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Article

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Exchange Rate Volatility and Oil Prices in South Africa

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ABSTRACT

The study examines the oil prices and exchange rate volatilities in South Africa. The study employs monthly time series data spanning for the period from 1960 M1 to 2021M11 using data collected from the SARB. The study employs a threshold generalized autoregressive conditional heteroskedasticity model to analyse the volatilities between oil prices and exchange rate. The study found that oil prices have a negative statistically significant impact on the exchange rates in South Africa. The study therefore recommends that the monetary authorities must monitor oil prices as they have an ability to cause exchange rate volatilities.

Keywords: Oil prices, Exchange rate volatility, Threshold generalized autoregressive conditional heteroskedasticity, SARB, South Africa
JEL Classifications: Q41, Q43, Q31, C22

1. INTRODUCTION

In most cases, oil imports account for a significant portion of a country's trade balance. Oriavwote and Eriemo (2012), Shakibaei et al. (2009), and Aziz and Bakar (2009) have all mentioned the potential impact of oil prices for exchange rate changes. In the case of a small open economy. Dawson (2004) shows that volatility in oil prices have a significant influence on the level values of the currency. While much has been written about the impact of oil prices on currency rates in oil-exporting nations, there is far less circumstantial evidence of energy-importing countries (Oriavwote and Eriemo, 2012; Shakibaei et al., 2009). As a result, this article utilizes the example of South Africa, a small open economy with exchange rate that is heavily reliant on brent crude oil prices, to demonstrate the volatility in oil prices and actual exchange rates. Oil prices are a major factor on economic growth around the world. As a result, governments must pay special attention to variations in oil prices to devise strategies to stabilize the volatility of the exchange rate.

1.1. Overview of the Study

Consumption of oil in South Africa is currently estimated to be around 20% of total energy utilization (EIA, 2013). South Africa has no proven commercial oil resources, it should rely on imported crude oil to meet its energy needs (Nkomo, 2009). According to available data, South Africa is heavily reliant on oil imports, accounting for 6% of total imports (EIA, 2013). Furthermore, South Africa imports over 90% of its crude oil conditions required (Nkomo, 2009). Because of its reliance on imported crude oil, South Africa is vulnerable to external shocks that destabilize or lead to higher oil prices, limiting economic growth and development. Another reason for concern is also that two of South Africa's core sectors, transportation, and agriculture, are strongly reliant on oil products, thus any change in oil prices will have a significant impact on the country.

Crude oil is a crucial input in South African economy for the production cycle of consumer goods, is it a powerful factor in determining the price of goods. An unfavorable oil price fluctuation not only reduces revenue of companies but also raises production costs, resulting in higher inflation rate. It declines the economy's global competitiveness, which may lead to additional issues such as extreme depreciation of the domestic currency. Both dependence and market asymmetry approaches have been used in studies. Using a GARCH framework, Fowowe (2014)

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observes that an increase in oil prices causes the South African rand to depreciate.

The link between crude oil and exchange rates is theoretically supported by the law of one price, the wealth effect, and the terms of trade effect. Initially, the law of one price assumes that the similarity characteristics of crude oil clearly show that a depreciation of the US dollar lowers oil prices in the global oil market. Blomberg and Harris (1995) proposed that a depreciation of the US dollar would benefit foreigners by lowering oil prices, resulting in an increase in purchasing power and thus demand for oil. Second, the relationship between crude oil and exchange rates resembles a wealth effect channel. Lastly, trade terms demonstrate and determine the oil price-exchange rate connection based on the country's consumption of both traded and non-traded goods.

A volatile exchange rate is a perplexing issue that has impacted South Africa for much more than a decade. Considering the high volatile exchange rate over the years, the following are the main concerns about the economy's performance regarding exchange rate variability: Is the rand affected by oil prices? What impact does the price of oil have on the rand exchange rate? What are the economic effects of rising oil prices? As a result, the primary aim of this study is to examine the volatility of exchange rate and oil prices in South Africa and review literature on the impact of oil prices and exchange rate; and make policy recommendations based on the study's findings.

2. LITERATURE REVIEW

2.1. Theoretical Literature

This study is based on the two theoretical literatures discussed below.

(i) This study is based on the hybrid or interest rate differential model of exchange rate proposed by Frankel (1979) and Dornbusch (1980). Because the exchange rate is the relative price of foreign and domestic money, it should be governed by the relative demand and supply of money, according to the monetary exchange rate model. We begin by expressing the real money demand function in logarithmic notation in home and foreign country as follows:

Home country: $p = m - \alpha\gamma + \beta_i$ (1)

Foreign country: $p^* = m^* - \alpha\gamma^* + \beta_i^*$ (2)

Where by, p and p^* represents home and foreign prices, respectively, m and m^* represents money demand in home and foreign country. γ and i represents output and interest rate for the other two countries. Assuming the purchasing power parity requirement remains in the long run, Equations 1 and 2 are combined to form Equation 3 below:

$$e = p - p^* = \left(m - m^*\right) - \alpha\left(\gamma - \gamma^*\right) + \beta(i - i^*) \quad (3)$$

Based on the two extra assumptions introduced in Frankel (1979) model, it differs from Equation 3 to some extent. The first assumption is that interest rate parity is linked to efficient markets in which various nation's bonds are ideal substitutes for each other as shown in the expression below:

$$Z = i - i^* \quad (4)$$

The predicted rate of depreciation is a function of the difference between the current spot rate and an equilibrium rate, as well as the expected long run inflation disparity between the home and foreign countries, according to the second central assumption as shown below:

$$z = -\vartheta(e - \bar{e}) + \pi - \pi^* \quad (5)$$

Where by, e is the log of the spot rate, π and π^* are the current rates of expected long run inflation at home and abroad, respectively. Taking equation 4 and 5 together, it gives us equation 6 below as follows:

$$e - \bar{e} = -\frac{1}{\vartheta}[\left(i - \pi\right) - \left(i^* - \pi^*\right)] \quad (6)$$

Utilising bars to denote equilibrium values, Frankel (1979) argues further that when $-\bar{e}$, $i - i^* = \pi - \pi^*$ in the long run and equation 3 is now expressed as follows:

$$\bar{e} = \bar{p} - \bar{p}^* = \bar{m} - \bar{m}^* - \alpha\left(\bar{\gamma} - \bar{\gamma}^*\right) + \beta(\bar{\pi} - \bar{\pi}^*) \quad (7)$$

Further more, by substituting Equation 7 for Equation 6 and assuming that the current equilibrium money supply and income levels are determined by their present actual levels, a full equation for determining spot rates may be found below in Equation 8:

$$\bar{e} = \bar{p} - \bar{p}^* = \bar{m} - \bar{m}^* - \alpha\left(\bar{\gamma} - \bar{\gamma}^*\right) - \frac{1}{\vartheta}\left(i - i^*\right) + (\frac{1}{\vartheta} + \beta)(\bar{\pi} - \bar{\pi}^*) \quad (8)$$

Equation can be rewritten in a more stochastic way as given in Equation 9 below:

$$\bar{e} = \bar{p} - \bar{p}^* = \bar{m} - \bar{m}^* - \alpha\left(\bar{\gamma} - \bar{\gamma}^*\right) - \varphi\left(i - i^*\right) + \delta\left(\bar{\pi} - \bar{\pi}^*\right) + \varepsilon \quad (9)$$

Where, $\varphi(= -\frac{1}{\theta})$ is hypothesized negative and $\delta(= \frac{1}{\theta} + \beta)$ is hypothesized positive and greater than α in absolute value. Frankel (1979) offered an innovation that seeks to combine the Keynesian assumption of sticky prices with the Chicago assumption of secular rates of inflation. Unlike the initial theory, the exchange rate is inversely associated to nominal interest rate disparity but favourably related to the predicted long run inflation differential.

(ii) According to Chen and Chen (2007) the domestic and foreign nation consumer price indices should be as follows:

$$cpi_h = (p^t)^{\alpha}(p_n)^{n-\alpha} \quad (10)$$

$$\rightarrow p_t = \log\left(cpi_h\right) = \alpha\log\left(p^t\right) + \left(1 - \alpha\right)\log(p^n)$$

$$\rightarrow p_t = \alpha p_l^t + (1 - \alpha)p_l^n$$

$$cpi_f = (p^{t*})^{\alpha*}(p^{n*})^{1-\alpha}$$

$$\rightarrow p_l^* = \log\left(cpi_f\right) = \alpha^* \log\left(p^{t*}\right) + \left(1-\alpha^*\right)\log(p^{n*})$$

$$\rightarrow p_l^* = \alpha + p_l^{t*} + (1-\alpha)p_l^{n*}$$

Whereby, p_l^t (p_l^{t*}) and p_l^n (p_l^{n*}) are domestic and foreign prices of traded and non-traded items, respectively. cpi_h and cpi_f represents home and international consumer price indices, respectively. α and α* weights reflect to the expenditure shares on traded items for home and foreign nations, respectively, around the point of approximation. The log of exchange rate is therefore represented as:

$$ex_r = \frac{p^*}{p} ex_n \quad (12)$$

$$\rightarrow \log\left(ex_r\right) = \log\left(ex_n\right) + \log\left(p^*\right) - \log(p)$$

$$\rightarrow lex_r = lex_n + P_l^* - P_l$$

Whereby, ex_r and ex_n epresents real and nominal exchange rates, respectively. The real exchange rate may thus be rewritten by noting Equation 10, 11 and 12 as:

$$lex_r = (lex_n + p_l^{t*} + p_l^t) \quad (13)$$

$$+(1-\alpha)(p_l^t - p_l^n)$$

$$-(1-\alpha^*)(p_l^{t*} - p_l^{n*})$$

From equation 14, if $\alpha \cong \alpha^*$, an increase in the relative price of domestic tradable depreciates the real exchange rate, the amount of the rise surpasses that of the rise in the relative price of foreign tradable, the real exchange rate depreciates. To look at it another way, if the home nation is more reliant on imported oil, a real increase in oil prices may raise the costs of tradable commodities in the home country by a higher percentage than in the foreign country, causing a real devaluation of the home currency.

Furthermore, if an oil price shock affects the term of trade, the home country's nominal exchange rate would have to be raised, resulting in additional real depreciation. The relationship between real exchange rates and real oil prices is experimentally investigated in this study. We investigate whether, as anticipated by the model, the real exchange rate is positively related to real oil price. We also investigate whether real oil prices can predict real exchange rate. Nonmonetary shocks are generally acknowledged to be the primary cause of real exchange rate changes. The relationship between oil prices and exchange rates has been studied by several scholars.

2.2. Empirical Literature

2.2.1. Studies that found positive relationship

Shakibaei et al. (2009) conducted a study on the long run relationship between oil prices and exchange rates in the OPEC region for the period from 1995 M1 to 2006 M12. The study employed panel Random Effect model and revealed that oil prices are dominant source of exchange rate movements, and they have a long run relationship. Aziz and Bakar (2009) investigates the long run effects of real oil price and interest rate differential on real exchange rate on a panel of 8 countries for the period from 1980 to 2008. The study found positive statistically significant relationship between oil prices and exchange rates by employing PMG model.

Oriavwote and Eriemo (2012) investigated the relationship between real oil prices and real exchange rate in Nigeria for the period from 1980 to 2010. The study employed a GARCH model and found the persistence of volatility between oil prices and real exchange rate. The researchers recommend that the government policies on tackling the impact of fluctuations in real oil prices are important source for stabilizing the movements in real exchange rate. Englama et al. (2010) investigated oil prices and exchange rate volatility in Nigeria by utilising monthly time series data spanning from 1991 M1 to 2009 M12. By employing a VECM model, the study found that oil prices have a positive effect on exchange rate volatility. The study recommends closely monitoring of exchange rate to move in tandem with the volatility in crude oil prices as Nigeria remains an oil-dependent economy.

Jain and Ghosh (2013) examines the cointegration and Granger causality among global oil prices, precious metal prices and exchange rate using daily data spanning from 2009 M1 to 2011 M12. By employing an ARDL model, the results revealed that the shocks in oil prices are transmitted to the Indian economy through exchange rates. Ferraro et al. (2015) found that oil prices are significant in forecasting exchange rates.

Delgado et al. (2018) analyses the relationships between oil prices, exchange rate and stock market index in Mexico utilising data spanning from 1992 M1 to 2017 M7. The study employed a VAR model and found that oil prices are statistically significant against the exchange rate, concluding that an increase in oil prices creates an appreciation of the exchange rate. Turhan et al. (2013) investigates oil prices and emerging market exchange rates using daily time series data spanning from 2003 3 January to 2010 2 June. The study employed a VAR model and revealed that a rise in oil prices leads to a significant appreciation of emerging economies' currencies against the US dollar. Their findings suggest that oil price dynamics changed significantly in the sample and the relationship between oil prices and exchange rates became more obvious after the 2008 financial crisis.

Mukhtarov et al. (2019) investigates the impacts of oil prices on inflation in Azerbaijan utilising data spanning from 1995 to 2017. The study employed a VECM model and found that oil prices and exchange rates have positive statistically significant impact on inflation in the long run. The results further reveal that the impact of exchange rate such that the drop in oil prices in 2014 caused devaluation of national currency. Narayan et al. (2019) investigates the influence of oil prices on Indonesia's exchange rate for the period from 1986 to 2017. The study employs an ARDL model and found that long-run cointegration relation between oil prices and the real exchange rate is sensitive to different exchange rate regimes in Indonesia.

Abraham (2016) examine the exchange rate policy and falling crude oil prices on the Nigerian stock market. By employing an ARDL model, the study found that oil prices are positively related with the performance of the Nigerian stock market thus would drag the market down in times of turmoil. The study further stress that devaluation of the Naira is found to be effective in cushioning the effect of crude oil price decline on the stock market. Duan et al. (2021) investigates how geopolitical risk drives exchange rate and oil prices using a wavelet-based analysis in Venezuela. The study found that bidirectional causality between oil prices and exchange rate.

Beckmann et al. (2020) reviews the existing theoretical and empirical research on the relationships between oil prices and exchange rates. The theoretical transmission channels point out to bidirectional causality while empirical literature shows strong links between exchange rates and oil prices frequently observed over the long run. Wen et al. (2020) employed a Granger causality model and found that risk spill overs are stronger from exchange rates to crude oil than those from oil to exchange rate markets.

Gomez-Gonzalez et al. (2020) explore predictive causality between oil prices and exchange rates. The study employed a VAR model and revealed that oil prices are net spill over receivers from exchange rate markets. The results also show bidirectional Granger causality which is detected for longer periods from exchange rates to oil prices. Devpura (2020) employs Westerlund and Narayan predictive regression model on data spanning from 1 June 2019 to 4 September 2020. The study found limited evidence that oil prices predict the Yen in Japan. Qiang et al. (2019) analyses the literature on oil prices and exchange rate and found that most of the studies focus on causality, nonlinear structure, and volatility spill over effects.

Zankawah and Stewart (2020) examines shock and volatility spill over effects from crude oil prices to Ghana's exchange rate and stock market utilising monthly data spanning from January 1991 to December 2015. The study employs a multivariate GARCH BEKK and TBEKK models and found that oil prices have significant spill over effects on exchange rates. Mofema and Mah (2021) found that interest rates have a positive impact on oil prices using a GARCH model for the data spanning from 2000 to 2020 in South Africa.

2.2.2. Studies that found inverse relationship

Brahmasrene et al. (2014) examines the short and long run dynamic relationships between the US imported crude oil prices and exchange rates utilising data spanning from 1996 M1 to 2000 M12. By employing a VAR model and Granger causality tests, the study found that crude oil prices granger cause exchange rate in the long run while exchange rate shock has a negative statistically significant impact on crude oil prices.

Turhan et al. (2014) conducted a comparative analysis of the dynamic relationship between oil prices and exchange rates in G20 members. The study employed a Dynamic Conditional Correlation model and found that for each pair of oil price-exchange rate, the empirical evidence confirms of a strengthening negative correlation in the last decade. Mendez-Carbajo (2011) conducted a study on the impact of energy dependence, oil prices and exchange rates in the Dominican economy for the period from 1990 to 2008. The study employed a VECM model and found that there is a negative relationship between the variables, that is, an increase in the price of oil leads to the depreciation of the peso and that causality runs from oil prices to exchange rate.

Anjum (2019) examines volatility dynamics of oil prices and the US dollar exchange rate using univariate and bivariate GARCH models on data spanning from 2 January 2000 to 31 December 2015. The results revealed no evidence of volatility transmission between oil prices and the US dollar exchange rate if structural breaks are ignored and significant volatility transmission when structural breaks are accounted for. Singhal et al. (2019) found that oil price negatively influences exchange rate in the long run in Mexico by employing an ARDL model on data spanning from January 2006 to April 2018.

Mukhtarov et al. (2020) investigates the effect of oil prices on macroeconomic variables in Azerbaijan for the period spanning from January 2005 to January 2022. The study employed a VECM model and found that oil prices have a negative impact on exchange rate. The study recommends that researchers and policy makers to comprehend the role of oil price shocks on economy in the case of Azerbaijan and other developing oil-rich countries. Villarreal-Samaniego (2020) using the ARDL model found that there is an inverse relationship between the exchange rate and the movements in oil prices.

2.2.3. Studies that found no relationship

Sari et al. (2010) examines the dynamics of oil prices, precious metals, and exchange rate by utilising data spanning from 1994 M1 to 2007 M10. The study employed a VAR model and revealed that changes in exchange rate and oil prices return do not have considerable linkages with each other, neither in the short nor long run period. Tiwari et al. (2013) investigates the influence of international oil prices on the real effective exchange rate in Romania in a wavelet transform framework. By employing Granger causality, the results reveal that oil prices have no influence on the real effective exchange rate in the short and long run period.

Reboredo (2012) modelled oil price and exchange rate co-movements for European countries, Australia, Canada, United Kingdom, Japan, Norway, and Mexico by utilising daily data spanning from 4 January 2000 to 15 June 2010. By employing a threshold generalized autoregressive conditional heteroskedasticity (TGARCH) model, results revealed that an increase in oil prices is weakly associated with USD depreciation and almost independent of each other. Reboredo and Rivera-Castro (2013) conducted a wavelet decomposition approach to crude oil price and exchange rate dependence. By employing a wavelet multi-resolution analysis, the study found that oil prices and exchange rates were not dependent in the pre-crisis period. The results further show that oil prices led exchange rates in the crisis period and recommend monetary policies to control oil inflationary pressures and fiscal policy in oil-exporting countries.

Chang et al. (2013) investigates the interactive relationships between crude oil prices, gold prices, and the NT-US dollar exchange rate in Taiwan for the period spanning from 3 September 2007 to 28 November 2011. The study employed VAR model and Granger causality test and found that oil prices and exchange rates remain independent from one another, meaning that policy makers should consider the separation of energy and financial policies.

2.2.4. Studies that found nonlinear relationship

Ji et al. (2019) analyses the dynamic dependence between WTI crude oil and the exchange rate of the United States and China, taking structural changes of dependence into account by using six time-varying copula models. The dependence between crude oil and the RMB exchange rate is faintly positive with lower tail dependence, while the dependence between crude oil and the US dollar index is significantly negative with lower-upper and upper-lower tail dependence. The CoVaRs results show significant asymmetry risk spill over from crude oil to Chinese and the US exchange rate markets. Balcilar et al. (2015) conducted a regime-dependent assessment of the information transmission dynamics between oil prices, precious metal prices and exchange rates. The study employed a Bayesian Markov-Switching Vector Error Correction model on daily data spanning from 1987 to 2012 and found that there is asymmetric relationship between oil prices and exchange rate volatility.

Saenong et al. (2020) conducted a symmetric and asymmetric effect of crude oil prices and exchange rate on bond yields in Indonesia utilising monthly data spanning from 2007 M1 to 2019 M4. The study employed ARDL and NARDL models and discovered that neither oil prices nor exchange rate has symmetric relationships to bond yields in the long run and vice versa in the short run. Zhu and Chen (2019) explores the symmetric effects of oil prices and exchange rates on China's industrial prices utilising monthly data spanning from 2000 M1 to 2019 M7. The study employed an NARDL model and found the inconsistency between the practice of oil price and exchange rate transmissions in China and the active roles of China's oil product mechanism and exchange rate policy reforms in mitigating transmission distortions.

Jammazi et al. (2015) conducted a wavelet based NARDL model for assessing the exchange rate pass-through to crude oil prices for 18 countries. The results found the evidence of significant and asymmetric pass-through of exchange rates to oil prices in both the short and long run period. The study suggests that denoising the crude oil and exchange rate data is effective and necessary before their interactions can be analysed. Aloui et al. (2013) study the conditional dependence structure between crude oil prices and the US dollar exchange rates using a copula-GARCH model. By utilising data spanning from 2000 to 2011, the study found evidence of significant and symmetric dependence for almost all the oil-exchange rate pairs, and the rise in oil prices is associated with depreciation of the dollar.

Chou and Tseng (2016) conducted a study on oil prices, exchange rate, and price asymmetry in the Taiwanese retail gasoline market. The study employed an NARDL model and found that oil prices responses to the exchange rate shocks were slow and complex and exhibited reverse adjustments during periods of initial exchange rate depreciation. Mohammadi and Jahan-Parvar (2012) investigates the oil prices and exchange rates in oil-exporting countries. By employing the TAR and M-TAR models, the study found that there is no evidence of short run causality, exchange rates adjust faster to positive deviations from equilibrium and that oil prices have a long run effect on the exchange rates.

Kumar (2019) examines the asymmetric impact of oil prices on exchange rate and stock prices using monthly data spanning from 1994 M1 to 2015 M12. The study employed a nonlinear Granger causality and NARDL models and found that the previous month positive and negative shocks in oil prices have positive and negative significant impact on exchange rate and stock prices. Kisswani et al. (2019) conducted an asymmetric analysis of the effects of oil prices on exchange rate in the ASEAN countries using quarterly data spanning from 1970 Q1 to 2016 Q4. The study employed an NARDL model and found long run asymmetry for Indonesia and Malaysia and mixed bidirectional causality oil prices and exchange rate.

Baek and Kim (2020) examines the relationship between crude oil prices and exchange rates in Sub-Saharan Africa employing an NARDL model and found strong evidence that changes in oil prices have asymmetric effects on the real exchange rates in the long run, that is, the movements in real exchange rates in selected countries appear to respond mostly more to oil price increase than to a decrease. Xu et al. (2019) explore a nonlinear relationship between crude oil prices and exchange rates from a quantitative and structural perspectives, employing a bivariate normal mixture model. The study found structural heterogeneity during economic expansion while little evidence of heterogeneity in recession.

Khraief et al. (2021) examines the nonlinear movements of oil prices and exchange rates in China and India. The study employed an NARLD model and found that only long run asymmetric effects of oil prices on exchange rates for both countries, however, after time-series noise removal, the asymmetric long-run effect becomes symmetric for India. Fasanya et al. (2021) model the relationship between oil price and exchange rate for Nigeria using monthly data from 1997 M1 to 2019 M12. The study employed ARDL and NARDL model and found that an increase in oil prices leads to depreciation of the Naira relative to the US dollar and oil price asymmetries seem to matter both in the short and long run period.

3. METHODOLOGY

3.1. Data Sources

The study utilises monthly time series data spanning for the period from 1960 M1 to 2021 M11 for exchange rate and oil prices in US Dollar. This data was sourced from online secondary source that is the South African Reserve Bank. Oil price (OP) represents Brent crude oil price in US Dollar and exchange rate (EXC) represents foreign exchange rate: SA cent per USA dollar middle rates (R1 = 100 cents).

3.2. Model Estimation

To study the exchange rate volatility and oil prices in South Africa, this study utilises exchange rate and oil prices to formulate bivariate model. The variables are transformed into logarithms to have the same unit of measurement. The model that will be used in this study can therefore be specified as given below:

$$LEXC_t = \alpha_1 + \alpha_{LOP} LOP_t + \varepsilon_t \quad (14)$$

Where by, LEXC is the logarithm of exchange rate, LOP is the logarithm of oil prices, α_1 is the constant and ε_t is an error term.

3.3. Data Analysis

This study adopts a TGARCH model used in the study conducted by Reboredo (2012). Because the residuals of an autoregressive (AR) moving-average model for crude oil spot price returns or exchange returns have fat tails and conditional heteroskedasticity, we use the TGARCH model (Reboredo, 2012). The TGARCH model was proposed by Zakoian (1994) and Glosten et al. (1993). As a result, the marginal model for the crude oil sport return may be written as follows:

$$r_t = \varnothing_0 + \sum_{j=1}^{p} \varnothing_j r_{t-j} + \varepsilon_t - \sum_{i=1}^{q} \theta_i \varepsilon_{t-i} \quad (15)$$

Where by, p and q are non-negative integers and where $\emptyset$ and θ are the AR and moving average (MA) parameters, respectively. The order of the AR terms, p, and the MA terms, q, is empirically determined by identifying the optimal model among alternative values for the parameters p and q using the Schwartz Criterion. The white noise process ε_t follows a skewed student-t distribution.

$$\varepsilon_t = \sqrt{\frac{\vartheta}{\sigma_t^2(\vartheta - 2)}}\varepsilon_t \sim iid \quad (16)$$

With ϑ degrees of freedom and σ_t^2 is the conditional variance of ε_t, which evolves according to:

$$\sigma_t^2 = \varphi + \sum_{j=1}^{r} \beta_j \sigma_{t-j}^2 + \sum_{i=1}^{m} \alpha_j \varepsilon_{t-i}^2 + \sum_{j=1}^{m} \gamma_j \varepsilon_{t-j} I_{t-j} \quad (17)$$

Whereby, φ is a constant, σ_{t-j}^2 is the previous period's forecast error variance, the GARCH component ε_{t-j} is news about volatility from previous periods, the ARCH component, $I_{t-j} = 1$ if $\varepsilon_{t-j} < 0$, otherwise 0, and where γ captures leverage effect. For $\gamma > 0$, the future variance will increase proportionately more following a negative shock than following a positive shock of the same magnitude. Leverage or inverse leverage effects have been found in some commodity prices (Reboredo, 2012).

4. RESULTS AND INTERPRETATION

The study performed the unit root test to determine the level of integration of the variables as shown in Table 1. By employing the Augmented Dickey-Fuller and Phillips-Perron unit root test, the variable, that is, oil prices and exchange rate were found to be stationary at first difference at 1% and 5% level of significance on the constant and trend and intercept form, respectively. The study therefore continues to estimate a TGARCH as given in Table 2.

The study employed TGARCH model, and the results are presented in Table 2. The coefficients of the mean equations are negative and statistically significant. The average oil price is 0.03 and it significantly predicts exchange rate of South African Rand to the US Dollar by 0.25. There is a negative statistically relationship between oil prices and exchange rate in South Africa. A 1% increase in oil prices in South Africa, will significantly result in exchange rates of the South African Rand to the US Dollar declining by 0.26%, ceteris paribus. These results are inconsistent with the studies carried Mofema and Mah (2021); Reboredo (2012), Anjum (2019), Zankawah and Stewart (2020) and Oriavwote and Eriemo (2012). This means that oil price increase is detrimental for the exchange rate of the SA Rand to the US Dollar. This means that policy makers need to put policies that reduce oil prices to safeguard the value of the South African Rand.

The GARCH(−1) term is <1 and it is positive and statistically significant at 5% level of significance. The constant of the variance term and ARCH terms is positive and statistically significant at 1% level. This gives the result of the GARCH model. The time varying volatility includes a constant (0.000673) plus its past (0.484902) and a component which depends on past errors (0.199143). This finding indicates the presence of time varying conditional volatility of returns on oil prices. These results indicates that the persistence of volatility shocks, as represented by the ARCH and GARCH terms is large. It denotes that the effect of today's shock remains in the forecast of variance for many periods in the future. The coefficient of the asymmetric term is negative ([−0.566370] and statistically significant at 1% level indicating that in this model there are asymmetries in news. Good news has the larger effects on the volatility of the exchange rates than bad news $b_1 + \gamma < b_1$, that is, 0.199143–0.566370 < 0.56637). The study therefore continues to perform TGARCH model diagnostics as given in Table 3 below.

Table 3 indicates the TGARCH (1,1) model diagnostic test. The p-value of the ARCH test is 0.8185 that is above the 0.05 critical value indicating that there are no ARCH effects present in the model since they have been incorporated in the TGARCH model. The Jarque-Bera normality test has P = 0.0000 that is <0.05 critical value indicating that the residuals are not normal. The probabilities of the sign-bias and joint-bias Engle-Ng test is >0.05 critical value indicating that the model does not suffer from any form of sign bias.

5. CONCLUSION AND RECOMMENDATIONS

The TGARCH model was employed to analyse volatility in South African exchange rates for the years spanning from 1960M1 to 2021M11. The results indicate a significant negative impact of Brent crude oil prices on the exchange rates of South African Rand to a US Dollar. Goods news was found to have larger impact on the volatility of exchange rates as compared to bad news. Volatility was found to be persistent overtime.

Based on the empirical evidence, the study therefore recommend that the government and policy makers must monitor past oil prices as they have a significant negative impact on the exchange rate

Table 1: Augmented Dickey-Fuller and Phillips-Perron unit root test

Variable	ADF				PP			
	Constant		Trend & Intercept		Constant		Trend & Intercept	
	Level	Δ	Level	Δ	Level	Δ	Level	Δ
OP	−2.1880	−18.560***	−3.8031**	−18.549***	−1.7179	−17.361***	−3.1939*	−17.346***
EXC	0.4375	−17.727***	−2.0439	−17.797**	0.4736	−19.447***	−1.9897	−19.446***

Author's own computation (*), (**), (***) significance at 10%, 5% and 1% respectively

Table 2: TGARCH (1,1)

Variable	Coefficient	Standard Error	z-Statistic	Prob
OP	−0.256657	0.014372	−17.85810	0.0000***
C	−0.030427	0.002599	−11.70544	0.0000***
Variance Equation				
C	0.000673	8.84E−13	7.62E+08	0.0000***
RESID(−1)^2	0.972231	0.094524	10.28551	0.0000***
RESID(−1)^2*(RESID(−1)<0)	−0.566370	0.099733	−5.678844	0.0000***
RESID(−2)^2	−0.222959	0.082830	−2.691773	0.0071***
RESID(−3)^2	0.427366	0.039907	10.70897	0.0000***
RESID(−4)^2	−0.153599	0.059927	−2.563095	0.0104**
RESID(−5)^2	0.199143	0.058197	3.421905	0.0006***
GARCH(−1)	0.484902	0.050928	9.521285	0.0000***

Author's own computation (*), (**), (***) significance at 10%, 5% and 1% respectively

Table 3: TGARCH (1,1) Model Diagnostic test

Test	Statistic	P-value	Conclusion
ARCH LM test	0.052679	0.8185	No ARCH effects
Jarque-Bera	7444.549	0.0000***	Non-normal
Engle-Ng Sign-Bias			
Sign-Bias	−0.116870	0.9070	No sign bias
Joint-Bias	1.387174	0.7086	

Author's own computation (*), (**), (***) significance at 10%, 5% and 1% respectively

of the South African Rand to the US Dollar. This will help keep the Rand stable to outward forces from Brent crude oil prices. The policy makers and the government will be able to monitor oil prices to avoid hideous depreciation of the rand and be able to implement policies that can keep the rand afloat during periods of outside shocks in the Brent crude oil prices.

The South African Reserve Bank must implement policies contractionary monetary policies. The higher oil prices can help improve the balance of payments in South Africa. When the brent crude oil prices rise, it will result in depreciation of the rand thereby resulting in fewer imports since it will be expensive to import goods from outside the country. This will also help South Africa to be self-reliant and introduce policies such as import substitution. These results also help the South African Department of Energy to know when is the right time and appropriate measures to implement in fuel prices when there is a shock in Brent crude oil prices in the international market. In conclusion, research in the future must also consider increasing the number of variables in the model to gain some new insights about the relationship between oil prices and exchange rate volatilities in South Africa.

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