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Asymmetric effect of Oil Prices on Inflation in South Africa: An Econometric Approach

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ABSTRACT

The surge in oil price levels remains a world-wide concern, more specifically to oil-importing countries such as South Africa. The dependence on crude oil from these net exporters makes the country vulnerable to external shocks, such as geopolitics. These effects have a pass-through effect to domestic headline inflation, induced by imported inflation. The general objective of the study is to investigate the asymmetric effect that the price of oil has on inflation in South Africa. To achieve these objectives, the study applied the Nonlinear Autoregressive Distributed Lags (NARDL), Error Correction Model (ECM), Pairwise Granger Causality, Impulse Response Function and Variance Decomposition. The bounds test of cointegration revealed that cointegration exists between the observed variables of the study. After estimating the error correction model, the study found that in the short-run, the relationship between a positive change in oil price and inflation is negative and significant. However, the relationship between a negative change in oil price and inflation in the short-run is now positive and significant. Therefore, the correction of disequilibrium will take place in the long run by means of short-run adjustments, with the speed of 1.71%. Pairwise Granger Causality test revealed that a unidirectional relationship occurs from oil prices to inflation. The Variance Decomposition results show that a shock to oil price accounts for a greater percentage of fluctuation in inflation. The Impulse Response Function reveals that within a 10-year period there is a positive response of inflation to oil prices, specifically from year three to year five. The study recommends the South African oil import diversification policy to source oil from multiple exporting countries to ensure steady supply and reduce dependence on any single source. This strategy improves security and reduces vulnerability to oil price shocks and supply disruptions caused by various factors.

Keywords: Oil Prices, Inflation, South Africa, Monetary Policy, Nonlinear Autoregressive Distributed Lags Model
JEL Classifications: C01; E31; E32; F31; Q43

1. INTRODUCTION

South Africa is a developing nation with a fragile economy, faced with many social and economic challenges which are detrimental to its economic growth and development. These problems stem from, among others, high levels of unemployment, unequal distribution of income, low output growth, and poverty. The Coronavirus pandemic (Covid-19) exacerbated these challenges. For the period 2010-2014, crude oil increased from $79.14 to $93.17, while inflation rate also increased for this period, from 4.1% in 2010 to 6.1% in 2014, which exceeds the upper bound of the targeted inflation rate, currently standing at 3 to 6 percent in South Africa. However, from the year 2015, crude oil declined from $48.66 to $39.68 in 2020, while the inflation rate saw a huge rise of roughly 6.6% in 2016, but from this period, inflation continued to decrease to a low 3.2% in 2020 (World Bank, 2020).

As revealed in the statistics above, the negative trajectory of oil prices began in 2014 and in 2020 oil prices collapsed during the economic downturn induced by the Covid-19 pandemic and the absence of cooperation among OPEC+ producers. The oil producers then reached a consensus on a historic reduction estimated at 100 million barrels per day (Jacobs, 2021). The decision concurred with the increasing international demand for vaccine rollouts in developed countries, and that has stabilised economic activity and backed growth in international trade. Consequently, the price of oil reached a staggering $70 per barrel of oil. The securities commodities unit of Investec projected that in the second half of 2021 and over to 2022, the price of Brent Spot oil would increase to an average of $75, relative to $65 a barrel in the first half of 2021. Other forecasters or economists even made a prediction of a rise to $100 per barrel in 2022. According to Writer (2021) oil prices surged to a record $129 per barrel which was induced by postponements in Iranian oil's potential return to international markets, and further fuelled by the United States and its allies in Europe imposing sanctions on the import of oil from Russia.

Crude oil is a critical fossil fuel energy source and is contemporarily perceived as a significant and essential energy source in the global market. By definition, crude oil can be described as a refined fossil fuel for the purposes of producing usable petrochemicals, including, *inter alia*, gasoline, petroleum, and diesel (SA shares, 2022). The oil market comprises two parts, which are activities in the upstream and the downstream. Upstream signifies the production and exploration of crude oil, while the downstream relates to the process of refining, transporting, and marketing of consumer products. The use of revenues generated from oil sales for infrastructure development by governments has resulted in rapid increases in consumption levels and improved standards of living in countries that export crude oil (Wang et al., 2013).

According to Department of Mineral Resources and Energy (2021), South Africa holds a refining capacity of 520 000 barrels each day. However, two of South Africa's local refineries are presently offline. Some of South Africa's refinery production is exported to neighbouring countries such as Botswana, Swaziland, Lesotho, and Namibia (Jacobs, 2021). Thus, the demand for oil domestically exceeds the supply that is available, and as a result, large quantities of refined oil are imported by South Africa. The supply of a commodity such as oil is not vulnerable solely to the supply disruptions of the oil producing nations and high costs of crude oil, but also to the political stability of transit nations (Nkomo, 2006). Thus, the demand for oil domestically exceeds the supply that is available, and as a result, large quantities of refined oil are imported by South Africa.

Although numerous studies have explored this connection, there is a lack of consensus and a dearth of comprehensive models that can account for the various factors at play (Arekzi and Nguyen 2020). The volatility of the oil price makes it quite challenging for net importing countries such as South Africa to impose effective policies that will curb the uncertain and volatile effects of oil prices. Therefore, the South African Reserve Bank, through its monetary policy, should continue to monitor oil price shocks to maintain price stability. This study then seeks to investigate the asymmetric effect that oil prices have on inflation in South Africa. This is to explore the magnitude of the effects of the increase and decrease of oil prices on inflation.

2. LITERATURE REVIEW

The theoretical debate on oil prices and inflation spans various economic schools of thought. Mercantilists argue that import substitution and export promotion are vital for economic growth, but rising oil prices can negatively impact GDP by increasing production costs and altering spending structures (Pentecost, 2000). Keynesian economics suggests that oil price hikes lead to demand-pull and cost-push inflation, where increased production costs are passed on to consumers (Phillips, 1958; Snowdon and Vane, 2005). The Quantity Theory of Money from Classical Economics indicates that while money supply changes influence prices, they do not affect real output, and oil price increases can hinder economic growth (Haslag, 1995; Snowdon and Vane, 2005). The transmission mechanism of oil price shock operates through supply, demand, and interest rate channels, affecting production costs, purchasing power, and central bank policies, respectively (Nordhaus et al., 1980; Loungani, 1986; Brown and Yucel, 2002; Segal, 2007; Zhang et al., 2022). This study aligns with the transmission mechanism theory, linking inflation to oil prices and incorporating variables like interest and exchange rates.

Numerous researchers have investigated the "asymmetric effect of oil prices on inflation" employing various methodologies and analysing different countries. Variations in findings are inevitable due to differences in countries, time periods, and methodological approaches utilized. Among these studies that investigated developed countries, those by LeBlanc and Chinn (2004), Bhar and Mallik (2010), and Antonio and Luis (2022) found a direct positive relationship between oil prices and inflation. LeBlanc and Chinn (2004) focused on G-5 nations and found that oil prices moderately affect inflation, with a 10% increase in oil prices leading to a 0.1-0.8% increase in inflation.

Cunado and de Gracia (2014) examined European states and discovered an asymmetric effect of oil prices on inflation and industrial production, influenced by factors like a nation's oil import/export status and monetary policy effectiveness. Bhar and Mallik (2010) analyzed inflation uncertainty and its impact on inflation and output growth in the USA, finding significant positive effects of inflation uncertainty on inflation and significant negative effects on output growth, with oil prices also significantly impacting inflation. Antonio and Luis (2022) investigated the euro/dollar exchange rates and oil prices' impact on inflation pass-through in the euro area, noting a reduction in oil price pass-through due to fluctuations in exchange rates. Renou-Maissant (2019) studied oil prices' effect on inflation for developed nations, highlighting a significant positive impact even during periods of low and stable inflation.

These discoveries were found when probing developing countries: Bala and Chin (2018) examined the nonlinear impact of oil prices on inflation in African OPEC member states using annual data from 1995 to 2014. They found that both positive and negative changes in oil prices had a positive impact on inflation, with a more significant effect observed during oil price declines. This suggests that policymakers should consider the impact of both positive and negative oil price changes on inflation, emphasizing the importance of monetary policy in reducing inflation rates. Gelos and Ustyugova (2017) analyzed Phillips curves across countries from 2000 to 2010 and found that fuel intensity and preexisting levels of inflation were significant factors explaining cross-country variations in the impact of oil price shocks and food prices. Monetary policy conduct and inflation-targeting regimes were not found to be critical factors in the pass-through degree of oil price changes.

Ozdemir and Akgul (2015) investigated the effects of crude oil imports and domestic gasoline prices on inflation in Turkey from October 2005 to December 2012. They found that sudden increases in gasoline prices had a more significant impact on inflation than oil price shocks, leading to economic crises. Mukhtarov et al. (2019) studied the relationship between oil prices, exchange rates, and inflation in Azerbaijan from 1995 to 2017. They found a long-run positive relationship between exchange rates, oil prices, and inflation, suggesting that increases in exchange rates and oil prices led to higher inflation. Lacheheb and Sirag (2019) focused on the non-linear effects of oil price changes on inflation in Algeria from 1970 to 2014. They found that positive changes in oil prices had a statistically significant positive impact on inflation, while negative changes were insignificant. This aligns with previous studies showing that oil price shocks positively affect inflation.

Various studies have also explored the relationship between oil prices and inflation, particularly focusing on South Africa, which is the geographical point of study. Dlamini (2015) investigated the impact of oil price shocks on South African monetary policy, finding an asymmetric response in output and inflation to oil price shocks. Positive oil shocks had an insignificant impact on output, while negative shocks increased output and decreased inflation. Ajmi et al. (2015) also studied this relationship using asymmetric Granger causality tests. They found that positive oil price shocks increased inflation more than negative shocks. Sibanda et al. (2015) studied oil prices, exchange rates and inflation expectations in South Africa. The study applied the vector autoregression model to analyze the effect of exchange rate and oil prices on inflation expectations in South Africa. The findings of the study reveal that the effect of exchange rates and the price of crude oil on inflation expectations is positive and statistically significant in South Africa.

Masipa (2015) examined the pass-through effect of oil prices on inflation, revealing a bi-directional causal link between the two variables. Balcilar et al. (2018) found a positive relationship between oil prices and inflation in South Africa, with positive oil shocks having a greater effect on inflation. Niyimbanira (2013) confirmed a unidirectional causality from oil prices to inflation. Similarly, Hassan and Meyer (2020) observed a significant impact of petrol price changes on inflation, with large increases exacerbating inflation levels. Rangasamy (2017) also found that petrol price rises significantly influenced inflation in South Africa. In general, these studies highlight the importance of understanding the intricate relationship between oil prices and inflation for effective monetary policy and economic stability in South Africa.

3. METHODOLOGY

To achieve the objectives of whether there is an asymmetric effect of oil prices on inflation, the Nonlinear Autoregressive Distributed Lag (NARDL), Error Correction Model (ECM), Pairwise Granger Causality, and Impulse Response Function and Variance Decomposition have been employed.

3.1. Model Specification

In investigating the asymmetric relationship between oil prices and inflation and following the empirical work of Zaghdoudi (2018) and Lacheheb and Sirag (2019), the model of the study can be expressed as follows:

$$LCPI_t = \alpha_0 + \alpha_1 LINTR_t + \alpha_2 LEXCH_t$$
$$+\alpha_3 LUNEMP_t + \alpha_4 LOP_t^+ + \alpha_5 LOP_t^- + \varepsilon_t \quad (4.1)$$

Where $LCPI_t$ is the consumer price index, as a proxy of inflation, LINTRt is interest rates, $LEXCH_t$ represents the exchange rate, $LUNEMP_t$ denotes unemployment, LOP is the price of oil, while alpha $\alpha = (\alpha_0, \alpha_1, \alpha_2, \alpha_3)$ is a vector of long-term parameters to be estimated in the study. The subscript "t" denotes the time period. Furthermore, equations (4.2) and (4.3) denoted $\alpha_4 LOP_t^+$ and $\alpha_5 LOP_t^-$ represent both the positive and negative changes in oil prices:

$$LOP_t^+ = \sum_{i=1}^{t} \Delta LOP_t^+ = \sum_{i=1}^{t} \max(\Delta LOP_t, 0) \quad (4.2)$$

And

$$LOP_t^- = \sum_{i=1}^{t} \Delta LOP_t^- = \sum_{i=1}^{t} \min(\Delta LOP_t, 0) \quad (4.3)$$

3.2. Data Collection

Annual time series data is employed to investigate the asymmetric effect of oil prices on inflation. The data to be fitted in the model of this study are collected from the International Monetary Fund (IMF), OPEC, and World Bank. This study will focus on the period from 1991 to 2020, which accounts for 30 observations.

3.3. Estimation Techniques

Since the majority of time series data exhibit non-stationarity, the initial step in time series analysis involves testing for unit roots. Pesaran et al. (2001) posited that before estimating the model at hand, the regressand variable should be non-stationary in order for the model to perform correctly. According to Arltová and Fedorova (2016), it is of great significance to determine the integration order for the examined time series by means of unit root tests in econometric modelling. The unit root tests to be applied in this study are the Kwiatkowski-Phillips-Schmidt-Shin test (KPSS test) test and Augmented Dickey-Fuller test (ADF test).

The Nonlinear Autoregressive Distributed Lag (NARDL) is employed to evaluate the relationship between oil prices and inflation. Shin et al. (2014) introduced the bound test in an effort to identify the existence of long-run asymmetrical cointegration. The application of bounds testing is advantageous since it does not require that the integration of variables be in the same order, meaning that it can be applied to different orders of integration. The attractiveness of the NARDL lies in the fact that it is a straightforward method to model a combination of short- and long-run asymmetries. Shin et al. (2014) established the short-run and long-run nonlinearities through the partitioning of explanatory variables into positive and negative partial sum decompositions.

The NARDL also makes provision for the Error Correction Model (ECM). The ECM demonstrates the speed at which adjustments occur, and the presence of a negative significant coefficient suggests that short-term fluctuations will ultimately lead to a stable long-term relationship between the variables, resulting in convergence to equilibrium (Pesaran and Shin, 1999). Therefore, the ECM functions to capture the short-term dynamics in conjunction with the long-term dynamics. According to Asteriou and Hall (2011), when there is an existence of cointegration among two or more variables, the obtained residuals from the regression of ordinary least squares can be used to estimate the ECM and analyse the short- and long-run effects of the variables and therefore comprehend how the periodic adjustment of the coefficient of the lagged residual terms takes place.

One of the primary goals of empirical econometrics is to examine the causal relationships between economic variables. Sorenson (2005) states that the pairwise Granger causality test estimates if a specific event occurs prior to another while also assisting with forecasting that event. Causality (also known as cause and effect) denotes a rational connection between two processes. While the second is partially or entirely dependent on the first, the first (the cause) is partially or entirely accountable for the second. The reason for the causality test is to examine how the variables respond to one another, and it decides whether the matched time series data have a relationship or not (Shaari et al., 2012).

The diagnostic tests are carried out to guarantee the dependability and strength of the error correction model adopted in the study. It is significant for a diagnostic test for normality, heteroscedasticity and serial correlation to be executed (Zeilies and Hothorn, 2002; Griliches, 1961; Kleiber and Zeileis, 2008). The intention behind testing diagnostics and stability is to avoid the chance of spurious results from the model. The model's stability is uncertain; hence, the Cumulative Sum (CUSUM) and Cumulative Sum of Squares (CUSUM of Squares) tests will be conducted to assess its stability. CUSUM of squares, a recursive structural stability test will be employed, typically analysing observations throughout a specified time interval from start to finish (Pesaran, 2001).

Vector autoregression (VAR) analysis commonly focuses on computing impulse response functions and forecast error variance decomposition, which trace the progression of economic shocks throughout the system (Swanson and Granger, 1997). Consequently, the dynamic interaction among variables is explored by generating variance decompositions (VDC) and impulse response functions (IRFs). As suggested by Soytas and Sari (2003), the validity of causality tests is applicable within the sample period. Therefore, variance decomposition enables the assessment of causality of the external sample between the series in the VAR system.

4. EMPIRICAL RESULTS AND DISCUSSION

Following the methodology outlined in the preceding section, this segment presents the empirical examination and interpretation of the results.

4.1. Unit Root Test

Table 1 shows the results of the Augmented Dickey-Fuller (ADF) test and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test for levels and first difference. The results of the ADF test find that LCPI, LOP, LEXCH, and LUNEMP are stationary at 1% and INTR at 10% significance level after the first difference. Therefore, the integration of variables is of both order I (0) and I (1), implying that H0 is rejected; as a result, there is stationarity. The results of the KPSS test find that LCPI and LEXCH are stationary at 1% significance level after the first difference. However, LCPI, LOP, LEXCH and INTR are also stationary at level form at 5% significance level. LUNEMP is stationary at 10% level of significance. In conclusion, the order of integration of variables is at both I (0) and I (1). The outcome of KPSS is consistent with the results of the ADF test and the requirements of the NARDL model. Therefore, the study fails to reject the null hypothesis (the series is stationary) and concludes that the series is stationary. Since all variables are stationary after the first difference, the bound test of co-integration will be applied.

4.2. Cointegration

As illustrated in Table 2, this study applies 2 lags for the NARDL model estimation, whereby the LR, FPE, AIC, and HQ suggest lag 2 as the appropriate lag length for the model.

Table 3 presents co-integration findings derived from bounds testing. The model evaluating the relationship between oil prices and inflation comprises five variables, indicating four independent variables in total, denoted by k = 4. The calculated F-statistic is 13.13277, surpassing the critical value (3.06) of the lower bounds and the critical value (4.15) of the upper bound at the 1% significance level. This confirms the presence of cointegration between the variables of the study. These cointegration findings align with those of Mukhtarov et al. (2019), who investigated the relationship between oil prices, exchange rate, and inflation in Azerbaijan.

Table 4 presents the long-run estimation results for the asymmetric ARDL model. With a lag length of the two lags chosen for the study, a significant finding indicates that oil prices exhibit an asymmetric effect on inflation. Positive changes in oil prices are positively associated with inflation, particularly in lag 2, with a 1% increase in oil prices leading to a 0.796617% increase in inflation. In contrast, negative changes in oil prices are negatively related to inflation, especially at lag 2, resulting in a 1.465587% decrease in inflation for every 1% decrease in oil prices. This aligns with previous research by Dlamini (2015), suggesting that negative oil price changes have a greater impact on reducing inflation

Table 1: Unit root test

Variable	Models	Levels		First difference	
		ADF	KPSS	ADF	KPSS
LCPI	Intercept	−3.740758***	0.667221**	−5.134976***	0.413042*
	Trend and intercept	−4.114199**	0.176893**	−5.347085***	0.500000***
	None	−2.029013**	–	−4.884478***	–
LOP	Intercept	−1.323120	0.540371**	−4.524430***	0.196910
	Trend and intercept	−1.156547	0.126691*	−4.615600	0.130298*
	None	0.287928	-	−4.478460	-
LEXCH	Intercept	−1.303478	0.650389**	−4.502789***	0.500000**
	Trend and intercept	−3.729417**	0.081133	−4.406899***	0.500000***
	None	−2.716965***	-	−4.566053***	-
INTR	Intercept	−1.739175	0.485176**	−1.672534	0.141360
	Trend and intercept	−2.328878	0.109770	−2.714272	0.130657*
	None	−0.663241	-	−1.609809*	-
LUNEMP	Intercept	−1.648010	0.374564*	−3.946381***	0.164736
	Trend and intercept	−2.241340	0.095891	−3.962277**	0.144104*
	None	−0.230511	-	−4.022320***	-

(*) significant at 10%, (**) significant at 5%, (***) significant at 1%

Source: Own calculation

Table 2: Selection order criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	−175.1905	NA	0.267541	12.87075	13.10864	12.94348
1	−72.77205	160.9433	0.001097	7.340861	8.768223*	7.777220
2	−38.24611	41.92436*	0.000672*	6.660436*	9.277267	7.460427*

Source: Own calculation

Table 3: NARDL Bound test

Test statistic	Value	K
F Statistic	13.13277	4
Critical value Bounds of F-statistic		
Significance level	I (0) Bound	I (1) Bound
10%	2.08	3
5%	2.39	3.38
2.5%	2.7	3.73
1%	3.06	4.15

Source: Own calculations

Table 4: Asymmetric ARDL long run results

Dependent variable= LCPI			
Variable	Coefficient	T statistics	Prob value
C	31.03475	6.631907	0.0000
LCPI (−1)	−0.368742	−1.775094	0.1012
LCPI (−2)	−0.342009	−1.769137	0.1023
LEXCH	−1.456222	−1.799924	0.1023
INTR (−1)	−0.205807	−2.760377	0.0173
INTR (−2)	0.094322	1.560365	0.1446
LOP_POS (−1)	−0.83334	−1.662607	0.1223
LOP_POS (−2)	0.796617	1.920281	0.0389
LOP_NEG (−1)	−0.194356	−0.590741	0.5657
LOP_NEG (−2)	−1.465587	−3.778150	0.0026
LUNEMP (−1)	−3.887099	−2.817349	0.0155

Source: Own calculation

compared to the extent to which a positive oil price changes increases inflation.

Unemployment demonstrates a significant negative relationship with inflation, with a 1% increase in unemployment leading to a 3.887099% decrease in inflation, consistent with Phillips' (1958) theory of the Phillips curve, which posits an inverse relationship between unemployment and inflation. The study also finds a negative and insignificant relationship between the exchange rate and inflation, which is in line with the findings of Gwili (2019). These results, however, diverge from economic theory expectations. Similarly, the relationship between interest rate and inflation is negative, but significant at lag 1, indicating that a 1% increase in interest rates results in a 0.205807% decline in inflation, consistent with the results of Mpofu (2011).

Table 5 shows a short-term connection between the variables analyzed in the study, indicating co-integration between them. The error correction term (ECT) at lag (−1) is negative and statistically significant at a 5% level, confirming the presence of cointegration and suggesting that the model will revert to equilibrium in the long run through short-run adjustments, with a speed of 1.71%. In the short run, a positive change in oil price correlates negatively and significantly with inflation, while a negative change in oil price correlates positively and significantly with inflation. Additionally, interest rates exhibit an insignificant positive relationship with inflation in the short run, but a negative and significant relationship at lag 1. Meanwhile, the relationship between unemployment and inflation remains negatively significant.

4.3. Pairwise Granger Causality

Table 6 presents the results of the Granger causality test, indicating that four variables Granger-cause each other, while the remaining four variables do not. Specifically, the null hypothesis suggesting that oil prices do not Granger-cause inflation is rejected, as the probability value (0.0428) falls below the 5% significance level. This rejection supports the existence of a unidirectional causal link from oil prices to inflation. These findings align with previous studies by Niyimbanira (2013) and Ajmi et al. (2015), which also identified oil prices as Granger-causing inflation. However, Masipa (2005) reported a bidirectional causal relationship between oil prices and inflation. This study has succeeded in identifying evidence supporting the previously estimated correlation in the asymmetric ARDL analysis using the bound test. Additionally, the Granger causality test has established a one-way causality relationship. Additionally, unemployment is not found to Granger-cause inflation, but the exchange rate is shown to have a causal effect on inflation. Moreover, there is a unidirectional relationship between interest rates and inflation.

4.4. Diagnostic Tests

Table 7 shows that the probability of all tests is >5% level of significance. Therefore, the study fails to reject the null hypothesis, and makes a conclusion that residuals are normally distributed, there are no signs of serial correlation in the series, and also no heteroskedasticity is detected.

4.5. Stability Test

The Ramsey reset test is used to test stability as represented in Table 8. Since the probability value is more than 5% level of significance, thus we fail to reject the null hypothesis and conclude that there is no misspecification in the model.

4.6. Recursive Estimates

H_0: Parameters are not constant over time
H_1: Parameters are constant over time

Table 5: Error correction model: Short run analysis

Dependent variable: D(LCPI) Sample size: 1991-2020 Included observations: 27				
Variables	**Coefficients**	**Std Error**	**T-statistic**	**Prob value**
D(LCP [−1])	0.342009	0.096202	3.555118	0.0040
D(INTR)	0.033993	0.031045	1.094945	0.2950
D(INTR[−1])	−0.094322	0.031322	−3.011362	0.0108
D(LOP_POS)	−1.469144	0.206950	−7.099041	0.0000
D(LOP_POS[−1])	−0.796617	0.204435	−3.896678	0.0021
D(LOP_NEG)	0.497929	0.129183	3.854440	0.0023
D(LOP_NEG [−1])	1.465587	0.230635	6.354585	0.0000
D(LUNEMP)	−1.652494	0.616523	−2.680344	0.0200
ECT(−1)	−1.710751	0.145685	−11.74283	0.0000
R-squared = 0.91				
DW statistic = 2.28				
Adjusted R-squared = 0.87				

Source: Own calculation

Figures 1 and 2 illustrate the outcomes of the recursive estimates for both the CUSUM test and CUSUM of squares test respectively. These tests find evidence of stability in the model, where the blue lines of both the CUSUM and CUSUM of squares fall within the 5% significance bound. As a result, H0 is rejected, and it is concluded that there is stability in the model/parameters, which are constant over time.

4.7. Variance Decomposition

The forecast error variance in inflation is attributable to its very own innovation, but also to oil prices, exchange rate, interest rate, and unemployment. As depicted in Table 9, the study has selected 5 years to elaborate on the variance decomposition. Firstly, in year 2, 90.32% of forecast error variance in inflation is explained by the variance itself (own shock). This simply explains that a shock in inflation can lead to 90.32% variation of the volatility in inflation. However, in year 4, inflation rate shocks can cause

Figure 1: Cusum test

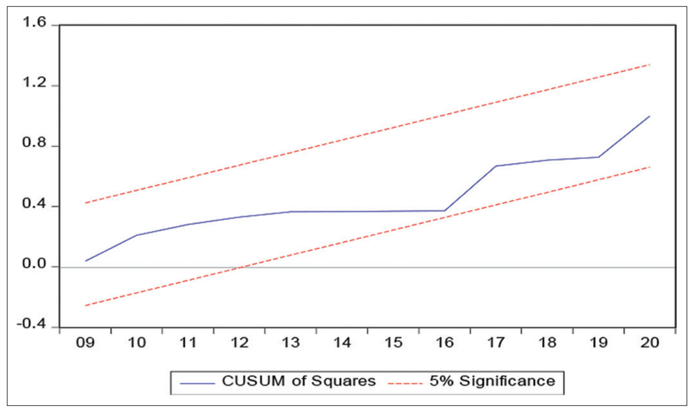


Figure 2: Cusum of squares test

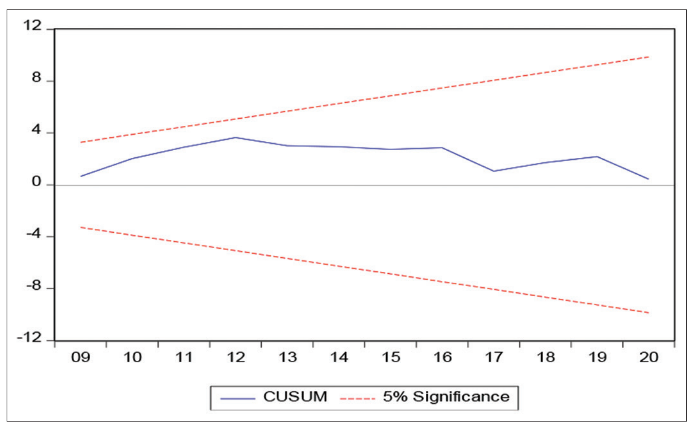


Table 6: Granger causality test results

Null hypothesis	Obs	F-statistic	P-value	Decision
LOP does not granger cause LCPI	28	3.52884	0.0428	Reject the null hypothesis
LCPI does not granger cause LOP		1.53012	0.2377	Accept the null hypothesis
LEXCH does not granger cause LCPI	28	4.17047	0.0285	Reject the null hypothesis
LCPI does not granger cause LEXCH		7.93285	0.0024	Reject the null hypothesis
LUNEMP does not granger cause LCPI	28	1.34905	0.2793	Accept the null hypothesis
LCPI does not granger cause LUNEMP		0.69798	0.5078	Accept the null hypothesis
INTR does not granger cause LCPI	28	0.56146	0.5780	Accept the null hypothesis
LCPI does not granger cause INTR		3.98362	0.0327	Reject the null hypothesis

Source: Own calculation

Table 7: Diagnostic tests results

Test	Jarque-Bera	Breusch-Godfrey	Breusch-Pagan-Godfrey	Harvey	White	Glejser
Null hypothesis	Residuals are normally distributed	No serial correlation	No heteroskedasticity	No heteroskedasticity	No heteroskedasticity	No heteroskedasticity
F statistics	1.005212	1.393469	3.174883	1.578995	1.794700	3.306248
Prob value	0.604952	0.0527	0.0951	0.2305	0.1946	0.0908
Conclusion	Fail to reject null hypothesis	Fail to reject null hypothesis	Fail to reject null hypothesis	Fail to reject null hypothesis	Fail to reject null hypothesis	Fail to reject null hypothesis

Source: Own calculation

Table 8: Ramsey's reset test

Null hypothesis	Ramsey test	Value	Degrees of freedom	Probability	Conclusion
No misspecification	t-statistic	0.751717	11	0.4680	Fail to reject H0
No misspecification	F-statistic	0.565078	(1, 11)	0.4680	Fail to reject H0

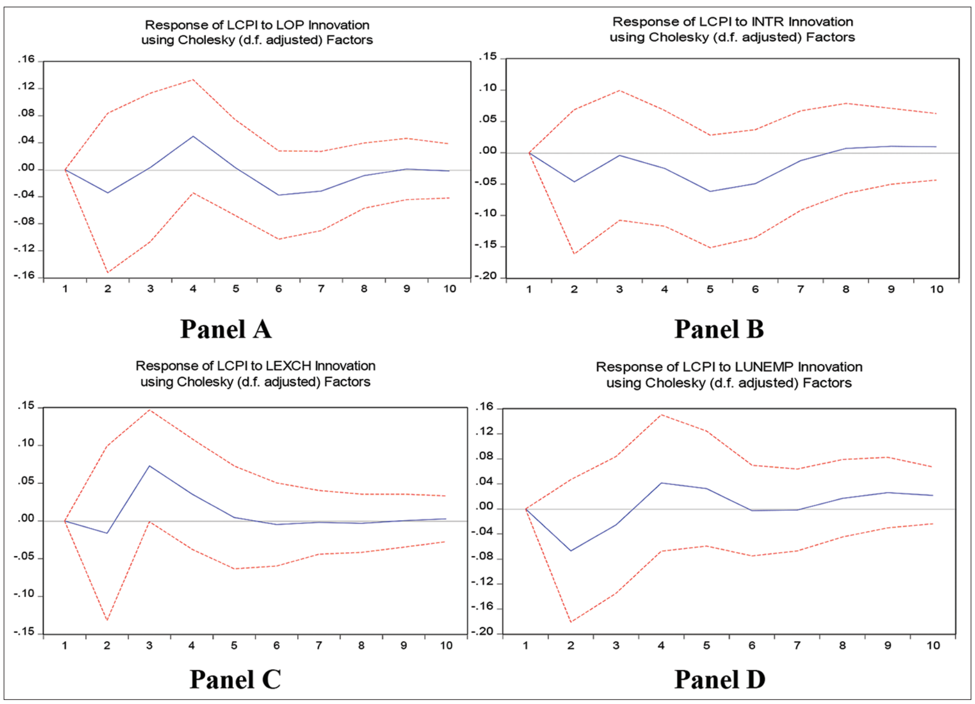
Source: Own calculation

Table 9: Variance decomposition of LCPI

Period	S.E.	LCPI	LOP	LEXCH	INTR	LUNEMP
1	0.265140	100.0000	0.000000	0.000000	0.000000	0.000000
2	0.288737	90.32135	1.412879	0.316446	2.566691	5.382630
3	0.299008	84.25327	1.331051	6.264184	2.412570	5.738921
4	0.309581	78.98141	3.790146	7.179814	2.900356	7.148278
5	0.317412	75.15247	3.611447	6.850916	6.534983	7.850183

Source: Own calculation

Figure 3: Results of the impulse response function



Source: Own calculation

78.98% fluctuations in inflation, while in year 5, they account for 75.15% fluctuations.

Secondly, an oil price shock in year 2 can result in 1.41% fluctuations in inflation. Furthermore, in the 4th year, an oil price shock causes inflation fluctuations to reach 3.79%. Third, year 2 depicts that a shock affecting the exchange rate can lead to 0.32% fluctuations in inflation, while in the 4th year, a shock in the exchange rate accounts for 7.18% fluctuations in inflation. Fourth, a shock to the interest rate in the 2nd year will account for 2.57% fluctuations in inflation, whereas in the 5th year it accounts for 6.53% fluctuations in inflation. Lastly, a shock in unemployment rate can account for 5.38% fluctuations in inflation in year 2, while a shock in unemployment in the 4th-year accounts for 7.14% fluctuations in inflation.

4.8. Impulse Response Function

The results displayed in Figure 3, depicting the impulse response function, show the reciprocal effects of the variables in response to a one standard deviation (SD) shock towards a residual. Panel (A) illustrates that one SD shock in oil prices elicits both positive and negative effects on inflation. Initially, there is a positive response from period 2 to period 4, followed by a decline until the sixth period, then an upward trend is observed, maintaining a positive trajectory thereafter. In panel (B), one SD shock to interest rates initially reduces inflation, remaining in the negative region from period 1 to period 7; subsequently, it begins to rise and reaches its steady-state value in the eighth period, transitioning into the positive region. Panel (C) indicates that inflation responds negatively in the short run from the first to the second period, then shows a positive response to exchange rate volatility following a one-SD shock from period 2 to 3. Additionally, it reveals that a one SD shock in unemployment induces a negative response from inflation in periods 1 and 2; however, from period 2 onwards, it exhibits an upward trend, reaching its steady state value post-period 3 and transitioning into the positive region.

5. CONCLUSION AND RECOMMENDATIONS

The study aimed to explore the asymmetric effect of oil prices on inflation in South Africa. The analysis utilized methodologies including Nonlinear Autoregressive Distributed Lags (NARDL), Error Correction Model (ECM), Pairwise Granger Causality, Impulse Response Function, and Variance Decomposition. Data spanning from 1991 to 2020 were collected from sources such as the International Monetary Fund (IMF), OPEC, and the World Bank to achieve these objectives.

The bound test found evidence of a long-run relationship between oil prices and inflation. The NARDL further revealed that this long-run relationship is positive in effect. The Error Correction Model (ECM) confirmed that the model will revert to equilibrium in the long run through short-run adjustments, at a speed of 1.71%. The Granger causality test indicated a unidirectional causal link from oil prices to inflation. The impulse response function revealed that one SD shock in oil price elicits both positive and negative effects on inflation. Variance decomposition findings suggest that an oil price shock can result in 3.69% fluctuations in inflation.

South Africa should endorse the development and exploration of alternative oil resources, for example, shale oil, and focus on the creation of a national oil reserve system by exploiting the benefit window of lower oil prices to vigorously stockpile oil by constructing an adequate amount of state oil reserves. The study also recommends minimising the inflationary effects of oil price fluctuations by diversifying energy sources and improving energy efficiency.

South Africa should effectively consider a gradual and progressive energy transition from harmful fossil fuels to alternative renewable energy sources such as wind power, solar energy, geothermal energy, hydropower, and bioenergy in order to reduce its reliability in oil consumption. Moreover, the government is advised to consider establishing strategic and sustainable petroleum reserves and implementing mechanisms to stabilize prices through effective monetary policy, thus mitigating the immediate impact of oil price fluctuations on inflation. Additionally, long-term strategies should prioritize energy efficiency and the promotion of renewable energy sources to enhance energy security and reduce vulnerability to oil price fluctuations.

The study also recommends the oil-import diversification policy by sourcing oil from multiple exporting countries to ensure a steady supply and reduce dependence on any single source. This strategy enhances security and lessens vulnerability to supply disruptions caused by various factors (terrorism, regime change, natural disasters, etc). For South Africa, diversifying oil imports away from high-risk regions like the Middle East towards lower-risk regions such as North America and Europe is recommended to reduce import-specific risks. Strengthening partnerships between state-owned entities such as the Central Energy Fund (CEF) and private firms is recommended to secure low-risk imports. Additionally, South Africa should establish bilateral relationships with oil suppliers like North America, Russia, and Europe, while considering cost factors carefully.

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