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Fuel Prices and Inflation in Zambia

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Abstract

This study examines the effect of fuel prices on inflation in Zambia using monthly data from January 2016 to December 2024. The empirical approach follows the bounds test cointegration methodology within the autoregressive distributed lag (ARDL) framework. Fuel prices are found to impact inflation both in the short and long-run. Inflation is also influenced by the exchange rate, world food prices, monetary policy rate and imported inflation from South Africa, a major trading partner of Zambia. These results emphasise the multi-faceted nature of inflation and suggest that measures to control inflation should mostly involve a policy-mix.

JEL E30, E31, 055
Keywords: Inflation, Petroleum, Autoregressive distributed lag

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1. Introduction

Since the 1990s, petroleum prices have generally been on the rise in Zambia, partly leading to upside pressures in inflation (Mutoti *et al*, 2011). Despite having a relatively small weight[2] in the consumer price index (CPI) basket, the impact of petroleum prices on overall consumer prices cannot be underestimated. According to Alvarez *et al* (2017), petroleum prices exert first, second and third round effects on inflation. They affect inflation directly through a corresponding adjustment in the energy component of the CPI. The indirect impact occurs through the rise in the prices of non-energy products in the CPI that require the use of petroleum as an input. Other subsequent effects occur through the dampening of aggregate supply (Alvarez *et al*, 2017). Rising energy prices lead to higher prices for other products, pushing overall inflation higher (IMF, 2000).

Inflation can take various types namely, policy induced caused mainly by expansionary monetary measures, non-policy caused by exogenous factors such as drought, cost-push caused by rising prices of factors such as energy, demand-pull caused by excess aggregate demand arising from internal or external shocks though mostly resulting from overly expansionary fiscal and monetary policies, and inertia inflation (Hall, 1982).

The response of inflation to higher fuel prices and the distributional consequences have been a central concern for policymakers, particularly where the anticipated adverse effect of higher fuel prices on the most vulnerable have led to social unrest (Kpodara and Liu, 2022). Petroleum products are important drivers of the economy world over. In Zambia, petroleum products, principally petrol, diesel and kerosene, are used to fuel industrial activity both at micro level (i.e. small shops use kerosene for lighting and petroleum products used to fuel tanks of automobiles) and macro level (i.e. to drive engines that dig copper). The cost and reliability of fuel supply are critical to the competitiveness of all economies and to the well-being of citizens. In Zambia, fuel is one of the largest imports and has been a major constraint to growth since the 1960s (Whitworth, 2011).

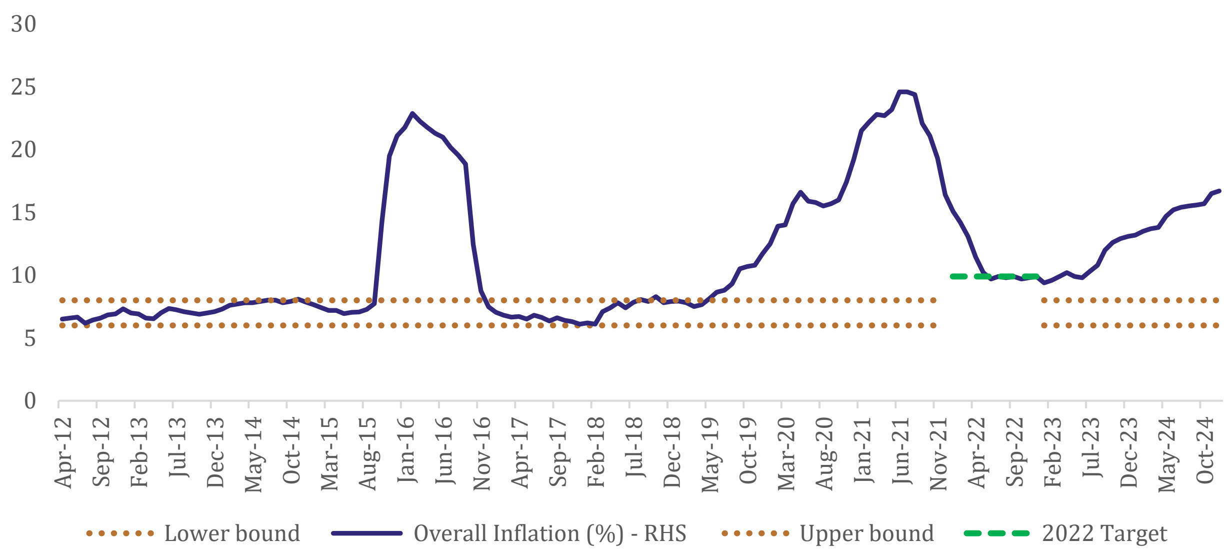
Inflation in Zambia has undergone various episodes. It averaged about 43 percent in the 1980s, rose to over 120 percent in the early 1990s but fell sharply to an average of 31 percent in the late 1990s. The high levels of inflation recorded over this period were mostly attributed to the sharp depreciation of the Kwacha, excessive money supply growth and supply shocks (Chipili, 2021). Further declines in inflation were recorded over the 2000-2001 period, averaging 25 percent. Inflation over this period was attributed to persistent high fiscal deficits coupled with accommodative monetary policy, adverse external shocks to the terms of trade and inadequate stabilization measures (Cheelo and Banda, 2017).

Since the introduction of the Monetary Policy Rate (MPR) in April 2012, inflation generally fluctuated within the target range of 6 to 8 percent until 2015 when it spiked to 20 percent, driven mainly by rising food prices on account of the drought and a weaker exchange rate (Chart 1). Following the dissipation of the 2015-16 supply shock, inflation decelerated to the

[2] Petroleum forms part of the housing, water, electricity, gas and other fuels category of the consumer price index (CPI) and accounts for 11.4 percent of the total CPI.

target band in 2017 until the first quarter of 2019. However, it breached the upper bound of the target band from May 2019, peaking at 24.6 percent by mid-2021, mostly on account of the COVID-19 pandemic shock. Inflation moderated towards the upper bound of the target range thereafter but remained outside the target band (Chart 1).

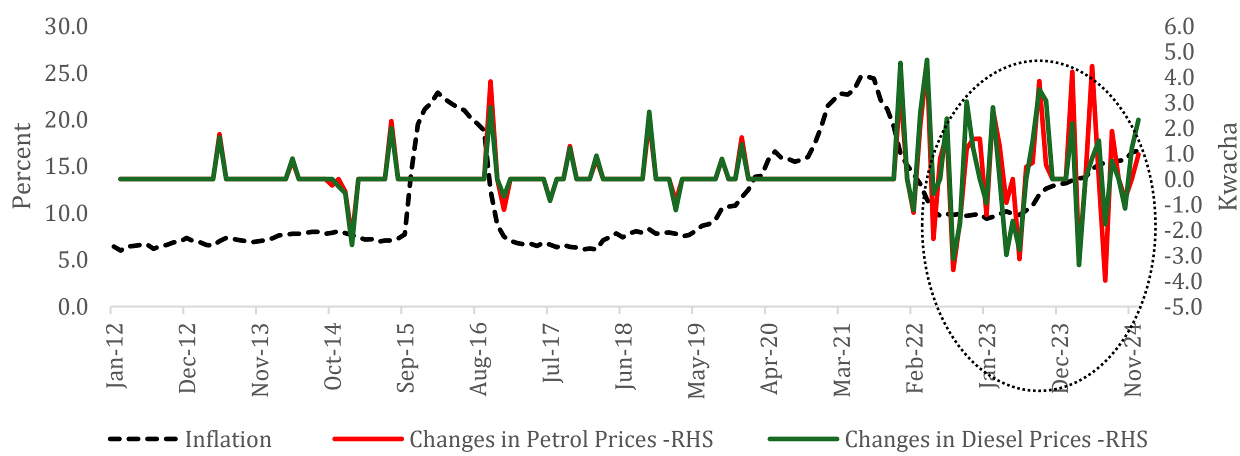
Chart 1: Trend in Overall Inflation



Source: Bank of Zambia

There appears to be a close relationship between petroleum prices and inflation in Zambia. Apart from the 2020–2021 period when inflationary pressures heightened principally on account of the COVID-19 pandemic shock, inflation was broadly stable (Chart 2). This coincides with a relatively stable process of diesel and petrol prices. In contrast, post the COVID-19 shock (2022–2024), when adjustments to petroleum prices were more frequent and mostly upwards, a steady rise in inflation is observed.

Chart 2: Changes in Petroleum Prices and Trend in Overall Inflation



Source: Bank of Zambia

Available studies on inflation in Zambia such as those done by Adams (1995), Mwenda (1996), and (Sgherri, 2001) largely focused on demand-pull factors. Few studies have investigated cost-push factors such as the impact of energy costs on inflation. Mutoti *et al*, (2011) modelled the relationship between oil prices and consumer price inflation in Zambia. A shortcoming of most studies in the literature that considered the inflationary impact of fuel price shocks is the reliance on crude oil prices data. Since domestic fuel prices in many developing countries are regulated, changes in contemporaneous crude oil prices may be a poor proxy of domestic fuel price dynamics. This may particularly occur in cases where importation of fuel is subsdised such that developments in domestic pump prices of fuel do not necessarily reflect the full effect of movements in international crude oil prices. Further, using international crude oil prices does not account for the exchange rate effect on domestic fuel prices. Moreover, from the perspective of households and firms, retail fuel prices—such as the retail price of diesel and petrol—are more relevant than measures of international crude oil prices since they are ultimately the basis on which these agents make economic decisions (Kilian, 2008).

This study contributes to the literature on inflation in Zambia by exclusively interrogating the pass-through from retail prices of petroleum (proxied by a weighted average of petrol and diesel prices) to consumer prices. The long-run effect of petroleum prices on inflation is significant and estimated at 0.26 percent. In the short-run, changes in petroleum prices are found to exert a significant but modest positive effect on inflation, estimated at 0.03 percent with a one-month lag. Other factors found to significantly impact inflation include world food prices, exchange rate, South African inflation and the Bank of Zambia Monetary Policy Rate (MPR).

The rest of the paper is organised as follows. Section 2 provides an overview of the energy sector and the pricing mechanism of petroleum products in Zambia. A survey of relevant literature following a global to country-specific approach is in Section 3. Methodological issues are presented in Section 4 while the data is described in section 5. Section 6 presents the empirical results. Section 7 presents the conclusion.

2. Brief Overview of Fuel Pricing Mechanism in Zambia

Prior to the liberalisation policy in the 1990s, the energy sector was dominated by monopolies operating under extensive government control. Consequently, there was no competition, and this stifled growth of the sector and the economy (Phiri, 2000). The adoption of the liberalisation policy in the 1990s brought major changes in the institutional and legal framework governing the energy sector such as the creation of a ministry responsible for energy and formulation of the National Energy Policy (NEP) of 1994 to guide developments in the sector.

Extensive consultations with stakeholders in the 1990s indicated the need for an autonomous energy regulatory authority for fruitful liberalisation and private sector participation in the sector (ERB, 2019). The Government established the Energy Regulation Board (ERB) through the Energy Regulation Act CAP 436 of the Laws of Zambia as amended in 2003. The mandate of the Board is to regulate the energy sector through the issuance of licenses to undertakings; monitoring the efficiency and performance of undertakings; receiving and investigating complaints; approval of location and construction of energy infrastructure; price adjustments of energy services and products; and development of standards codes, guidelines, and other regulatory interventions.

Economically, petroleum products are consumed mainly by three sectors, namely, retail, mining, and non-mining. Retail refers to petroleum products that are sold at service stations while mining refers to petroleum products delivered to and directly consumed by the mining companies. Non-mining refers to all the other sectors in the economy. The retail sector accounts for the highest proportion of petroleum consumption followed by the mining sector and then the non-mining sector (ERB, 2019).

The petroleum supply structure comprises Government, ERB, TAZAMA Pipelines Limited (TAZAMA), Indeni Petroleum Refinery Company Limited (INDENI), Ndola Fuel Terminal, Oil Marketing Companies (OMCs), dealers and transporters. Players in the supply-chain have specific functions that include procurement of finished petroleum products conducted by the private sector following recent reforms in the sector; pricing of petroleum products by the ERB; pumping, storage and selling of refined products by TAZAMA; distribution of petroleum products throughout the country by OMCs and delivery to consumers by transporters (ERB, 2020).

Petroleum prices in Zambia are determined through the Cost-Plus Pricing Model (CPM), which has been in effect since January 2008. The CPM is used to determine prices for each cargo. The total cost is converted into Kwacha using a projected exchange rate between the Kwacha and US dollar (K/US$). In January 2022, the ERB migrated to a monthly pricing cycle from quarterly. With this approach, prices are adjusted monthly based on market fundamentals that principally include the exchange rate and international crude oil prices (ERB, 2022). Table 2 provides the breakdown of the petroleum price determination.

Table 1: Petroleum Pump Price Determination

Cost Item	Amount	Code
Wholesale Price to OMC		a
Terminal Fee	K0.025 per litre	b
Marking Fee	K0.10 per litre	c
Excise Duty (incl.) road levy	K0.62 per litre	d
Ex NFT Gate		$e = (a + b + c + d)$
Transport Cost	K0.26 per litre	f
OMC Margin	K0.56 per litre	g
Total (Excl VAT)		$h = (e + f + g)$
Dealer Margin	K0.38 per litre	i
Price to Dealer		$j = (h + i)$
ERB Fees	0.70 percent	k
Strategic Reserves Fund	K0.15 per litre	l
Price before VAT		$m = (j + k + l)$
VAT	16 percent	n
Uniform Pump Price	Kwacha per litre	$o = (m + n)$

Source: Energy Regulation Board

3. Literature Review

Modern macroeconomics describes inflation using a Phillips curve that shifts because of such matters as supply shocks and inflation becoming built into the normal workings of the economy (Phillips, 1958). The Phillips curve analyses the trade-off between inflation and output. When there is a decrease in the amount of unused productive resources, inflationary pressures manifest since overall demand for goods and services grows faster than supply. The unused resources are measured by the deviation of actual real output from the economy's potential output—the real output gap. However, the most common measure of the unused resources is the unemployment rate that measures unused resources in the labour market (Phillips, 1958).

Persistent increases in oil prices may trigger a change in the production structure and have a deeper impact on unemployment. A rise in energy (fuel) prices tends to reduce the return on energy-intensive sectors. This can incite firms to adopt and construct new production methods that are less intensive in energy-inputs so as to enable them curb high energy costs. This generates capital and labour reallocations across sectors and ultimately affects unemployment. However, the workers and producers may resist declines in their real wages and profit margins hence putting upward pressure on the unit labour costs and the prices of finished goods and services and ultimately lead to inflationary pressures (Odongo, 2012).
It is conceptually useful to examine the transmission from changes in petroleum prices to inflation (Rehman, 2013). Delbrück (2005) submits that, from the central bank's point of view, the impact of changes in petroleum or energy prices on medium-term inflation is of particular interest. Most literature that considers the inflationary effect of changes in prices of petroleum products has used prices of crude oil as a proxy for petroleum. However, in countries where the retail prices of petroleum products are regulated such as in Zambia, it is empirically relevant to consider the impact of retail prices of petroleum on consumer prices. To this effect, Kpodar and Liu (2022) show that studies that use crude oil prices instead of retail petroleum prices to estimate the pass-through from energy prices to inflation significantly underestimate it.

Findings in this strand of literature are mostly mixed. For instance, Baek and Koo (2010) established that the role of energy prices in driving food price inflation should not be exaggerated. Similarly, Abdallah and Kpodar (2020) found that, on average, the effects of fuel price changes are modest and do not contribute to a sustained impact on inflation This position is also supported by earlier findings by Lambert and Miljkovic (2010). In a similar exercise, Irz, Niemi and Liu (2013) found that energy prices play a significant but quantitatively more limited role in determining the equilibrium level of food prices.

In contrast, McCarthy (2000) used a vector autoregressive (VAR) model incorporating a distribution chain of pricing to examine the impact of oil price movements on domestic producer prices and inflation in selected industrialized economies. The study shows that imported prices have more effect on domestic prices and inflation and the pass-through was found to be stronger in oil importing countries. Similarly, Valadkhani and Mitchel (2002) employed a modified input-output price model to simulate the impact of a twofold increase in petrol prices on the sectoral and aggregate price indices in Australia. They find a significant effect of petrol prices on inflation.

Using an autoregressive distributed lag (ARDL) model, analysing both direct and indirect impacts, Perera (2005) used data for the period 2002-2004 to estimate the effect of changes in petroleum prices (using diesel as a proxy) on inflation in Sri Lanka. The results revealed a significant pass-through from petroleum prices to inflation. Cuñado and Gracia (2005) examined the impact of oil prices on inflation and industrial manufacturing for several European countries for the period 1960-1999. They found an asymmetric effect of oil price on production and inflation. In contrast, Clark and Terry (2009) used a VAR model and contended that core inflation did not respond rapidly to changes in energy prices in the United States.

Cologni and Manera (2008) employed a cointegrated VAR framework for G-7 countries to investigate the impact of oil prices on inflation and interest rates using quarterly data for the period 1980-2003. The study results show that, except for Japan and the UK, oil prices significantly affect inflation, which is transmitted to the real economy by increasing interest rates. Further, impulse response function analysis suggested the existence of a temporary effect of oil price change on inflation.

Celic and Akgul (2011) examined the relationship between inflation and oil prices in Turkey using monthly data over the period 2005-2010. Employing the vector error correction model, the results revealed that a 1 percent increase in fuel oil prices caused the consumer price index to rise by 1.26 percent with an approximate one-year lag. Moreover, the change in oil prices was found to be a one-way granger cause for changes in the consumer price index.

Long and Liang (2018) used the augmented Phillips curve framework to estimate the asymmetric and nonlinear pass-through of global crude oil prices to China's producer price index (PPI) and consumer price index (CPI) using quarterly data from 1998 to 2014. The estimation method employed both the autoregressive distribution lag (ARDL) and non-linear and asymmetric autoregressive distribution lag (NARDL) models. The results indicated that the impact of a rise in global oil prices is greater than the impact of a decline on PPI and CPI for China.

In Africa, Kiptui (2009) employed the traditional Philips curve framework to estimate the pass-through from oil prices to inflation in Kenya using quarterly data from 2002 to 2008. The estimation method followed the ordinary least squares (OLS) technique. The study established that oil prices have a significant impact on inflation. Further, inflation is significantly influenced by exchange rate and changes in aggregate demand captured by the output gap.

Bobai (2012) employed the OLS method to estimate the impact of increases in petroleum prices on inflation in Nigeria using data from 1990 to 2011. The results indicated that an increase in petroleum prices tends to increase the inflation rate in Nigeria. Kargbo (2018) also explored the dominance of structural factors such as real gross domestic product (GDP), exchange rate, pump price of petrol and monetary factors on domestic price determination in Sierra Leone using error-correction equations. The results indicated that pump prices of fuel as well as the exchange rate were significant in the inflationary process at least in the short-run. Odongo (2012) analysed the impact of oil price changes on inflation in Kenya during the period 1996Q1 - 2011Q4, characterized by a world economic crunch, increased investment and development activities and a liberalized environment. The study employed the Johansen cointegration analysis. The results showed that in the short-run, increases in oil prices and money supply would lead to the rise in inflation.

Rangasamy (2017) analysed the impact of petrol price movements on inflation in South Africa since the mid-1970s. The results showed that over time, the direct contribution of petrol inflation to headline inflation had increased. In addition, Granger causality tests and the autoregressive distributed lag approach to cointegration testing revealed that petrol prices had an important bearing on the prices of other (non-petrol) commodities in the economy. The results essentially showed that petrol price increases had an important bearing on inflation outcomes in South Africa. The significant effect of changes in petrol prices on inflation in South Africa was also established by Hassan and Meyer (2020) using a vector error correction model (VECM).

Abdallah and Kpodar (2020) estimated the dynamic responses of domestic inflation to fuel price shocks. Unlike most studies on the relationship between fuel price changes and inflation, they used a rich novel dataset on monthly retail domestic fuel prices for a large set of high income, emerging and low-income countries over the period 2000 - 2016. They found that, on average, the effects of fuel price changes were modest and did not contribute to a sustained impact on inflation. However, the short to medium-term effects varied considerably across different income groups depending on the way in which monetary policy reacted to the domestic fuel price shocks. For example, accommodating or not accommodating such shocks may potentially matter for how domestic inflation responds to them.

Specific to Zambia, Mutoti *et al.* (2011) used Engle and Granger’s cointegration framework to model the relationship between oil prices and the three categories of consumer inflation, namely, overall, food and non-food inflation. The results revealed that the impact of oil prices on overall consumer price inflation was mainly through the non-food inflation component. In the long-run, oil prices affect non-food inflation through both the direct and indirect channels. The study further established that domestic oil prices had only an indirect effect on non-food inflation in the long-run through the supply side as they affected the cost of production. However, in the short-run, oil prices impacted overall inflation through both food and non-food inflation. Chipili (2021) employed a single-equation error correction model based on quarterly data over the period 1994Q1-2019Q4 to investigate the underlying inflation dynamics in Zambia. The empirical results revealed that inflation exhibited persistence and seasonality. In the long-run, inflation was found to be determined in the external sector market where the exchange rate and world non-food prices drove domestic prices. In the short-run, overall inflation was influenced by movements in the exchange rate, adjustments in energy prices, imported inflation from South Africa and changes in maize prices.

4. Model Specification and Methodology

This study employs the theoretical underpinnings of the Phillips curve in which inflation is primarily driven by expected inflation and the unemployment rate. However, modern macroeconomic models often employ an augmented version of the Phillips curve in which the output gap replaces the unemployment rate as a measure of aggregate demand relative to aggregate supply. The theoretical formulation of the modern Phillips curve is given by

$$\pi_t = \pi_e + \beta(y - \tilde{y}) + v_t \qquad 1$$

where π_t represents actual inflation, π_e is expected inflation, $y - \tilde{y}$ represents the output gap such that y denotes actual real GDP and $\tilde{y}$ is the Hodrick-Precott filtered trend of real output used as a proxy for potential output, β is a parameter that measures the response of inflation to the output gap and v_t represents supply shocks.

In line with Long and Liang (2018), equation 1 is augmented by adding confounding variables to yield the empirical model presented as equation 2. This takes the approach that inflation, measured using the consumer price index (CPI), is dependent on movements in petroleum prices, exchange rate, world food prices, output gap, South African inflation and the Bank of Zambia Monetary Policy Rate (MPR).

$$\begin{aligned}\Delta log\_cpi_t = {} & \alpha_1 + \alpha_2 logcpi_{t-1} + \alpha_3 logpet\_p_{t-1} + \alpha_4 logwfi_{t-1} + \alpha_5 log\_exch_{t-1} + \\ & \alpha_6(y_{t-1} - \tilde{y}_{t-1}) + \alpha_7 i_{t-1} + \alpha_8 logsa\_cpi_{t-1} + \sum_{i=0}^{m1} \beta_{1i}\, \Delta log\_cpi_{t-m} + \\ & \sum_{i=0}^{m2} \beta_{2i}\, \Delta log\_pet\_p_{t-m} + \sum_{i=0}^{m3} \beta_{3i}\, \Delta log\_exch_{t-m} + \sum_{i=0}^{m4} \beta_{4i}\, \Delta logwfi_{t-m} + \\ & \sum_{i=0}^{m5} \beta_{5i}\, \Delta(y_{t-m} - \tilde{y}_{t-m}) + \sum_{i=0}^{m6} \beta_{6i} \Delta\, i_{t-m} + \sum_{i=0}^{m7} \beta_{7i}\, \Delta log\_sa\_cpi_{t-m} + \varepsilon_t \end{aligned} \qquad 2$$

where the variables are as defined above while *m1, m2, m3, m4, m5, m6 and m7 are* lags on the respective variables representing the lag order of the model denoted as ARDL (*m1, m2, m3, m4, m5, m6 and m7*). The long-run effects are estimated by α_2, α_3, α_4, α_5, α_6, α_7, and α_8 while the short-run parameters are given by β_1, $\beta_2, \beta_3, \beta_4, \beta_5$, β_6 *and* β_7. The error correction term is computed by linearly combining the lagged levels of all variables in the model.

The log–log functional form is adopted so that the coefficients can be interpreted as pseudo-elasticities reflecting the relative influence of each variable on the CPI. The selection of variables mostly follows Chipili (2021). The functional form of the model is:

$$Log\ (cpi) = f[Log\ (pet\_p), Log\ (exch), Log\ (wfi), (output\_gap), Log\ (sa\_cpi),\ (i)] \qquad 3$$

where cpi is the consumer price index for Zambia, pet_p represents petroleum prices, $exch$ is the Zambian Kwacha per United States dollar exchange rate, wfi is an index of world food prices, sa_cpi is the consumer price index for South Africa and i is the Bank of Zambia Monetary Policy Rate.

The autoregressive distributed lag (ARDL) method of cointegration is used to estimate equation 2. The ARDL is adopted due to its flexibility as it can be applied when the underlying variables are integrated of order one, order zero or fractionally integrated. Secondly, it is relatively more efficient in the case of small and finite sample data sizes. Finally, it leads to unbiased estimates of the long-run model.

A bounds test based on the joint F-statistic is employed to test for cointegration based on the hypothesis set-up given below. In the null hypothesis, the long-run parameters are jointly insignificant which implies the absence of cointegration. The alternative hypothesis suggests existence of a long-run equilibrium. The first step in the ARDL bounds approach is to estimate equation (2) by ordinary least squares (OLS) and then employ the bounds test for cointegration:

$H_0: \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = 0$ [No Cointegration]
$H_1: \beta_1 \neq 0, \beta_2 \neq 0, \beta_3 \neq 0, \beta_4 \neq 0, \beta_5 \neq 0, \beta_6 \neq 0$[Evidence of cointegration]

The Wald or F-test statistic with critical values provided by Pesaran *et al* (2001) is used to test the above hypothesis. Two asymptotic critical values are used to detect the presence of cointegration. The first value is calculated on the assumption that all the variables included in the ARDL model are integrated of order zero while the second one is calculated on the assumption that the variables are integrated of order one. The null hypothesis of no cointegration is rejected when the value of the test statistic exceeds the upper critical bounds value and accepted if the test statistic is lower than the lower bounds value. The test is inconclusive if the test statistic falls within the critical value bounds. In the last case, knowledge of the order of integration of the regressors is required to further examine the relationship. Once cointegration is established, estimates of the long-run coefficients are obtained and the ECM associated with the long-run coefficients is estimated.

5. Data

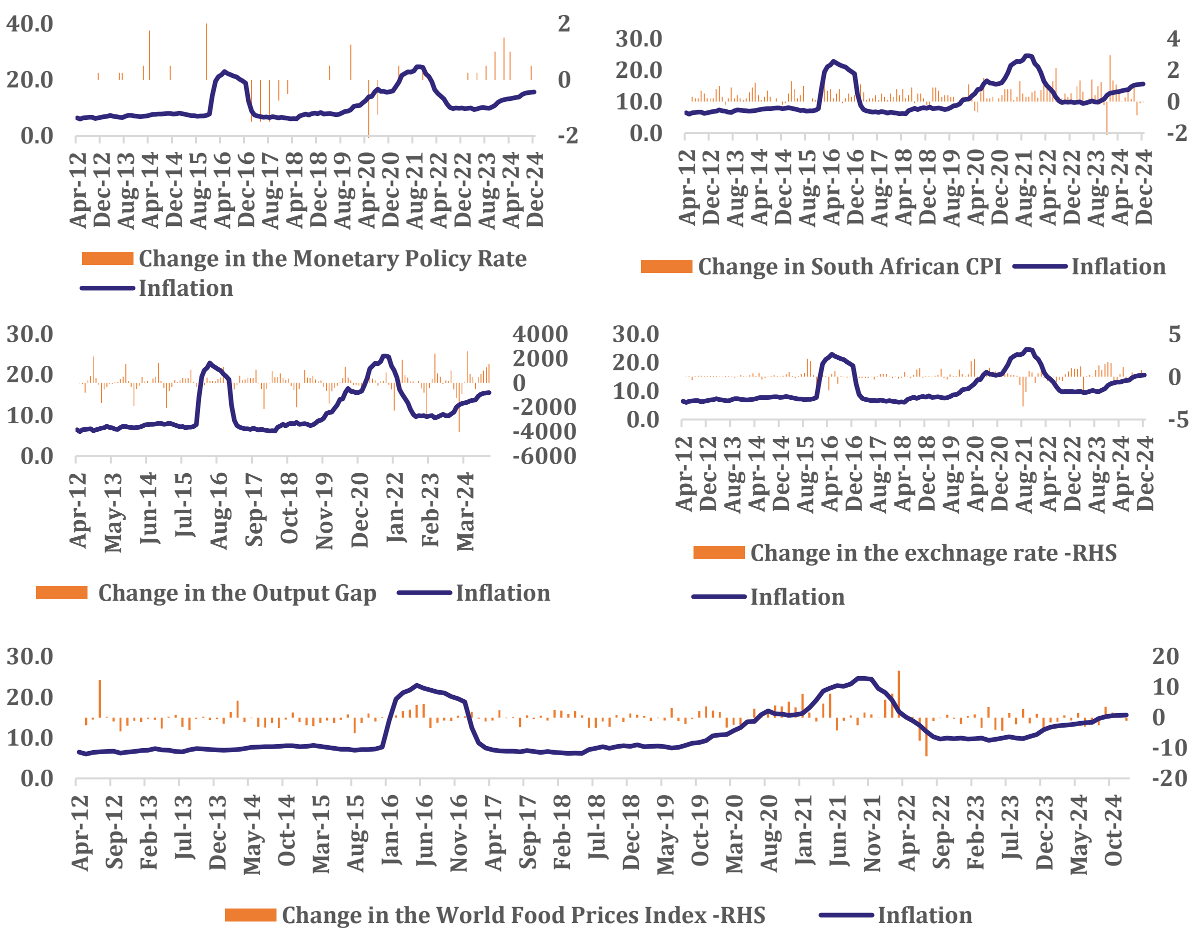
The study uses monthly data spanning January 2016 to December 2024 on the consumption price index (CPI) for Zambia and a petroleum price index computed as a weighted average of pump prices of diesel and petrol. The relative percent shares of diesel and petrol consumed out of the total diesel and petrol imported are used as weights in the construction of the petroleum price index. The shares are based on 2024 ERB statistics. The Kwacha per US dollar exchange rate, output gap, Bank of Zambia Monetary Policy Rate (MPR), index for world food prices and CPI for South Africa are included in the model as control variables.

Data on the CPI for Zambia, exchange rate and the MPR were obtained from the Bank of Zambia. The diesel and petrol price series were obtained from the ERB. The world food price index data was obtained from the World Bank Commodity Price Data (The Pink Sheet). Data on GDP was accessed at a quarterly frequency from the Zambia Statistics Agency. Hence, the quadratic sum frequency conversion technique was applied to decompose the series into monthly. The advantage of this technique is that it retains the underlying trend in the original series. The output gap is computed as the difference between actual real gross domestic output and trend (proxy for potential output) using the HP filter.

The exchange rate, world food prices and CPI for South Africa are included to capture the inflationary pressures stemming from the external sector given that Zambia is largely import-dependent. As argued by Chipili (2021), the rationale for considering inflationary pressures from South Africa is due to strong trade links between Zambia and South Africa. The world food prices index is considered on account of its relevance to Zambia given the dominance of maize and wheat prices in the index as these two items have a substantial combined weight of 145.8 out of 550.1 in the food CPI basket. The output gap measures aggregate demand pressures in the domestic economy while the MPR is included to capture the role of monetary policy.

As depicted in chart 2 (section 1), there appears to be a positive relationship between changes in fuel prices and inflation, with periods of infrequent changes in the former being characterised by relatively stable inflation while rising fuel prices are mostly associated with increasing aggregate prices. The rest of the explanatory variables appear to be ambiguously correlated with inflation (Chart 3).

Chart 3: Relationships between Inflation and the Model Explanatory Variables



Source: Bank of Zambia, Zambia Statistics Agency, World Bank, Energy Regulation Board and Author Compilations

6. Empirical Results and Discussion

Table 2 presents the augmented Dicky Fuller unit root test results. All the variables except the output gap are non-stationary at level but stationary at first difference and therefore integrated of order 1. The output gap is stationary at level and, therefore, integrated of order zero. Given the mixed order of integration, the ARDL model is considered to examine the short-run and long-run dynamics.

Table 2: Unit Root Test Results

	ADF t-statistic (Level)	ADF t-statistic (First Difference)	Conclusion
CPI *(cpi)*	-0.890	-5.878*	I (1)
Petroleum Price *(pet_p)*	-0.288	-11.709*	I (1)
Exchange Rate *(exch)*	-0.534	-8.786*	I (1)
World Food Prices *(wfi)*	-1.506	-8.691*	I (1)
Output gap ($\boldsymbol{y}-\widetilde{\boldsymbol{y}}$)	-3.981*	-3.354*	I (0)
MPR *(i)*	-1.834	-4.749*	I (1)
SA_CPI *(sa_cpi)*	-0.897	-10.260*	I (1)

Source: Estimation output from STATA

Note: *, ** and *** denote statistical significance at 1, 5 and 10 percent levels of significance, respectively.

The bounds test results are reported in Table 3. The F-statistic is larger than the I(1) critical bound values at all conventional levels of statistical significance. This implies that while the I(1) variables included in the model are not stationary at level, there exists a linear combination of these variables (a long-run equilibrium) which yields stationary residuals. This suggests the rejection of the null hypothesis of no cointegration in favour of the alternative. Hence, there is a valid long-run relationship among the variables included in the model.

Table 3: Bounds Test Results

Probability	I (0)	I (1)	F - Statistic	Result
1%	2.660	4.050	42.494	Cointegration exists
5%	2.040	3.240	42.494	Cointegration exists
10%	1.750	2.870	42.494	Cointegration exists

Source: Estimation Output from E-Views

Long-run results are presented in Table 4.

Table 4: Long-Run Model Results

Variable	Coefficient	t-statistic	Probability
lpet_p	0.261	2.578	0.011
lexch	0.554	8.957	0.000
lwfi	0.329	3.274	0.001
output gap	-0.000	-3.231	0.023
i	-0.007	-1.420	0.159
lsa_cpi	0.079	0.370	0.712

Source: Estimation Output from E-views

Petroleum prices exert a significant impact on consumer prices in the long-run: a percent increase in petroleum prices raises consumer prices by 0.26 percent. This could reflect the consideration of fuel costs in the supply-chain of goods and services over a longer horizon given the significant role that diesel and petrol play in the production and transportation of goods in the economy. Similarly, a percent depreciation of the exchange rate raises the aggregate price level by 0.55 percent in the long-run. This is consistent with extant literature on exchange rate effects on inflation in Zambia which established evidence of incomplete pass-through from the exchange rate to inflation (Mutoti *et al* 2011, Zgambo, 2015 and Chisha *et al* 2023).

Domestic consumer prices are also significantly impacted by world food prices, rising by 0.33 percent following a percent increase in the latter. This signifies the reliance of Zambia on imported food products, which makes the domestic economy susceptible to external food-price related shocks. The long-run effect of the output gap on consumer prices is muted and counter-intuitively signed though statistically significant. The muted effect of the output gap (proxy for aggregate demand pressures) could imply that much of the long-run inflationary pressures over the data span were supply driven. However, the output gap coefficient is interpreted with caution as the counter-intuitive sign could reflect measurement deficiencies, particularly for the trend (potential output).

The long-run impact of the MPR, though correctly signed, is relatively low due to the statistically insignificant coefficient. This is similar to Chipili (2021) who finds that money (proxy for monetary policy) did not appear to have long-run influence on consumer prices in Zambia. Similarly, the pass-through from South African consumer prices to domestic consumer prices appears to be weak in the long-run.

Table 5 presents the ECM or short-run results. The general to specific approach is employed to arrive at a parsimonious model. The ECM is estimated using heteroscedasticity and autocorrelation consistent (HAC) standard errors to correct for heteroscedasticity and autocorrelation in the residuals.

Table 5: Short-Run Model Results

Variable	Coefficient	t-Statistic	Prob*
ecm (-1)	-0.046	-17.800	0.000
l_cpi (-1)	0.954	70.82	0.000
l_pet_p	0.002	0.265	0.791
l_ pet_p (-1)	0.025	2.394	0.018
l_ pet_p (-2)	-0.015	-1.658	0.100
l_exch	0.025	3.769	0.000
l_wfi	0.040	1.821	0.071
l_wfi (-1)	-0.025	-1.229	0.222
output_gap	-0.000	-3.277	0.001
i	0.001	1.044	0.299
i (-1)	0.001	1.015	0.312
i (-2)	-0.000	-0.312	0.755
i (-3)	-0.002	-2.458	0.015
l_sa_cpi	-0.151	-1.351	0.180
l_sa_cpi (-1)	-0.031	-0.331	0.741
l_sa_cpi (-2)	-0.113	-0.903	0.368
l_sa_cpi (-3)	0.299	3.503	0.000

	p-value
R-squared	0.999
Jarque-Bera Normality	0.170
S.E. of regression	0.004
Ramsey RESET	0.195

Source: Estimation Output from E-views

The estimated model specification is free from multicollinearity given variance inflation factors of less than the threshold of 10 in Table 6.

Table 6: Variance Inflation Factors (VIF) Tests Results for Multicollinearity

Variable	Coefficient VIF
l_cpi (-1)	0.000181
l_petp	6.30E-05
l_petp (-1)	0.000110
l_petp (-2)	8.43E-05
l_exch	4.55E-05
l_wfi	0.000489
l_wfi (-1)	0.000418
output_gap	1.27E-13
boz_i	1.07E-06
i (-1)	1.60E-06
i (-2)	1.64E-06
i (-3)	8.65E-07

Source: Estimation Output from E-views

The coefficient on the error correction term in Table 5 is statistically significant and bears the expected sign. However, the results reveal a modest adjustment towards long-run equilibrium, signifying persistent inflationary pressures. The speed of adjustment towards long-run equilibrium is estimated at 0.05 percent. This implies that if inflation is 1 percent above equilibrium in the current period, it will fall by approximately 0.05 percent in the next period towards long-run equilibrium.

In the short-run, inflation is persistent as last period inflation feeds significantly into current inflation. A percent increase in last period inflation raises current period inflation by 0.9 percent, significant at 1 percent. This is consistent with Chipili (2021) who found evidence of inflation inertia in Zambia.

Changes in petroleum prices impact inflation with a one-month lag in the short-run. A percent increase in petroleum prices leads to a 0.03 percent rise in inflation the following month. This modest short-run inflationary effect could reflect the time it takes for the cost of petroleum products, mostly input into production and/or transportation of goods, to be transmitted to the final prices of goods and services. Similarly, a percent depreciation of the exchange rate raises inflation by 0.03 percent in the short run and occurs contemporaneously. This aligns with Mutoti et al (2011), Zgambo (2015) and Chisha *et al* (2023). The domestic aggregate price level is also significantly impacted by changes in world food prices in the short-run, signifying the pass-through from food imports. When world food prices, measured by the world food price index, increase by 1 percent, domestic inflation contemporaneously rises by 0.04 percent.

The short-run effect of a widening output gap on inflation is muted and counter-intuitively signed, though statistically significant at 1 percent. The negative sign could be interpreted as widening of the output gap occasioned by actual output falling below potential output (negative output gap). This slows down the economy and dampens the rise in consumer prices. However, the output gap coefficient is interpreted with caution as explained earlier.

The short-run effect of changes in the MPR on inflation is significant. When monetary policy is tightened by a percentage point, inflation responds with a lag after three months, declining by 0.002 percent. This compares with Wakumelo (2024) who estimates the eventual impact of a percent increase in the MPR on inflation to be modest, around 0.004 percent. Further, the results reveal a statistically significant and lagged (by 3 months) pass-through from inflationary pressures in South Africa to consumer prices in Zambia, with a percent rise in the former causing the latter to increase by 0.29 percent in the short-run. This is consistent with Chipili (2021) and underscores the dependence of Zambia on South Africa for imports.

7. Conclusion

This study examined the pass-through from petroleum prices (proxied by the prices of petrol and diesel) to inflation in Zambia using monthly data from January 2016 to December 2024. The exchange rate, world food prices, output gap, Bank of Zambia Monetary Policy Rate and the South African consumer price index are included in the model as confounding variables. The autoregressive distributed lag (ARDL) model was employed to study the short-run and long-run dynamics.

In the long-run, petroleum prices are found to significantly impact domestic consumer prices, with a more pronounced effect than in the short-run. Similarly, the long-run effects of the exchange rate and world food prices are significant. However, the impact of monetary policy on inflation is relatively low. Similarly, the effect of imported inflation from South Africa is weak in the long-run. The impact of output gap is muted, potentially signifying supply-driven rather than demand-driven inflationary pressures over the data span.

In the short-run, inflation is found to be persistent as last period inflation feeds significantly into current inflation. Changes in petroleum prices have a modest effect on inflation. Exchange rate movements exert a contemporaneous impact on inflation. Inflation is also affected by movements in world food prices, the Bank of Zambia Monetary Policy Rate and imported inflation from South Africa. The effect of the output gap remains muted.

Since the effect of petroleum prices on inflation is more pronounced in the long-run, measures to address petroleum-price induced inflation should be mostly focused on reforms in the energy sector to effectively manage fuel supply and demand.

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