Exchange Rate Pass-Through to Domestic Prices: Evidence from VECM

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Abstract

Inflation, exchange rate and gross domestic product (GDP) are critical variables to macroeconomic stability. For a small economy like Zambia, it is imperative for central authorities to establish the size and degree of the exchange rate pass-through (ERPT) to domestic prices and output as they formulate monetary policies. This paper examines the effect of ERPT to domestic prices and local production using the vector error correction model (VECM) for the period 1995Q1 to 2019Q4. The study utilizes the baseline and alternative models for intra study comparisons. Results show that the ERPT to domestic prices is high, persistent, and incomplete in the baseline model while the alternative model depicts a low, persistent, and incomplete ERPT in the long run. Furthermore, the long run ERPT to local production was found to be high, persistent, and complete. Policy implications are that monetary and fiscal policies should be geared towards exchange rate measures that would contribute to both internal and external balances and nurture macroeconomic stability. The measures would include management of exchange rate volatility, effective debt sustainability strategies and reviving as well as broadening the manufacturing sector in Zambia to nurture an export-oriented economy.

Keywords: Price; exchange rate; local production; VECM

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1.0 Introduction

Most developing countries Zambia inclusive have adopted the managed floating exchange rate regime to allow for capital mobility and interventions to keep exchange rates in desired bandwidths. Countries with a managed floating exchange rate regime are concerned with the fluctuations in the nominal exchange rate as this influences the calibration of monetary policies by the central bank authorities. Particularly, for small open economies that are susceptible to global shocks, understanding the extent and size of the exchange movements are of great importance as these effects eventually affect domestic price level, local production and in turn overall output of an economy (Aliyu, 2009). It is widely believed that an understanding of the impact of exchange rate movements on prices would help to gauge the appropriate monetary policy responses to currency movements. Responses by the central banks are therefore aim at mitigating the impact of these fluctuations on the price level and output. In this regard, Zambia's central bank policymakers strive to contribute to macroeconomic stability and attainment of economic growth through formulation of appropriate monetary policies. Zambia adopted a managed floating exchange rate system in 1994 with the implication that the Bank of Zambia (BoZ) intervenes in the foreign exchange market merely to smoothen out short-term fluctuations (Chipili, 2014).

Several studies have been carried out on exchange rate pass-through measurements for developed countries while literature on the subject matter remains limited for developing countries. Most of these studies in developing countries have focussed on measuring the magnitude and timing of the exchange rate pass-through, with very little work focusing on the transmission of the pass-through effects to local production and eventually output of the economy. In line with which, Zgambo (2015) and Aliyu (2009) analysed pass- through effects to domestic prices for Zambia and Nigeria, respectively. This paper, however, intends to fill the knowledge gap by focusing on the exchange rate pass-through to local prices and production using the vector error correction model (VECM) to account for policy changes.

Exchange rate pass-through is defined as the effect of a change in the exchange rate to domestic prices (Peter, 2003). In other words, it is the change in domestic prices that can be attributed to a prior change in the nominal exchange rate. Balance-of-payments models normally assume a one-for-one response of import prices to exchange rates, which is called complete exchange rate pass-through. However due to varying microeconomic and macroeconomic factors across economies, the one-for-one response of domestic prices to exchange rate movements is not guaranteed.

The study, therefore, aims at examining the domestic price and production adjustments to changes in nominal exchange rate in Zambia for the period 1995 to 2019. Specifically, it seeks to determine the magnitude and timing of exchange rate pass-through on consumer prices and to determine the speed of adjustment as well as establish the magnitude of pass-through effects to local production.

Therefore, the overall objective of this paper is to examine the domestic price level and production adjustments to changes in nominal exchange rate for the period 1995Q1 to 2019Q4. The specific objectives of the paper include:

- To determine the size and timing of ERPT on consumer prices in Zambia.
- To determine the speed of adjustment of consumer prices to ERPT.
- To determine the magnitude of ERPT to local production.

Zambia imports raw materials, intermediate products, and finished products whose import values are contingent on fluctuations in the exchange rate and ultimately affect the general commodity price level. Additionally, the cost of local production of goods that use imported raw materials and intermediate goods in the production process is also affected. Simply put the exchange rate pass-through not only affects inflation but also overall production and as such, policymakers seeking macroeconomic stability should focus on understanding the transmission mechanism for appropriate policy formulation. The study of ERPT is of paramount importance particularly for Zambia that is import dependent. According to IMF (2020), between 2010 and 2019, Zambia's imports averaged above 30 percent of GDP, which makes Zambia susceptible to effects of ERPT. Thus, fluctuations in the exchange rate greatly affect the Zambian economy and requires in-depth understanding of ERPT and its effects for sound macroeconomic policy calibration.

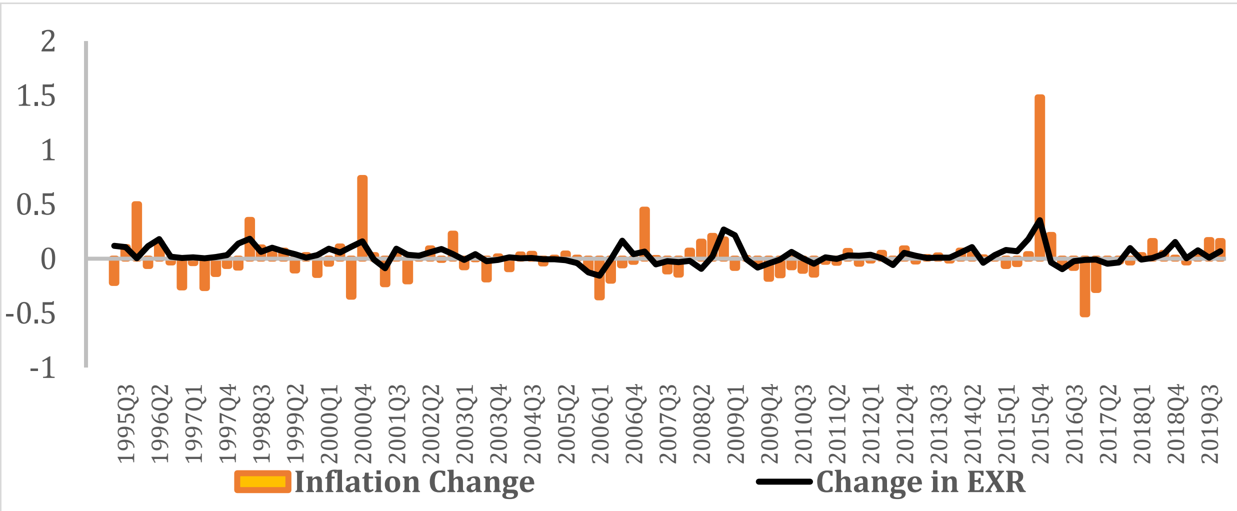
1.1 Brief stylized facts on Zambia Exchange rate and Inflation

Zambia, being a small and open commodity-dependent economy regularly faces changes in the inflation rate arising from a change in the exchange rate. From 1994, when Zambia adopted the floating exchange rate regime, the primary objective of the central bank has been to achieve and maintain price stability. Arising from this, the central bank intervenes to reduce volatility of the Kwacha and maintain its stability thereby minimizing its effects on inflation.

The graph below traces the key macroeconomic variables relevant to our study by observing their changes (the exchange rate and the inflation rate) since 1995, after the floating exchange rate regime was introduced in 1994 and captures the entire period for the study. As can be seen from the graph below, periods with changes in the exchange rate have been accompanied by changes in the inflation rate in the same direction, that is periods with kwacha appreciation have experienced reduced inflation and vice versa.

The sharp increase in inflation from 2015 to 2016 is attributed to the Kwacha depreciation arising from deterioration of confidence in the economy and sustained loadshedding that affected production and ultimately exports of the country BoZ (2015). Observed increases in the inflation from 2007 to 2008 arose from the global recession that affected the mining sector which is Zambia's major source of foreign exchange. Chipili (2022) acknowledges the significance of external shocks which are transmitted through the exchange rate on inflation which was notable during the period 2008-2009 and post 2011 periods as can be seen from the graph. Periods post 2012 are characterized with inflows from in the form of large commercial Eurobonds placements (2012, 2014 and 2015) which played a role in the stabilization of the Kwacha and in turn inflation World bank (2017). Similarly, the period 2005 to 2006 which experienced an appreciation in the Kwacha is accompanied by a fall in inflation.

Chart 1: Changes in Inflation and Nominal Exchange Rate



Source: Author's Computations

From the correlation table 1 below, an increase in the exchange rate of one unit is expected to lead to an increase in inflation by 49 percent which further strengthens the need to measure the actual pass-through to domestic prices. The observed correlation coefficient could have been stronger if there was no central bank intervention in the foreign exchange market to reduce depreciation pressures. It is also highly depictable that the period 2011q1 to 2015q4 has the highest coefficient of 83 percent depicting the macroeconomic challenges Zambia faced due to drought and power rationing which adversely affected productivity as well as forex earnings.

Table 1: Correlation Results

Period	Correlation Value
Whole sample (1995q1-2019q4)	0.487
1995q1 - 2000q4	0.352
2001q1 -2010q4	0.377
2011q1-2015q4	0.826
2016q1-2019q4	0.166

Source: Author's Computations

The rest of the paper is arranged as follows: Chapter 2 presents the theoretical and empirical literature review; Chapter 3 explains the methodology; Chapter 4 discusses and analyses the findings; Chapter 5 provides the conclusion and policy recommendations based on the results obtained.

2.0 Literature Review

Measuring the exchange rate pass-through has increasingly become an important subject for developing and developed countries due to increased interdependence among countries and ultimately how these interactions affect the production and ultimately the price level. Arising from this many scholars have gone on to write on ERPT on with main assumption that the Law of One Price (LOOP) holds and proceed to classify the pass-through as either complete or incomplete. The latter depends on whether the domestic economy has a monopolistic or imperfectly competitive structure, and whether consumers maximize their utility by consuming locally produced goods rather than imported ones (Arisen, 2021). Dornbusch (1987) suggests that the adjustment of mark-up to changes in the exchange rate depends on the relative market shares of foreign and domestic firms, the degree of product homogeneity and substitutability, the market concentration, and the level of price discrimination possible. ERPT can be a consequence of domestic producers' motivations to protect profits by fully reflecting exchange rate changes into sales prices. However, the magnitude of the ERPT depends, among other things, on macroeconomic and microeconomic conditions of the affected country whether and is an empirical matter.

Traditionally, monetary growth is perceived as a primary source of inflation and partly a source of instability in the exchange rate. Conventional to this economic wisdom, is that fluctuations in the nominal exchange rate can be a source of inflation when producers and retailers adjust their prices to mitigate losses arising from the exchange rate changes. The responsiveness of prices to exchange rate fluctuations can either be complete or partial depending on the pricing mechanism adopted. The relationship between the exchange rate and prices rests on three theoretical underpinnings: the purchasing power parity (PPP), law of one price (LOOP) and the monetary theory of exchange rate determination (Bitan, 2004; Phibean, 2006). Many scholars have concluded that understanding the impact of exchange rate movements on domestic prices is of paramount importance and a basis for policy prescription for a given economy.

The LOOP states that in the absence of friction between global markets, the price for any asset will be the same. The LOOP is achieved by eliminating price differences through arbitrage opportunities between markets. Market equilibrium forces would eventually converge the price of the asset. The existence of trade restrictions makes the LOOP not to hold in certain instances. This is because factors such as production costs, producers' mark-up and exchange rate fluctuations exert pressure on domestic import prices. As outlined by Frankel et al. (2005), any theory of incomplete ERPT must begin with the reasons why the LOOP fails due to barriers to arbitrage. These authors outline these barriers which include transport costs (proxied by bilateral distance between the exporting and importing country), trade barriers (proxied by commodity-specific tariffs) and lastly costs of distribution and retail (proxied by the country's wage rate).

PPP is the generalization of the LOOP because LOOP focuses on the exchange rate of one commodity whereas PPP focuses on a basket of commodities. It is worth noting that the PPP does not hold in the short-run due to the existence of transaction costs, non-tradable goods, price stickiness and imperfect competition (Aliyu, 2009).

The PPP theory states that a basket of identical commodities, adjusted for exchange rate, should have the same price across different countries. In other words, in the absence of trade frictions and under conditions of free competition and price flexibility, identical goods sold in different locations must sell for the same price when prices are expressed in a common currency. This implies that at equilibrium, prices of tradable goods in different markets are not expected to differ when expressed in a common currency thus guarantying a complete pass-through. However, in the real world, this does not hold. Trade restrictions exist which make this assumption not to hold.

Algebraically, the PPP theory without transport costs can be written as:

$$P_t^a = \mathrm{NER}_t * P_t^* \quad (1)$$

Where P_t^a represents domestic prices at the time *t,* P_t^* stands for the world's import price and NER_t is the bilateral exchange rate.

The monetary theory of exchange rate determination is a combination of the LOOP and PPP theories (Aliyu, 2009). The theory suggests that the rate of increase in money supply should be of equal magnitude to the increase in the rate of inflation and exchange rate, ceteris paribus. This implies that in the long run, all variables; money supply, interest rates, price level and exchange rate are interlinked and hence, monetary policy can fully affect significant economic outcomes through effective management of monetary variables.

Additionally, a large body of empirical literature on ERPT to domestic prices in countries with similar economic environments as Zambia is available with very scanty evidence of ERPT to local production. The available literature mostly demonstrates ERPT using VECM, SVAR, impulse responses (IFRs), variance decomposition, Johansen Cointegration, Augmented Error Correction Models (ECM) or a combination of two or more of the mentioned methods. Results are diverse about the precursors of ERPT in these studies but there is convergency on ERPT being incomplete, low, or high and persistent depending on the macroeconomic environments. In this paper, the author demonstrates this evidence by giving extracts from Aliyu (2009), Ghosh and Rajan (2009), Shefeeni and Ocran (2013), Zgambo (2015), Bada et al. (2016), Roger et al. (2017), Kapembwa (2017), Mwila et al. (2017) and Chipili (2021).

Aliyu (2009) conducted a study on exchange rate pass-through to domestic prices in Nigeria using a VECM. In this study, he examined the degree of exchange rate pass-through to import and consumer prices. The results indicated that exchange rate pass-through rate was low, significant, consistent, and persistent although slightly higher in imports than in consumer prices. In addition, the study revealed that the exchange rate pass-through in Nigeria declines along the price chain and partly overturns the conventional arguments in literature that exchange rate pass-through is always considerably higher in developing economies. He concluded that prices react less proportionately to exchange rate shocks which is useful to policymakers, especially in the design and implementation of monetary policy.

Furthermore, Ghosh and Rajan (2009) conducted a study to estimate the ERPT elasticities for Korea and Thailand which were facing greater exchange rate flexibility following the 1997-1998 currency crisis. The study considered the use of three exchange rates for analysis namely, bilateral nominal exchange rate per unit of the United States dollar USD, the Japanese yen, as well as for their Nominal effective exchange rate (NEER). The study also proceeded to examine the dynamics of ERPT over time and analyzed possible impacts of the macro-fundamentals on ERPT time varying elasticities. The findings were consistent with theory that ERPT tends to be greater in lower income economies and relatively smaller and more open ones. The findings also showed that the impact of exchange rate changes on consumer price index CPI is much more indirect than it is on import prices.

Shefeeni and Ocran (2013) also carried out a similar study in Namibia using the impulse response functions (IRFs) and variance decomposition obtained from a structural vector autoregressive (SVAR) model. The results from the IRFs showed that there was a high and long-lasting effect on domestic prices from the changes in the exchange rate. Similarly, the forecast error variance decomposition results indicated that changes in the price level evolve endogenously with changes in the exchange rate. These findings confirmed an incomplete pass-through, indicating that the purchasing power parity theory does not hold in Namibia.

Zgambo (2015) investigated the exchange rate pass-through to domestic prices in Zambia using the SVAR framework for the period 1993Q1 to 2014Q4. The study indicated an incomplete, persistent, and low-to-moderate exchange rate pass-through to prices. He found that shocks to the exchange rate exerts more influence on food prices than on non-food and overall prices. The study therefore recommended that authorities should pursue prudent monetary and fiscal policies aimed at fostering macroeconomic stability, reflected in the low and stable inflation to anchor inflation expectations and minimize exchange rate pass-through.

Bada et al. (2016) examined the exchange rate pass-through effect at the aggregate level into import and consumer prices in Nigeria for the period 1995Q1 to 2015Q1. Using the Johansen approach to cointegration and a vector error correction methodology, it was found that the exchange rate pass-through to Nigeria's CPI was incomplete. The study also revealed that the effect was higher in import than consumer prices, implying that the pass-through effect declines along the pricing chain.

Roger et al. (2017) using a SVAR model with quarterly data for the period 1995 to 2014 investigated the dynamics between exchange rate and consumer price inflation in Zambia. The findings from the study suggested that the pass-through of exchange rates to consumer prices depends greatly on the shock that originally caused fluctuations in the exchange rate. They argued that despite copper being the most important driver of the exchange rate, fluctuations it caused were mainly associated with low pass-through. They found that food inflation was equally affected by genuine exchange rate shocks but seemed more reactive to changes in copper prices or the money supply. Historical variance decomposition showed that, across periods, the main drivers of exchange rate fluctuations varied substantially.

Kapembwa (2017) examined the exchange rate pass through to domestic prices for the period 2001 to 2014. This study involved using innovation accounting tools more specifically impulse response functions and variance decomposition within the SVAR framework. The study also explained the relative importance of several variables like output gap and oil prices in explaining changes in domestic prices. The results obtained from the study indicated that the exchange rate pass–through from the import weighted exchange rate like the bilateral Kwacha/US dollar, was low, incomplete, and persistent.

Mwila et al. (2017) focused on the impact of exchange rate changes on food prices and the consumer price index in Zambia using monthly data from 1994M1 to 2013M12. Using a SVAR and VECM, the empirical findings suggested that there was a strong significant relationship between the consumer price indices and the exchange rate in Zambia, and that depreciation caused consumer prices to increase over the period under consideration with food prices responding faster to depreciation than the general price level. The implication was that depreciation of the exchange rate was a significant cause of inflation in Zambia. However, exchange rate pass-through was low, partial, and persistent. Therefore, despite a continuous depreciation, the price level could remain relatively stable over time.

Chipili (2021) assessed the empirical drivers of inflation in Zambia over the period 1994Q1 to 2019Q4. A single-error correction model was used in which the underlying determinants of both food and non-food components of inflation as well as supply constraints were incorporated in the overall inflation equation. The empirical results revealed that the long-run sources of overall inflation were determined in the external sector market where the exchange rate and world non-food prices drive domestic prices. In the short-run, overall inflation was influenced by movements in the exchange rate and adjustments in energy prices. Additionally, the results showed that overall inflation exhibited persistence and seasonality. Further, the two sub-components of inflation displayed different characteristic behavior. This underscored the importance of employing a disaggregated approach to modelling inflation to improve information content and policy response.

Three policy lessons can be drawn from these empirical results. The dominant influence of the exchange rate on overall inflation and its sub-components deserves serious policy attention requiring consistent actions to dampen excessive depreciation of the Kwacha against the US dollar. In the case of the pass-through from imported inflation, expanding and diversifying the manufacturing base to limit the current high dependence on imports of final consumer and capital goods remains a policy priority. Finally, the role of supply shocks evident in the impact of maize prices on inflation necessitate immediate significant reforms in the agriculture sector to boost productivity using modern techniques such as irrigation to reduce dependence on rain fed practices.

The added value of this study is three-fold. First, it provides up-to-date estimates of ERPT for the Zambian economy. This is important considering that very few studies have been conducted on ERPT in Zambia recently and as such, this paper provides updated data which is useful for policymakers. Second, the study captures estimates of ERPT to local production, a new dimension to ERPT studies that have been carried out for Zambia. Third, the study captures ERPT developments in Zambia during the period the economy faced two droughts in 2015 and 2018 which affected productivity and so reduced copper earning which ultimately affected exchange rate and price level. Our study is exempted from testing for structural breaks arising from droughts during modelling because VECM takes care of structural breaks. Moreover, the paper uses unique estimation methods of using the baseline and alternative models in the model estimation which allows for comparability within the study.

3.0 Model Specification, Methodology and Data Description

3.1 Model Specification

The model used for estimating ERPT in this paper is adopted from the study by Ghosh and Rajan (2009) who formulated two equations; viz: the baseline model that utilized the bilateral NER and the alternative model that employed the Nominal Effective exchange rate (NEER) to estimate exchange rate pass-through elasticities for Korea and Thailand. The equations were stated as:

Baseline Model: $In(p^i)_t = \alpha_0 + \alpha_1 In(E^i_j)_t + \alpha_2 In(GDP^i)_t + \alpha_3 In(PPI^j)_t + \mathcal{E}_t$ (2)

Alternative Model: $\mathrm{In}(\mathrm{p}^{\mathrm{i}})_{\mathrm{t}} = \beta_0 + \beta_1 \mathrm{In}(\mathrm{NEER}^{\mathrm{i}}_{\mathrm{j}})_{\mathrm{t}} + \beta_2 \mathrm{In}(\mathrm{GDP}^{\mathrm{i}})_{\mathrm{t}} + \beta_3 \mathrm{In}(\mathrm{CPI}^{\mathrm{w}})_{\mathrm{t}} + \mathcal{E}_t$ (3)

Where i is Korea or Thailand, j is USA or Japan, p^i is import prices or CPI of Korea or Thailand, E^i_j is the bilateral exchange rate of Korea and Thailand per USD or JPY, PPI is the producer price index of USA or Japan, GDP is the gross domestic product of Korea or Thailand and $\mathrm{CPI}^{\mathrm{w}}$is the world CPI.

This model was later modified by Bada et al. (2016) to include international crude oil prices that were critical to the Nigerian economy in terms of forex accreditation and arrived at the following two equations:

Baseline Equation: $In(CPI)_t = \alpha_0 + \alpha_1 In(NER)_t + \alpha_2 In(USPPI)_t + \alpha_3 In(OILP)_t + \alpha_4 In(RGDP)_t + \mathcal{E}_t$ (4)

Alternative Model: $In(CPI)_t = \alpha_0 + \alpha_1 In(NEER)_t + \alpha_2 In(USPPI)_t + \alpha_3 In(OILP)_t + \alpha_4 In(RGDP)_t + \mathcal{E}_t$ (5)

Where NER is the bilateral exchange rate between the naira and the US dollar (US$), NEER is the nominal effective rate, USPPI is the USA producer price index to proxy import prices, OILP is the international crude oil price, RGDP is the real GDP growth and $\mathcal{E}_t$ is the white noise error term.

For the Zambian case, consistent with Ghosh and Rajan (2009) and Bada et al. (2016), we consider the law of one price in absolute terms as stated previously. Transforming equation (1) into logarithms yields the following equation:

$$\Delta In(P_t^a) = \Delta In(NER)_t + \Delta In(P_t^*) \tag{6}$$

Where Δ is the change operator while P_t^* is the import price and NER is the nominal exchange rate of Kwacha relative to the US dollar.

Equation (6) is then augmented with control variables. The baseline model applies the NER while the alternative model uses NEER consistent with Ghosh and Rajan (2009) who demonstrated that use of NEER for NER is more appropriate because it is a broader measure and has more variations than NER. Additionally, Jiang and Kim (2013) and Bada et al. (2016) used the same model with modifications to suite their economic environments. An increase in NER implies a depreciation while a rise in NEER index depicts an appreciation in the Kwacha. The world import price P_t^* is proxied by crude oil price (OILP); export price dynamics are captured by copper prices (CU); local production is represented by the domestic output (GDP); domestic prices are captured through the CPI and finally, the monetary variable included is interest rate captured by 91- days treasury bill rate (TB). Thus, the models used to estimate the pass-through effects to Zambia's domestic consumer prices are as follows:

Baseline Model: $In(CPI)_t = \alpha_0 + \alpha_1 In(NER)_t + \alpha_2 In(CU)_t + \alpha_3 In(OILP)_t + \alpha_4 InGDP_t + \alpha_2 In(TB)_t + \mathcal{E}_t$ (7)

Alternative Model: $In(CPI)_t = \alpha_0 + \alpha_1 In(NEER)_t + \alpha_2 In(CU)_t + \alpha_3 In(OILP)_t + \alpha_4 InGDP_t + \alpha_2 In(TB)_t + \mathcal{E}_t$ *(8)*

Consequently, the ERPT baseline and alternative models to local production are stated as follows:

Baseline Model: $InGDP_t = \alpha_0 + \alpha_1 In(NER)_t + \alpha_2 In(CU)_t + \alpha_3 In(OILP)_t + \alpha_4 In(CPI)_t + \alpha_2 In(TB)_t + \mathcal{E}_t$ (9)

Alternative Model: $InGDP_t = \alpha_0 + \alpha_1 In(NEER)_t + \alpha_2 In(CU)_t + \alpha_3 In(OILP)_t + \alpha_4 In(CPI)_t + \alpha_2 In(TB)_t + \mathcal{E}_t$ (10)

Where: $In(CPI)_t$, $InGDP_t$, $In(NER)_t$, and $In(NEER)_t$ are the variables of interest. Furthermore, $In(CU)_t$, $In(OILP)_t$, and $In(TB)_t$ are control variables while $\mathcal{E}_t$ is the white noise error term.

3.2 Estimation Method and Procedure

Most reviewed studies on ERPT to domestic prices applied SVAR models as well as cointegration methodologies to analyze ERPT in many countries. This study, however, utilizes the VECM, which is ideal for its ability to account for the non-stationarity of data and seasonality properties. It also allows for analysis of ERPT in both the short-run and long-run periods. This is in line with the works of Bada (2016), Aliyu et. al (2009), Ghosh and Rajan

(2009), Ca' Zorzi and S'anchez (2007) and McCarthy (2000). The general VAR model from which the VECM is derived takes the following form:

$$Y_t = \text{c} + \sum_{i=1}^{p} \Phi_i \, Y_{t-1} + \mathcal{E}_t \tag{11}$$

Where: Y_t represents the vector of endogenous variables, c is a vector of constants, $\emptyset_i$ denotes the matrices of autoregressive coefficients and $\mathcal{E}_t$ is a vector of white noise autoregressive processes.

The estimation starts with checking the time series properties of the variables (i.e., stationarity) using the Augmented Dickey Fuller (ADF) and Philips-Perron (PP) to establish order of integration and avoid the incidence of spurious regression estimates. A time series that has a stochastic trend is said to have a unit root. Although the ADF is widely used, PP was also used to circumvent borderline issues where data appears to be barely stationary and ADF test's limitation on detecting autocorrelation and heteroscedasticity.

This section then proceeds to test for cointegration using the Johansen (1991) maximum likelihood procedure by estimating the following cointegration equation:

$$\Delta x_t = \alpha + \beta + \delta x_{t-1} + \sum \Delta x_{t-1} + \varepsilon_t \tag{13}$$

Where: x in the above equation is the variable under consideration

The estimation of the VECM is as follows:

$$\Delta X_t = \mu + \sum \Gamma_i \, \Delta X_{t-i} + \prod X_{t-p} + \varphi_t \tag{14}$$

(Log form of the variables is used to infer elasticities).

Where: Δ is the first difference lag operator, X_t is a (6x1) random vector of time series variables with I (1) , μ is a (6x1) vector of constants, Γ_i are (6 x 6) matrices of parameters, φ_t is a sequence of zero-mean p- dimensional white noise vectors, and Π is a (6 x 6) matrix of parameters.

Anguyo (2008) and Ca' Zorzi et. al (2007) argues identification of the structural shocks is achieved via ordering variables of interest and applying Cholesky decomposition to the variance-covariance matrix of the reduced form residuals, ε_t. As a matter of procedure, this paper will apply the approach together with the relevant economic theories in ordering the variables in the adopted models.

From economic theory we expect TB, OILP and NER to have a positive relationship with CPI whereas CU and GDP have negative associations. Furthermore, NEER, CU and GDP have a negative association with CPI while TB and OILP impact CPI positively. Additionally, CU is expected to have a positive association with GDP in the local production model while CPI, NER, TB, and OILP are expected to have negative impact on GDP. Moreover, NEER is expected to impact GDP positively in the alternative model for local production.

Post-estimation diagnostic tests were done using the Best Linear Unbiased Estimator (BLUE) properties of minimum variance, unbiased, consistent, linear, and normally distributed in a class of all linear, unbiased estimators (Gujarati, 1995). Hence, autocorrelation, heteroscedasticity, normality, and stability tests were undertaken using residual serial correlation LM test, White's heteroscedasticity test, normality test and AR root stability test, respectively. Moreover, the IRFs are further used to trace the effect of a shock emanating from an endogenous variable to other variables in the VECM. Finally, variance decomposition is applied to show the relative importance of each shock in explaining the variation for each of the variable under discussion (i.e., CPI and GDP).

3.3 Data Sources and Description

Data used in this study was obtained from Zambia Statistics Agency (ZSA), the Bank of Zambia (BoZ), London Metal Exchange (LME) and International Monetary Fund (IMF). Specifically, the quarterly time series data will be used on the following variables:

- Copper Price as proxy of Zambia's exports.
- Crude Oil to represent Zambia's imports.
- TB 91 days to represent interest rates and act as monetary variable.
- Gross Domestic Product as local production.
- Consumer Price Index to proxy Zambia's price level.
- Exchange Rate to be represented by NER for the baseline model and NEER for the alternative model.

Whereas all the data series were obtained in the quarterly frequency, GDP data before 2010 was only compiled on an annual frequency. Thus, we decomposed the annual data into quarterly GDP data using the EViews software using linear averaging to make it uniform with the other data series in the model.

4.0 Empirical Results and Discussion

4.1 Unit Root Tests

Results from both the ADF and PP tests (Table 2) show that all variables are non-stationary in level form but stationary after differencing once. Therefore, variables are integrated of order 1 and this allows for testing for cointegration using the Johansen cointegration procedure.

Table 2: Unit Root Test Results

	Level: P-Values		First Difference: P-Values		Comment
Variable	ADF	PP	ADF	PP	
LCPI	0.9899217	0.2658	0.008	0.0000	*I(1)*
LNER	0.9892526	0.3351	0.000	0.0000	*I(1)*
LNEER	0.7601	0.7601	0.000	0.0000	*I(1)*
LCU	0.8998544	0.6353	0.000	0.0000	*I(1)*
LOILP	0.8177023	0.6427	0.000	0.0000	*I(1)*
LGDP	0.9183089	0.929	0.003	0.0000	*I(1)*
LTB	0.466519	0.1417	0.000	0.0000	*I(1)*

Source: Author's Computations

4.2 Lag Selection

Since the variables are integrated of the same order, it is necessary to test for cointegration to determine if there is a long-run equilibrium relationship among the variables. However, before conducting the cointegration test, the optimal lag length is determined using Akaike Information Criteria (AIC). Results show that the optimal lag length is three for both the baseline model and the alternative model for CPI and GDP (see appendix).

4.3 Cointegration Analysis

Using three as the optimal lag length, results from the Johansen approach (Table 3) indicate existence of cointegration among the variables. The evidence of cointegration implies that there is a long-run relationship between the variables in the system and thus, justifies the need to estimate a VECM. The results show the presence of at least two cointegrating equations on both the trace and maximum eigenvalue statistics at the one percent level of both the baseline and alternative models.

Table 3: Cointegration Relationship Test Results

Baseline Model				
Hypothesized No. of CE(s)	Max-Eigen Statistic	Critical Value (Eigen) @ 5%	Trace Value Statistic	Critical value (trace) @ 5%
None	83.85969*	46.23142	198.7728*	125.6154
Atmost 1	45.79263*	40.07757	114.9131*	95.75366
Atmost 2	25.97685	33.87687	69.12049	69.81889
Atmost 3	16.66912	27.58434	43.14364	47.85613
Atmost 4	14.13006	21.13162	26.47452	29.79707
Atmost 5	8.446032	14.26460	12.34446	15.49471
Atmost 6	3.898426*	3.841466	3.898426*	3.841466
Alternative Model				
None	79.3464*	46.23142	182.7242*	125.6154
Atmost 1	38.52389	40.07757	103.3777*	95.75366
Atmost 2	23.38402	33.87687	64.85386	69.81889
Atmost 3	18.38351	27.58434	41.46983	47.85613
Atmost 4	11.03973	21.13162	23.08633	29.79707
Atmost 5	8.244593	14.26460	12.04659	15.49471
Atmost 6	3.802002	3.841466	3.802002	3.841466

*Denotes rejection of the hypothesis at 5% level of significance.

Source: Author's Computations

4.4 VECM Estimates of the Pass-Through Effects

4.4.1 ERPT to Consumer Prices

Cognizant of the presence of cointegration among variables, the long-run pass-through effects from exchange rate to domestic prices and local production is estimated using VECM. Table 4 provides a summary of the cointegrating results for both the baseline and alternative models. Empirical results from the CPI normalized cointegrating equations indicate that all variables except for copper price (LCU) have anticipated signs as informed by theory. Moreover, LCU was statistically insignificant for both the baseline and alternative models.

Table 4: CPI Model Normalized Cointegrating Coefficients

Baseline Model							
LCPI	LCU	LNER	LNEER	LGDP	LOILP	LTB	C
1.000	-0.149 (-0.917)	-0.634 (-7.085)		-0.383 (-2.360)	-0.081 (-1.023)	-0.205 (-3.732)	-0.269
Alternative Model							
1.000	-0.039 (-0.114)		0.144 (1.945)	-0.184 (-0.431)	-0.283 (-1.053)	-0.406 (-2.779)	-1.881

t-Statistics in Parentheses
Source: Author's Computations

Baseline Model[2]*:* $In(CPI)_t$ = 0.268 + $0.634In(NER)_t$ + $0.149In(CU)_t$ + $0.081In(OILP)_t$ + $0.383InGDP_t$ + $0.205In(TB)_t$ + $\mathcal{E}_t$ (7)

Alternative Model: $In(CPI)_t$ = 1.881 - $0.144In(NEER)_t$ + $0.039In(CU)_t$ + $0.282In(OILP)_t$ + $0.184InGDP_t$ + $0.406In(TB)_t$ + $\mathcal{E}_t$ *(8)*

We found that the long-run ERPT elasticity to Zambia's domestic prices (CPI) for the sample period was 0.63 percent for the baseline model and 0.14 percent for the alternative model. Besides, changes in nominal exchange rate (LNER) of 0.63 percent, local production (LGDP) of 0.38 percent and interest rate (LTB) of 0.21 percent have the greatest positive impact on domestic prices (LCPI) for the baseline scenario while that for interest rates (LTB) of 0.41 percent and imports (LOILP) of 0.28 percent have the greatest positive effect on domestic prices in the alternative model. The implication is that a one percent depreciation in the Zambian Kwacha relative to the USD will lead to 0.63 percent and 0.14 percent change in the Zambian domestic prices using the baseline model and alternative model, respectively. However, we did not find any significant import price pass-through effects to inflation in both the baseline and alternative models in the long run. Furthermore, for both the baseline and alternative models, the ERPT was asymmetric and not moderated along the supply chain contrary to the previous studies by Bada et al. (2016), Zgambo (2015) and Aliyu (2016). From the results the pass-through is persistent up to the 10^{th} month (Charts 1 and 2).

The short-run dynamics are presented in Table 5 below. The coefficients of the error correction terms are negative 0.11 and negative 0.05 for the baseline and alternative models, respectively. They are both negative and highly significant implying that any deviation from the long-run equilibrium relationship is adjusted by about 11 percent and 5 percent within a quarter for the two model specifications, respectively. This implies that it will take approximately 10 quarters for the domestic prices (LCPI) to adjust to its long-run path after an ERPT shock in both models. The speed of adjustment is quite low and can be partly

[2] All coefficients in the normalized equations are interpreted in reverse (i.e., positive means negative and otherwise).

attributed to the composition of the Zambian consumer price index basket and the monetary policy transmission mechanism. This is partly because most of the basket items are produced locally and partly because of a lagged monetary policy transmission process. The nominal exchange rate plays a dual role in macroeconomic adjustments: viz; it is part of the transmission mechanism of monetary policy in Zambia, and it also helps accommodate external and domestic shocks through its effect on the real exchange rate. The short-run ERPT elasticities are found to be 0.029 percent for the nominal exchange rate (LNER) and 0.007 percent for nominal effective exchange rate (LNEER) in the first quarters respectively. Furthermore, the short-run ERPT elasticities are found to be 0.100 percent for the nominal exchange rate (LNER) and 0.006 percent for the nominal effective exchange rate (LNEER) in the second quarter, respectively. Additionally, during the first quarter both the short-run ERPT for the baseline and alternative models are insignificant which is consistent with the law of purchasing power parity theory[3] for the baseline and alternative models, respectively. Additionally, the ERPT effect is significant only in the baseline model after two quarters. The policy implication is that in Zambia the change in the nominal exchange rate (LNER) only affects the domestic prices in the second quarter after a shock. Nevertheless, we did not find any significant pass-through effects to inflation in the short run from the nominal effective exchange rate (LNEER).

Table 5: CPI Short-Run VECM Coefficients

Baseline Model								
Lags	ΔLCPI	ΔLCPRICE	ΔLNER	ΔLNEER	ΔLGDP	ΔLOILP	ΔLTB	ECM
1	-0.161	-0.021	0.029		-0.049	0.023	-0.025	-0.113
	(-1.740)	(-0.787)	(0.596)		(-1.365)	(1.119)	(-2.764)	(-7.163)
2	-0.253	0.061	0.100		-0.048	0.032	-0.008	
	(-2.722)	(2.245)	(2.074)		(-1.332)	(1.594)	(-0.815)	
Alternative Model								
1	-0.148	-0.031		0.007	-0.049	0.004	-0.018	-0.045
	(-1.502)	(-1.204)		(1.056)	(-1.336)	(0.205)	(-1.987)	(-6.562)
2	-0.207	0.034		0.006	-0.068	0.029	-0.011	
	(-2.129)	(1.257)		(0.891)	(-1.901)	(1.403)	(-1.196)	

t-Statistics in Parentheses
Source: Author's Computations

4.4.2 ERPT to Local Production

Furthermore, empirical results from the local production (LGDP) cointegrating equation reveal that all variables except copper price (LCU) had their correct anticipated signs. Additionally, copper price (LCU) was not statistically significant for both the baseline and alternative models implying that it had no direct impact on the domestic prices in Zambia (Table 6). We found that the long-run ERPT elasticity to Zambia's GDP for the sample period

[3] PPP does not hold in the short run.

was 1.65 percent for the baseline model and 0.78 percent for the alternative model. Besides, changes in nominal exchange rate (LNER) and copper price (LCPI)of 1.65 percent and 2.61 percent have the greatest impact on local production (LGDP) for the baseline while copper price (LCPI) with 5.44 percent and interest rate (LTB) with 2.21 percent have the greatest effect on local production in the alternative model. The implication is that a one percent depreciation in the Zambian Kwacha relative to the USD will lead to 1.65 percent decline and 0.78 percent increase in the Zambian GDP using the baseline and alternative model, respectively. This is mainly due to the effect of the movements in exchange rate (NER and NEER) on imports, raw materials as well as intermediate goods that are used in the local production process. However, we did not find any significant import price pass-through effects to local production in the long run as the effect is reflected indirectly through the exchange rate channel. More so, there was no significant short-run local production (GDP) relationship in either the baseline and alternative models (consistent with LOOP and PPP) hence their omission.

Table 6: GDP Normalized Cointegrating Coefficients

Baseline Model							
LGDP	LCU	LNER	LNEER	LCPI	LOILP	LTB	C
1.000	0.390	1.653		-2.609	0.212	0.534	0.700
	(1.129)	(1.989)		(-3.407)	(0.828)	(3.505)	
Alternative Model							
1.000	0.214		-0.783	-5.443	1.538	2.209	10.24
	(0.161)		(-1.952)	(-4.739)	(0.933)	(2.798)	

t-Statistics in Parentheses
Source: Author’s Computations

Baseline Model: $InGDP_t = -0.700$ - $1.653In(NER)_t$ - $0.390In(CU)_t$ - $0.212In(OILP)_t$ + $2.609In(CPI)_t$ - $0.534In(TB)_t$ + $\mathcal{E}_t$ (9)

Alternative Model: $InGDP_t = -10.239$ + $0.783In(NEER)_t$ - $0.214In(CU)_t$ - $1.538In(OILP)_t$ + $5.443In(CPI)_t$ - $2.209In(TB)_t$ + $\mathcal{E}_t$ (10)

Diagnostic tests were utilized for checking validity of fitted models. Consequently, VECM based diagnostic tests were employed; viz: residual serial correlation LM tests, White’s heteroskedasticity, normality tests and AR root stability tests. The results indicate that, there was no serial correlation in the residuals, the residuals were, homoscedastic and stable in both models. However, they were not normally distributed in both models consistent with Ngoma and Chanda (2020) and Diouf (2007) who argued that such results were amenable for policy use as the Johansen cointegration method was robust to non-normal errors.

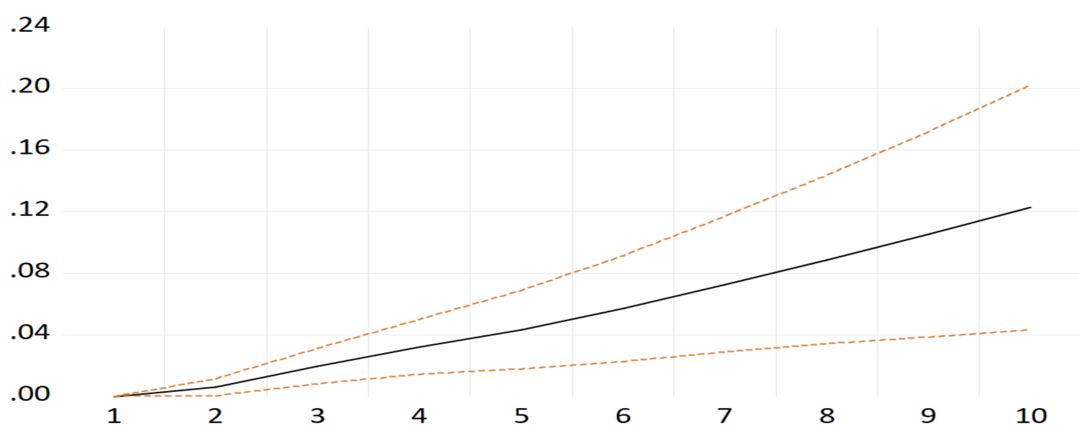
4.5 Impulse Response Functions

Impulse response functions (IRFs) trace the effect of a shock from an endogenous variable to other variables in a VECM. In this respect the accumulated response functions for variables of interest in both the domestic prices (LCPI) and gross domestic product (GDP) models to one-standard deviation structural innovations are shown in charts 1 up to 4 below. The dashed lines represent a one standard error confidence band around the estimates of the coefficients of the impulse response functions[4]. Chart 2 shows the response of domestic prices to structural innovations of the nominal exchange rate (LNER) while chart 3 shows the response of domestic prices to nominal effective exchange rate (LNEER). Similarly, charts 4 and 5 depict the responses of gross domestic product (GDP) to LNER and LNEER, respectively.

4.5.1 Response of Domestic Prices to Nominal Exchange Rate

Results from impulse responses in chart 2 indicate that a positive shock to nominal exchange rate (LNER) is associated with a sustained rise in domestic price. The result was broadly in line with empirical evidence which suggest that pronounced exchange rate changes may strongly impact both inflation and economic activity Anderton et al, 2004; Hahn, 2003; Farquee, 2004; and Angeloni et al. 2003). The impact is asynchronous after an exchange rate shock and could only significantly affect domestic prices in the second quarter. This was consistent with the psychological phenomenon that has had dominated Zambian commodity markets to adjust domestic prices even for non-tradable goods immediately after an exchange rate shock. The impact is persistent up to the tenth quarter in the baseline model. The results also show that ERPT effect on the exchange rate itself in the baseline model is high, persistent, consistent, and significant, implying exchange rate depreciation leads to further depreciation consistent with Aliyu (2009).

Chart 2: Accumulated Response of LCPI to LNER One S. D Innovation +/- 2 Analytic Asymptotic S. Es



Source: Author's Computation

4.5.2 Response of Domestic Prices to Nominal Effective Exchange Rate Index

Results from chart 3 indicate that a positive shock of the nominal effective exchange rate Index (LNEER) endogenously lead to statistically significant and persistent decrease in the

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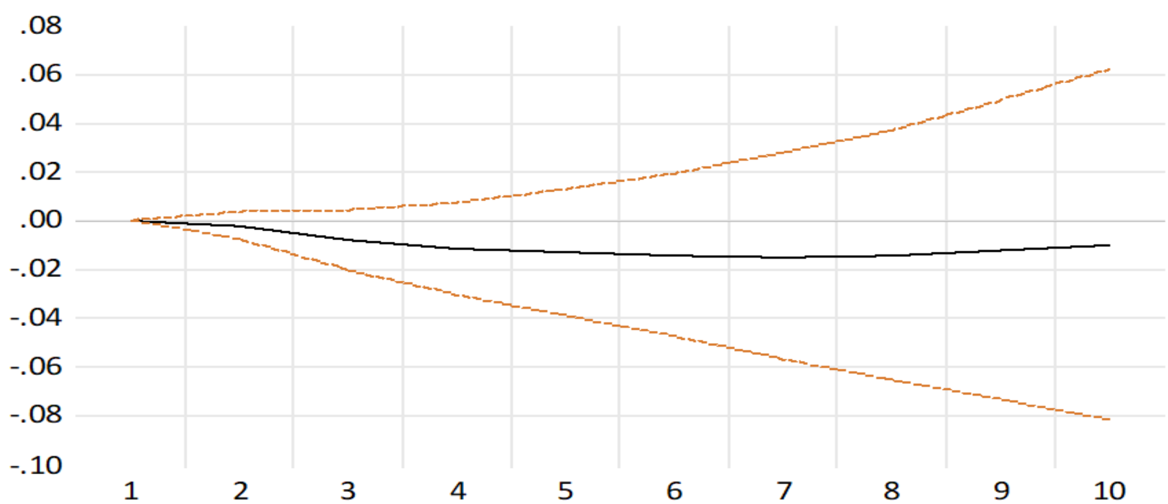
[4] The coefficient bands are obtained using Monte Carlo integration as described by Sims (1980), where 5,000 draws were used from asymptotic distribution of the VAR coefficients.

domestic prices (LCPI). The implication that an appreciation of the Zambian kwacha relative to a basket of major convertible currencies leads to a lagged fall in the domestic prices by a quarter. The prices thereafter consistently fall slowly up to the eighth quarter when it starts rising slowly. The phenomenon that could only be supported by LNEER being a composite of several currencies some of which are rarely used in Zambia's importation of goods and services. The sustained downward trend is mostly supported by the high weight that the US dollar holds in the basket of currencies that are used to compute the LNEER index in Zambia.

Chart 3: Accumulated Response of LCPI to LNEER One S. D Innovation +/-2 Analytic Asymptotic S. Es



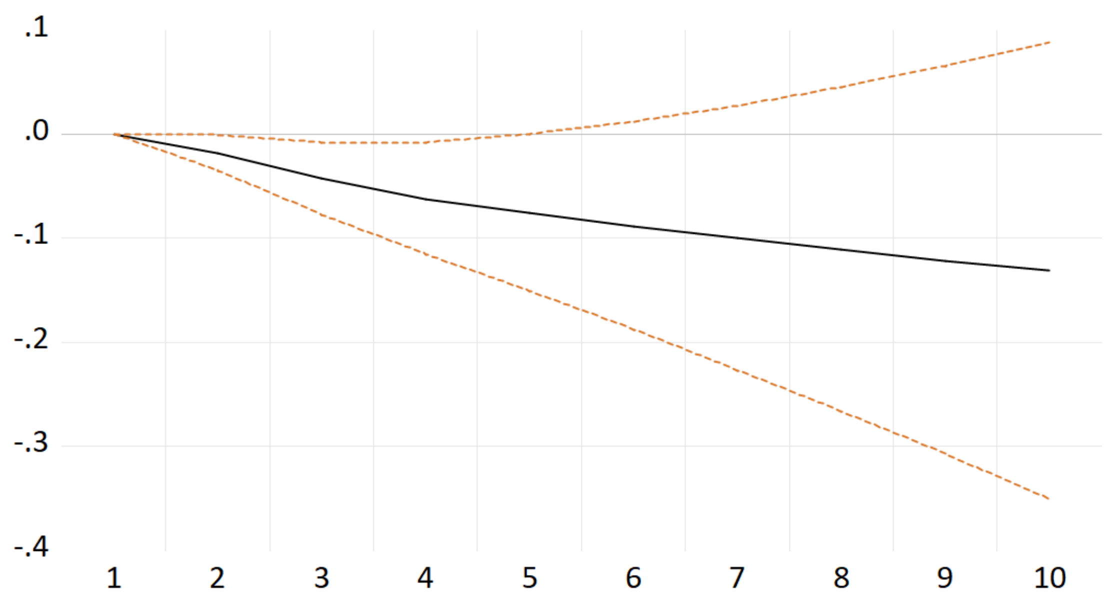
Source: Author's Computation

Furthermore, the impact of import prices (LOIL) on domestic prices (LCPI) is insignificant throughout up to the tenth quarter (see appendix). However, impact of nominal exchange rate (LNER) on import prices (LOIL) is very low in the first three quarters after which it moderates up to the tenth quarter implying that ERPT effects slowly reduce up to the tenth month in Zambia. Besides, exports (LCU) have a moderating effect with a lag of two quarters on the movements in the LCPI through its accreditation impact on foreign exchange earnings in the economy. The findings on the impact of copper on the domestic prices and nominal exchange rate are consistent with Bada et al. (2016) who argued that major exports (copper) were critical precursors of exchange rate movements as they contributed to forex accumulation. Moreover, LCPI has a significant impact on itself throughout the 10-quarter period after a shock which implies that high domestic prices lead to higher domestic prices in future. For all variables the developments are similar to those in the alternative model. However, the response of LGDP to LNER shock is negative until the third quarter when it cools off while the response of LGDP to LNEER is persistently and consistently positive from impact up to the tenth month.

4.5.2 Response of Local Production to Nominal Exchange Rate

It is clear from the literature that the effects of nominal exchange rate (LNER) from structural shocks to local production (LGDP) should be negative. The impulse response of local production to nominal exchange rate are presented in chart 4 below. A positive innovation in nominal exchange rate is associated with statistically significant negative effect on local production. The response of local production is persistent and consistently negative from impact of the exchange rate shock up to the tenth quarter. Policy implications are that the nominal exchange rate was one of the main contributors to movements in the local production through the importation of both primary and intermediate goods. The impact of imports (LOIL) on the local production (LGDP) is intense during the first three quarters then it levels up to the tenth quarter. Moreover, a positive copper price (LCU) to local production (LGDP) culminates into a positive, high, persistent, and consistent impact. Policy implication is that apart from copper being the major export and contributing significantly to forex earnings in Zambia, it also has a higher weight in local production.

Chart 4: Accumulated Response of LGDP to LNER One S. D Innovation +/-2 Analytical Asymptotic S. Es

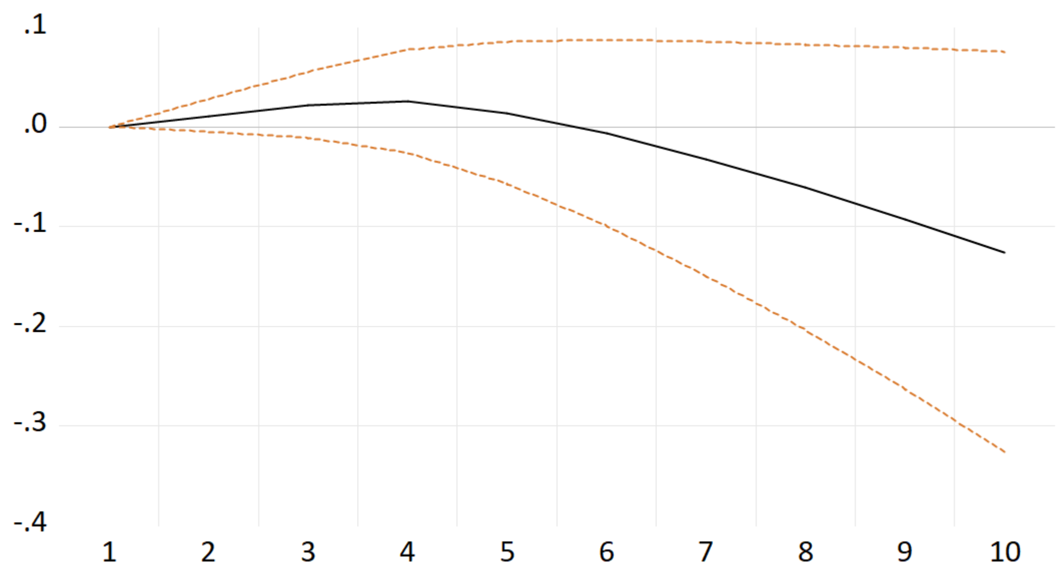


Source: Author's Computation

4.5.2 Response of Local Production to Nominal Effective Exchange Rate

Results from the impulse response show that positive structural shocks to nominal effective exchange rate index (LNEER) lead to a slow rise in local production (LGDP) in the first four quarters after which the effects wane off up to the tenth quarter (Chart 5). Policy implication is that the appreciation of the Kwacha against a basket of major convertible currencies positively impacts on local production in the first four quarters. The impact of imports (LOIL) on the local production (LGDP) is low but persistent during the first three quarters then it drops up to the tenth quarter. Moreover, a positive copper price (LCU) to local production (LGDP) culminates into a positive, high, persistent, and consistent impact similar to the effects of nominal exchange rate. Policy implication is that apart from copper being the major export and contributing significantly to forex earnings in Zambia, it also has a higher weight in local production.

Chart 5: Accumulated Response of LGDP to LNEER One S. D Innovation +/- 2 Analytical Asymptotic S. Es



Source: Author's Computation

4.6 Variance Decomposition

The variance decomposition indicates the amount of information each variable contributes to the other variables in the autoregression. It determines how much of the forecast error variance of each of the variables can be explained by exogenous shocks to the other variables. In this regard, the variance decomposition tables for variables of interest in both the domestic prices (LCPI) and gross domestic product (GDP) models are shown in tables 7 and 8 below. Table 6 shows the variance decomposition of domestic prices (LCPI) as well as that of local production (LGDP).

4.6.1 Variance Decomposition of Domestic Prices

Results from the variance decomposition (Table 7) show that domestic prices (LCPI) accounts for 100.0 percent of its own variance in the first quarter but declines slowly to 95.11 percent in the second quarter in the baseline model. Furthermore, it declines persistently and consistently to 55.5 percent in the tenth quarter. The alternative model depicts a similar pattern in which domestic prices (LCPI) accounts for 100 percent of its variance during the first quarter but declines slowly to 97.59 percent in the second quarter. Consequently, the variance declines persistently to 65.2 percent in the tenth quarter. The impact of the nominal exchange rate intensifies from second quarter throughout to the tenth quarter in both models but is more significant in the baseline model than the alternative model. Whereas copper prices (LCU)exhibit a waning effect on domestic prices (LCPI), the effects of nominal exchange rate (LNER) and nominal effective exchange rate (LNEER) intensify from the second quarter up to the tenth month though more pronounced in the baseline model consistent with Ghosh and Rajan (2009) who asserted that variations were more in LNEER than LNER since it encompassed a basket of currencies. The policy implications are that on impact, both the LNEER and LNER shocks are not contemporaneous with movements in the LCPI but intensify after the second quarter with long lasting effects.

Table 7: Variance Decomposition of Domestic Prices

Baseline Model					
	2 Quarters	4 Quarters	6 Quarters	8 Quarters	10 Quarters
LCPI	95.11	76.02	69.59	61.31	55.5
LCU	0.73	0.68	0.56	0.58	0.45
LOIL	1.39	5.32	5.55	6.92	8.03
LGDP	0.002	0.12	0.32	0.45	0.72
LNER	2.75	15.87	18.04	19.91	20.61
Alternative Model					
LCPI	97.59	88.81	82.77	72.77	65.19
LCU	1.47	1.59	1.21	1.15	0.86
LOIL	0.36	3.99	4.46	6.36	7.66
LGDP	0.001	0.57	2.14	4.11	5.69
LNEER	0.001	0.57	2.14	4.11	5.69

Source: Author's Computation

4.6.1 Variance Decomposition of Local Production

Results from the variance decomposition of local production (LGDP) (Table 8) reveal that, local production (LGDP) accounts for 100 percent of its variance in the first quarter then drops to 61.3 percent in the second quarter. Furthermore, the variance moderates consistently to 55.5 percent in the tenth quarter or the baseline model. Copper price (LCU) has the second highest impact of 25.6 percent and LNER with 11.0 percent has the third highest impact in the second quarter of the baseline model. While the impact of local production (LGDP) on itself moderates steadily up to the tenth quarter, the effects of the copper prices (LCU), oil price (LOIL) and nominal exchange rate (LNER) on local production (LGDP) intensifies during the same period. More so, the effect of domestic prices (LCPI) on local production (LGDP) is mixed as it depicts a downward trend between 2nd and 4th quarters, a rise between 4th and 6th Quarters and finally a sustained fall between 6th and 10th quarters. Policy implication is that movements in exports, imports and nominal exchange rate play dominant and persistent roles in explaining the movements in the local production. Moreover, local production has the greatest effect on itself.

Table 8: Variance Decomposition of Local Production

Baseline Model					
	2 Quarters	4 Quarters	6 Quarters	8 Quarters	10 Quarters
LGDP	61.32	42.89	39.02	30.5	35.32
LCPI	1.36	1.15	1.69	1.63	1.6
LCU	25.55	37.84	40.46	42.41	43.21
LOIL	0.31	2.05	2.32	2.35	2.28
LNER	10.96	15.71	16.03	16.63	17.03
Alternative Model					
LGDP	67.95	52.07	48.04	45.56	44.39
LCPI	0.84	1.32	2.02	2.05	2.03
LCU	29.34	42.79	45.89	48.26	49.33
LOIL	0.46	1.93	2.16	2.17	2.09
LNEER	1.16	1.39	1.52	1.7	1.86

Source: Author's Computation

Similarly, in the alternative model, local production (LGDP) accounts for 68.0 percent of its variance in the second quarter and the impact declines steadily up to the tenth quarter while the impacts of domestic prices (LCPI), copper prices (LCU), oil prices (LOILP) and nominal effective exchange rate index (LNEER) on local production (LGDP) are persistent and consistent during the same period (Table 7). Policy implication is that movements in exports, imports and nominal exchange rate play dominant and persistent roles in explaining the movements in the local production. Moreover, local production has the greatest effect on itself.

5.0 Conclusion

The study examined the degree of exchange rate pass-through to domestic prices and local production proxied by GDP for the period 1995Q1 to 2019Q4. The methodology estimated the baseline and alternative models, which enabled for intra-model comparability. The baseline model used the nominal exchange while the nominal effective exchange rate was used in the alternative model as proxies for the exchange rate between the Zambian Kwacha and US dollar. The study then estimated the exchange rate pass-through to both consumer prices and GDP by employing a VECM. The results for both the baseline and alternative models showed that the ERPT was persistent, consistent, and incomplete and consistent with studies by Zgambo (2015), Kapembwa (2017) and Mwila et. al (2017). However, ERPT was found to be high and overturned the findings of the other studies in Zambia but was in line with the findings of Aliyu (2009). The development broadly attributed to the adverse macroeconomic conditions the country had experienced between 2015 and 2019 due to external debt service, climate change and exchange rate depreciation. Exchange rate pass-through was more intense in the baseline models than the alternative models for both domestic price and local production models.

The long-run exchange rate pass-through to domestic prices estimated from the baseline model (0.63) was far higher than that estimated using the alternative model (0.14). This is because bilateral exchange rate (Kwacha per dollar) used in the baseline model only focuses on the dollar while the nominal effective exchange rate index used in the alternative model encompasses a basket of currencies. Most of the intercountry transaction are done in dollars and as such the dollar carries more weight especially for a country like Zambia that imports crude oil in dollars which is an engine of the economy.

From the VECM estimated, the pass-through to GDP was 1.65 percent (baseline model) and 0.78 percent (alternative model). The high estimates for pass-through are consistent with that found by Gaulier et. al (2008) who found the ERPT to product level was 0.8 on average after one year. Furthermore, the results obtained show that raw materials and intermediate goods price increases emanating from exchange rate depreciation have spillover effects to local production and output of the economy which is critical to macroeconomic stabilization.

The finding that the ERPT to domestic prices is incomplete for Zambia has great implications about the effectiveness of exchange rate measures which are intended to stabilize the price level and improve local production (GDP). Adolfson (2001) and Smet and Woutes (2007) showed that incomplete pass-through makes the exchange rate channel less effective. Arising from the above, there is need for the Central Bank and authorities at large to gauge monetary policy response in mitigating the pass-through effects. This is because the effects of the pass-through not only have impact on the domestic price level but also the level of output and in turn economic growth. The development that demands monetary, fiscal, and structural policies aimed at maintaining the exchange rate within a certain bandwidth, effective debt sustainability strategies as well as reviving and broadening the manufacturing sector in Zambia to reduce on the imports but increase export base.

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APPENDIX

Lag Selection

VAR Lag Order Selection Criteria
Endogenous variables: LCPI LCPRICE LNEXRATE LNGDP LOILPRICE LTBRATE
Exogenous variables:
Date: 12/09/21 Time: 11:38
Sample: 1995Q1 2019Q4
Included observations: 92

Lag	LogL	LR	FPE	AIC	SC	HQ
1	558.9081	NA	4.66e-13	-11.36757	-10.38078*	-10.96929*
2	601.1531	73.46965	4.10e-13	-11.50333	-9.529755	-10.70678
3	644.1730	69.20583*	3.60e-13*	-11.65593*	-8.695574	-10.46111
4	677.6115	49.43080	3.98e-13	-11.60025	-7.653102	-10.00715
5	697.9642	27.43201	6.02e-13	-11.26009	-6.326158	-9.268715
6	733.9743	43.83835	6.76e-13	-11.26031	-5.339590	-8.870658
7	769.9797	39.13632	8.02e-13	-11.26043	-4.352921	-8.472500
8	792.8645	21.88978	1.37e-12	-10.97532	-3.081021	-7.789111

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Serial Correlation Test (Baseline Model)

VEC Residual Serial Correlation LM Te...
Null Hypothesis: no serial correlation at...
Date: 11/17/21 Time: 08:52
Sample: 1995Q1 2019Q4
Included observations: 97

Lags	LM-Stat	Prob
1	40.78370	0.2682
2	34.93084	0.5193
3	35.29090	0.5021

Probs from chi-square with 36 df.

Serial Correlation Test (Alternative Model)

VEC Residual Serial Correlation LM Te...
Null Hypothesis: no serial correlation at...
Date: 11/17/21 Time: 08:55
Sample: 1995Q1 2019Q4
Included observations: 97

Lags	LM-Stat	Prob
1	27.28795	0.8516
2	36.25757	0.4566
3	27.04925	0.8593

Probs from chi-square with 36 df.

Normality Test (Baseline Model)

VEC Residual Normality Tests
Orthogonalization: Cholesky (Lutkepohl)
Null Hypothesis: residuals are multivariate normal
Date: 11/17/21 Time: 09:04
Sample: 1995Q1 2019Q4
Included observations: 97

Component	Skewness	Chi-sq	df	Prob.
1	0.969391	15.19213	1	0.0001
2	-1.705155	47.00546	1	0.0000
3	0.403356	2.630252	1	0.1048
4	0.296747	1.423613	1	0.2328
5	-0.514377	4.277436	1	0.0386
6	1.464100	34.65469	1	0.0000
Joint		105.1836	6	0.0000

Component	Kurtosis	Chi-sq	df	Prob.
1	7.497570	81.75540	1	0.0000
2	13.39626	436.8322	1	0.0000
3	4.272228	6.541697	1	0.0105
4	4.480981	8.864604	1	0.0029
5	3.638563	1.648041	1	0.1992
6	10.80138	245.9817	1	0.0000
Joint		781.6237	6	0.0000

Component	Jarque-Bera	df	Prob.
1	96.94753	2	0.0000
2	483.8377	2	0.0000
3	9.171949	2	0.0102
4	10.28822	2	0.0058
5	5.925477	2	0.0517
6	280.6364	2	0.0000
Joint	886.8073	12	0.0000

Normality Test (Alternative Model)

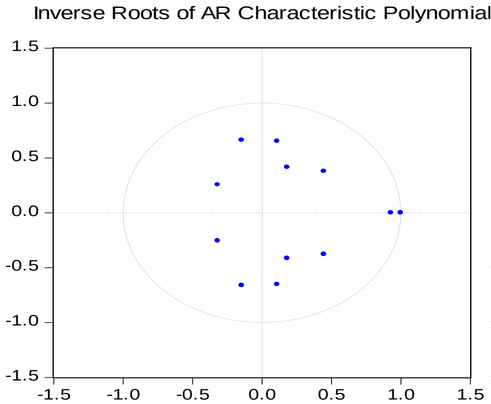
VEC Residual Normality Tests
Orthogonalization: Cholesky (Lutkepohl)
Null Hypothesis: residuals are multivariate normal
Date: 11/17/21 Time: 09:07
Sample: 1995Q1 2019Q4
Included observations: 97

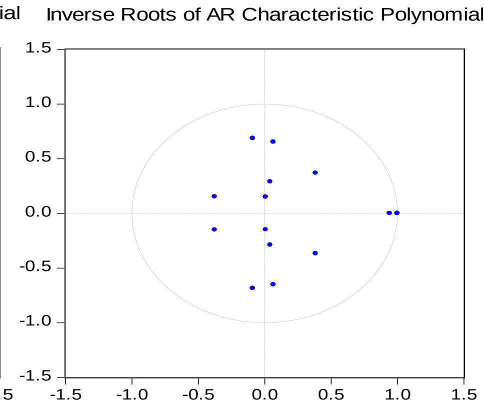
Component	Skewness	Chi-sq	df	Prob.
1	0.447373	3.235641	1	0.0721
2	-1.130154	20.64883	1	0.0000
3	-8.117306	1065.232	1	0.0000
4	0.951857	14.64750	1	0.0001
5	-0.413239	2.760725	1	0.0966
6	1.671152	45.14942	1	0.0000
Joint		1151.674	6	0.0000

Component	Kurtosis	Chi-sq	df	Prob.
1	6.966512	63.58841	1	0.0000
2	10.98927	257.9730	1	0.0000
3	76.62856	21910.54	1	0.0000
4	6.112292	39.14905	1	0.0000
5	3.768803	2.388860	1	0.1222
6	12.40810	357.7376	1	0.0000
Joint		22631.38	6	0.0000

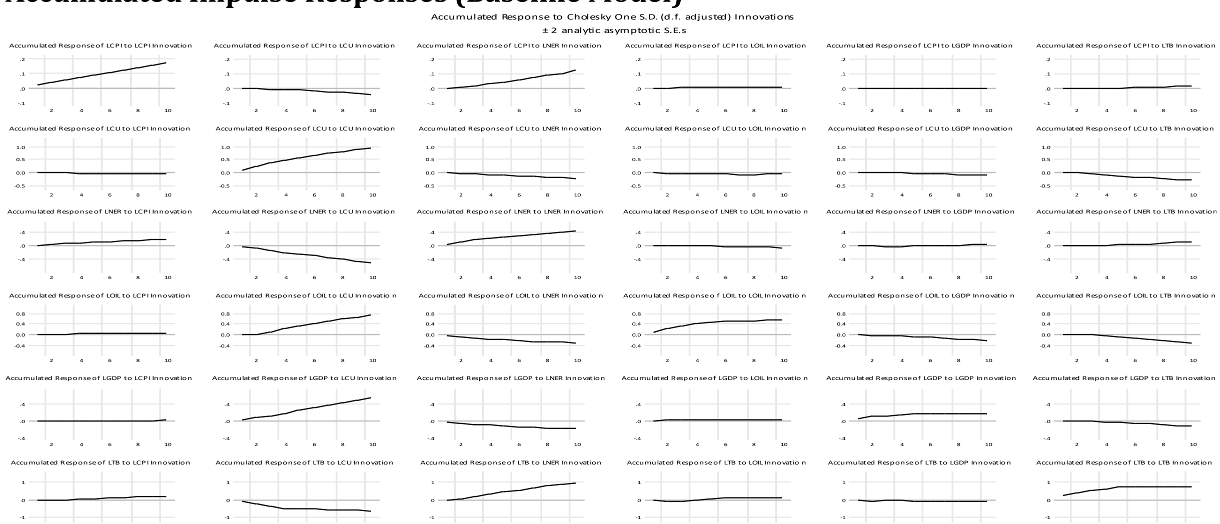
Component	Jarque-Bera	df	Prob.
1	66.82405	2	0.0000
2	278.6218	2	0.0000
3	22975.78	2	0.0000
4	53.79655	2	0.0000
5	5.149585	2	0.0762
6	402.8870	2	0.0000
Joint	23783.06	12	0.0000

Normality Test (Alternative Model) **AR Stability Test (Baseline Model)**





Accumulated Impulse Responses (Baseline Model)



Accumulated Impulse Responses (Alternative Model)