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THE NONPARAMETRIC RELATIONSHIP BETWEEN OIL AND SOUTH AFRICAN AGRICULTURAL PRICES

ABSTRACT

The aim of this paper is to investigate the causal relationship between agricultural prices in South Africa and global oil prices. A nonlinear Granger causality test based on moment conditions, introduced by Nishiyama *et al.* (2011) is employed and we find that there is indeed a causal relationship between global oil prices (OPEC basket (sourced from OPEC) and Brent Crude (sourced from the Fred database of the Federal Reserve Bank of St. Louis)) and certain South African agricultural commodity prices (sourced from Johannesburg Stock Exchange) over the period of 2003-2014 using daily data. The mean price of wheat, sunflower and soya are Granger caused by OPEC basket oil price. OPEC basket oil prices also cause volatility of wheat, sunflower seed and sorghum prices.

Keywords: Agricultural Prices, Oil Prices, Granger Causality, Nonlinearity, South Africa
JEL Classification: C32, Q11, Q40

RIASSUNTO

La relazione nonparametrica tra il prezzo del petrolio e i prezzi dei prodotti agricoli in Sud Africa

Lo scopo di questo studio è analizzare la relazione causale tra il prezzo del petrolio a livello mondiale e i prezzi dei prodotti agricoli in Sud Africa. Viene utilizzato il test di nonlinearità di Granger causality (ideato da Nishiyama *et al.*, 2011) basato su condizioni di momento. I risultati indicano che effettivamente c'è una relazione causale tra i prezzi del petrolio (paniere OPEC), il prezzo Crude Brent (banca dati Federal Reserve Bank of St. Louis) e i prezzi di alcuni prodotti agricoli del Sud Africa (fonte: Borsa di Johannesburg) nel periodo 2003-2014, con utilizzo di dati giornalieri. Il prezzo medio della farina, girasole e soia sono Granger causati dal prezzo del

petrolio del paniere OPEC. Quest'ultimo è causa anche della volatilità dei prezzi della farina, dei semi di girasole e del sorgo.

1. Introduction

From the beginning of 2006, through to mid-2008, global food prices increased by 38.2 percent (Food and Agriculture Organisation of the United Nations (FAO, 2014)), resulting in a global food crisis and political and economic unrest in both developed and emerging economies. According to the FAO Food Commodity Prices Indices, the average price of agricultural commodities, such as cereals and oils, increased by 122 percent and 144 percent respectively over the period. This resulted in increased interest as to what factors drove the rapid escalation in prices. Global oil prices were identified as one of the key drivers (Nazlioglu, 2011), as there was a concurrent increase in prices.

Various research has identified a causal relationship between global oil and agricultural commodity prices. Nazlioglu (2011) identifies direct and indirect oil price transmissions to agricultural commodity prices. Through the direct price transmission, higher oil prices result in increased agricultural input costs, through higher chemical, fuel and transportation costs. Indirectly, agricultural commodity prices are affected through higher demand for corn- and soybean-based biofuels, as a substitute for traditional fuel, which drives up corn and soybean prices.

What is less certain is whether there is a causal relationship between global and domestic agricultural prices. South Africa is regarded as a net exporter of food (Department of Agriculture, Forestry and Fishing, 2014), though is not a key global agricultural exporter, and thus domestic commodity prices would not be expected to have any significant impact on global oil prices.

However, crude oil accounts for a significant portion of South Africa's import basket, and is a key input to various sectors. Indeed, oil prices play an important role in agricultural production in South Africa, and consequently agricultural prices. Thus, fluctuations in global oil prices should have ramifications for domestic agricultural prices. According to industry data (Quantec, 2014) coke and refined petroleum accounted for about 10 percent of intermediate input costs into agriculture, forestry and fishing in 2013, an increase from 8.8 percent in 2010. Additionally, oil prices affect agricultural prices through indirect channels, such as chemicals and transport. Additionally, the energy costs have exhibited an increasing trend since 1995.

TABLE 1 - *Energy Costs*

	Coke & Refined Petroleum	Basic Chemicals	Transport & Storage
	%	%	%
1995	5.74	15.07	11.46
2000	7.34	17.93	14.33
2005	7.99	18.39	13.80
2010	8.82	18.04	14.64
2013	10.06	18.04	13.28

Note: Data obtained from Quantec Standardised Industry Database.

The aim of this paper is to investigate the causal relationship between agricultural prices in South Africa and global oil prices. The agricultural commodities of interest in this empirical analysis are white and yellow maize, wheat, sunflower seeds, soya, corn and sorghum. Using daily data on South African agricultural commodity prices and the OPEC basket, spanning 11 years, we conduct a nonparametric test for causality[1].

Owing to the presence of structural breaks and nonlinearity in the data, the standard linear Granger causality test will provide biased and unreliable results. Instead we employ one of most powerful nonlinear Granger causality test based on moment conditions, introduced by Nishiyama *et al.* (2011). The nonlinear Granger causality test allows us to test causality, both in the mean and in the variance.

From our analysis we find that there is indeed a causal relationship between global oil prices and certain South African agricultural commodity prices. The results indicate that OPEC oil prices significantly influence the mean price and volatility of wheat and sunflower seed prices. In addition, we find that OPEC oil prices have a significant influence on the mean price of soya, but in the case of sorghum, only affect volatility. However, we failed to detect a significant impact of oil prices on the mean prices and price volatility of both white and yellow maize, as well as corn[2].

[1] The Brent Crude oil price was also used in this study, but was found to be less significant than the OPEC oil prices in explaining the causal relationship between agricultural prices in South Africa and global oil prices.

[2] Similar results are found with respect to Brent Crude oil prices, except that the mean price of wheat is not Granger caused by Brent Crude oil.

The remainder of the paper is organised as follows: Section 2 will provide a brief review of existing literature, Section 3 discusses the data and methodology employed in this study, Section 4 presents the empirical results, and finally, Section 5 concludes our study.

2. Literature review

Various studies have previously investigated the causal relationship between global oil and agricultural commodity prices (Avalos, 2014; Baumeister and Kilian, 2014; Chen *et al.*, 2010; Nazlioglu, 2011), employing different methodologies and finding varying results. Fowowe (2014) also conducted a study to investigate the linkages between oil prices and agricultural prices in South Africa.

Nonlinear Granger causality tests have been employed by numerous authors to determine relationships between certain economic factors in various areas of economics, specifically financial economics. Nishiyama *et al.* (2011) make use of an empirical example using financial data to illustrate the application of the nonlinear Granger Causality test. These authors test the causality between stock price and traded volume and conclude that the volatility of Nikkei 225 futures is caused by its past volume change. Hiemstra and Jones (1994) investigate both the linear and nonlinear relationship between daily Dow Jones stock returns and observe bidirectional nonlinear Granger causality between returns and volume. Ajayi and Serletis (2009) employ a nonlinear causality test developed by Baek and Brock, Hiemstra and Jones and modified by Diks and Panchenko (2006) to examine the dynamic relationship between daily Eurodollar and US certificate of deposit interest rates. These authors obtain significant bidirectional nonlinear causality between the Eurodollar and US certificate of deposit interest rates.

Studies that have employed nonlinear methodologies have proven more successful in finding causality, while those relying on linear methods have proven less successful. Nazlioglu (2011) relies on both linear and nonlinear methods to establish causality. In this study, linear methods fail to establish causality, thereby supporting the neutrality hypothesis that there is no causal relationship between oil and agricultural commodity prices. Baumeister and Kilian (2014) also fail to establish a causal relationship.

However, studies have had more success in proving causality when employing nonlinear methods of estimation. Because agricultural commodity prices exhibit nonlinear behaviour over time, nonlinear methodologies are more effective in establishing causality (Nazlioglu, 2011). The volatility of agricultural commodity prices varies over time, which results in the nonlinear behaviour of prices. The inability of competitive speculators to hold negative stocks of commodities also results in the nonlinearity in stock prices. Furthermore, changes in economic policies may lead to nonlinear price behaviour. Further, nonlinear methods are also crucial to accommodate for structural breaks in the relationships, which is likely to occur (and as we show below they do) especially given that we use high frequency (daily) data from the financial market.

Still other studies have employed partial and computable general equilibrium (CGE) models (see for example Chantret and Gohin, 2010; Tokgoz *et al.*, 2008; Vincent *et al.*, 1979 and OECD-FAO, 2008). However, these were found to be unsuccessful in modelling the causal relationship between oil and agricultural prices since these models are subjected to calibrated price elasticities (Nazlioglu, 2011).

A caveat, as identified by Baumeister and Kilian (2014), is that oil price increases during the period of food price escalation did not occur in isolation; increased economic activity in emerging markets such as China resulted in increased demand for food, which would have contributed to agricultural commodity price inflation.

Previous studies have also identified important implications for social and energy policy as a result of the relationship between oil and agricultural prices (Fowowe, 2014). In emerging markets, such as South Africa, where a portion of the population relies on agricultural production as a source of income, there are important concerns about poverty and inequality, and also a lack of sustainable energy sources.

3. METHODOLOGY

To study the nonlinear relationship between OPEC basket oil prices and agricultural prices we first conduct a standard linear Granger Causality test, followed by tests for structural breaks, nonlinearity and finally the nonlinear Granger causality test. The standard linear Granger test tests the causality between two stationary series and can be described using the concept of predictability (Granger, 1969). We test whether x_t "Granger" causes y_t by estimating a p-order linear vector autoregressive model. The null hypothesis of this test is non-causality (therefore x_t

does not "Granger" cause y_t) against the alternative hypothesis of causality. Given our analysis we therefore test whether oil prices Granger cause agricultural prices.

Structural breaks are tested using the Global Information Criteria of Bai and Perron (2003) to select the number of breaks. This method summarizes the results according to the LWZ and Schwarz Criterion. To test for nonlinearity we employ the BDS independence test, which is used to detect serial dependence. The null hypothesis of this test is that of independence and identically distributed variables. If the presence of structural breaks and nonlinearity between the variables are detected, nonparametric tests will be the logical next step.

Many nonparametric tests have been proposed in the literature (see for example Hiemstra and Jones,1994 and Diks and Panchenko, 2006). Recently, Nishiyama *et al.* (2011) introduced one of the most powerful nonlinear Granger causality tests based on moment conditions, i.e., when dependence on high moments looks like an issue of interest. Their test is restricted to the case when the series under investigation follows a stationary nonlinear autoregressive process under the null. Nishiyama *et al.* (2011) motivated the high-order causality by using the following nonlinear dependence between series,

$$x_t = g(x_{t-1}) + \sigma(y_{t-1})\epsilon_t \quad (1)$$

where $\{x_t\}$ and $\{y_t\}$ are stationary time series, $g(.)$ and $\sigma(.)$ are unknown functions which satisfy certain conditions for stationary. In general, y_{t-1} has information in predicting x_t^K for a given integer K. Consequently, the null hypothesis of non-causality in the K^{th} moment is given by,

$$H_0: E(x_t^K | x_{t-1}, \ldots, x_1, y_{t-1}, \ldots, y_1) = E(x_t^K | x_{t-1}, \ldots, x_1)\ w.p.1. \quad (2)$$

where $w.p.1$ abbreviates to "with probability one". Formally, we say that y_t does not cause x_t up to the K^{th} moment if

$$H_0: E(x_t^K | x_{t-1}, \ldots, x_1, y_{t-1}, \ldots, y_1) = E(x_t^K | x_{t-1}, \ldots, x_1)\ w.p.1.\ \text{ for all } k = 1, \ldots, K \quad (3)$$

when K = 1, this definition reduces to non-causality in mean. Nishiyama *et al.* (2011) note that is easy to construct the test statistic $\hat{S}_t^{(k)}$ for each of $k = 1, \ldots, K$. In order for practice use, they recommend to test causality successively especially when K is small. In this line, we implement the test for K = 1 to test causality in the first moment (non-causality in mean), and for K = 2 to test causality in the second moment.

In addition, Nishiyama *et al.* (2011) show that their test has nontrivial power against $\sqrt{T}$- local alternatives, where T is the sample size. Also, they used the weighting function $w_i = 0.9^i$ in their simulation study and provide that the test has quite good empirical size and power for a variety of linear and nonlinear models. The critical value of the asymptotic distribution is calculated by a Monte Carlo simulation with this choice of w_i. The upper 5% critical value is estimated as 14.38. If the test statistic is larger than the critical value of 14.38, we reject the null hypothesis of non-causality in the mean and/or second moment. Note that, to keep our results comparable between the linear Granger causality test and the nonparametric test, we use a lag-order of 1.

3.1 Data

This study makes use of daily data from 3 January 2003 to 31 July 2014. The main variables for commodity prices include white maize (*white*), yellow maize (*yellow*), wheat, sunflower seed (*suns*), soya, corn and sorghum (*sorg*). Agricultural price daily data were obtained from the Johannesburg Stock Exchange (JSE). Due to missing observations, the data for sunflower seed only start from 14 October 2003 onwards, soya data is only available from 19 April 2005, corn data from 28 January 2009 and finally for sorghum data starts from 19 May 2010. For oil prices, we use the OPEC basket oil obtained from Organization of the Petroleum Exporting Countries data[3]. Note that, to ensure that we capture the exogenous impact of (world) oil shocks on South African food prices, the oil price is retained in terms of US dollars and not converted into rands using the nominal rand US dollar bilateral exchange rate. This also avoids feeding in the impact of exchange rate changes into the domestic food prices. Oil prices and the main variables employed in this empirical analysis for South Africa, are plotted over the 2003 to 2014 period, in Figure 1 and Figure 2, respectively.

[3] Brent crude oil price is also used in this study to test the causal relationship of agricultural prices and global oil prices, with the results reported in Appendices. We chose to report the results based on the OPEC oil price in the main text, given that, South Africa imports 90 percent of its oil from OPEC countries (EIA, 2011). Note that, the daily data for Brent Crude oil prices were obtained from the Federal Reserve Bank of St. Louis Economic Data.

FIGURE 1 - *Agricultural Prices for the South African Economy from 2003 to 2014*

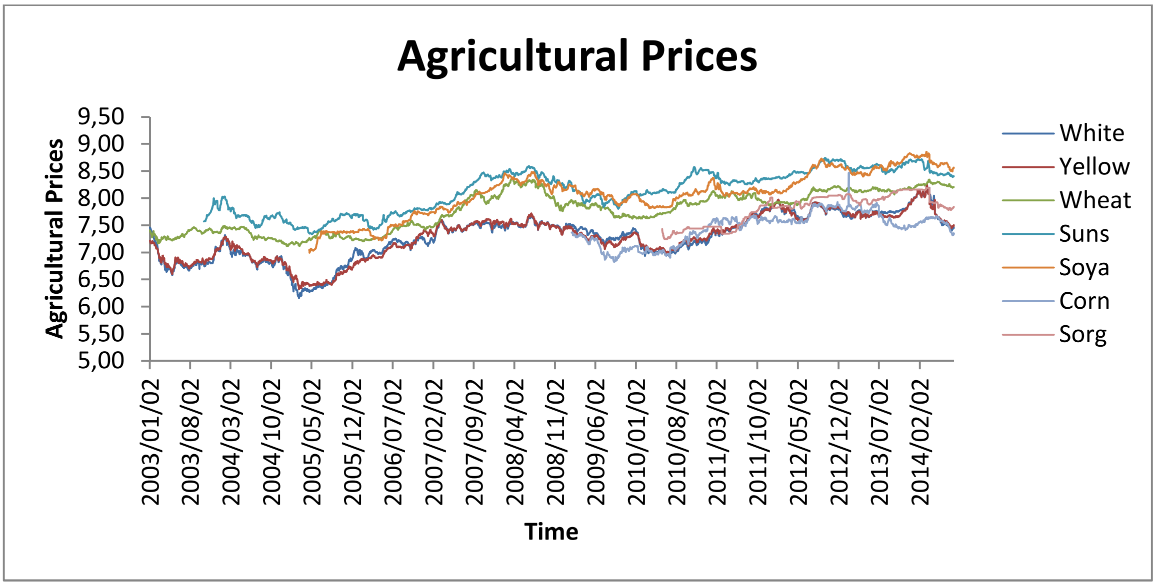

FIGURE 2 - *Oil Prices for the South African Economy from 2003 to 2014*

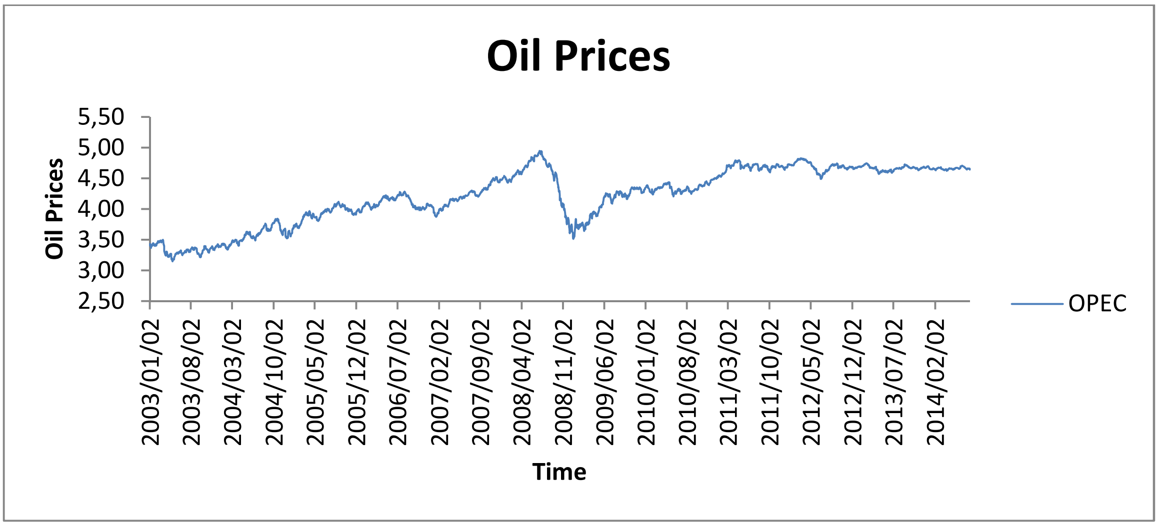

Figure 1 and 2 presents our data transformed into natural logarithms. From Figure 1 we observe how agricultural prices move together over time. The maize surplus crisis (which caused to the decrease of white and yellow maize price) is seen over the period 2004 to 2005. Figure 2 presents OPEC basket oil daily data over our period of investigation. For robustness sake we also conducted our study considering Brent Crude oil. The global financial crisis is obvious in Figure 2 with OPEC basket oil price falling significantly, but stabilising later on again.

3.2 Results

The results of the linear Granger causality test, structural break test, BDS Independence test and nonparametric test are discussed in this section. Before conducting our analysis with a non-linear model, we first test if the variables have unit roots (in natural logarithm), using the ADF, PP, DF-GLS and NG-Perron methodology. We test the period from 2003 to 2014, which include 2842 observations. First checking for stationarity in levels, we then considered first-differences of the data and it was evident that the all variables are stationary in first difference. We transformed the data into their growth rates. It was apparent that Sorghum and Brent crude oil were non-stationary according to the NG-Perron in first difference. We avoid spurious regressions by ensuring variables used in our analysis are stationary and that Ordinary Least Squares are valid.

With the standard linear Granger causality test we therefore test whether OPEC basket oil granger cause agricultural prices. The Granger causality tests indicate that we reject the null-hypothesis of no granger causality, in favour of the alternative hypothesis that OPEC oil prices do granger cause agricultural prices at a 10% level of significance.

According to this traditional Granger causality test, OPEC basket oil and Brent Crude oil is said to granger cause prices in agricultural commodities (except in the case of sorghum prices).

We detected structural breaks in our data with the use of Global Information Criteria as methodology. According to the Schwarz- and LWZ-Criterion, structural breaks exist in all agricultural price data further motivating the use of nonparametric estimation of the relationship between oil and agricultural prices. The results of our structural break tests are available in the appendix of this paper.

TABLE 2 - *Granger-Causality Test*[4]

Agricultural and OPEC Oil Prices (2003 to 2014)	
	OPEC
White Maize	9.28***
Yellow Maize	6.79***
Wheat	3.59*
Sunflower Seed	5.48**
Soya	1.10
Corn	4.04**
Sorghum	2.02

Note: This table report the test-statistics (Chi-square values) of the Granger Causality tests. *, ** and *** indicate the rejection of the null hypothesis of absence of causality at the 1%, 5% and 10% level of significance.

TABLE 3 -*BDS Independence Test*[5]

Test for Non-Linear Relationship Agricultural and OPEC Oil Prices (2003 to 2014)							
	Dimension	White	Yellow	Wheat	Suns	Soya	Sorg
	2	0.000	0.000	0.000	0.000	0.000	0.000
	3	0.000	0.000	0.000	0.000	0.000	0.000
OPEC	4	0.000	0.000	0.000	0.000	0.000	0.000
	5	0.000	0.000	0.000	0.000	0.000	0.000
	6	0.000	0.000	0.000	0.000	0.000	0.000

Note: Table reports the p-values of the BDS test.

[4] Table A1 in the appendix presents the results for Brent Crude granger causality test, over the period 2003 to 2014.
[5] See Table A3 in appendix for Brent Crude BDS independence results.

We use the BDS Independence test to check whether the data generating process is linear or nonlinear. This test is a powerful tool in detecting serial dependence in time series. The BDS Independence test therefore detects nonlinearity in data. Table 3 reports the p-values associated with the BDS Independence test.

From our results, we reject the null-hypothesis of a linear relationship in favour of the alternative hypothesis, that there may exist a non-linear relationship between oil and agricultural prices. The presence of nonlinearity and structural breaks indicates that variables and the relationship between variables may be of a nonlinear nature, thus motivating our use of a nonparametric test.

TABLE 4 - *Nonlinear Granger Causality Test*

OPEC Basket vs. Agricultural Commodities		
Null Hypothesis	Test Statistics	
	$\hat{S}_T^{(1)}$	$\hat{S}_T^{(2)}$
OPEC ≠> White	5.6216	13.6787
OPEC ≠> Yellow	2.3267	8.41171
OPEC ≠> Wheat	21.2680**	19.1698**
OPEC ≠> Suns	970.7499**	994.0552**
OPEC ≠> Soya	34.6743**	11.2567
OPEC ≠> Corn	5.5358	5.1482
OPEC ≠> Sorg	13.5077	14.8459**

Note: ** Indicates rejection of null hypothesis of non-causality at a 5% critical value estimated at 14.38.
$\hat{S}_T^{(1)}$ - causality in the mean.
$\hat{S}_T^{(2)}$ - causality in the variance.

Finally and most importantly we analyse the nonparametric relationship between OPEC oil prices and agricultural prices[6]. We consider this relationship both in the first moment (mean) and in the second moment (variance). The nonparametric test for Granger-type causality between OPEC basket oil and agricultural prices will be discussed[7].

From our analysis we reject the null hypothesis of non-causality in the mean and second moment for wheat and sunflower seed. OPEC oil therefore significantly influences the mean price and also the volatility of wheat and sunflower seed prices on a 5% level of significance. The null hypothesis of non-causality in the mean is also rejected for soya, while non-causality in the second moment is rejected for sorghum. OPEC basket oil significantly affects the mean price of soya commodities, although it only causes sorghum price volatility.

We fail to reject the null-hypothesis of non-causality in the mean and second moment for white and yellow maize, as well as corn, hence causality in the mean and second moment is not detected. OPEC oil therefore does not granger cause prices of white maize, yellow maize and corn up to the first and second moment. Causality is also not detected in the second moment of soya and in the mean for sorghum[8].

While studies have shown that an increase in global oil prices does cause higher agricultural commodity prices, this does not occur in isolation. For example, during the 2007-2008 so-called 'global food crisis', there was an increase in international oil prices, but also a simultaneous increase in demand for agricultural commodities and supply shortage (IRIN, 2008).

As with our analysis considering OPEC basket oil we fail to reject the null hypothesis of non-causality in the mean and second moment for white maize, yellow maize and corn. Wheat and maize are among the five most consumed food types in South Africa, and thus are considered staple foods. According to the Bureau for Food and Agricultural Policy (BFAP), maize porridge accounts for 54% of energy intake amongst poor South Africans (IRIN, 2008). Aside from consumption and animal feed, maize may be used as an input to bio-ethanol production, as a renewable fuel. However, the use of maize as such in South Africa is not permitted, as it may lead to increased price instability and food insecurity (Radebe, 2013). In addition, maize is also an

[6] We also analysed the effect of Brent Crude prices.

[7] Table A4 in the appendix presents the results for Granger-type causality between Brent Crude oil and agricultural prices.

[8] Our analysis considering Brent Crude oil gives similar results to what our analysis yielded considering OPEC basket oil. Causality in the mean and second moment is detected for sunflower seeds, while we only reject the null hypothesis of non-causality in the mean for soya. Non-causality in the second moment is rejected for wheat and sorghum.

important export commodity in South Africa (DAFF, 2014). Thus, the price of maize in the domestic market is impacted by international maize prices and exchange rate movements. However, net importers of maize would be more vulnerable to increases in oil prices, because of increased transport costs. As South Africa is a net exporter of maize, the impact of higher international oil prices may have less of an impact on domestic prices (Dillon and Barrett, 2013).

South Africa is a net importer of wheat (DAFF, 2014), which suggests that the domestic price of wheat is more vulnerable to changes in global prices, proved by our rejection of non-causality in the second moment for wheat. As stated, previous studies have found a causal relationship between global oil and agricultural commodity prices, thus fluctuations in global wheat prices as a result of higher oil prices would result in higher domestic wheat prices. Minot (2013) finds that increased wheat prices in Africa are caused as a result of higher global prices, while maize prices are not. The author suggests that the increase in maize prices is as a result of substitution effects with rice and wheat, both of which South Africa is a net importer. In addition, higher international oil prices resulted in higher transport costs, which would have increased the cost of importing wheat.

Agricultural production of sunflower seeds in South Africa is small-scale relative to wheat and maize. While the bulk of production is domestic, South Africa is a net importer of sunflower seeds, primarily from Ukraine and Russia (DAFF, 2014), and may be more vulnerable to fluctuations in global sunflower seed prices. This provides a possible explanation as to the significant influence of global oil prices on domestic sunflower seed prices we found.

South Africa also produces soybeans on a smaller scale relative to other crops. It is also a net exporter of soybeans, and therefore domestic prices should be less vulnerable to global food price fluctuations than wheat and sunflower seed prices. However, it is an important source of animal feed. Thus, the price of soybean may increase when other animal feed prices increase and it is increasingly used as a substitute, as a result of increased demand.

We find that higher oil prices Granger cause increased price volatility in sorghum prices. According to the National Agricultural Marketing Council (NAMC, 2007), the high volatility in sorghum prices results from the way in which its price is determined. The NAMC states that, in a given year, if sorghum-based food and beverage consumption is in excess of local production, the price is determined by the lowest price of competing grains, either white or yellow maize.

The volatility of sorghum prices is in contrast to a previous finding (Minot, 2013) that sorghum has relatively low price volatility, which is possibly attributable to its high resistance to drought.

However, Minot also finds that there is less price volatility among agricultural commodities that are tradeable, such as wheat and than those that countries are self-sufficient in producing, such as sorghum. While South Africa is a net importer of sunflower seeds, the bulk of production is domestic, and thus sunflower seeds may be considered a self-sufficient good in South Africa, which may explain increased price volatility.

Considering the results for the nonparametric tests of Granger-type causality, we can conclude that the mean price of wheat, sunflower and soya are caused by OPEC basket oil price[9]. The volatility of wheat, sunflower seed and sorghum prices are caused by OPEC basket oil[10]. We did not test for reverse order causality in this study, as it makes no economic sense that South African agricultural prices would influence world oil prices at any level[11].

4. Conclusion

We conclude that fluctuations in global oil prices[12] do have a significant impact on certain domestic agricultural commodity prices, while others remain unaffected. This has important policy implications, especially in the case of a developing country like South Africa, where poverty is of great concern and research into renewable energy sources is gaining momentum.

Higher oil prices not only affect the price of fuel in South Africa, but also the prices of consumer goods. Oil is a substantial input cost to many South African industries, whether directly through food, or indirectly, through channels such as transportation. In the context of agricultural production, higher oil prices result in the increase of certain grain and seed commodity prices, which in turn increases the cost of meat and dairy products.

Higher oil prices may also result in increased demand of biofuels, some of which are produced using corn and soya. Thus, the demand for these agricultural commodities will increase, resulting in farmers facing a trade-off: they must choose to produce agricultural produce for consumption or as an input to biofuels. This will result in added upside pressure to food prices.

[9] While Brent Crude oil prices granger cause the mean price of sunflower and soya.

[10] We also found that Brent Crude oil causes the volatility of wheat, sunflower seed and sorghum prices.

[11] Based on the suggestion of an anonymous referee we extended the sample of our analysis till 29th of January, 2016, i.e., added 371 additional data points. However, our results were qualitatively the same, but only marginally quantitatively weaker, but not enough to change the significance level of the statistics. The results suggested that the current decline in oil prices and the recent drought situation in South Africa did not play strong enough role to change the causal relationship between agricultural and oil prices. Complete details of these results are available upon request from the authors.

[12] Both the OPEC basket and Brent Crude prices.

Because food accounts for a significant portion of the CPI basket, an escalation in food prices may result in increased CPI inflation, which in turn may precipitate a monetary policy reaction. High CPI inflation not only poses a downside risk to economic growth and development, but also further constrains consumers.

Furthermore, establishing a causal relationship is significant for energy research. As a result of increased oil prices, the price of biofuels, which are used as a substitute for traditional fuels, increased. In emerging markets, particularly in Africa, where energy sources are scarce, there is increasing interest in potential sources of sustainable energy. In some cases, governments have provided subsidies and other incentives aimed at proliferating renewable sources of energy (Fowowe, 2014). However, increased demand for biofuels may result in increased agricultural commodity prices, and the reverse is also true. Because both food and fuel constitute a significant portion of consumer expenditure, government should consider proposed policies carefully, as they may adversely affect the poor.

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APPENDIX

TABLE A1 - *Granger-Causality Test*

Agricultural and Brent Crude Oil Prices (2003 to 2014)	
	Brent Crude
White Maize	9.12***
Yellow Maize	6.72***
Wheat	3.77*
Sunflower Seed	5.57**
Soya	1.13
Corn	4.49**
Sorghum	1.88

Note: This table reports the test-statistics (Chi-square values) of the Granger Causality tests. *, ** and *** indicate the rejection of the null hypothesis of absence of causality at the 1%, 5% and 10% level of significance.

TABLE A2 - *Structural Break Test for Agricultural, Brent-Crude and OPECP Prices*

Test for Structural Breaks Agricultural and Oil Prices (2003-2014)								
	OPEC				Brent-Crude			
	Breaks	Estimated Break dates	Schwarz - Criterion	LWZ- Criterion	Breaks	Estimated Break dates	Schwarz - Criterion	LWZ- Criterion
White	4	2004/09/20 2006/09/06 2010/01/19 2011/10/19	-2.219	-2.168	4	2004/09/20 2006/09/06 2010/01/20 2011/10/20	-2.244	-2.197
Yellow	4	2005/01/07 2006/09/22 2010/01/05 2012/06/01	-2.271	-2.220	4	2004/09/20 2006/09/06 2010/01/27 2011/10/27	-2.301	-2.249
Wheat	5	2004/09/17 2006/06/06 2008/10/09 2010/11/04 2012/09/21	-2.400	-2.332	4 5	2004/09/17 2006/06/06 2008/10/13 2010/10/04 2012/07/10	-2.434	-2.382
Suns	4 5	2005/05/20 2007/02/28 2008/10/13 2011/01/14 2012/09/06	-2.164	-2.106	4	2005/05/20 2008/10/13 2011/01/12 2012/09/04	-2.158	-2.103
Soya	3 4	2007/05/18 2008/10/07 2010/03/01 2012/06/01	-2.415	-2.356	4	2006/09/06 2008/10/07 2010/03/01 2012/05/31	-2.502	-2.441
Corn	4	2009/11/23 2011/02/24 2012/06/04 2013/07/16	-3.053	-2.968	4	2009/11/23 2011/02/24 2012/06/04 2013/07/16	-3.106	-3.021
Sorg	3 5	2011/01/04 2011/08/24 2012/05/31 2013/04/12 2013/12/12	-4.234	-4.142	3 5	2011/01/04 2011/08/24 2012/05/31 2013/04/08 2013/12/12	-4.180	-4.086

Note: * The highlighted dates indicate the estimated break dates that are included in the higher break value.

TABLE A3 - *BDS Independence Test*

Test for Non-Linear Relationship Agricultural and Brent-Crude Prices (2003 to 2014)							
	Dimension	White	Yellow	Wheat	Suns	Soya	Sorg
Brent Crude	2	0.000	0.000	0.000	0.000	0.000	0.000
	3	0.000	0.000	0.000	0.000	0.000	0.000
	4	0.000	0.000	0.000	0.000	0.000	0.000
	5	0.000	0.000	0.000	0.000	0.000	0.000
	6	0.000	0.000	0.000	0.000	0.000	0.000

Note: Table reports the p-values of the BDS test.

TABLE A4 - *Nonlinear Granger Causality Test*

Brent vs. Agricultural Commodities		
Null Hypothesis	Test Statistics	
	$\hat{S}_T^{(1)}$	$\hat{S}_T^{(2)}$
Brent ≠> White	7.6799	9.3917
Brent ≠> Yellow	5.5250	3.8822
Brent ≠> Wheat	14.0770	19.8768*
Brent ≠> Suns	968.759**	992.2128**
Brent ≠> Soya	29.4685**	6.4433
Brent ≠> Corn	3.4847	3.7655
Brent ≠> Sorg	13.7966	15.0342**

Note: ** Indicates rejection of null hypothesis of non-causality at a 5% critical value of 14.38.
$\hat{S}_T^{(1)}$ - causality in the mean
$\hat{S}_T^{(2)}$ - causality in the variance