REER RATE (-1))	0.583	0.095	6.127	0.000
LOG (REER RATE (-2))	0.062	0.109	0.572	0.569
LOG (REER RATE (-3))	0.175	0.092	1.904	0.060
LOG (COPPER PRICE)	-0.149	0.034	-4.342	0.000
LOG (CPI RATE)	-0.032	0.026	-1.248	0.215
LOG (ZAMBIA GDP)	-0.047	0.022	-2.088	0.039
LOG (TOT)	0.046	0.029	1.604	0.112
LOG (TOT (-1))	0.046	0.027	1.697	0.093
LOG (TOT (-2))	0.044	0.030	1.450	0.150

LOG (TOT (-3))	-0.001	0.028	-0.043	0.966
LOG (TOT (-4))	0.104	0.028	3.722	0.000
LOG (CHINA GDP)	-1.152	0.273	-4.216	0.000
LOG (CHINA GDP (-1))	1.737	0.530	3.279	0.001
LOG (CHINA GDP (-2))	-0.767	0.282	-2.722	0.008
C	1.053	0.316	3.329	0.001
<hr/>				
R-squared	0.956	Mean dependent Var	1.548	
Adjusted R-squared	0.950	S.D. dependent Var	0.182	
S.E. of regression	0.041	Akaike info criterion	-3.453	
Sum squared residual	0.170	Schwarz criterion	-3.101	
Log likelihood	218.743	Hannan-Quinn criteria	-3.310	
F-statistic	160.472	Durbin-Watson stat	1.992	
Prob (F-statistic)	0.000			
<hr/>				

### 7.8 ARDL cointegration test

The results for the long-run relationship between the REER and the explanatory variables are reported in Table 9.

The long-run coefficient for copper prices is statistically significant at 0.174. Thus, for every 1% increase in copper prices the long-run positive effect on the conditional mean of the REER is 0.17%. Therefore, copper appears to play a significant role in determining the real effective exchange rate in the long-run. This finding accords with Chipili (2015) who finds a positive long-run relationship between copper prices and the ZMW/USD exchange rate. From a policy perspective, the REER can be impacted both positively and negatively in the long-run by copper production, demand and pricing of copper on the LME. The long-run coefficient for the CPI rate is 0.019, but this factor is insignificant and thus indicates that CPI has no significant effect on the REER. Bova (2012) notes that co-movements of the CPI and Kwacha suggest the existence of pass-through effect from inflation to the exchange rate. However, his empirical results are inconclusive, indicating that a nonlinear dynamic relationship may exist between the CPI rate and the REER.

The long-run coefficient for Zambia's GDP is statistically significant at 0.071; therefore, it is expected that for every 1% movement in the GDP the conditional mean of the REER will adjust by 0.1%. This has significant policy implications for a net importing country such as Zambia. Shula (2015) states that an appreciation of the Kwacha leads to a reduction of the foreign exchange



cost for imports and this is significant in the case of a non-diversified developing country such as Zambia. Furthermore, a nominal appreciation resulting from increases in productivity, combined with declining inflation, results in continued export competitiveness and a stronger currency (*ibid*). However, Bova (2012) reports that the Export Board of Zambia and Zambia National Farmers Union find that a strong Kwacha has a negative impact on the volume of non-traditional exports. Thus, the GDP driven appreciation of the exchange rate can stimulate imports but negatively affect export volumes, which could in turn increase the current account deficit.

The long-run cointegration coefficient for the terms-of-trade volatility on the REER is negative 0.658. This result accords with Bleaney *et al.* (2001) examination of 14 sub-Saharan countries (excluding Zambia) as they similarly find that volatility in the terms of trade has a significantly negative impact on growth, investment and the exchange rate. They find a correlation of -0.68 between the export share of primary products and the estimated coefficient of the time trend and suggest that in the absence of any trend deterioration in the terms of trade it is difficult to explain real depreciation as an equilibrium adjustment. They further suggest that there is a combination of significant trade liberalisation (requiring an accompanying equilibrating real depreciation) and the elimination of real exchange rate overvaluation among the countries in the sample. Hence, Chipili (2013) argues that countries such as Zambia need to consider the effect on trade policies when formulating long-term monetary policies and inflation targeting measures.

The long-run coefficient for China on the conditional mean of the REER is -0.572. Thus, every 1% increase in China's GDP is likely to be accompanied by negative impact of -0.57% on the conditional mean of the REER in the long-term. The result is unanticipated and warrants a basis for future validation and research considering that China's is the major importer of copper from Zambia. Shula (2015) reports that official statistics indicate that Switzerland is the single largest importer of copper from Zambia, but Switzerland neither imports nor exports copper as it serves as the site for the exchange of copper contracts. Hence, Switzerland merely serves as a commodity broker. Thus, the results imply that China's continued GDP growth is likely to be one of the significant factors contributing to the depreciation of the Kwacha in the long-run. This strengthens the argument for the country to have a deliberate strategy for a diversified export base and diverse trading partners. 'Diversification and industrialization remain the best means in the long-run, for developing countries to reduce their vulnerability to the adverse effects of commodity price volatility' (UNCTAD Secretariat, 2012).

Table 9: ARDL cointegration test and Long Run Form

Long Run Coefficients				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG (COPPER PRICE)	0.174	0.036	4.852	0.000
LOG (CPI RATE)	0.019	0.025	0.758	0.450
LOG (ZAMBIA GDP)	0.071	0.022	3.242	0.002
LOG (TOT)	-0.658	0.056	-11.768	0.000
LOG (CHINA GDP)	-0.572	0.024	-24.232	0.000
C	1.025	0.287	3.571	0.001

Cointegration = LOG(REERRATE) - (0.1738\*LOG(COPPERPRICE) + 0.0192

\*LOG(CPIRATE) + 0.0714\*LOG(ZAMBIAGDP) -0.6576\*LOG(TOT) -0.5723

\*LOG(CHINAGDP) + 1.0250)

### 7.9 ARDL diagnostic tests

The Breusch-Godfrey serial correlation LM test results are summarised in Table 10 below. As can be seen, the F statistic of 0.479 is significant supported by a significant p-value of 0.692, which is greater than the significance level. Therefore, the null hypothesis of no serial correlation, is not rejected, for a lag order of 4 and at the 5% confidence level.

Table 10: Breusch-Godfrey Serial Correlation LM Test

F-statistic	0.479	Prob. F (4,99)	0.751
Obs* R-squared	2.239	Prob. Chi-Square (4)	0.692

The results of the White test (1980) for heteroskedasticity are presented in Table 11. The results, indicate that the critical value of Chi-square 14, is less than the white test statistic of 20.669 (i.e. test statistic > the critical); Therefore, the null hypothesis is for heteroskedasticity is rejected.

Table 11: Heteroskedasticity Test: White

F-statistic	1.562	Prob. F (14,103)	0.103
Obs* R-squared	20.669	Prob. Chi-Square (14)	0.110
Scaled explained SS	43.090	Prob. Chi-Square (14)	0.0001

### 7.10 Stability tests

The methodology incorporates the test for stability using the cumulative sum to detect systematic changes from the coefficients of regression, and the CUSUM of square test, to detect sudden

changes from constancy of regression coefficients (Jawaid *et al.*, 2013). Figure 3 (CUSUM test) and Figure 4 (CUSUM squares test), show that the data lies within the confidence bands of 5%. Therefore, the null hypothesis for parameter stability is not rejected.

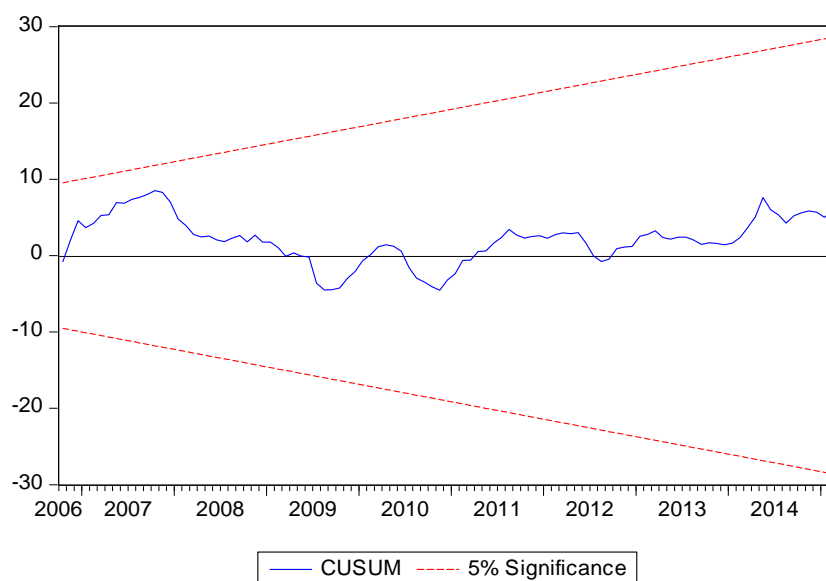


Figure 3: CUSUM test for parameter stability

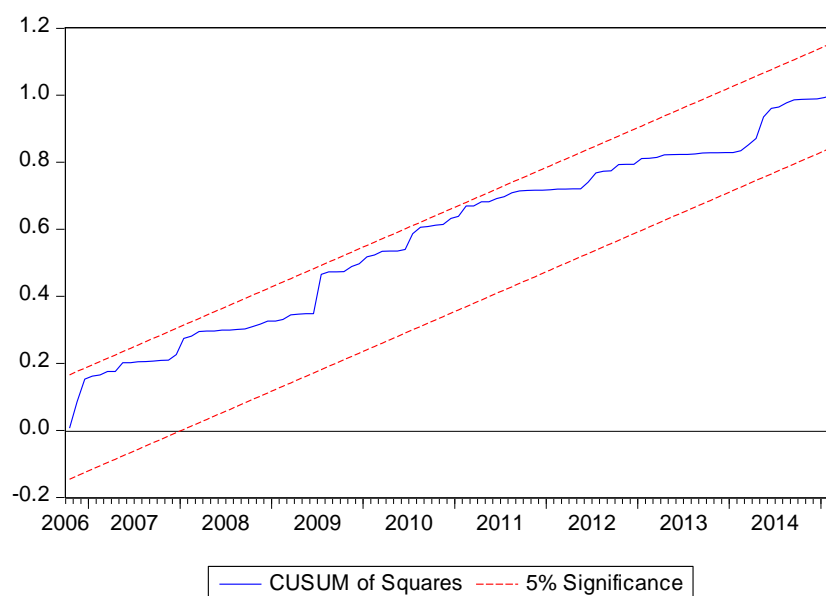


Figure 4: CUSUM of squares test for parameter stability

### 7.11 Summary discussion of the results

In summary, the analysis and accompanying discussion, attempts to provide an insight into the empirical relationship between monthly spot copper price movements and the monthly Zambian Kwacha-US Dollar spot exchange rate over the period of January 2005 to February 2015. The results show that there is both a positive and negative interaction of copper prices on the exchange rates in the short-run. Although both the positive and negative coefficient values are high in the

short-run, the overall impact of copper prices on the REER is not significant in the short-run, which accords with Chipili (2015). Lee (2012), also finds a weak commodity price-exchange rate connection in the short-run for a large set of developing countries. However, this result does not accord with Ferraro *et al.* (2015), who find the existence of a robust short-run relationship between copper prices and the Chilean-peso-US Dollar exchange rate.

In the long-run, the results reveal that copper price movements have a statistically significant positive effect on the exchange rate, which accords with Cashin *et al.* (2004). Furthermore, the coefficient values for the short-run and long-run equation estimates (i.e. -0.17 for the short-run estimate in the initial month and 17% for the long-run) reveal that copper price movements are a significant factor in determining the variation in the conditional mean of the exchange rate. This statistical significance lends support in favour of the argument that the Zambian Kwacha is a commodity currency. In addition, the results reveal that CPI has a statistical weak impact on the exchange rate in both the short-run and long-run while Zambia GDP has a negative impact in the short-run and a positive effect in the long-run. The results further reveal that movements in the terms-of-trade have a weak effect on the exchange rate in the short-run, which accords with Cashin *et al.* (2004) and Coudert *et al.* (2015); but are significantly negative in the long-run. Lastly, the results show that China's GDP has both a significant positive and negative interaction on the exchange rate in the short-run, and a negative impact on the exchange rate in the long-run.

This chapter covered the analysis and discussion of the research findings. The chapter commences with an overview of the descriptive statistics and an outline of the test results for unit root and stationarity. Thereafter, results from the Auto Regressive Distributed Lag method are presented and discussed, including the implications for policy. The chapter concludes with a series of diagnostic tests for serial correlation, heteroscedasticity, and assessments of the model's stability. The conclusion and recommendations are presented in the next chapter.

## 8.0 Conclusion and recommendations

This section summarises the research findings and discusses the conclusion emanating from the research analysis. The chapter also outlines recommendations arising from the research findings.

### 8.1 Summary, policy recommendations and conclusion

This study aims to determine the empirical relationship between monthly spot copper price movements and monthly Zambian Kwacha / US Dollar spot exchange rates, for the period January 2005 to February 2015. The two primary variables of interest are the month-end mid real effective spot exchange rate and the month-end spot copper prices per tonne. Control factors include, monthly inflation rates, monthly terms-of-trade index as well as Zambia and China's real GDP growth rates, which are interpolated to monthly data.

The analytical framework used to conduct the empirical analysis is the autoregressive distributed lag (ARDL) bounds test procedure developed by Pesaran and Shin, 1999 and Pesaran *et al.*, 2001. The results show both the monthly consumer price index and the terms-of-trade index have statistically weak effects on the exchange rate in the short and long run. Zambia's GDP has a negative impact on the exchange rate in the short-run, but has a significantly positive long-run effect. China's real GDP growth rate shows both positive and negative interaction on the exchange rate during the short-run, and a significant negative long-run effect on the exchange rate.

Results of the Auto Regressive Distributed Lag bounds procedure reveals a weak short-run relationship between copper prices and real effective spot exchange rate movements but the interaction of copper prices on exchange rates in the short-run is not statistically significant. In contrast, the ARDL cointegration and long-run tests confirm the presence of a significant positive long-run relationship between spot copper prices and exchange rates. Hence, increases in copper prices have a positive long-run effect on the exchange rate. Therefore, the study concludes that the relationship between commodity price volatility and exchange rate stability in Zambia, is significant in the long-run but not in the short-run.

It is recommended that monetary institutions continue intervening to curb exchange rate shocks due to exogenous or endogenous factors to correct exchange rate misalignment and maintain exchange rate stability thereby maintaining FDI and achieving trade competitiveness. Remedial policy measures must be tailored to address the long-run effects of commodity price volatility. Given the long-run negative impact of China's GDP growth on the exchange rate, it is prudent that a deliberate policy be pursued to explore other trading partners, supplemented with a more

diversified export base that can be achieved through industrialisation and an advancement in financial and service industries.

In conclusion, the study finds the empirical relationship between monthly spot copper price movements and monthly Zambian Kwacha / US Dollar spot exchange rates, over the period of January 2005 to February 2015, to be statistically significant in the long-run. The study reveals a weak negative short-run relationship between copper prices and exchange rates during the period under study. The study establishes that during the period under review, copper price movements have a long-run effect on exchange rate stability in Zambia, but not in the short-run. Thus, in the short-run, copper price movements have a weak negative effect on exchange rates in Zambia. However, in the long-run, copper price movements show a significant positive effect on exchange rates in Zambia.

## 8.2 Recommendations for further research

Future empirical research on the subject matter should incorporate the effects of copper production and supply from Chile. Investing News (2015), reports that Chile's copper mines account for over 30% of global production and sales. UNCTAD Secretariat (2012), reports that commodity production often faces a risk of oversupply and declining prices and vice versa. Therefore, supply shocks emanating from Chile may have an impact on copper prices on the LME which may in turn affect exchange rate movements in Zambia. Researchers must also attempt to consider exchange rate movements attributed to the effects of speculative money-market traders, carry and momentum traders. The "Dutch Disease" effect on some commodity exporting countries is aggravated by international carry traders who have become the single most important determinant of cross-border capital flows (UNCTAD Secretariat, 2012). In addition, research on Zambia must take advantage of continual improvements in the quality and availability of data from monetary and regulatory authorities in Zambia to enhance validity and robustness of findings. For instance, the Central Statistics Office has created a national data portal and has recently begun to compile quarterly GDP data on Zambia, which is unavailable prior to 2014. Lastly, the Central Statistics monthly report (2015), states that imports from South Africa constitutes 30%, of total imports with capital flows between the two countries. Therefore, future research on the subject matter may want to consider the impact of the South African Rand on exchange rate stability in Zambia.

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