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Inflation Sensitivity Towards Fuel Price and Electricity Distribution in South Africa

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The determination of prices for goods and services in a specific economy is significantly influenced by commodity prices and the distribution of energy. Hence, this study aims to examine the impact of fuel prices and electricity supply on the inflation rate in South Africa. The empirical analysis focuses on a time series data covering the period from January 2009 to December 2021. The study utilizes the Johansen test for cointegration, Vector Error Correction Model (VECM), and Granger approaches to establish the relationship between the variables. The empirical findings indicate the existence of a long-term relationship among the variables, indicating that long-term changes in electricity supply and fuel prices have an influence on South Africa's inflation levels. Similarly, the short-term results suggest an inverse relationship between fuel prices, electricity supply, and the inflation rate. In order to reduce the inflation rate, it is recommended to decrease spending on imported fuel and enhance electricity supply through increased investment in renewable energy and research and development (R&D).

Keywords: *energy price, fuel price, inflation, CPI, electricity distribution, load shading, VAR model, South Africa*

JEL Classification*: E31, L11, Q41*

1. Introduction

Oil plays a vital role in the global economy as a significant source of energy. However, the volatility in oil prices since the 1970s has presented challenges for business leaders, policymakers, and other economic stakeholders. In the 1990s, the global oil price fluctuated around $20 per barrel before reaching a record high of $150 per barrel between 2004 and 2005. This increase was short-lived, as the 2008 financial crisis caused the oil price to plummet to $30 per barrel. By 2012 and 2013, the average oil price rose to $104 per barrel before dropping to $47 in 2015. More recently, the conflict between Russia and Ukraine, since February 2022, has led to a significant increase in oil prices. In April 2022, crude oil reached an average price of $114.27 per barrel. This surge in fuel prices has resulted in a rise in food prices, and it was anticipated that the South African consumer price index (CPI) or inflation would average 5.5 percent by the end of 2022.

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The general perception of the relationship between oil price fluctuations on inflation is that the presence of the former within a given economy reduces economic activities while creating a rise in the inflation rate. The effect of oil price fluctuations on both economic activities and inflation is spread through various transmission channels. For instance, an increase in oil prices may lead to high prices of various sources of energy which result in high costs of production and transportation (Lescaroux and Mignon, 2008) and thereafter cause low consumer purchasing power (Fedderke and Liu, 2018). Consequently, the oil price is more likely to have both direct and indirect direct impacts on production costs and selling prices.

South Africa is one of countries that are currently experiencing energy supply and oil/fuel price issues. Oil price fluctuation and electricity distribution, as a major source of energy, plays an indispensable role in the production and conservation of food; and therefore influence the South African purchasing power and economic growth. However, over the recent decade, the country has been undergoing an imbalance between electricity demand and supply. The ESKOM (South Africa's public electricity provider) being the only major provider of electricity throughout the country has increased the electricity bill while remaining unable to meet the public demand for electricity (du Venage, 2020). Electricity being one of the core inputs or factors of production has a significant impact on food production output. High prices and shortages of electricity can cause an increase in selling prices. Given the importance of fuel prices and electricity supply in South Africa, the current study aims at investigating the impact of fuel prices and electricity supply on the inflation rate in South Africa. To achieve this objective, the rest of the article is structured as follows: the next section discusses the literature related to the topic. Section 3 focuses on research methodology while section four is dedicated to empirical estimation and result discussion. The last section of the study provides a concise summary followed by the study recommendations..

2. Literature Review

Owing to the role it plays in most countries' economies, oil price volatility occupies a significant place in the recent decade of research. The effect of oil prices started becoming a more interesting research topic after the oil price shocks experience between 1973 -1974 and between 1979 and 1978 as those shocks cause instabilities within many countries' economies (Jalles, 2009). During this period various studies were conducted to determine the effect of oil prices on both output and inflation. Those studies include Bruno and Sachs (1982), Hamilton (1983), Hamilton (2008), Hooker (2002), Lee, Olasehinde-Williams and Özkan (2023), and Lescaroux and Mignon (2008). Empirical findings from these studies suggest an inverse relationship between inflation and fuel price fluctuation and suggested that high fuel price results in low output and high inflation.

Besides the post second world war oil shocks since 1946 and those experienced in the 1970s caused by supply disturbances (when members of the Organization of the Petroleum Exporting Countries (OPEC) quadruple the oil price (Kettell, 2022); the word commodity market experienced other oil shocks in the 20th and 21 centuries that significantly initiated changes in the global economy. The recent oil price crises include 2007–2008 caused by high demand associated with stagnating production (Hamilton, 2009), and oil price fluctuations experienced by oil exporters between 2014 and 2016 caused by high investment in oil production (Grigoli et al., 2017). Additionally, global prices experienced a significant decline in 2020 owing to economic challenges caused by the outbreak of the coronavirus (Engebretsen and Anderson, 2020). The most recent and skill being experienced at present is the oil crisis caused by the war between Russia and Ukraine. All of these aforementioned oil crises had and still have a paramount impact on economic performance and particularly on the consumer price index or inflation. The subsequent paragraph provides some empirical studies that scrutinised how changes in fuel prices may influence a country's inflation rate.

Analysing the effect of oil price shocks on inflation in the G7 country, the study by Wen et al. (2021) found that changes in oil prices vary with time and their magnitude on a given country's inflation depends on the country's previous economic conditions. Using the ordinal risk of square (OLS) Anwar et al. (2015) analysed the impact of oil price chance on inflation in Pakistan's economy, the study results indicated a positive linear relationship between oil price and inflation. This implies that the high price of oil commodities leads to a high inflation rate. Another study was conducted by Rangasamy (2017) using the Granger causality test to assess how oil price influences price in South Africa, the study findings revealed that changes in oil price cause fluctuation in the market price of other goods and services. The relationship between inflation and oil price within the US and the EU zone was also analysed using the Vector Auto-Regression (VAR) model. The results inferred that the higher the oil price, the higher the inflation rate within those countries (Conflitti and Luciani,

2019). Some other studies were conducted to assess the same relationship between inflation and oil price and all of them confirmed that high oil price results in a high inflation rate (Bala and Chin, 2018; Sibanda et al., 2015; Subhani et al., 2012). Irrespective of the positive relationship between inflation and oil price supported by the aforementioned study, Živkov et al. (2018) suggested the absence of a significant relationship between oil price and inflation rate in the central and Eastern European countries.

In addition to the oil price, electricity price and supply is other sources of energy that may have a significant impact on most African industry's output and South African firms in particular (Dinh and Clarke, 2012). Owing to the country's abundance of coal and tax exemption, the South African electricity price has been low and at a declining rate compared to other African countries. However, policies implemented by the post-apartheid government fuelled by the 2007-08 financial crisis, the electricity started increasing up to 10.6 percent in 2008 (Deloitte, 2012). In the post-apartheid era, many South Africans got involved in the economy and changed their ways of living which resulted in high electricity demand. In addition to the low price of electricity, the low price of electricity caused the inability to proper maintenance, renovation, and expansion of power utilities (Kenny 2015) and thereafter resulted in electricity shortages and imbalances between demand and supply.

Electricity is one of the factors of production and conservation, its shortage and high price have a significant effect on the country's prices and consumer price index in particular (PCW, 2022) as electricity is considered a key component of economic growth (Costantini and Martini, 2010). The electricity shortage in South Africa remains one of the production and product conservation constraints. It also impacts the country's business competition (Fedderke, 2014) as it remains one of the major causes of price fluctuations in South Africa. To the best knowledge of the authors, no study was conducted to determine the effect of electricity supply on the inflation rate, thus the next paragraph provides approaches used in this study to determine the relationship that exists between those two economic variables.

3. Research Data and Methodology

The main objective of the current study is to assess inflation sensitivity towards fuel prices and electricity distribution in South Africa. The analysis of the study is built on 144 monthly observations from January 2009 to December 2021. Although the entire world experienced an exorbitant increase in Petrol prices during the first quarter of 2022 owing to the invasion of Russia into Ukraine, the data is not yet available. Hence, the study utilized a restricted sample of data spanning from January 2009 to December 2021. The decision to include only this time period was twofold: firstly, the closing date was determined by the availability of data, and secondly, the starting point was chosen to account for the fluctuations triggered by the 2008 financial crisis. It was crucial to avoid mixing data from before and after the crisis to mitigate the risk of obtaining misleading outcomes. Fuel price and electricity supply are the study's independent variables while the consumer price index (CPI) or inflation is the dependent variable. The analysed data was acquired from Statistics South Africa (Stats SA).

3.1. Model Specification

In this study the analysis of the relationship between the dependent and independent variables was expressed in a simple way as follows:

$$CPI_t = \text{f}\,(ELS_t + FUP_t + E_t) \quad (1)$$

The CPI_t Equation 1 represents inflation, ELS_t represents electricity supply, FUP_t represents fuel price and E_t represents other variables that may influence changes in South African inflation yet are not included in the model. The letter t attached to each variable denotes the sample period. Given the historical changes of both dependent and independent variables influence the current rate of inflation, the researcher employed the vector a Vector autoregressive (VAR) approach to determine the interrelationship between variables. As suggested by Chan (2010) and Maddala (2001), when applying a multivariate regression, it is important to start with the Vector Autoregressive and then continue with other approaches such as causality, co-integration, vector error correction, impulse responses and variance decomposition. From Equation 1, the following VAR model was formulated:

$$CPI_t = \propto_1 + \sum_{j=1}^{k} \beta_{1j} CPI_{t-j} + \sum_{j=1}^{k} \delta_{1j} ELS_{t-j} + \sum_{j=1}^{k} \gamma_{1j} FUP_{t-j} + u_{1t} \quad (2)$$

$$ELS_t = \propto_2 + \sum_{j=1}^{k} \beta_{2j} CPI_{t-j} + \sum_{j=1}^{k} \delta_{2j} ELS_{t-j} + \sum_{j=1}^{k} \gamma_{2j} FUP_{t-j} + u_{2t} \quad (3)$$

$$FUP_t = \propto_1 + \sum_{j=1}^{k} \beta_{1j} CPI_{t-j} + \sum_{j=1}^{k} \delta_{1j} ELS_{t-j} + \sum_{j=1}^{k} \gamma_{1j} FUP_{t-j} + u_{3t} \quad (4)$$

Where $\propto_n$ denotes the constant, β_n , δ_n and γ_n denote the regression coefficients, k denotes the optimum number of lags and lastly, u_{1t} to u_{3t} are the model shocks or stochastic error terms. Prior to the VAR estimation, it was necessary to conduct a unit root then to insure both the stationarity of selected variables and the accuracy of the selected approach for cointegration analysis. The Augmented Dickey-Fuller test was used to determine the integration order for the study variables. The aim was that in case all variables a stationary at I (0) only VAR was going to be performed; however, if variables become stationary at I (1) the cointegration test should be performed. In case of variables cointegrate, the following vector error correction model (VECM) equations are estimated:

$$\Delta CPI_t = \propto_1 + \sum_{j=1}^{k} \beta_{1j} \Delta CPI_{t-j} + \sum_{j=1}^{k} \delta_{1j} \Delta ELS_{t-j} + \sum_{j=1}^{k} \gamma_{1j} \Delta FUP_{t-j} + \varphi_1 ECT_{1t-1} + u_{1t} \quad (5)$$

$$\Delta ELS_t = \propto_2 + \sum_{j=1}^{k} \beta_{2j} \Delta CPI_{t-j} + \sum_{j=1}^{k} \delta_{2j} \Delta ELS_{t-j} + \sum_{j=1}^{k} \gamma_{2j} \Delta FUP_{t-j} + \varphi_2 ECT_{2t-1} + u_{2t} \quad (6)$$

$$\Delta FUP_t = \propto_1 + \sum_{j=1}^{k} \beta_{1j} \Delta CPI_{t-j} + \sum_{j=1}^{k} \delta_{1j} \Delta ELS_{t-j} + \sum_{j=1}^{k} \gamma_{1j} \Delta FUP_{t-j} + \varphi_3 ECT_{3t-1} + u_{3t} \quad (7)$$

Where the symbol Δ denotes the I(1) operator, ECT_{1t-1} to $\varphi_3 ECT_{3t-1}$ represents the error correction terms with coefficients φ_1 to φ_3. While the coefficients β_n , δ_n and γ_n are used to capture the model's short-term dynamics, error correction coefficients (φ_1, φ_2 and φ_3) determine the model speed of adjustment towards long-run equilibrium. The selected optimum number of lags were selected using the Akaike Information Criterion (AIC) and prior to the regression result interpretation, various diagnostic test was conducted to ascertain that the selected model meets the stochastic properties (Maddala, 2001). The impulse response and variance decomposition results are also discussed when analysing the responsiveness of inflation to shocks in both fuel price and electricity supply.

4. Empirical Analysis and Discussion

4.1. Research Context and Preliminary Analysis

Table 1 displays the descriptive statistic summary of variables analysed in this study. The electricity supply (ELS) has the highest mean with the smallest standard deviation among other variables. This implies that the electricity supply in South Africa does not experience significant changes. The low standard deviation in ELS justifies why the electricity price has an upward trend as the demand increases while the supply remains constant or declines. The standard deviation of the fuel price is high compared to other variables suggesting a significant shock in the oil price over the analysed period.

Table 1: Variables statistics summary

	CPI	**ELS**	**FUP**
Mean	4.515028	9.834308	7.088566
Maximum	4.819475	9.931151	7.579168
Minimum	4.178992	9.555418	6.356108
Std. Dev.	0.188853	0.051717	0.247216
Kurtosis	1.699373	7.476610	2.980452
Observations	156	156	156

4.2. Unit Root Test

Table 2 represents the results from the augmented dickey-fuller unit root test. As displayed in the table, the results indicate that none of the variables is stationary at level. However, all variables become stationary after the first difference. In other words, all the selected variables are I(1). This implies the appropriateness of the selected approach for cointegration as it meets the requirement discussed in section 3. Therefore, the subsequent step is to test cointegration amongst variables.

Table 2: Augmented Dickey-Fuller unit root results

	At level		At first difference		
Variable	**intercept**	**Intercept & Trend**	**intercept**	**Intercept & Trend**	**Status**
LCPI	0.8285	0.8605	0.0000*	0.0000*	I(1)
LELS	0.5892	0.1733	0.0000*	0.0000*	I(1)
LFUP	0.4126	0.1704	0.0000*	0.0000*	I(1)

Note: * denotes stationarity at 0.05 significant level

4.3. Optimum Lag Selection

The step that follows the integration order for the study variables determines to determine the appropriate number of lag for both the Johansen test for cointegration and vector error correction. As depicted in Table 3, four out of six lag length criteria suggested five lags as the optimal number of lags. Consequently, five lags were used throughout the remaining sections of the study.

Table 3: Lag length selection results

Lag	LogL	LR	FPE	AIC	SC	HQ
0	421.3016	NA	7.59e-07	-5.577355	-5.517142	-5.552893
1	1184.654	1485.992	3.25e-11	-15.63538	-15.39453	-15.53753
2	1208.013	44.53804	2.69e-11	-15.82684	-15.40535	-15.65560
3	1237.709	55.43322	2.04e-11	-16.10279	-15.50066*	-15.85817
4	1257.647	36.42013	1.76e-11	-16.24863	-15.46587	-15.93062
5	1273.641	28.57470*	1.61e-11*	-16.34188*	-15.37847	-15.95048*
6	1280.448	11.89041	1.66e-11	-16.31264	-15.16860	-15.84785

Note: *denotes the coefficient associated with the optimal number of selected lags

Source: Author's compilation

4.4. Cointegration Analysis

Table 4 represents the cointegration analysis results. The null hypothesis suggesting the absence of cointegration among variables is rejected in favour of the alternative hypothesis suggesting that at most one cointegration equation exists among variables. Probability values and both Trace and Max-Eigen Statistics confirm that one cointegration equation exists between the inflation rate, fuel price and electricity supply in South Africa.

Table 4: Johansen test for cointegration results

H_0: Number of Co-Integrating Equations	Trace Statistic	P-values*	Max-Eigen Statistic	P-values*
None *	57.61066*	0.0000*	43.59779*	0.0000*
At most 1	14.01286	0.0826	13.45841	0.0667
At most 2	0.554450	0.4565	0.554450	0.4565

Note: * denote the rejection of H_0 at 0.05 significance level.

Source: Author's compilation

$$\begin{array}{llll} \text{LCPI} = & 41.4539 + & 4.131847\text{LELS} + & 0.522363\ \text{LFUP} \\ \text{[T-stat]} & & \text{[8.33669]} & \text{[-6.17127]} \end{array} \quad (8)$$

The results in Equation 8 confirm the assumption or the hypothesis suggesting that inflation responds positively toward positive changes in fuel prices. On the other hand, an inverse long-run relationship exists between electricity supply and inflation rate. As displayed in equation 8, the South African inflation rate would

decline by 4.13 percent if the electricity supply were to increase by 1 percent; while an increase of 1 percent in petrol price would cause an inflation rate of 0.52 percent. Based on these findings, it can be concluded that the pressure of electricity shortage on inflation is greater compared to how the latter is influenced by changes in fuel price. Numerous studies have also found similar results. For instance, studied by Bobai (2012), Chen *et al.* (2020) and Rangasamy (2017) found that an increase in fuel price or any price of petroleum and energy products causes an increase in the inflation rate within domestic markets. Therefore, the electricity shortage can be the cause of the high inflation rate. This implies that solving the issue of the growing inflation rate in South Africa will depend on the country's policies on energy supply.

4.5 Error Correction Model and Short-Run Relationship

The general rule of thumb in econometric analysis highlights the importance of an error correction model when the analysed variables cointegrate or have a long-run relationship. In the case of this study, the Johnsen test for cointegration conferment the presence of a long-run relationship between inflation rate, electricity supply and fuel price. Thus, the next step is to determine both the error correction model and the short-run relationship. The result in Table 5 shows that the error correction terms for both D(LCPI) and D(LELS) are negative and statistically significant. This implies that the model's short-run changes are monthly adjusted towards long-run equilibrium. The short-run results indicate that the lagged value of both inflation and fuel price negatively influences the current rate of inflation rate while a positive short-run relationship exists between the inflation rate and electricity supply. Variance decomposition and impulse (Variance decomposition and impulse response results can be requested from the author) results confirmed and indicate that fuel pieces and electricity supply are useful variables to explain shocks or short-run changes in the inflation rate.

Table 5: Error correction and short-run dynamics results

Error Correction:	**D(LCPI)**	**D(LELS)**	**D(LFUP)**
CointEq1	-0.004697*	-0.149083*	-0.009805
	[-2.59858]	[-6.59083]	[-0.45430]
D(LCPI(-1))	0.258421*	0.669167	1.137384
	[2.82954]	[0.58555]	[1.04305]
D(LCPI(-2))	-0.192481*	-3.466808*	0.133385
	[-2.09254]	[-3.01200]	[0.12145]
D(LELS(-1))	0.018358*	-0.052892	0.174473
	[2.39778]	[-0.55209]	[1.90862]
D(LELS(-2))	0.018612*	0.311113*	-0.021518
	[2.88509]	[3.85405]	[-0.27937]
D(LFUP(-1))	0.003740	0.005787	0.343633*
	[0.47344]	[0.05855]	[3.64361]
D(LFUP(-2))	-0.017111*	0.113332	-0.373149*
	[-2.26202]	[1.19734]	[-4.13161]
C	0.003850*	0.010364	0.001897
	[7.46214]	[1.60544]	[0.30799]

Note: T-statistics in [ ], *significant at the 5% level, 2 legs were selected based on AIC

Source: Author's compilation

4.6. Granger Causality

The presence of a short-run relationship is also confirmed by the Granger causality results as presented in Table 6. Bidirectional causation exists between the inflation rate and electricity simply while a unidirectional causality exists between the inflation rate and fuel price. In other words, in the short run, it is not the electricity supply that can cause changes in the inflation rate, the latter can also influence changes in electricity production and supply.

Table 6: Pairwise granger causality results

Null Hypothesis:	F-Statistic	Prob.
LELS does not Granger Cause LCPI	5.06775	0.0003*
LCPI does not Granger Cause LELS	10.8396	8.E-09*
LFUP does not Granger Cause LCPI	2.38165	0.0415*
LCPI does not Granger Cause LFUP	1.87247	0.1029
LFUP does not Granger Cause LELS	2.66866	0.0245*
LELS does not Granger Cause LFUP	2.35902	0.0432*

Note: * indicates significance at 0.5 level

Source: Authors' compilation

5. Conclusion and Recommendations

The current study aimed to examine the impact of fuel price shocks and electricity supply shortages on inflation in South Africa. A significant rise in fuel prices and a decrease in electricity supply can have detrimental effects on economies and lead to cost-push inflation, particularly in oil-importing countries like South Africa. To achieve the study's objective, the Johansen test for cointegration was applied to time series data from January 2009 to December 2021.

The empirical analysis confirmed that fluctuations in fuel prices and electricity supply have a significant influence on the long-term inflation rate in South Africa. Higher fuel prices were found to contribute to increased inflation, while a decrease in electricity supply resulted in higher inflation. This finding is logical as both fuel and electricity play crucial roles in the production and supply of goods in South Africa. Additionally, the study revealed that electricity supply has a substantial impact on the consumer price index (inflation) as it is not only used in production but also in the storage and preservation of goods.

However, the study has its limitations due to data availability. It focused on only two independent variables, neglecting other economic factors that may influence changes in the inflation rate. Future research should include more observations and explanatory variables to ensure a comprehensive analysis of all or most of the factors impacting the consumer price index (inflation).

The implications of the study suggest that both electricity supply and fuel prices significantly influence the inflation rate in South Africa. Therefore, efforts should be made to increase and stabilize electricity supply, while also maintaining stable and affordable fuel prices. This combination of a reliable electricity supply and low fuel costs would contribute to a lower inflation rate. Additionally, South Africa should invest in research and development for alternative and sustainable energy sources to reduce its dependence on electricity supply and imported fuel. The results of this study can provide valuable insights for policymakers to reassess energy accessibility policies in relation to household and government expenditures in South Africa.

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