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Oil Prices and Agricultural Growth in South Africa: A Threshold Analysis

Goodness C. Aye[1*] and Nicholas M. Odhiambo[2]

Abstract

Oil plays a pivotal role in the growth of agriculture as a combustion lubricant for machineries and equipment used in the farming enterprise. Several studies have shown that a relationship exists between oil prices and agricultural growth without clear boundaries beyond which these prices are detrimental to the growth. Therefore, this study is conducted to identify the threshold above which oil prices will adversely affect agricultural growth in South Africa. Real West Texas Intermediate (WTI) and Real Brent crude oil prices in both Dollars and Rands were used as threshold variables in the threshold regression model of agricultural growth. The findings showed that beyond the threshold values of 12.99%, 15.68%, 15.69% and 15.70%, the prices of Real WTI crude oil in Dollars, Real Brent crude oil in Dollars, Real WTI crude oil in Rands and Real Brent crude oil in Rands respectively will have significant negative effects on agricultural growth in South Africa.

Keywords: Oil prices; agricultural growth; threshold effect

Introduction

South Africa produces insignificant quantities of oil and gas with total proven oil reserves of approximately 15 million barrels (Oberholzer and Davidson, 2017; Oberholzer, 2021). Commercial oil production in the country in the interim is only found in the Bredasdorp Basin. Although oil discoveries are made off the west coast, in the Pletmos and Orange Basin, none of these fields have yet entered commercial production. Approximately 60% of South Africa's domestic fuel requirements are met by imported crude oil, with 50% of the refined product coming from local crude oil refineries and 10% being imported from international refineries (Oberholzer and Davidson, 2017).

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South Africa is a price-taker on the international oil market as it imports small quantities (0.8%) of oil compared to the other major net importing countries such as China (22.6%) and the United States of America (12.5%) (Wakeford, 2006; Rangasamy, 2017; Workman, 2021). However, the downstream domestic liquid fuels industry is subject to government regulation. Petrol and diesel prices are administered by the government, which imposes various levies and taxes, and sets retail and wholesale margins over and above a "basic fuel price". The basic fuel price is an import parity pricing formula, which depends on the international spot price of refined oil (South African Petroleum Industry Association, SAPIA, 2006a).

Due to the arid nature of South Africa's soils, only 13.5% of all soil can be put into successful agronomic usage with just about 3% of the soil being considered high potential land (Mohamed, 2000). According to Human Rights Watch (2001), Agriculture contributes about 10% (which is relatively low when compared to other African economies) of formal employment and around 2.6% of GDP in South Africa. However, the current report shows that the contribution of agriculture's value added to GDP declined from 3.9% in 1994 to 2.2% in 2017 (The South African Directorate Statistics and Economic Analysis, Department of Agriculture, Forestry and Fisheries, 2018). Despite its relatively small share of the total GDP, Agriculture is an important sector in the South African economy and remains a significant provider of employment, especially in the rural areas and a major earner of foreign exchange. The total gross value of agricultural production (total production during the production season valued at the average basic prices received by producers) for the 2017/2018 financial year was estimated at R281 370 million, compared to R268 671 million (4.7% above) the previous year. This increase was attributed mainly to an increase in the value of animal products. The gross value of animal products, horticultural products and field crops contributed 50.6%, 27.7% and 21.7%, respectively, to the total gross value of agricultural production (Department of Agriculture, Forestry and Fisheries, 2018).

Theoretically, no single theory explains the relationship between crude oil price and output. Thus, different theoretical approaches have been advanced in the literature to ascertain this relationship. These include the Dutch Disease, neoclassical growth theory, mainstream theory, Renaissance and growth theory (Ibrahim, 2018), among others. One can also explain the relationship between oil prices and agricultural growth from the game theory perspective (Jannuzzi, 1991; Pakrooh et al., 2021). Game theory is a major method used in mathematical economics and business for modeling competing behaviours of interacting agents (Aumann, 2008). It usually involves the concept of zero-sum games, in which each participant's gains or losses are exactly balanced by those of the other participants, assuming that two players are involved, namely energy and agricultural producers. In this context, gains in oil prices result in losses in agricultural growth, and vice versa. In other, words, the zero-sum game here is such that one player (energy producer) can only be made better off by making the other player (agricultural player) worse off. In zero-sum games, the utility functions of these players will be mirror images of each other, with one player's highly ranked outcomes being ranked low for the other, and vice versa (Ross, 2019).

Thus, if the energy producer is playing a strategy that maximizes his minimum payoff or profit if the agricultural producer plays the best he can, and the agricultural producer simultaneously doing the same thing, this is just equivalent to both playing their best strategies, so this pair of so-called 'maximin' procedures is guaranteed to find the unique solution to the game, which is its unique Nash Equilibrium (Ross, 2019). One could also formulate this as a seller monopoly market scenario builds by non-cooperative games in which there is no contract between players as suppliers tend to maximize profit regardless of the consumer applicants. In this case, the cost function of the energy supplier will determine the price and quantity (Pakrooh et al., 2021). Economic theory suggests that increasing crude oil prices directly affect agricultural prices through higher input and transportation costs (Gardebroek and Hernandez, 2013). As an energy-intensive sector, agriculture plays a big role on the demand-side of the energy equation. The sector is directly affected by high and volatile world oil prices which, in turn, affects the cost of agricultural production (Nazlioglu and Soytas, 2011).

Findings from several empirical studies, as evidenced in the literature review section, show a general negative impact of oil prices on agriculture with a few demonstrating neutral effects. However, none of the studies could specifically suggest a threshold (that is, the level at which oil prices start having an effect on agricultural growth) effect of oil prices on agricultural growth. Moreover, while several studies have considered the effect of oil prices on aggregate economic growth and on agricultural product prices, there is a dearth of studies dealing with the real agricultural sector growth. Therefore, a pertinent study is required to pinpoint the heights (threshold) of oil prices that have a significant effect on the agricultural growth of the South African economy. This is the focus and contribution of the current study.

The rest of the paper is organized as follows: the next section presents the review of empirical studies. In section 3, the data and empirical model are discussed. In Section 4, the results are presented, while the conclusion is drawn in section 5.

Literature Review

Several empirical studies have been conducted on the relationship between oil prices and agriculture. For example, Sands and Westcott (2011) examined the impact of higher energy prices on agriculture using the Food and Agricultural Policy Simulator (FAPSIM) – a multi-commodity model of the U.S. agriculture sector – and farm-level partial budget models. The results show that production expenses rise while net farm incomes decline with a higher energy price. Their results varied by region and commodity in terms of the magnitude of effect. Using a dynamic global partial equilibrium model of agricultural trade, Getachew et al. (2014) simulated changes in energy prices due to changes in energy policy and found that higher energy prices increase input costs while lower energy prices lead to a slight decline in input costs. In terms of the effect of energy prices on production, the effect varied by country with higher energy prices increasing ethanol production in Brazil but decreasing wheat production in the EU. Production in the US and India is relatively unaffected by a change in energy prices.

Wang and Zhang (2014) examined the asymmetric impact of global oil price shocks on China's fundamental industries: grains, metals, petrochemicals and oil fats. In addition, the effect of jump behaviour or extreme price movements in the oil markets on commodity markets were also assessed. They found that negative oil price shocks have a stronger effect than positive oil price shocks with the effect being more severe in the petrochemical industry and least severe in the grain market. Their findings thus provided evidence of asymmetric effects. Oluwatayo (2015) examined the effect of petroleum prices on agricultural production in Nigeria using an error correction model.

The author found that an increase in the petroleum price (consumption) leads to an increase (decreased) in agricultural output. Furthermore, Ibrahim (2018) showed that aggregate output increases with oil price fluctuation while agricultural growth declines. Using the differential approach, Moss et al. (2010) examined the effect of increased energy prices on U.S. agriculture by estimating the elasticity of demand for energy on agriculture. Their results show that the derived input demand for energy is inelastic and that the agricultural supply function is responsive to energy prices.

Using a Bayesian dynamic latent factor model, Chen (2015) disentangled the common and idiosyncratic sector-specific factors of the prices of a group of China's commodity sectors including the grain sector, and employed a VAR model to examine the effects of oil price shocks on the common factors. The results show that at long horizons, oil price shocks have strong effects on the common movements in addition to their domestic macroeconomic fluctuations, while at short horizons, domestic macroeconomic fluctuations had a lesser effect on the common movements relative to the global oil shocks. Shahzad et al. (2018) analyzed the asymmetric risk spillover between oil prices and the price of agricultural commodities such as wheat, maize, soybeans, and rice. They documented evidence of symmetry in the tail dependence between the variables, but asymmetry in the spillovers from oil to agricultural commodities. The spillover effect was more pronounced during financial turmoil.

Using structural breaks co-integration tests, Fowowe (2016) showed that there exists no long-run relationship between oil prices and agricultural commodity prices in South Africa. Moreover, the results from nonlinear causality tests did not support causality between agricultural commodity prices and oil prices in South Africa. These findings support the neutrality of South Africa’s agricultural commodity prices to global oil prices. Chiweza and Aye (2018) analysed the effects of oil price uncertainty on economic activities in South Africa using the Structural Vector Autoregressive (SVAR) model. Their results showed that oil price uncertainty has a negative effect on economic activities in South Africa. Nazlioglu (2011) found that Turkish agricultural prices do not significantly respond to oil price and exchange rate shocks in the short run and in the long run; hence, supporting the neutrality of agricultural commodity markets in Turkey to both direct and indirect effects of oil price changes. Using National Agricultural Statistics Service (NASS) data, Beckman et al. (2013) found that the response to higher energy prices varied by commodity in proportion to the use of energy-related inputs like fertilizer.

Oseni and Kinbode (2018) analyzed the impact of oil price shocks on agricultural commodity prices in Nigeria using the Non-Linear Autoregressive Distributed Lag (NARDL) approach and monthly data on oil prices, maize, wheat and soybean, and on the exchange rate from 1997 to 2016. They found that increases in oil price lead to increases in agricultural commodities in all cases. Similarly, the exchange rate, which is a control variable, showed a positive significant relationship with agricultural commodities. They established evidence of asymmetric effects of oil prices on agricultural commodity prices in Nigeria.

Charles et al. (2010) derived input demand elasticities for energy as well as capital, labor, and materials using the differential supply formulation. They showed that the derived input demand for energy is inelastic; hence, it is price-responsive than the other inputs. They also found that the U.S. aggregate agricultural supply function is responsive to energy prices. Balcilar et al. (2016) analyzed the relationship between oil and agricultural commodity (soya beans, wheat, sunflower and corn) prices in South Africa using a quantile causality approach. They found that the effect of changes in oil prices on agricultural commodity prices varies across the different quantiles with the impact on the tails being lower relative to the rest of the distribution.

Using the ARDL approach, Eleni et al. (2018) confirmed that crude oil prices affect the prices of agricultural products used in the production of biodiesel and ethanol; thus validating energy-agricultural commodity markets interactions. Yu et al. (2008) could not find support that energy prices drive food prices. Yasmeen et al. (2019) examined the short-run and long-run relationship between oil price fluctuation and Pakistan’s real sector including livestock growth. Using annual time series data and the ARDL model, they show that changes in oil price have an adverse effect on the livestock sector both in the short run and in the long run. Paris (2018) examined the long-term effect of the price of oil on agricultural commodity prices by accounting for the influence of biofuel production. Using a nonlinear, cointegrating regime-switching processes, the results show that biofuel development has led to an increase in the oil-price effect on agricultural commodity prices.

Su et al. (2019) analyzed the dynamic causal relationship between oil prices and agricultural commodity prices and found a time-varying positive bidirectional causality supporting evidence of market integration through the direct biofuel and indirect channels. Liu et al. (2019) analyzed the dependence structure between crude oil futures price (WTI and Brent) and 12 kinds of Chinese agricultural commodity futures prices. Results based on Markov-switching GRG copula show that the prices of 11 agricultural commodity futures out of 12 mainly present positive correlations with crude oil futures prices. Taghizadeh-Hesary et al. (2019) analysed the linkages between energy price and food prices using a Panel-VAR model and data from 2000 to 2016 for eight Asian economies. Their results show that agricultural food prices respond positively to oil prices, justifying a nexus between energy and food security via price volatility.

Zafeiriou et al. (2018) analyzed the relationship between crude oil agricultural (corn soybean) futures prices using the ARDL model. Crude oil was found to share a long-run relationship with each of the agricultural commodity prices, and the effect is significant both in the long run and in the short run. Eissa and Refai (2019) used linear and nonlinear ARDL models to assess the dynamic nexus between oil prices and agricultural commodities. While the linear model shows no long-run co-movement between these series, the nonlinear model shows that barley, corn and rapeseed oil co-move with oil prices in the long run. Further, the effects of the dynamic multipliers show that barley, corn, and rapeseed oil prices respond rapidly and strongly to the cyclical downturns of oil prices in the short run.

Using data from 1986 to 2018 and the Structural Vector Autoregressive (SVAR) model, Vu et al. (2019) examined the effects of agricultural shocks on oil and agricultural markets in the United States. They show that oil prices are affected by agricultural prices through the indirect cost-push and direct biofuel effects. The response of oil price to corn and sorghum price shocks were significant due to the impact of agricultural demand shocks on oil price, while the agricultural supply shocks played an insignificant role. Using monthly data from January 1990 to June 2017, Cheng and Cao (2019) examined the relationship between crude oil and food prices and found a significant bidirectional nonlinear causal relationship between global crude oil and food price indices. Moreover, the results from the TVAR and TVECM show that the adjustment process of the food price indices towards equilibrium is highly persistent and grows faster than oil price when a threshold is reached.

Yip et al. (2020) examined the volatility spillover between crude oil and agricultural commodities (corn, wheat and soybean) using fractionally integrated VAR and Markov Switching Autoregressive models. Their findings show that the net volatility spillover effect from crude oil to all agricultural commodities decreased in the low-volatility regime but increased in the high-volatility regime. Gokmenoglu et al. (2020) used monthly data on cocoa, coffee, wheat, palm oil, soybeans, beef and crude oil from 2006 to 2015 to analyze the dynamic relationship between oil and agricultural commodity prices in Nigeria. Results based on panel methods showed that in the long run oil price has a significant positive effect on agricultural commodity prices. However, there was no causal relationship between oil and agricultural commodity prices in Nigeria.

Sun et al. (2021) found bidirectional causality between oil and agricultural commodity prices based on results from full sample and rolling window causality tests. Furthermore, both agricultural commodity and oil prices remain insusceptible to the shocks that originated in both markets during the entire time period of the COVID-19 pandemic. Kumar et al. (2021) analyzed the dependence structure between oil and five agricultural commodity markets using dependence-switching copula. The results show that the crash of oil markets and agricultural commodities happen at the same time, especially during crisis periods, in contrast to during normal economic conditions. Further, they provided evidence of risk spillover from oil to agricultural markets, particularly during the financial crisis.

From the foregoing, it is evident that several studies have been conducted on the effects of oil prices on agriculture across the globe. While the majority focused on agricultural prices, only a few focused on agriculture output or its growth. More crucial is the fact that none of these studies could specifically point out the extent to which oil prices could rise or decrease before a consequent effect on agricultural growth would be felt. Again, the South African economy currently produces insignificant quantities of oil and, as such, relies heavily on oil importation; this makes the country vulnerable to external oil price determination. There is, therefore, a need for a study that pinpoints a given threshold of oil prices below or beyond which the agricultural growth of a country like South Africa, which is largely a price taker in the oil trade, will be affected.

Data and Empirical Model

The study used quarterly time series data from 1980:01 to 2020:01 to examine the threshold effect of oil prices on South Africa's agricultural growth. The starting and end of the sample period were determined by the availability of data on crude oil prices and agricultural value added, respectively. The proxy for agricultural growth is the change in the real value added for agriculture. This was sourced from South Africa's Reserve Bank (SARB). For oil prices, data on the West Texas Intermediate (WTI) and U.K. Brent crude oil were obtained from the International Monetary Fund (IMF). These were converted to real values using the US consumer price index. Subsequently, the two were also converted to rand equivalent using South Africa's rand per US dollar exchange rate. Hence, four proxies were used for oil prices for robustness check: WTI and Brent expressed in both US dollar and South African rand per barrel.

Control variables included are: producer price index for agriculture, foreign direct investment (FDI) as a percentage of GDP, rand – dollar exchange rate and money supply (M1), which were all sourced from the SARB, except for FDI, which was sourced from the World Bank. These were included based on previous related empirical literature (Nazlioglu, 2011; Oseni and Kinbode, 2018; Yasmeen et al., 2019). All data were transformed to their natural logarithms and growth rates were taken, with the exception of FDI whose logs were not taken before growth rate because of negative values. Data on FDI were only available in annual frequency; hence, they were converted to quarterly frequency for consistency with the rest of the series. The descriptive statistics of the data are presented in Table 1. All the variables have a positive growth rate on average with the exception of oil prices, which have a negative mean growth rate.

Table 1: Descriptive Statistics of Variables

Acronym	Name	Mean	Standard Deviation
GDPAGR	Real agricultural value added	0.346	7.365
Initial	Lag of log agricultural value added	10.882	0.232
PPI	Producer price index of agriculture	1.705	4.014
FDI	Foreign direct investment	27.977	633.895
M1	Money supply	3.546	3.583

EXCH	Exchange rate	1.835	6.587
RWTI_$	Real West Texas Intermediate crude oil price in USD	-0.618	13.985
RBRENT$	Real Brent crude oil price in USD	-0.578	14.545
RWTI_Rand	Real West Texas Intermediate oil price in Rands	1.217	13.695
RBRENT_Rand	Real Brent crude oil price in Rands	1.257	14.107

As the objective of this study is to identify the threshold above which oil prices will adversely affect agricultural growth in South Africa, the analysis naturally lends itself to a threshold model. Threshold models are designed to obtain a threshold value, which is not possible with the conventional VAR models. They are useful not only for identifying the specific threshold value but also for asymmetric analysis. Threshold models, as a specific class of nonlinear models, have the potential to minimize the introduction of biases into the analyses of time series that may arise due to assumptions of linearity and stationarity (Zapata and Gauthier 2003; Tong, 2011). To estimate the relationship between oil price and agricultural growth, the threshold autoregression model is used, following Tong (1983; 1990) and Hansen (2011). The threshold model with two regimes defined by a threshold γ is specified as:

$$y_t = \mathbf{X}_t\beta + \mathbf{Z}_t\delta_{\mathbf{1}} + \varepsilon_t \qquad \text{if} \qquad -\infty < \omega_t \leq \gamma$$

$$y_t = \mathbf{X}_t\beta + \mathbf{Z}_t\delta_2 + \varepsilon_t \qquad \text{if} \qquad \gamma < \omega_t < \infty \tag{1}$$

where y_t is the dependent variable, $\mathbf{X}_t$ is a $1\times \mathrm{k}$ vector of covariates including lagged values of y_t. β is a $\mathrm{k}\times 1$ vector of regime-invariant parameters, ε_t is an IID error with mean 0 and variance σ^2, $\mathbf{Z}_t$ is a vector of regressors with regime-specific coefficient vectors , $\delta_{\mathbf{1}}$ and δ_2. ω_t is a threshold variable that may also be one of the variables in $\mathbf{X}_t$ or $\mathbf{Z}_t$. Regime 1 is defined as the subset of observations in which the value of ω_t is less than the threshold γ. Analogously, Regime 2 is defined as the subset of observations in which the value of ω_t is greater than γ. The parameters of the threshold regression model are estimated using conditional least squares. The threshold value is estimated by minimizing the sum of squared residuals (SSR) obtained for all tentative thresholds.

In our model, $\mathbf{X}_t$ contains the log of initial agricultural value added, PPI, FDI, M1 and EXCH[3], while $\mathbf{Z}_t$ contains real oil price (ROP), which could be either WTI or Brent in either US dollars or South African rands. ROP also serves as the threshold variable. Therefore, the empirical model estimated for this study is given as:

$$\Delta \ln GDPAGR_t = \beta_1 \ln Initial + \beta_2 \Delta \ln PPI + \beta_3 \Delta FDI + \beta_4 \Delta \ln M1 + \beta_5 \Delta \ln EXCH + \delta_1 \Delta \ln ROP_t + \varepsilon_t$$

if $-\infty < \Delta \ln ROP_t \leq \gamma$

$$\Delta \ln GDPAGR_t = \beta_1 \ln Initial + \beta_2 \Delta \ln PPI + \beta_3 \Delta FDI + \beta_4 \Delta \ln M1 + \beta_5 \Delta \ln EXCH + \delta_2 \Delta \ln ROP_t + \varepsilon_t \text{ if }$$

$$\gamma < \Delta \ln ROP_t < \infty \qquad (2)$$

All variables are as defined in Table 1.

Results and Discussion

Table 2 presents the estimates of the threshold regression model of agricultural growth in South Africa. The estimated results support the choice of a single threshold (in other words, two regions or regimes) with a clear difference between the estimates in the two regimes. The results show that; below the threshold values of 12.986%, 15.684%, 15.685% and 15.700%, the prices of Real West Texas Intermediate crude oil in dollars, Real Brent crude oil in dollars, Real West Texas Intermediate crude oil in rands and Real Brent crude oil in rands, respectively will have no significant effects on agricultural growth in South Africa. However, above the threshold of 12.986%; the price of Real West Texas intermediate crude oil in dollars will have a negative significant impact (-0.440) on agricultural growth in South Africa. Beyond the threshold of 15.684%, the price of Real Brent crude oil in dollars will equally have a negative significant effect

[3]Exchange rate is included only when the oil price is in US dollars.

(-0.454) on agricultural growth in South Africa. Further, above the threshold of 15.685%, the price of Real West Texas intermediate crude oil in rands will have a negative significant impact (-0.586) on agricultural growth in South Africa and the price of Real Brent crude oil in rands will have a negative significant impact (-0.538) on agricultural growth in South Africa if the price goes beyond the threshold of 15.700%.

It can be seen from the results that when oil prices either in dollars or rands increase beyond the aforementioned thresholds, then agricultural growth will decline in South Africa. This is because farm mechanization is the main feature of modern-day agriculture and a pillar for sustainable growth in the agricultural sector. Mechanized farming relies largely on oil for combustion; therefore, if oil prices hike beyond a certain threshold with a resultant increase in production cost, then farmers will be faced with difficult managerial scenarios such as: reduction in the scale of production, difficulty or inability to repay borrowed capital (loans), declined demand for farm produce due to high prices occasioned by increased cost of production. As shown by Chen et al. (2010), a rise in oil price significantly increases agricultural commodity prices and the folding up of production, in worst instances.

The production and distribution of fertilizers require machineries that are oil dependent; therefore, increases in oil prices will translate into high cost of production and distribution of fertilizer and other farm inputs, which will lead to high cost of farm produce resulting in a decreased demand for farm produce (the higher the price, the lower the demand), thereby retarding growth in the agricultural sector. Also, to maximize profit, agricultural produce are processed and stored; processing and storage create additional utility of farm produce and, as such, command higher profits for the farmer. However, processing and storage machines require oil as a major source of energy, higher oil prices will entail a higher cost of processing and storage, which will have an adverse effect on the growth of the agricultural sector in the long run.

Again, industry data show that coke (a black substance produced from coal and burnt to provide heat) and refined petroleum accounted for about 10% of intermediate input costs into agriculture, forestry and fishing in 2013 in South Africa (Quantec, 2014). South Africa is a net importer of crude oil; therefore, any increase in the international oil prices beyond a certain threshold will have significant consequences on its agricultural growth.

Table 2: Estimates of Threshold Regression Model of Agricultural Growth

VARIABLES	Model 1 RWTI_$	Model 2 RBrent_$	Model 3 RWTI_Rand	Model 4 RBrent_Rand
Regime independent regressors:				
Initial	-6.581*	-6.672*	-7.492**	-7.238**
	(0.065)	(0.061)	(0.043)	(0.049)
PPI	-0.076	-0.066	-0.019	0.006
	(0.615)	(0.657)	(0.887)	(0.962)
FDI	0.001*	0.001*	0.001*	0.001*
	(0.092)	(0.093)	(0.097)	(0.092)
M1	-0.374*	-0.396**	-0.334	-0.380*
	(0.061)	(0.049)	(0.117)	(0.073)
EXCH	0.193**	0.218***		
	(0.010)	(0.006)		
Regime dependent regressors:				
Regime 1:				
RWTI_$	0.017			
	(0.590)			
RBrent_$		0.022		
		(0.504)		
RWTI_Rand			0.016	
			(0.600)	
RBrent_Rand				0.019
				(0.580)
Constant	82.747**	73.841*	81.629**	80.069**
	(0.043)	(0.061)	(0.045)	(0.050)
Regime 2:				
RWTI_$	-0.440**			
	(0.010)			
RBrent_$		-0.454***		
		(0.000)		
RWTI_Rand			-0.586**	
			(0.030)	
RBrent_Rand				-0.538***
				(0.000)
Constant	83.797**	86.642**	98.033**	95.847**
	(0.036)	(0.030)	(0.021)	(0.021)
Threshold value	**12.989**	**15.684**	**15.685**	**15.700**

Robust pval in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Aside from oil prices, macroeconomic factors such as the exchange rate, money in supply and foreign direct investment have a significant effect on agricultural growth. For instance, exchange rate has a positive effect on agricultural growth. This implies that an increase in the amount of rands exchanged for US dollars (that is, depreciation) increases agricultural growth. It is worthwhile to note that exchange rate depreciation could have either a contractionary or an expansionary effect on economic growth (Razzaque et al., 2017). Our result is supported by the economic theory that posits that devaluations may have two main expansionary effects (Razzaque et al., 2017): first, by prompting an expenditure-switch in domestic demand away from imports and towards locally produced import-competing goods; second, by improving international competitiveness and bolstering exports. This finding is consistent with that of Tada (1999), who found that exchange rate depreciation in Thailand favoured the production and export of many agricultural commodities. This is also consistent with Oseni and Kinbode (2018), who found that exchange rate has a positive effect on agricultural commodities. However, Razzaque et al. (2017) found contractionary and expansionary effects of exchange rate deprecation in the short run and in the long run, respectively.

Further, the results show that money supply has a negative significant effect on agricultural growth. This may be explained by the fact that increasing the supply of money increases the liquidity of goods and services, which facilitates the exchange process that may reduce buyers' reliance on borrowed money. Moreover, an increase in money supply implies that money demand is being met. This can bring down the interest rates, thus making lending less profitable. As a result, the sector's growth may be negatively affected by an increase in money supply. Moreover, the increased money supply also reduces the options for firms' saving and investment, given that the interest rates are low. This finding is consistent with that of Yasmen et al. (2019), who found that money in circulation hurts the livestock sector in the long-run.

The effects of foreign direct investment on South Africa's agricultural growth could be positive or negative. The benefits or risks depend on several factors, such as the legal and institutional framework in the host country, the terms and conditions of the investment contract, an inclusive business model, and the social and economic conditions in the investment area, among others (Liu, 2014). In this study, the effect of FDI is positive though not highly significant. More so, the magnitude of the effect is minimal. It is possible that the FDI in South Africa is dedicated mostly to other sectors of the economy. This may not be surprising given that less than 5 % of FDI goes to agriculture in sub-Saharan Africa (Gerlach and Liu, 2010). Foreign direct investment plays a complementary role to that of domestic investment as it could make a contribution to bridging the investment gap in developing countries' agriculture. It can generate some benefits for the agricultural sector of South Africa, such as better access to capital and markets, employment creation and technology transfer. Therefore, policy efforts towards attracting agricultural sector-specific foreign investors and effective utilization of the same could improve not only the sector but also its contribution to overall economic growth. This finding contrasts with that of Yasmeen et al. (2019), who found a negative effect of foreign direct investment on the livestock subsector.

Conclusion and Policy Implications

Oil is a very essential input in modern-day economies. The survival of many sectors largely depends on the prices of oil, which are determined internationally. Fluctuations in the global oil prices generally have significant consequences on the growth of agriculture, as stated in various literatures. This study, therefore, was conducted to find out specific extents (thresholds) beyond which oil prices begin to have a significant effect on the agricultural growth of South Africa. Findings from the study show that when oil prices both in Dollars and Rands increase beyond the identified thresholds, the agricultural growth in South Africa will be adversely affected. Further, the included control variables such as foreign direct investment, exchange rate and money supply have a significant effect on agricultural growth. Specifically, the effect of exchange rate and foreign direct investment is positive, while that of money supply is negative.

The findings from this study have important policy and practical implications. Though natural oil is a matter of natural endowment and since South Africa is not endowed with it in sufficient quantities, the authorities through a deliberate policy can alternatively embark on biofuel production which will boost agricultural growth as biofuel can be extracted from agricultural plants. The price of the biofuel may be regulated locally to favour the farm enterprise during higher regimes of natural oil prices. Also, the provision of incentives such as grants/loans to farmers to encourage all-year production and lowering import duties on agricultural equipment and inputs during regimes of high oil prices will help to cushion the effect of high oil prices on agricultural growth. Furthermore, given that oil price inflation has an adverse effect on agricultural growth and hence food security, there is a need to diversify the energy consumption in this sector. Policy efforts to reduce the reliance on fossil fuels to an optimal combination of renewable and nonrenewable energy resources, such as solar energy, will improve both energy and food security. Moreover, devising an energy consumption policy and adopting new technologies that use alternative energy will attract both domestic and foreign direct investment into South Africa's agricultural sector. This will help to boost agricultural growth and welfare since growth in this sector has been found to be a panacea for poverty and hunger. Strengthening the legal and institutional framework in South Africa may assist in attracting foreign direct investment to the sector.

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