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PRICE DISCOVERY IN THE SOUTH AFRICAN WHITE MAIZE AND WHEAT FUTURES MARKET: A VECM CAUSALITY APPROACH

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Abstract
The main justification for the existence of commodity futures markets is the supposed role they fulfil in ensuring efficient price discovery and price risk mitigation. The futures market price barometer role influences farmers production decisions since these markets supposedly provide commodity price information. This study examined price discovery in the white maize and wheat futures market of South Africa. The Vector Error Correction model was used to investigate the short run and long run relationship between spot and futures prices of white maize and wheat traded on South Africa Futures Exchange Agricultural Products Division. The data for the spot and futures was collected from South Africa Futures Exchange website. The study found that spot prices of wheat and white maize contain useful information which could be used to predict future prices. Furthermore, long run and short run causality was found in the spot and futures price series of white maize and wheat contracts. The study failed to confirm both short run and long run causality from futures to spot prices hence refuting the price discovery role of futures markets. Prices are discovered in the spot markets of South Africa grain markets a finding which suggests that price changes are due to fundamental changes rather than speculation that is characterised with futures markets. The implication of this finding is that farmers have to watch spot market activity as it would determine prices and ultimately influence production decisions.

Keywords: Price Discovery; White maize; Wheat; Futures; Spot Prices; VECM.

1. Introduction

The Neo-Classical microeconomic theory has been suggested to be an appropriate tool for price determination in the market for goods and services. Price is determined by the interaction of demand and supply which is referred to as the price mechanism. Production decisions are largely influenced by the commodity price since producers are driven by self-interest as well as the profit motive. Producers who are on the supply side are willing to supply more at higher prices. Since prices play a significant role in production decisions as well as possible exploitation of resources for profit it is imperative to understand the source of price discovery. Price discovery, according to Schreiber and Schwartz (Schreiber and Schwartz, 1986) is the process in which markets attempt to reach equilibrium prices. It is also defined by Thomsen and Foote (1952) as the process of arriving at transaction prices for a given quality and quantity of a commodity at a given time and place. When information is transformed into prices then price discovery has

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occurred. The rate at which markets reveal new information differs and arguments as to why some are quicker to reveal common information typically revolves around transparency, transaction costs and other market structure issues. Futures market are expected to serve as a price discovery vehicle for investors in spot market.

Early studies have shown that futures market serve an important role of price discovery. This has been well proclaimed by many studies which used a variety of methods for example(Schreiber and Schwartz, 1986; Herbst, McCormack and West, 1987; Kawaller, Koch and Koch, 1987; Harris, 1989; Brenner and Kroner, 1995a; Fortenbery and Zapata, 1997; Yang, Bessler and Leatham, 2001). This is also supported by some recent studies such as (Silvapulle and Moosa, 1999; Garcia Martinez *et al.*, 2006; Hernandez and Torero, 2010; Theissen, 2012; Yan and Reed, 2014) who have found that future prices contain useful information about future spot prices, concluding that futures lead spot prices in price discovery. However, some of the recent literature seem to be refuting the price discovery role of the futures markets though the evidence is mixed for example(Leatham and Yang, 1999; Peri, Baldi and Vandone, 2013; Strydom and McCullough, 2013; Ohemeng, Sjo and Danquah, 2016).

Yan and Reed(Yan and Reed, 2014) argue that spot prices are discovered in the futures market for Chinese corn and GMO soyabean. However for non-GMO soyabean spot prices were found to lead futures prices. Similarly, Peri et al. (Peri, Baldi and Vandone, 2013) found mixed evidence though greater part of the evidence they gathered was in line with majority of literature findings which emerge from spot-future price relation studies. Ohemeng et al.(Ohemeng, Sjo and Danquah, 2016)study utilised data from the Coffee, Sugar and Cocoa Exchange (CSCE) to test efficiency and price discovery mechanism in market for cocoa and found that cocoa spot prices contained useful information which could be used to predict the futures prices. Ohemeng et al. (Ohemeng, Sjo and Danquah, 2016)asserted that cash prices cannot be rejected to be a random walk, implying that it is not possible to reject the null hypothesis that cash prices contain all relevant information about future cash prices.

There is a rich debate on the direction of causality of future and spot price in the equities market, Some scholars that investigated the S&P500 futures market have submited that S&P 500 futures prices lead spot price(Kawaller, Koch and Koch, 1987; Stoll and Whaley, 1990). The views by Pizzi *et al.*(Pizzi, Economopoulos and O'Neill, 1998) are in tandem with the argument of the foregoing, however, they went a step further to suggest a bidirectional relationship. Both studies considered the S&P 500 futures and stock index. Oellermann et al. (Oellermann, Brorsen and Farris, 1989) as well as Schroeder and Goodwin (Schroeder and Goodwin, 1991) investigate the short run price discovery mechanism for livestock. They found that information tends to be discovered first in the futures markets and then transferred to cash markets. They also confirm a short run relationship between cash and futures prices based on Garbade-Silber model. However, they failed to prove existence of a long run relationship utilising the either Granger-causality or cointegration procedures. Yang *et al*. (2001) set out to find the price discovery performance of futures markets for storable and non-storable commodities. They submitted that asset storability does not affect the price discovery function; nonetheless, it may bias futures markets estimates. Their findings led them to the conclusion that futures markets can be used as a price discovery tool in both types of markets.

Security prices on the same underlying asset price in a frictionless market should be correlated and no lead-lag relationship must exist (Chaihetphon, 2008). If futures price for wheat leads the spot price of wheat, then we say that price is discovered in futures markets as it is the first market to respond to new information. In addition, despite the short term deviations of prices from each other, the prices should be cointegrated. Strydom et al.(Strydom and McCullough, 2013) utilised the VECM model and impulse response graphs to investigate the short run and long run relation between spot and futures price of white maize. Distinct from Strydom and McCullough (Strydom and McCullough, 2013)this study uses VECM and Wald statistic test. This is the first paper to the best of the authors' knowledge which has used the VECM and Wald Test statistic method to establish the short run and long run relationship between spot and future prices of white maize and wheat in South Africa. Wheat and White maize were used in this study as they are the most liquid contracts traded on South Africa Futures Exchange Agricultural Products Division (SAFEX) APD.

2. Materials and Methods

The data that was used in this study was collected from Johannesburg Stock Exchange South Africa Futures Exchange website. Similar to other studies for example (Beck, 1994; McCullough and Strydom, 2013) different time horizons were used in order to investigate the spot future prices relationship in South Africa grain market. The rationale behind the use of different time horizons was to ensure that the study did not reach a biased conclusion influenced by the time period picked or the observations included. Wheat contracts price data for the four week horizon covers the period from 22 January 2003 to 23 November 2012. Furthermore, wheat futures contract and spot prices for the period 18 December 1997 to 31 July 2014 are used for the six week horizon. The four week horizon white maize data sample series is for the period between 22 May 1996 and 19 March 2010, and there was a total of 146 observations. As for the white maize six week horizon, a total of ninety-three observations are obtained after collection of both spot and future prices data from 26 February 1996 to 30 September 2014. The data that was used for the yellow maize six week horizon covers the period 2 May 1996 to 31 July 2014.
A simple dynamic model of a short-run adjustment model(Brooks Chris, 2008) is given by:

$$y_t = b_0 + \gamma_0 x_t + \gamma_1 x_{t-1} + b_1 y_{t-1} + \varepsilon_t \text{.....................................} 1.1$$

y_t is the dependent variable , x_t is the independent variable, x_{t-1} and y_{t-1} are lagged values of x_t and y_t respectively $b_0, b_1, \gamma_0, \gamma_1$ are parameters and ε_t is the error term assumed to be $\varepsilon_t \sim iN(0, \delta^2)$.Both the spot price and the futures prices would be interchangeably used as dependent and independent variable. There are some shortcomings which are associated with the use of the short run model which are listed as follows:

Spurious correlation: This is a circumstance in which two variables which have no causal relation, are inferred as doing so as a result of a certain third unforeseen factor called a common influence on the two variables.

Multicollinearity: This is a situation in which two or more independent variables in a multiple regression model are highly correlated.

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These problems, at the very least, are counteracted and at the very best, resolved by estimating the first differences of equation 1.1 to obtain

$$\Delta y_t = b_0 + \gamma_0 \Delta x_{t-1} + \gamma_1 \Delta x_{t-1} + b_1 \Delta y_{t-1} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1.2$$

Differencing however introduces problems of loss of information about the long run equilibrium and the economic theory is differenced away. In order to circumvent these two issues, one needs to adopt the error correction mechanism (ECM) formulation of the dynamic structure. The ECM is set up as follows:

$$y_t = b_o + \gamma_0 x_t + \gamma_1 x_{t-1} + b_1 y_{t-1} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1.3$$

Subtracting the term y_t on both sides leads to

$$\Delta y_t = b_0 + \gamma_0 x_t + \gamma_1 x_{t-1} - (1 - b_1) y_{t-1} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1.4$$

Subtracting the term $\gamma_0 x_{t-1}$ on both sides equation 5.31 becomes

$$\Delta y_t - \gamma_0 x_{t-1} = b_0 + \gamma_0 x_t - \gamma_0 x_{t-1} - (1 - b_1) y_{t-1} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots 1.5$$

Reparameterisation reduces the above equation to

$$\Delta y_t = \gamma_0 \Delta x_t - (1 - b_1)\left[y_{t-1} - \frac{b_0}{1-b_1} - \left(\frac{\gamma_0 + \gamma_1}{1-b_1}\right) x_{t-1}\right] + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots 1.6$$

Taking $\beta_0 = \frac{b_0}{1-b_1}$ and $\beta_1 = \frac{\gamma_0 + \gamma_1}{1-b_1}$ the equation given above becomes

$$\Delta y_t = \gamma_0 \Delta x_t - (1 - b_1)[y_{t-1} - \beta_0 - \beta_1 x_{t-1}] + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots 1.7$$

Which is the ECM with $-(1 - b_1)$ as the speed of adjustment and $\varepsilon_{t-1} = y_{t-1} - \beta_0 - \beta_1 x_{t-1}$ as the error correction mechanism which measures the distance of the system away from equilibrium. The coefficient of ε_{t-1} should be negative in sign in order for the system to converge to equilibrium. The magnitude of the coefficient $-(1 - b_1)$ is an indication of the speed of adjustment towards equilibrium.

2.1 The Estimated Model

The Johansen-Juselius Multivariate Cointegration Model(Brooks Chris, 2008) is given below in equation 5.35

$$\Delta Y_t = \sum_{i=1}^{p-1} \Gamma_i \, \Delta X_{t-i} + \Pi X_{t-1} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1.8$$

Where X_t is the 2x1 vector (White Maize Spot Price, White Maize Future Price) respectively, Δ is a symbol of difference operator, ε_t is a 2x1 vector of residuals. Information about both the short and long run adjustment to changes in X_t is contained in the VECM model through the estimated parameters Γ_i and Π respectively. Here the expression ΠX_{t-1} is the error correction term and Π can be factored into two separate matrices α and β such as $\Pi = \alpha\beta'$, where β' denotes the vector of cointegrating parameters while α is the vector of error correction coefficients measuring the speed of adjustment to the long run steady state.

The causal relationship between spot and futures prices in the SAFEX APD was investigated by a vector error correction model (Brooks Chris, 2008).When cointegrated future and spot markets are expected to return to long run equilibrium after possible short run adjustments, Vector Error Correction Model is used to specify the cointegrated variables, in which the error(e_t) refers to long run equilibrium that is

$$e_t = F_t - \alpha - \beta S_t \text{...1.9}$$

$$\Delta F_t = \alpha + \delta e_{t-1} + \sum_{i=1}^{k} \beta_i \Delta F_{t-1} + \sum_{j=1}^{k} \gamma_i \Delta S_{t-1} + v_t \text{......2.0}$$

$$\Delta S_t = \alpha' + \delta' e_{t-1} + \sum_{i=1}^{k} \beta'_i \Delta F_{t-1} + \sum_{j=1}^{k} \gamma_i{}' \Delta S_{t-1} + v_t{}' \text{...2.1}$$

Where, F and S refer to the future and spot prices, respectively. v_t is the white noise.
The data for wheat that was used in this study is from December 1997 to July 2014. The one was for white maize was from the period February 1996 to September 2014. All the data used in this study was collected from the SAFEX APD website.

3. Results

3.1 Wheat

3.1.1 Futures prices as the dependent variable

A VECM model was developed whose results are used to explain the short run and long run causality between wheat futures and spot prices. The VECM model is represented by equation 2.2. This equation is created in Eviews 8, the software used in analysing the data in this study. The equation represents the short run and long run relationship between wheat spot and futures prices. The equation of the model is given below:

D(LNWHFUT) = C(1)*(LNWHFUT(-1) - 0.986157897627*LNWHSPOT(-1)-0.0920600271185) + C(2)*D(LNWHFUT(-1)) + C(3)*D(LNWHFUT(-2)) + C(4)*D(LNWHFUT(-3)) + C(5)*D(LNWHFUT(-4)) + C(6)*D(LNWHSPOT(-1)) + C(7)*D(LNWHSPOT(-2)) + C(8)*D(LNWHSPOT(-3)) + C(9)*D(LNWHSPOT(-4)) + C(10) 2.2

The equation above shows the relationship between spot and futures prices and it is the one used to establish the short run and long run relationship between the two price series. If there is a long run relationship between wheat spot and futures prices the coefficient of the error correction term will be significant as well as negative. C(1) represents the coefficient of the error correction term.

The error correction term is represented by (-1.86744) in Table 1.1 and it is negative. The probability value of the error correction term (-1.86744) is zero percent which is significant. Since the error correction term is significant and negative the study concludes that there is a long run relationship between wheat spot and futures prices. In other words, wheat spot prices have long run causality on wheat futures price.

Table 1.1: Coefficients of VECM for wheat future prices as the dependant variable

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-1.86744	0.34944	-5.34408	0.00000*
C(2)	0.54128	0.30821	1.75623	0.08350***
C(3)	0.33049	0.25178	1.31261	0.19370
C(4)	0.11768	0.17852	0.65916	0.51200
C(5)	-0.09231	0.09948	-0.92795	0.35670
C(6)	-0.83322	0.33727	-2.47047	0.01600**
C(7)	-0.44868	0.28832	-1.55617	0.12420
C(8)	-0.29572	0.22704	-1.30250	0.19710
C(9)	-0.18634	0.14737	-1.26440	0.21030
C(10)	0.03254	0.00898	3.62492	0.00050*

***; **; * Significant at 1%; 5% and 10% levels

The short run relationship is explained by C (6), C(7), C(8) and C(9). The chi-square value of (8.7886) and the probability value of 6 percent presented in Table 1.2 below are not significant at 5 percent. Therefore, we cannot reject the null hypothesis that the coefficients of wheat spot prices are jointly zero in the model. This implies that all the wheat spot prices variables cannot jointly influence the futures prices. Price distortions which may be caused by speculation in the futures markets may occur in the short run (Dimpfl *et. al* (2017).This explains the deviation in findings here where spot prices are not influencing futures prices in the short run. However, at 10 percent level of significance we can reject the null hypothesis that the coefficients of wheat spot prices are jointly zero in the model. Therefore, all the four spot prices variables have short run causality on the wheat futures prices. This findings concurs with findings by Irwin *et al*. (2009) who fully attributed price discovery to spot markets and Dolatababi *et al*. (2015) who reported mixed findings but showed also the price discovery role of spot markets.

.

Table 1.2: Wald Test Statistic

Test Statistic	Value	Df	Probability
F-statistic	2.1972	(4, 69)	0.0783
Chi-square	8.7886	4	0.0666

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3.1.2 Spot price as the dependent variable

The equation for the VECM is represented by equation 2.3 below:

D(LNWHSPOT) = C(1)*(LNWHSPOT(-1) - 1.0140363956*LNWHFUT(-1) + 0.0933522180779) + C(2)*D(LNWHSPOT(-1)) + C(3)*D(LNWHSPOT(-2)) + C(4)*D(LNWHSPOT(-3)) + C(5)*D(LNWHSPOT(-4)) + C(6)*D(LNWHFUT(-1)) + C(7)*D(LNWHFUT(-2)) + C(8)*D(LNWHFUT(-3)) +C(9)*D(LNWHFUT(-4)) + C(10)…………………………………………………………………………..…….2.3

The study considered the coefficients in the above equation in order to establish a short run and long run relationships between wheat spot and futures prices. C (1) as stated before represents the error correction term.

Table 1.3: Coefficients of VECM for wheat prices as the dependent variable

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.85431	0.584398	1.461862	0.1483
C(2)	-0.676585	0.571959	-1.182927	0.2409
C(3)	-0.225788	0.488952	-0.46178	0.6457
C(4)	-0.034235	0.385024	-0.088916	0.9294
C(5)	0.110525	0.249923	0.442235	0.6597
C(6)	0.409778	0.522676	0.784001	0.4357
C(7)	0.072641	0.426986	0.170125	0.8654
C(8)	-0.146994	0.30275	-0.48553	0.6288
C(9)	-0.101591	0.168707	-0.602174	0.549
C(10)	0.027398	0.015225	1.799615	0.0763

***; **; * Significant at 1%; 5% and 10% levels

Table 1.3 shows that C(1) , that is, the coefficient of the error correction term is not significant, the p-value is greater than 5 percent. The p-value is 14 percent while the coefficient is (0.85431). The coefficient of the error correction term is not negative which therefore nullifies the notion that there is long run causality between wheat spot and futures prices. In simple terms, wheat future prices have no long run causality on wheat spot prices. If there was a long run causality, the error correction term will be negative hence implying that if future prices wander away they will return to equilibrium at some point in future where spot price and future price are the same. Since error correction term is positive, this hence suggests there is no long run causal relationship. In order to establish the short run relationship the null hypothesis of whether C(6); C(7); C(8) and C(9) are jointly zero is investigated using the Wald statistic. These results suggests that causality runs from spot prices to futures prices. When spot prices are the dependent variable there is no evidence of a significant relationship running from futures to spot prices. Strydom and McCullough (2013) also report similar findings suggested the price

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discovery role of spot prices. This is also supported by Kuiper et al. (2002) and Mohan and Love (2004) who also found that spot prices lead futures prices in terms of price discovery.

Table 1.4: Wald Test Statistic

Wald Test Statistic			
Test Statistic	**Value**	**df**	**Probability**
F-statistic	0.571332	(4, 69)	0.6843
Chi-square	2.28533	4	0.6834

Table 1.5: Wald Test Statistic-Short run Coefficients

Wald Test Statistic			
Normalized Restriction (= 0)		**Value**	**Std. Err.**
C(6)		0.409778	0.522676
C(7)		0.072641	0.426986
C(8)		-0.146994	0.30275
C(9)		-0.101591	0.168707

The results in Table 1.4 and Table 1.5 show that the null hypothesis whether C(6); C(7); C(8) and C(9) are jointly zero cannot be rejected since the p value and the chi-square statistic are not significant. This implies that wheat futures prices variables cannot jointly influence wheat spot prices. This result confirms earlier results (Strydom and McCullough, 2013; Mohan and Love, 2004; Kuiper et al., 2002), which point to causality running from spot to futures prices and not *vice versa*.

3.2 White Maize

3.2.1 Future prices as dependant variable

The VECM model is represented by equation 2.4. This equation represents the short run and long run relationship between white maize spot and futures prices.

D(LNWHMFUT) = C(1)*(LNWHMFUT(-1) - 1.04557263399*LNWHMSPT(-1) + 0.354996392145)+C(2)*D(LNWHMFUT(-1))+C(3)*D(LNWHMFUT(-2))+ C(4)*D(LNWHMFUT(-3)) + C(5)*D(LNWHMSPT(-1)) + C(6) *D(LNWHMSPT(-2)) + C(7)*D(LNWHMSPT(-3)) + C(8) …………………………………….2.4

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Table 1.6: Coefficients of VECM

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.5497	0.0823	-6.6778	0.0000
C(2)	-0.0650	0.0944	-0.6878	0.4936
C(3)	-0.0455	0.0941	-0.4831	0.6303
C(4)	-0.1279	0.0937	-1.3650	0.1760
C(5)	-0.5380	0.1368	-3.9316	0.0002
C(6)	-0.3850	0.1311	-2.9374	0.0043
C(7)	-0.4461	0.1298	-3.4367	0.0009
C(8)	0.0325	0.0196	1.6553	0.1017

When the maize futures price is made the dependant variable the model produces equation 2.4 above. The results of this model given in Table 1.6 report on the coefficients of white maize spot prices (which represent short run relationship if any); as well as the error correction term which represents the long run relationship if there is any. In equation 2.4 the white maize future price is the dependent variable and the white maize spot price is the independent variable. C(1) is negative and is also (Table 2.4), the p value is zero which is significant. Therefore, this means the error correction term is significant. Since the error correction term is negative (-0.549731) this suggests that the log differenced white maize spot prices have a long run causality on log differenced white maize futures prices. This therefore means that white maize spot prices Granger cause white maize futures prices in the long run. In other words, there exists long run causality from white maize spot prices to white maize future prices a finding confirmed by other scholars (Dimpfl *et al.* 2017;Strydom and McCullough, 2013; Mohan and Love, 2004; Kuiper et al., 2002). To establish the short run causality the study uses the Wald statistic test from white maize spot prices to white maize futures prices. From equation 2.4 the maize spot prices are represented by the following coefficients, C(5); C(6) and C(7). If all these coefficients jointly influence white maize future prices, then it can be concluded that there is short run causality running from spot prices to futures prices.

Table 1.7: Wald Test Statistic

Test Statistic	Value of	Df	Probability
F-statistic	7.265903	(3, 81)	0.0002
Chi-square	21.79771	3	0.0001

The result of the Wald Test statistic in Table 1.7, for the Chi-square test statistic is significant therefore we can reject the null hypothesis stated in Table 1.8. This means that C(5); C(6) and C(7) are not jointly zero. The implication of this result is that all the lags of white maize spot prices jointly Granger cause white maize future price. In other words, all the white maize

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spot price lags jointly influence futures prices. This means there is causality coming from spot prices to futures prices.

Table 1.8: Wald Test Statistic Short Run Coefficients

Null Hypothesis: C(5)=C(6)=C(7)=0		
Null Hypothesis Summary:		
Normalized Restriction (= 0)	Value	Std. Err.
C(5)	-0.5380	0.1368
C(6)	-0.3850	0.1311
C(7)	-0.4461	0.1298

The conclusion the study has arrived at from the model is that there is long run causality from spot prices to future prices. There is also short run causality from spot prices to futures prices.

3.2.2 Spot prices as the dependant variable

The equation for the VECM with white maize spot prices being the dependent variable is given below (equation 2.5)

D(LNWHMSPT) = C(1)*(LNWHMSPT(-1) - 0.95641370814*LNWHMFUT(-1) - 0.339523415787) + C(2)*D(LNWHMSPT(-1)) + C(3)*D(LNWHMSPT(-2)) + C(4)*D(LNWHMSPT(-3)) + C(5)*D(LNWHMFUT(-1)) + C(6)*D(LNWHMFUT(-2)) + C(7)*D(LNWHMFUT(-3)) + C(8)…………………………………………………2.5

Table 1.9: Coefficients of VECM for white maize spot prices as the dependant variable

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.1621	0.0834	-1.9432	0.0555**
C(2)	0.1841	0.1326	1.3886	0.1688
C(3)	-0.0103	0.1270	-0.0814	0.9353
C(4)	0.2269	0.1258	1.8033	0.0751*
C(5)	-0.0955	0.0915	-1.0431	0.3000
C(6)	-0.0975	0.0912	-1.0699	0.2879
C(7)	0.1231	0.0908	1.3560	0.1789
C(8)	0.0070	0.0190	0.3666	0.7148

Significant at 1%; 5% and 10% levels

Table 1.9 presents the results of the coefficients of the VECM. The error correction term in Table 1.9 is represented by C(1) and it is significant. It is also negative which means that there is a long run causality relationship running from futures prices to spot prices. Therefore, there is long run causality from white maize futures prices to white maize spot prices confirming the findings by

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Strydom and McCullough (2013) who investigated price discovery for white maize in South Africa as well. This is in line with findings from previous research see for example (Dimpfl *et al.* 2017, Irwin *et al*, 20009; Sanders *et al*., 2010). This suggests that price of maize is determined in the spot market and not in the futures market. The study also checked short run causality from maize futures prices to maize spot price. In the model equation, white maize futures is captured by C(5); C(6) and C(7) which are the coefficients of white maize futures. The Wald Statistic was used to check whether C(5); C(6) and C(7) jointly influence white maize spot prices or not.

Table 2.0: Wald Test Statistic

Test Statistic	Value	df	Probability
F-Statistic	1.62234	(3,81)	0.1906
Chi-square	4.867019	3	0.1818

The results of the Wald Test Statistic presented in Table 2.0 and Table 2.1 show the hypothesis that C(5),C(6) and C(7) are jointly zero. The Chi-square test statistic is not significant as well as the probability value, therefore the null hypothesis that C(5)=C(6)=C(7)=0 cannot be rejected. If we cannot reject the null hypothesis it means all the white maize future prices lag variables jointly do not influence spot maize prices. This means that all the three variables (future price lags) have no short run causality on white maize spot prices. This is similar to findings by Dimpfl et al. (2017)

The conclusion that is made from this model is that there is long run causality between white maize futures and spot prices relation running from futures to spot prices since the error correction term is significant. However, there is no short run causality between white maize future prices and white maize spot prices.

Table 2.1: Wald Test Statistic

Null Hypothesis: C(5)=C(6)=C(7)=0		
Null Hypothesis Summary:		
Normalized Restriction (= 0)	**Value**	**Std. Err.**
C(5)	-0.0955	0.0915
C(6)	-0.0975	0.0912
C(7)	0.1231	0.0908

4. Discussion

The results of the study for the wheat four week and six week horizon indicated that the futures-spot price relationship is one that is dominated by the spot prices. The results of the VECM Granger Causality test were used to confirm that there is a long run relationship between spot and futures prices. A lead lag relationship exist between spot and futures prices. The results indicated that there is indeed a short run causality from wheat spot to wheat futures prices. The study concludes that wheat spot prices embed information and properties that can be used to forecast wheat futures prices. The four week horizon as well as six week horizon price discovery results for white maize are similar to those of wheat which indicated that the spot price plays a significant role in price discovery. The VECM results of the white maize six week horizon indicated that there is long run causality from futures prices to spot prices. Therefore, white maize futures prices Granger cause white maize spot prices in the long run, however short run causality was not proven. The result found for white maize indicates that there is a bidirectional relationship in the maize market for South Africa. This bidirectional relationship occurs in the long run and may occur in swap fashion since cointegration tests only found one cointegrating equation. Chhajed *et al.*(Chhajed and Mehta, 2013) also found a bidirectional relationship for most of the nine commodities that they investigated in the Indian commodity futures market. Similar results were also reported by Silvapulle and Moosa (Silvapulle and Moosa, 1999) who reported a bidirectional relationship between crude oil spot and futures prices. Since their results indicated one cointegrating equation they concluded the pattern of the lead-lag relationship was dynamic over time. This study has found similar results, the only difference in findings is Silvapulle and Moosa (Silvapulle and Moosa, 1999) suggested that futures market play a more dominant role yet this study finds that spot prices play more dominant role in price discovery. The implication of this is that the maize contract behaves similar to some of the commodities that are traded in Indian future market. South Africa and India are both members of Brazil, Russia, India, China (BRICS) trading bloc so it is interesting that the results are comparatively similar. South Africa and India are both emerging economies and their markets may behave in a similar way. The fact that the results of this study are comparable and similar to results of other emerging market economies gives the researcher confidence in the findings.

One of the main findings of this study that adds to the body of knowledge is that spot prices lead grains futures prices in price discovery. This ambiguous findings is strongly supported by Dimpfl et al (2017) who argued that long run efficient price of agricultural commodities is determined on the spot market. The findings of this study and the one by Dimpfl et al. (2017) can be interpreted as support for the argument by Irwin et al (2009) and Sanders et al (2010) that futures speculation is not a key factor in determining commodity prices as the futures market contribute little to the efficient commodity price. Another reason that may explain this is the challenge that SAFEX APD has, that is, narrowness of trades in comparison to other international exchanges. This could explain the reason why prices are discovered in the spot market rather than the futures market. In the futures market hedgers as of 2009 dominated the market accounting for 60 percent while speculators and arbitrageurs who are supposed to induce liquidity in the market only accounted for 40 percent, which is a very low percentage, compared to global futures markets (Mbeng Mezui *et al.*, 2013).

South Africa is unlike other emerging economies like India were futures commodity exchanges have been banned at certain periods of their history because they are believed to cause volatility in spot markets (Soni, no date; Elumalai, K Rangasamy, 2009) volatility in spot markets cannot be attributed to speculation in futures market. A number of scholars have argued that futures prices do no cause volatility in spot markets, (Peck, 1976; Weaver and Banerjee, 1990; Darrat and Rahman, 1995; Alphonse, 2000; Ohemeng, Sjo and Danquah, 2016). All the same there seems to be misunderstanding with regards to the operation and role futures markets play. The spot market in South Africa leads the futures market therefore volatility in spot prices may not be attributed to speculators in futures market. The findings of this study are in contrast to findings of similar studies in US,(Brenner and Kroner, 1995b; Yang, Bessler and Leatham, 2001)) just to mention a few who found that prices are discovered in futures markets. It was only for white maize futures market where proof was found of futures market price discovery. Other scholars in the financial and agricultural economics literature who have indicated the futures price leadership role in price discovery include (Kawaller, Koch and Koch, 1987; Pizzi, Economopoulos and O'Neill, 1998; Alphonse, 2000) amongst many others.A good and clear understanding of the operation of the futures markets would ensure sustainable economic growth. The power and potential of the futures markets has been embraced in the developed countries but there is still indeed a lot of potential in emerging economies like South Africa. The conclusion reached by this study that prices are discovered in the spot markets advocates a case for futures markets to be used as a price risk management tool. Futures markets have been attacked for speculation within the markets which would result in prices in spot markets not truly reflecting market fundamentals. However, in the case of South Africa stakeholders in the grain market can make production as well as investment decisions guided by spot markets for wheat and both spot as well as future market for maize.

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