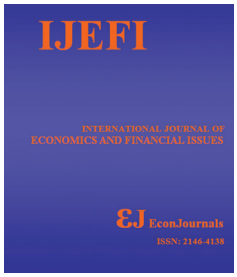


International Journal of Economics and Financial Issues

ISSN: 2146-4138

available at http: www.econjournals.com

International Journal of Economics and Financial Issues, 2022, 12(5), 57-63.

Inter-commodity Price Transmission between Maize and Wheat in South Africa

Philly Ramoroka, Chiedza L. Muchopa*

Department of Agricultural Economics, University of Limpopo, Polokwane, South Africa. *Email: chiedza.muchopa@ul.ac.za

Received: 01 May 2022 **Accepted:** 10 August 2022 **DOI:** https://doi.org/10.32479/ijefi.13033

ABSTRACT

The relevance of price transmission studies has grown in momentum in the Sub-Saharan Africa region over the last few decades especially in relation to grains that are also linked through food supply chains. Such studies give clear and insightful information into markets particularly the supply side and led to a better understanding of how sustainable supply chains can be delivered in the wake of climate change impacts. Hence, the study aimed at investigating inter-commodity producer price transmission between maize and wheat in South Africa. The study employed secondary time series data that covered a sample size of 29 years (1990-2018). Graphical trends revealed that prices of both commodities followed an upward trend although fluctuations were observed in specific periods. Granger causality tests were performed and revealed no bidirectional causality relationship between maize and wheat producer prices. However, unidirectional causality was found from maize to wheat prices. The significance of these findings is in their capacity to inform and bridge the knowledge gap in identifying patterns which can be used in interpreting price trends in maize and wheat markets (across commodities). The development of effective policies to improve marketing performance is important for sustainable supply of food.

Keywords: Agri-food, Supply Chain, Price Transmission, Maize and Wheat Prices, Granger Causality
JEL Classifications: Q13, Q11, C32

1. INTRODUCTION

Price fluctuations and uncertainties such as climate change compound the decisions that farmers have to make especially in the grain sector and particularly for maize and wheat which are seen worldwide as the most important crops produced and consumed (du Plessis, 2003; Shiferaw et al., 2011; Hellin et al., 2012; Erenstein et al., 2021; DAFF, 2013). Hellin et al. (2012) posited the importance of maize and wheat research in enhancing not only food security but climate change adaptation and mitigation research. Kwaw-Nimeson and Tian (2021) investigated the producer price-sustainability nexus in agriculture and highlighted that the producer price is an important driver of agricultural sustainability and food security. The grain industry is one of the largest sectors within agriculture that is making a major contribution to the total gross agricultural production in South Africa (The South African Oilseed and GrainIndustry and Agbiz Grain, 2015; Grain, 2019). The Department of Agriculture, Forestry and Fisheries in 2017 reported that the grain industry is the largest in South African agriculture, producing between 25% and 33% of the total gross value of agricultural production (Department of Agriculture, Forestry and Fisheries, 2017). Since its introduction in South Africa, maize production has become dominant, with 2.6 million hectares of maize commercially planted in the 2020-2021 marketing season (Donley, 2020). Wheat is also regarded as one of the most important grain crops produced in South Africa with uses ranging from mainly human consumption as bread wheat, pasta, breakfast cereals and biscuits among other products and the remaining used as seed and animal feed (DAFF, 2014). Globally, maize in the same manner as wheat, has a dual use as food and feed (Wieser et al., 2020). Specifically, for South Africa, the maize sector has a two-fold major importance as a feed and as a staple grain forming part of daily diets (DAFF, 2016; Lacambra et al., 2020).

Several reasons can be put forward on the need to focus attention on commodities such as wheat and maize. A report of World Grain in 2016 noted the complex relationship of the wheat and maize markets in which the two grains are considered to be substitutes in the pork and poultry feed grain markets and it was also reported that the relationship is dependent on prices of the commodity. Misallocation of production inputs can result if the relationships between producer prices are not well understood enough for producers to make informed decisions. Therefore, the producer price relationships of these two commodities are a key factor in market developments including the understanding on how to deliver sustainable food supply chains. Such producer price relationships need to be examined in the South African context where maize is a staple food. Inter-commodity price transmission has rarely been investigated and there have not been any studies to analyse the causality between the two variables identified for this study, therefore this study contributes to the body of literature on inter-commodity or cross-commodity price transmission. A question of importance therefore, is whether wheat producer prices drive maize producer prices or vice versa. The answer to this question is important given that most published South African related studies and elsewhere (Traub et al., 2010; Ghoshray, 2011; Acosta, 2012; Listorti and Esposti, 2012; Myers and Jayne, 2012; Kharin, 2018; Pierre and Kaminski, 2019) examining price transmission have mainly focused on single commodities across vertical, horizontal or international markets with very limited or no focus on inter-commodity or cross-commodity price transmission.

As far back as the 2000's in a South African study by Chabane (2002), high producer price increases were reported for maize and the author alluded to the theoretical expectations that there would be substitutability of outputs as producers make decisions that favour own profitability (Chabane, 2002). In separate studies (DAFF, 2019a; DAFF, 2019b) of the South African maize and wheat value chains, fluctuating trends in the values of production were reported from 2004 onwards further indicating that lower producer prices were experienced for both wheat and maize in the 2009-–2010 production season. The studies further reported an increase in the value of maize production for the seasons from 2010 to 2017 and another increase thereafter. Roughly the same trends were also observed for the value of wheat production with observations being made that the fluctuations in the value of production was based on fluctuations in producer prices (DAFF, 2019a; DAFF, 2019b). Rashid (2011) suggests that where substitutable cereals account for a large share of agricultural value added, it becomes important to understand the price relationships from a policy making perspective and this is a case in point for this present study.

As noted in De Villiers (2019), the grain industry in general which is responsible for feeding rapidly growing global populations is important to South Africa at the domestic level as well as neighbouring countries as grains demand continues to rise. Such a scenario, however, poses a lot of strain and possible price fluctuations within the grain industry. The changes occurring in one commodity sector over time could influence occurrences in the other, hence the need to examine the prices as these may be of interest to the policymakers. Luo and Tanaka (2020) allude to the existence of various studies on price transmission in food commodity markets. This present analysis falls within the context of horizontal price transmission studies and specifically across two different commodities of focus in this study. The authors have not identified studies focusing on inter-commodity price transmission in the maize and wheat markets and in general there are few studies focusing on inter-commodity price transmission in other markets, therefore this study adds to that literature. The present study bridges the gap between single commodity price transmission and inter-commodity price transmission and therefore contributes to the literature on price transmission. The analysis of single commodity markets does not give a complete understanding of the possible price relationships between commodities. Inter-commodity price transmission assists in anticipating future price relationships in related markets therefore the information will be useful to policymakers.

Vavra and Goodwin (2005) indicate that price transmission is a subject of interest in agricultural commodity markets and Karikallio (2015) stresses that stabilisation of prices is a major concern for policy makers who must deal with commodity price shock transmissions between commodities. The present paper analyses price transmission between maize and wheat in South Africa from 1990 to 2018. The objectives were to describe trends in annual producer prices for maize and wheat markets and to determine the direction of causality between maize and wheat producer prices. The analytical procedures followed included the testing of stationarity of individual price series for both commodities. The test was done using the Augmented-Dickey Fuller (ADF) technique. Secondly, the Vector Auto-regression (VAR) Lag Order Selection Criteria was used for precise specification of the VAR model suitable for VAR-based Granger Causality test. Lastly, the Granger Causality tests were then done to check the causal relationship between the price series.

The paper is organised as follows. The next section is a presentation of the review of price transmission studies. Section 3 presents data and methodology while, section 4 presents the results and discussions. Section 5 presents the study conclusions.

2. REVIEW OF PRICE TRANSMISSION STUDIES

Price transmission studies focused on different commodities is important as an input to policy makers who have to develop policies for substitute or complementary products. Saadi (2011) in explaining the drivers of inter-commodity price transmission, identified the notion of product substitutability and complementarity relations. In this regard, price transmission theory contributes to the understanding of the extent of the efficiency with which price information functions between markets (Abdulai, 2007; Bergmann et al., 2016; Nzuma and Kirui, 2021). As noted in Wang and He (2018), transmission of prices between markets is also important to reflect the production cost between commodities, however Saadi (2011) qualifies that cost as a driver of price transmission among other financial market drivers, applies to the transmission of prices from non-agricultural to agricultural commodities. Changes in one market may or may not have an effect on other markets. The seminal work of Schwartz and Willett (1994) explains that

price transmission examines how changes in one market affects changes in other markets and the article teases out the common factors of causality, lags, asymmetry and market structure that are taken into consideration. Though price transmission is analysed in different vertical and horizontal contexts, Listorti and Esposti (2012) noted that although the theoretical explanations of price transmission differ, the methods of analysis are common and the review of literature below demonstrates the same.

The focus of this present study is on producer price variables in two different markets and as such this is one of the cases of horizontal price transmission. The changes in prices between markets may reflect market power (Zlatcu, 2015). Price transmission explains the nature of relationships of price series in different markets of market levels and can also be a factor in the success of reforms in the market (Abdulai, 2007). In the price transmission model the actions of different market agents or participants are reflected. The implication of inter-commodity price transmission is that any necessary price policy reforms have to take cognisance of the response of shocks in one market emanating from another given that demand may shift according to the price changes as noted in Karikallio (2015). Price stabilisation as a policy mechanism would therefore benefit from evidence based research that emanates from studies of inter-commodity price transmission.

Using the Vector Autoregression Model, Kharin (2018) investigated vertical price transmission along the milk supply chain in the Russian market. With the use of the cointegration technique, the study found bidirectional Granger causality from farm to retail prices and vice versa. However, the response of the farm-gate price to a change in retail price was greater and slightly longer than the price response of the retail price to a change at the farm level. It is reported in the study that the findings support the assumption that price changes are not transmitted efficiently from one level to another. On vertical price transmission of the integrated broiler market in Malaysia, the study of Muazu et al. (2014) examines how price changes are transmitted between farm-wholesale-retail market levels of broiler meat in Peninsular Malaysia. Having used cointegration technique to examine whether a long run relationship between the price indices exists, the results indicated there is long run equilibrium relationship between the market price levels. The formal test of asymmetry proved symmetric retail-wholesale price transmission and asymmetry behaviour for retail to farm. Zlatcu (2015) though focusing on wheat and maize in Romania differs from the present study in that the focus of analysis was on price transmission from international prices into domestic prices. The study concluded that the international prices of the two commodities move together with their corresponding domestic prices following the international prices and the authors confirmed a long term relationship between the domestic and international prices using the Vector Error Correction Model (ECM). The study of Zlatcu (2015) does not analyse inter-commodity price transmission for these two commodities. Price risk is another aspect of importance studied in commodity markets as demonstrated in the study of Singh et al. (2005) that used ADF test and error correction mechanisms to conclude on the existence of price convergence showing that there is price risk mitigation in wheat and maize spot and futures price contracts in India.

Various economic insights on cross commodity price transmission are outlined in past studies such as Rashid (2011), Karikallio (2015), Bergmann et al. (2016), Zungo (2017), Ruranga et al. (2018) and Putra et al. (2021). Analysing inter-commodity price transmission in Ethiopian cereal markets Rashid (2011) concluded that markets in the major grain producing regions are integrated and that maize is the most important of the three cereals, followed by wheat and then teff. Moreover, while shocks to both maize and wheat have significant long-run impacts on each other, these do not transmit to teff markets. On analysis of inter-commodity price transmission of maize and rice for Tanzania, Zungo (2017), asserted that prices follow an upward trend though there are fluctuations in specific periods. The trend reported in the study displayed some co-movement with the price variation consistently high in all the markets for maize and rice. The ECM revealed that many of the market pairs denied price transmission between the two commodities in the short run with lags of three months. Bidirectional causality was observed between the two commodities in many cases rather than unidirectional causality. Karikallio (2015), analysed horizontal cross-commodity price transmission and integration of the EU livestock market of pork and beef. The study utilised panel time-series techniques with monthly data on pork and beef prices in the EU seeking to investigate whether or not there are long-term and short-term relationships between pork and beef prices. The results revealed that there exists bi-directional relationship between pork and beef prices in the EU in long run. However, in the short run the study finds evidence of price transmission from pork to beef prices and not the other way around. The position in the article of Bergmann et al. (2016) shows that at a global level in the analysis of price and volatility transmission in butter, palm oil and crude oil markets using VAR models combined with a multivariate GARCH model, there are strong price and volatility transmission effects between the EU and World butter prices. While the EU butter shocks further spill over to palm oil volatility, the study also shows evidence that palm oil prices spill over to World butter prices and World butter volatility. Ruranga et al. (2018), analysed a spatial price transmission of beans and rice markets in Rwanda using Granger causality tests and the study found a unidirectional Granger causality between prices in varying markets whereas for retail prices of rice there was a bidirectional Granger causality.

This present study is therefore informed by previously conducted studies focused on price transmission within market levels for a range of commodities. The studies on inter-commodity price transmission are not focused between maize and wheat producer prices and there is not enough information about the maize and wheat in the grain industry price transmission in South Africa. Thus, the present study is well placed to provide some market insights of the grain market in South Africa and to fill the information gap. Two output products (maize and wheat) for which producers possibly make output production decisions on the basis that the products can be substitutable in production are considered and as noted in Chabane (2002), producer decisions are price based among other factors, hence this study estimates the price transmission between these two outputs to give an insight into production decisions. The primary interest of this present study is to therefore determine whether there is unidirectional or

bidirectional causality between the two products following the Granger causality framework relevant to price transmission studies and elaborated in past studies reviewed above.

3. DATA AND METHODOLOGY

Historical secondary time series data used in this study was obtained from the Department of Agriculture, Land Reform and Rural Development formerly the Department of Agriculture, Forestry and Fisheries (DAFF). Annual data of a 29-year timeframe from (1990 to 2018) was covered for wheat and maize producer prices. The analysis was done with the use of EViews 11. The study employed descriptive and econometric analysis to analyse data collected and to examine the relationship between the producer prices of maize and wheat grains in South Africa. Descriptive analysis trends for the two commodities were described with the use of graphs while econometric analysis determined the direction of causality for both commodities with the use of the Granger Causality test. The descriptive statistics of the data on maize and wheat producer prices are reported in Table 1.

In contrast to wheat, the mean producer price for maize is low and the summary statistics indicate that mean prices are higher for the wheat price series. The standard deviation is larger for the wheat price showing that it is more volatile than the maize price.

After a graphical presentation of the time series variables, inter-commodity price transmission was tested within the framework of techniques illustrated in Figure 1 and described below as follows (i) testing for stationarity of the time series variables, (ii) differencing the variables that were found non-stationary and checking the order of integration of the variables, (iii) automatic selection of the lag order to implement the Granger causality test in a VAR framework.

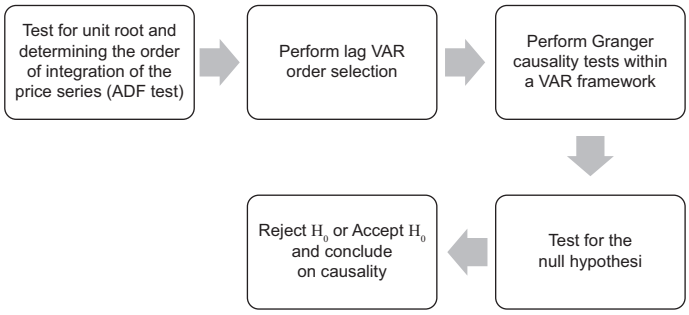
3.1. Investigating the Unit Root

The ADF test (ADF) were used on producer prices of both commodities to legitimately determine whether the price series contained a unit root. Vavra and Goodwin (2005) detailed that a variable contains a unit root if it is non-stationary. In an event where the variables are non-stationary, they must be transformed first in order to proceed with the econometric analysis.

Table 1: Descriptive statistics for maize and wheat producer prices (Rands/ton) in South Africa (1990-2018)

	Mean	Std.	Min	Max
Maize	1249.58	825.53	304.00	3649.03
Wheat	1791.84	1075.29	521.43	3772.44

Figure 1: Framework for price transmission analysis. Source: Authors' presentation based on literature reviewed in the text



3.2. Analytical Techniques to Investigate the Causal Relationship

Given the notion elaborated in Goshray (2011) wherein price transmission is described as the effect of prices in one market on the prices of another market, this study uses the Granger Causality to determine the direction of causality for both commodities. Following the stationarity test on individual price series for both commodities and determining the degree of integration, lag order selection was conducted. To help the precise specification of the VAR model, according to Granger (1969), optimal lag length tests should be estimated before Granger causality tests. The VAR Lag Order Selection Criteria was used to automatically make the selection. The Granger Causality Test was then done to check the causal relationship between the price series.

The autoregressive model of two variables established are:

$$PPoM_t = \alpha + \sum_{j=1}^{p} \beta_j (PPoM)_{t-j} + \sum_{j=1}^{p} \partial_j (PPoW)_{t-j} + E_1(t) \quad (1)$$

$$PPoW_t = \theta + \sum_{j=1}^{p} \varnothing_j (PPoM)_{t-j} + \sum_{j=1}^{p} \varphi_j (PPoW)_{t-j} + E_2(t) \quad (2)$$

p is the optimal lag length.
E is the error term.
PPoM is producer price of maize measured in Rands per ton.
PPoW is producer price of wheat measured in Rands per ton.
t is trend term
β, ø, ∂, ϕ are coefficients.

Having selected the optimal model VAR (p) which minimises the Akaike (AIC), Shwarz-Bayesian (BIC) and Hannan-Quinn (HQ) lag selection criteria, Granger causality is evaluated based on the following equations following Granger (1969).

$$PPoM_t = c_1 + b_1(PPoM)_{t-1} + b_2(PPoM)_{t-2} \ldots b_p (PPoM)_{t-p} + a_1 (PPoW)_{t-1} + a_2 (PPoW)_{t-2} \ldots a_p (PPoW)_{t-p} + u_t \quad (3)$$

The hypothesis test is that, wheat producer price (PPoWt) does not Granger-cause maize producer price (PPoMt) such that the coefficients of the lags of one of the producer prices are jointly equal to zero in the equation of the other producer price variable.

$$H_0: a_1 = a_2 = .. a_p = 0 \quad (4)$$

$$H_1: a_i \neq 0 \quad (5)$$

4. RESULTS AND DISCUSSION

The results of the techniques used to test different components of price transmission are reported below including the graphical trends.

4.1. Graphical Trends

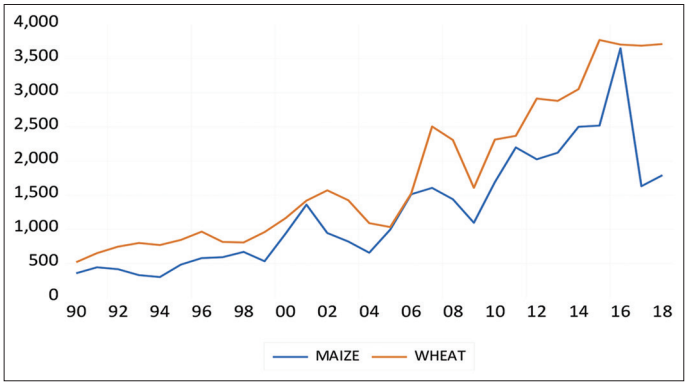
The graph shows upward and downward trends for both maize and wheat prices and an upward trend in prices over time. The visual inspection shows that the wheat prices are higher than the maize prices. Maize prices do fluctuate but under wheat prices. The price trends also show how the commodities are also connected to markets globally manifesting thorough the observed sharp spike in prices in the period 2007-2008 which is associated with the global financial and food crisis. The maize prices showed a drastic declining between 2017 and 2018. This is attributed to the low production in 2016-2017 that caused shortage of maize in the market (Grain, 2019). The relative prices for wheat and maize shown in Figure 2 slope upwards indicating that wheat is becoming more expensive than maize over the years. This has been explained on the basis of South Africa's agricultural markets deregulation that drastically impacted the agricultural commodities, such as wheat (Esterhuizen, 2020). In the long run the price series do not show a stable relationship, and this is confirmed through the ADF test for stationarity and an economic interpretation of the movements is given in the section 4.2 below on econometric analysis and on causality.

4.2. Econometric Analysis

The VAR model was implemented to study the causality between maize and wheat prices. The results of the ADF test for stationarity are presented in Table 2.

The ADF tests conducted for both price series covering the period from 1990 to 2018 prove that both variables had a unit root at level form. Hence, the null hypothesis was not rejected at 1%, 5% and 10% levels of significance. This was due to the ADF test statistic values of maize and wheat prices showing a greater value than the Mackinnon critical values for rejecting the null hypothesis of a unit root. The Durban Watson (DW) Statistics are all significant enough to reject the presence of serial correlation in each of the series showing reliability. Thus, maize and wheat producer prices are non-stationary. These findings are consistent with other studies (Ghoshray, 2011; Wang and He, 2018) where time series variables were found to be non-stationary. Vavra and Goodwin (2005) asserted that the transformation of non-stationary economic time series data by differencing or de-trending is required, otherwise the results would be spurious. Following Vavra and Goodwin (2005), both variables were differenced, tested for stationarity and the results in Table 2 show that the null hypothesis at first difference was rejected, signifying that there is no unit root. Thus, it can be concluded that the series of prices were stationary at first differences.

Figure 2: A line graph for maize and wheat price trends



The lag length selection was conducted to select the number of observations to use in making the predictions in the VAR framework and the results are presented in Table 3.

Based on each of the following lag order selection criteria – AIC, SC and HQ, the lag that is associated with the minimum value is 2. Table 4 presents Granger Causality test results for maize and wheat producer prices.

The P = 0.1279 is more than 5% so the null hypothesis that wheat producer price does not Granger cause maize producer price cannot be rejected; the null hypothesis is accepted. On the other hand, the P = 0.0121 is significant and the hypothesis that maize producer price does not Granger cause wheat producer price is rejected. The results show a causal relationship between wheat prices and maize prices from a unidirectional way. Therefore, maize producer prices Granger cause wheat producer prices and not the other way. The results are consistent with Wang and He (2018). The producer price of maize is already lower than the producer price of wheat in South Africa and the possible implication for the direction of flow is that, when the maize producer price rises farmers likely make decisions to produce more maize thus limiting the land under wheat cultivation resulting in increased wheat producer prices when wheat production decreases. It has also been shown in Midgley (2016) that the area under wheat cultivation in South Africa declined between 2004 and 2013. The present study's findings on causality have a further implication for policy that, wheat policies need to be considered in the national context given that the relationship identified is of interest not only to the wheat producer industry participants but consumers that may face food security challenges due to price volatility. Therefore, policymakers need to consider wheat prices when considering maize prices because of implications on food production if prices changes were to induce substitutability in production of grains. This is mentioned in the study of Bergmann et al. (2016) characterising unwanted consequences for food production where a rise in the price of one commodity may lead to a reduction in supply of another commodity. In addition, Singh et al. (2005) asserted the notion of price risk management in wheat and maize futures markets due to price convergence of these two commodities.

The results of this present study are however not confirmed by all studies reviewed (Rashid, 2011; Karikallio, 2015; Bergmann et al., 2016; Zungo, 2017; Ruranga et al., 2018; Putra et al., 2021)

Table 2: Augmented Dickey-Fuller (ADF) unit root testing results for maize and wheat (Levels and 1st difference)

Variables	ADF statistic at levels	P-value at levels	DW stat	ADF statistic 1st difference	P-value at 1st difference	DW stat
Maize price	0.83216	0.3720	2.416726	–4.430036	0.0003*	1.759783
Wheat price	2.933139	1.0000	2.339080	–5.189227	0.0000*	2.187610

Table 3: Vector auto regressive lag order selection criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	–424.3485	NA	1.78e+11	31.58137	31.67736	31.60991
1	–391.0090	59.27020	2.03e+10	29.40808	29.69604	29.49370
2	–382.5303	13.81711*	1.47e+10*	29.07632*	29.55626*	29.21903*

*Indicates lag order selected by the criterion, LR: sequential modified LR test statistic (each test at 5% level) FPE: Final prediction error, AIC: Akaike information criterion, SC: Schwarz information criterion, HQ: Hannan-Quinn information criterion

Table 4: Results of the Granger causality test

Null hypothesis	F statistic	Df (lags)	Prob.	Decision
Wheat producer price does not Granger cause maize producer price	2.26086	2	0.1279	Do not reject
Maize producer price does not Granger cause wheat producer price	5.42769	2	0.0121	Reject

as some show bidirectional causality in some instances with differences that can also be commodity and country specific. This revelation therefore supports context specific studies such as the present study given that findings from price transmission studies in their multiplicity cannot be generalised to differing contexts. Various types of price failures which are not the focus of this study can also affect markets and further investigation can be conducted in future studies.

5. CONCLUSIONS

The primary purpose of the study was to provide information on inter-commodity price transmission between maize and wheat market. The graphical trends indicated an upward trend for both commodities and test for stationarity was done before analysing price transmission. The optimal lag length tests generally chose two lags for both maize and wheat which were used for Granger causality tests. The test suggested that maize Granger cause wheat prices and that wheat does not Granger cause maize price revealing that there is no bidirectional causality relationship between maize and wheat producer prices. Maize producer prices in South Africa can therefore be used to forecast wheat producer prices. The study recommends that maize producer price policies should take cognisance of the possible substitutability of production between wheat and maize given that maize prices Granger cause wheat prices. The wheat industry is already vulnerable to international market forces given the reliance on imports and thus strategic responses are needed to maintain food security given that the wheat value chain contribution to wheat based staple food such as bread.

REFERENCES

Acosta, A. (2012), Measuring spatial transmission of white maize prices between South Africa and Mozambique: An asymmetric error correction model approach. African Journal of Agriculture and Resource Economics, 7(1), 1-13.

Bergmann, D., O'Connor D., Thummel, A. (2016), An analysis of price and volatility transmission in butter, palm oil and crude oil markets. Agricultural and Food Economics, 4(23), 1-13.

Chabane, N. (2002), An Evaluation of the Influences on Price and Production in the Maize Market Following Liberalisation. In TIPS Forum. Available from: https://www.tips.org.za/files/566 [Last accessed on 2021 Oct 27].

De Villiers, J. (2019), The State of the Grain Industry. Nation in Conversation News. South Africa: AFGRI Services. Available from: https://www.afgri.co.za/tag/nampo-2019 [Last accessed on 2021 Aug 11].

Department of Agriculture, Forestry and Fisheries (DAFF). (2013), Trends in the Agricultural Sector. Pretoria, South Africa: Department of Agriculture, Forestry and Fisheries. p3-5.

Department of Agriculture, Forestry and Fisheries (DAFF). (2014), A Profile of the South African Wheat Market Value Chain. Pretoria, South Africa: Department of Agriculture, Forestry and Fisheries. p9-19.

Department of Agriculture, Forestry and Fisheries (DAFF). (2017), A Profile of the South Africa Maize Market Value Chain. Pretoria, South Africa: Department of Agriculture, Forestry and Fisheries. p1-5.

Department of Agriculture, Forestry and Fisheries (DAFF). (2019a), A Profile of the South African Maize Market Value Chain. Pretoria, South Africa: Department of Agriculture, Forestry and Fisheries. p1-5.

Department of Agriculture, Forestry and Fisheries (DAFF). (2019), A Profile of the South African Wheat Market Value Chain. International Trade Administration Commission (ITAC). Pretoria, South Africa: Department of Agriculture, Forestry and Fisheries. p1-4.

Donley, A. (2020), South Africa Planting More Corn in 2020-21. Available from: https://www.world-grain.com/articles/14446-south-africa-planting-more-corn-in-2020-21 [Last accessed on 2021 Oct 27].

Du Plessis, J. (2003), Maize production. Department of Agriculture, Directorate Agricultural Information Services with ARC-Grain Crops Institute. p1-5.

Erenstein, O., Chamberlin, J., Sonder, K. (2021), Estimating the global number and distribution of maize and wheat farms. Global Food Security, 30, 100558.

Esterhuizen, D. (2020), South African Wheat Prices Reach Record High Levels. Grain and Feed. Pretoria, South Africa: United States Department of Agriculture, Foreign Agricultural Services.

Ghoshray, A. (2011), Underlying Trends and International Price Transmission of Agricultural Commodities. Manila, Philippines: ADB Economics Working Paper Series No. 257.

Grain, S.A. (2019), Agri SETA. Available from: https://www.agriseta.co.za/wp-content/uploads/2021/02/grain.pdf [Last accessed on 2021 Aug 10].

Granger, C.W.J. (1969), Prediction with a generalized cost of error function. Operational Research Society, 20(2), 199-207.

Hellin, J., Shiferaw, B., Cairns, J., Reynolds, M. (2012), Climate change and food security in the developing world: Potential of maize and wheat research to expand options for adaptation and mitigation. Journal of Development and Agricultural Economics, 4(12), 311-321.

Karikallio, H. (2015), Cross-Commodity Price Transmission and Integration of the EU Livestock Market of Pork and Beef: Panel Time-Series Approach. Milan, Italy: Abstract No. 211832 of International Association of Agricultural Economists Conference. p9-14.

Kharin, S. (2018), Price transmission analysis: The case of milk products in Russia. AGRIS on-line Papers in Economics and Informatics, 10(1), 15-23.

Kwaw-Nimeson, E., Tian, Z. (2021), The impact of agricultural producer price on sustainable food security in Africa-a system GMM approach. Agricultural Resource Economics, 7(3), 60-76.

Lacambra, C., Molloy, D., Lacambra, J., Leroux, I., Klossner, L., Talari, M., Cabrera, M.M., Persson, S., Downing, T., Downing, E., Smith, B. (2020), Factsheet Resilience Solutions for the Maize Sector in South Africa. Washington, DC.

Listorti, G., Esposti, R., (2012), Horizontal price transmission in agricultural markets: Fundamental concepts and open empirical issues. Bio Based and Applied Economics, 1(1), 81-96.

Luo, P., Tanaka, T., (2021), Food import dependency and national food security: A price transmission analysis for the wheat sector. Foods, 10(8), 1715-1725.

Midgley, S.J.E., (2016), Commodity Value Chain Analysis for Wheat. WWF-SA: South Africa. Available from: https://www.awsassets.wwf.org.za/downloads/wwf_pfu_commodity_report___dairy__lowres_.pdf [Last accessed on 2021 Dec 15].

Myers, R.J., Jayne, T.S., (2012), Multiple-regime spatial price transmission with an application to maize markets in Southern Africa. American Journal of Agricultural Economics, 94(1), 174-188.

Nzuma, J.M., Kirui, P.K., (2021), Transmission of global wheat prices to domestic markets in Kenya: A cointegration approach. African Journal of Agricultural and Resource Economics, 16(1), 80-93.

Pierre, G., Kaminski, J., (2019), Cross country maize market linkages in Africa: integration and price transmission across local and global markets. Agricultural Economics, 50(1), 79-90.

Putra, A.W., Supriatna, J., Koestoer, R.H., Soesilo., T.E.B., (2021), Differences in local rice price volatility, climate, and macroeconomic determinants in the Indonesian market. MDPI Sustainability, 13(1), 4465.

Rashid, S. (2011), Inter-Commodity Price Transmission and Food Price Policies: An Analysis of Ethiopian Cereal Markets. Vol. 11. The International Food and Policy Research Institute (IFPRI) Discussion Paper. The Ethiopia Strategy Support Program II (ESSP II) Working Papers. p7-20.

Ruranga, C., Mugenzi, M., Mutabazi, A. (2018), A Spatial Price Transmission Analysis of Beans and Rice Markets in Rwanda. East Africa Collaborative Ph.D. Program in Economics and Management. East Africa Research Papers in Economics and Finance. Vol. 25. Sweden: Jönköping University. p8-24.

Saadi, H., (2011), Price co-movements in international markets and their impacts on price dynamics. In: Methods to Analyse Agricultural Commodity Price Volatility. New York: Springer. p149-163.

Schwartz, L.A., Willett, L.S. (1994), Price Transmission Theory and Applications to Agroindustry: An Annotated Bibliography. Available from: https://www.ecommons.cornell.edu/handle/1813/65411 [Last accessed on 2021 Nov 15].

Shiferaw, B., Prasanna, B. M., Hellin, J., Banziger, M. (2011), Crops that feed the world 6. Past successes and future challenges to the role played by maize in global food security. Food Security, 3(3), 307-327.

Singh, N.P., Kumar, R., Singh, R.P., Jai, P.K. (2005), Is futures market mitigating price risk: An exploration of wheat and maize market. Agricultural Economics Research Review, 18(1), 35-46.

South African Grain and Oilseed Industry and Agbiz Grain (2015). The South African grain and oilseed industry. Available from: https://agbiz.co.za/uploads/AgbizNews/15115_Grainpublication.pdf [Last accessed 2021 Aug 10].

Traub L.N., Myers, R.J., Jayne, T.S., Meyer, F.H. (2010), Measuring Integration and Efficiency in Maize Grain Markets: The Case of South Africa and Mozambique (No. 308-2016-5051). Available from: https://www.ageconsearch.umn.edu/record/96644 [Last accessed on 2021 Nov 02].

Muazu, U.A., Mohamed, Z., Mad Nasir, S., Ismail, A. (2014), Vertical price transmission: A case of integrated Malaysian broiler industry. Global Journal of Science Frontier Research, 4(5),1-9.

Vavra, P., Goodwin, B.K. (2005), Analysis of Price Transmission along the Food Chain. Paris: OECD Food, Agriculture and Fisheries Papers.

Wang, L., He, P. (2018), Empirical study on the relationship between the price of maize and wheat. Asian Journal of Agricultural Resource, 10(7), 26-28.

Wieser, H., Koehler, P., Scherf, K.A. (2020), Wheat-an Exceptional Crop: Botanical Features, Chemistry, Utilization, Nutritional and Health Aspects. Amsterdam: Elsevier.

World Grain. (2016), Corn-Wheat Price Relationship Complicates Wheat Market. India: World Grain. Available from: https://www.world-grain.com/articles/6084-corn-wheat-price-relationship-complicates-wheat-market [Last accessed on 2021 Oct 27].

Zlatcu, I. (2015), Price Transmission in the Romanian agricultural Sector. Paper Presented at Romanian Association of Economic Faculties International Conference Development as Purposed of Human Action. Romania: Bucharest. p20-21. Available from: https://www.store.ectap.ro/suplimente/international_conference_development_as_purpose_of_human_action_nov_2015.pdf#page=97 [Last accessed on 2021 Nov 24].

Zungo, S. (2017), Inter-commodity price transmission: An Analysis of Tanzanian Maize and Rice Markets. Morogoro, Tanzania: Dissertation submitted in the degree of Master of science in Agricultural economics of Sokoine University of Agriculture.