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The Linkage between Governments' COVID-19 Response Measures, Real Exchange Rate, and Grain Prices in South Africa

Moses Herbert Lubinga*, Fezeka Matebeni, Corné Dempers, Ndiadivha Tempia

Markets and Economic Research Centre, National Agricultural Marketing Council, Pretoria, South Africa

Abstract: Coronavirus disease (COVID-19) outbreak disrupted global supply chains as countries imposed various response measures to contain the spread. This paper examines the nexus between governments' COVID-19 response measures, real exchange rate, and prices of wheat and maize in South Africa. We used daily data, spanning from February 07 until September 25, 2020, for the stringency index, import parity, and South African Futures Exchange (SAFEX) prices of maize and wheat. We considered South Africa's major suppliers of wheat and maize, i.e., Argentina, Germany, and the United States (US). Maize was disaggregated into two categories, namely: white and yellow maize. Both descriptive and Pearson correlation analyses were used to establish the nexus. Findings suggest that COVID-19 response measures are associated with the observed depreciation of South Africa's Rand against the US Dollar and the spikes in SAFEX prices of wheat and maize. Furthermore, results reveal a moderate to a strong positive relationship between South Africa's real exchange rate and the prices of wheat and maize. However, consumers' increases in wheat and maize prices were borne, as exhibited in higher retail prices observed in South Africa between February and September 2020. Results also reveal a strong nexus between the levels of strictness imposed by the different countries. Therefore, imposing very strict measures in one country tends to lead to similar strict measures in other countries. The significance of the results in minimizing the COVID-19 outbreak is twofold. First, countries may consider revisiting the restrictive response measures put in place, given that the measures affect supply chains in other countries. Second, South Africa needs to diversify the sources from which it imports maize and wheat.

Keywords: food price inflation, import parity price, National Agricultural Marketing Council, SAFEX Price, South African Grain Information Service.

南非政府的新冠肺炎應對措施、實際匯率和糧食價格之間的聯繫

摘要: 冠狀病毒病 (新冠肺炎) 的爆發擾亂了全球供應鏈，因為各國採取了各種應對措施來遏制這種傳播。本文研究了南非政府的 新冠肺炎應對措施、實際匯率以及小麥和玉米價格之間的關係。我們使用了 2020 年 2 月 7 日至 9 月 25 日的每日數據，用於玉米和小麥的嚴格指數、進口平價和南非期貨交易所 (國家外匯管理局) 價格。我們考慮了南非小麥和玉米的主要供應國，即阿根廷、德國和美國。玉米分為兩類，即：白玉米和黃玉米。描述性和皮爾遜相關分析都用於建立聯繫。調查結果表明，新冠肺炎應對措施與觀察到的南非蘭特兌美元貶值以及小麥和玉米 國家外匯管理局價格飆升有關。此外，結果顯示南非的實際匯率與小麥和玉米價格之間存在適度至強的正相關關係。然而，小麥和玉米價格的上漲由消費者承擔，正如南非在 2020 年 2 月至 9 月期間觀察到的零售價格上漲所表明的那樣。結果還顯示，不同國家實施的嚴格程度之間存在密切聯繫。因此，在一國實施非常嚴格的措施往往會導致其他國家採取類似的嚴格措施。結果在最大限度地減少 新冠肺炎爆發方面的重要性是雙重的。首先，鑑於這些措施影響到其他國家的供應鏈，各國可能會考慮重新審視已實施的限制性應對措施。其次，南非需要使其進口玉米和小麥的來源多樣化。

关键词： 食品價格通脹、進口平價、國家農業營銷委員會、國家外匯管理局價格、南非糧食信息服務。

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About the authors: Moses Herbert Lubinga, Ph.D., Fezeka Matebeni, MSc, Corné Dempers, MSc, Ndiadivha Tempia, Ph.D., Markets and Economic Research Centre, National Agricultural Marketing Council, Pretoria, South Africa

Corresponding author Moses Herbert Lubinga, moseslubinga@yahoo.co.uk, hlubinga@namc.co.za

1. Introduction

Since November 2019, the outbreak of coronavirus responsible for the disease known as COVID-19 has been ravaging several countries, irrespective of whether a country is regarded as developed or not. Many countries imposed various response measures to ensure that citizens are food secure, including lockdowns [1-3] coupled with temporary trade restrictions on some agricultural products, entailing cereals, fruits, and vegetables. The COVID-19 outbreak occurred at a critical time amid a raging global oil-price war between Russia and other oil producers, while on the other hand, China and the United States (US) were battling in trade wars. These shocks compounded the pressure on the global systems, including agriculture, financial, health, and trade sectors. The straining situation inevitably spilled to disrupt global supply chains, hence the worst recession since the Great Depression as reported by [3].

The spread of COVID-19, fluctuating exchange rate, and the oil-price war have been noted to be key drivers of commodity prices, although it is still early to ascertain the full impact of the pandemic on the global economy. However, the National Agricultural Marketing Council [4] associated the higher food price inflation (4%) in 2020 compared to 3.1% food inflation of 2019 to an increase in meat prices and other food products rather than the pandemic. In South Africa, as President Cyril Ramaphosa declared a national state of disaster on March 16, 2020, thereby imposing restrictions on schools and borders, among other measures in a bid to contain the spread of the disease, the Africa All-Share Index at Johannesburg Stock Exchange (JSE) dropped by 12%, the biggest decline ever since August 2013 [5]. At the same time, the Rand lost value by 2.2% against the United States (US) Dollar. At the time, South Africa's economy was also internally struggling due to power shortages, the unsustainable national carrier (South African Airways), and the weak business confidence, among other factors. Hence, the president indicated that

"It is going to harm our economy, our economy which is already in a technical recession".

In response to the pandemic, many sectors within the economy, except for agriculture, to a great extent, reduced their activities to a bare minimum. Activities within the agricultural sector were generally permitted to go on smoothly to ensure continued production and supply of food as the sector is considered an essential service. However, South Africa imposed restrictions on the sale, distribution, and consumption of some non-essential products, including alcoholic beverages and tobacco products directly linked to primary agricultural products like wine grapes, barley, and tobacco. Due to the backward and forward linkages in the sector, the ban on the sale, distribution, and consumption of alcoholic beverages was reported to affect not only the wine and beer industries but also other value chain actors including, tavern owners, restaurateurs, and firms that make packaging materials like glass bottles and cans. The wine industry reckoned that the ban on local sales during levels 5 and 4 of the lockdown resulted in losing more than 20% of market share, translating into revenue losses of over R4.5 billion, and the industry shed over 18 000 jobs [6, 7]. After that, the restriction on the sale, distribution, and consumption of alcoholic beverages was relaxed on conditions that distributors and consumers adhered to certain regulations.

Beyond South Africa, some countries including, Russia, Colombia, Oman, Nigeria, and the Eurasian Economic Union, imposed temporary trade measures on wheat and maize. This is a unique case for South Africa to scrutinize the nexus between the imposed measures, real exchange rate, and the price of wheat and maize. It is important to note that maize and wheat are key staple foods in South Africa. In 2020, South Africa's annual per capita consumption of maize was estimated at 90 kilograms (kg) per person, while wheat stood at 55 kg per person [8]. A 2021 report by the South African Grain Information Services (SAGIS) indicated that annual wheat consumption in South Africa increased by 41.6% from 2.4 million tons in 2000/01 to 3.4 million tons in 2019/20. South Africa is a net importer of wheat but a net exporter of maize.

South African supply and demand estimates of August 2020 show that the total supply of white maize during the 2020/21 marketing season was estimated at 9.27 million tons, while yellow maize was projected at about 6.67 million tons [9]. On the other hand, the total wheat supply during the same marketing season was projected at 3.98 million tons. South Africa is projected to export 1.17 million tons and 1.37 million tons of white and yellow maize. However, neither white nor yellow maize is projected to be imported into the country. South Africa anticipated importing about 1.7 million tons of wheat while exports were projected at 0.135 million during the 2020/21 marketing season [9].

1.1. What is Known So Far?

There is a fast-growing body of anecdotal evidence on how the pandemic affected agriculture and the food system in South Africa, but little empirical work has been done to substantiate this. Therefore, the reviewed literature focuses on the agricultural sector and the food system, entailing anecdotal evidence and empirical studies. Broadly, the imposed measures in response to the pandemic significantly disrupted the agri-food supply chains. Due to the restrictions on the movement of people, disruptions were more eminent at the food processing, distribution, retailing, and consumption stages along the supply chain [10].

At the production phase, there was minimal disruption since most activities are mechanized amongst the large-scale farmers. However, in the case of the smallholder farmers, disruptions arose as laborers could not easily go to farms because of the restrictions during lockdown level 5. Furthermore, at the time (March 2020) when lockdown measures were imposed in South Africa, most summer crops (wheat and maize inclusive) had almost reached the harvesting stage. Hence there was a negligible effect. Based on secondary data obtained from SAGIS, the volume of white maize delivered by producers was slightly below the usual average compared with the deliveries during recent years. This suggests that the disruptions due to the COVID-19 pandemic had minimal effect on the quantities of white maize delivered by farmers.

During the weeks early into the lockdown, the demand for basic food items increased due to panic buying as consumers were very much uncertain how long the lockdown would last, thereby spurring a spike in prices. For instance, disruptions led to short-term shortages of cereal products, including maize meals in retail shops in some parts of the country [11, 12]. However, by late June 2020, the prices of some basic food items had dropped back to almost the pre-COVID-19 situation, while the volume of processed white maize had increased by over 10% compared to the volume processed in May 2020. According to SAGIS data, a higher volume of white maize was processed in March 2020, possibly due to the high demand in preparation for the lockdown, but during the subsequent months, the quantities processed dropped. The decline was possibly due to the restricted movement, coupled with the requirement that travelers (employees in this case) had to present a travel permit which could not be issued to some workers during level 5 of the national lockdown.

Based on data from Statistics South Africa [13] and using 2015 as a baseline, the food manufacturing and beverages industry registered a drastic drop in the volume of food and beverages manufactured during the hard lockdown in April 2020. However, as the lockdown measures were eased in the subsequent months, the volumes processed rose again.

Unlike in 2019 and the other years, food production capacity in 2020 (specifically during the first two quarters) was below the average, according to data from Stats SA. This observation was attributed to the low demand. For instance, the low demand for non-alcoholic drinks was attributed to restricting the hospitality industry from trading while keeping in mind that a total ban on the sale, distribution, and consumption of alcoholic drinks had also been imposed during level 5 of the lockdown.

About trade, as the fear of contagion increased among the people and in some instances, employees testing positive for COVID-19 at food retail stores coupled with fewer customers visiting the outlets, some shops closed down [14, 15]. Closing shops not only affected the quantities of agricultural products sold but also contributed to the rise in the price of basic staple food items, given the uncertainty of the extent of damage the pandemic would cause. According to [16, 17], prices of basic food items were greatly affected by the pandemic and imposed lockdown measures. For instance, between February and June of 2020, the price of rice increased by 51%, while the price of a 2.5 kilogram (kg) wheat-based cake flour increased by 17%.

Similar increases in many other food items were observed at the start of the lockdown period, but as the country eased some restrictive measures in June and the subsequent months, prices of some products declined. For instance, from February to April, the price of stewing beef had increased by 20%, but by May and June, prices declined by 3% and 7%, respectively, while between February and June, the price of eggs greatly varied with a 58% increase in April and then an 18% drop in May [16, 17]. Also, during the same period, some countries, including Vietnam and those ascribing to the Eurasian Economic Commission (EEU), started to impose temporary trade measures (e.g., export bans) on food items [18]. Many South Africans could hardly afford a basic healthy food basket due to the high food items, largely attributed to the pandemic [19].

Therefore, it is against this background that this paper aimed at establishing the nexus between governments' strictness during the lockdown in response to the pandemic, exchange rate, and the prices of wheat and maize in South Africa. This paper contributes to the existing body of knowledge as follows: First, we assess the evolving impact of COVID-19 response measures, as measured by the stringency index, on prices of the major grains in South Africa by comparing the percentage change in prices during the different levels of stringency measures used. Second, we explore how the exchange rate fluctuates as South Africa's major suppliers of maize and wheat impose various COVID-19 response measures. Third, our findings may provide insights for policymakers within South Africa and other countries into how to strike a balance between imposing very restrictive COVID-19 response measures and sustaining continuity of economic activities during this unprecedented time of the pandemic.

1.2. Research Hypotheses

Based on this paper's aims and the existing literature, it is assumed that various levels of strictness imposed by governments in response to COVID-19 negatively affect the real exchange rate and the price of wheat and maize in South Africa. Three hypotheses were tested.

For real exchange rate, the null hypothesis (Ho): There is no effect of governments' strict COVID-19 response measures on the mean daily real exchange

rate in South Africa. (Ho: μ ≤ mean daily real exchange rate).

Alternative hypothesis (Ha): There is a positive effect of governments' strict COVID-19 response measures on the mean daily real exchange rate in South Africa. (Ha: μ > mean daily real exchange rate)

In the case of grain prices, the focus was drawn on SAFEX prices. Thus, for wheat;

Null hypothesis (Ho): Governments' strictness in response to COVID-19 does not affect wheat's mean daily SAFEX price. (Ho: μ ≤ mean daily SAFEX price of wheat).

Alternative hypothesis (Ha): Governments' strictness in response to COVID-19 affects wheat's mean daily SAFEX price. (Ha: μ > mean daily SAFEX price of wheat).

For maize, the tested hypothesis focused on white maize, which is mainly used for human consumption.

Null hypothesis (Ho): Governments' strictness in response to COVID-19 does not affect white maize's mean daily SAFEX price. (Ho: μ ≤ mean daily SAFEX price of maize).

Alternative hypothesis (Ha): Governments' strictness in response to COVID-19 affects white maize's mean daily SAFEX price. (Ha: μ ≤ mean daily SAFEX price of maize).

2. Methods and Materials

2.1. Data

The study used daily data spanning from February 07 to September 25 for 2020, except for weekends and public holidays during which the JSE does not operate. The analysis took into consideration of Argentina (Arg), Germany (Ger.), and the United States (US), which are the major suppliers of wheat. In contrast, in the case of maize, the analysis was based on Argentina and the US. Maize was disaggregated into two categories, namely: white and yellow maize. In South Africa, yellow maize (YM) is mostly used for animal feeds, while white maize (WM) is for human consumption. Two types of prices for wheat and maize, i.e., import parity price and SAFEX price obtained from Grain South Africa (Grain SA), were used. Grain SA is a commodity body responsible for providing strategic support and services to the South African grain sector.

Import parity price refers to the price payable by a purchaser for imported goods. It constitutes the cost, insurance, and freight (c.i.f.) import price plus tariff and the transport cost to a purchaser's location. Available import parity prices were for wheat sourced from the US, Argentina, and Germany and yellow maize (YM) sourced from the US and Argentina. White maize (WM) is sourced from the US, thus the only available import parity price data. SAFEX price, on the other hand, is the price of a good at a given time as at the South African Futures Exchange, a subsidiary of the JSE. Daily price data was extracted from [20]. The stringency index, extracted from [21], was used as the yardstick to measure any government's strictness during the different phases of the lockdown, based on the various response measures employed to curb the pandemic. The index ranges between 1 and 100, whereby one (1) is the least strict level, and 100 is the strictest. Daily real exchange rate data was obtained from [22].

2.2. Data Analysis

Descriptive analysis and Pearson's correlation analysis were used to establish the linkage between governments' strictness during the lockdown, the exchange rate, and the price of wheat and maize. Correlation analysis was used to test the strength of the relationship between the variables. A significantly high positive correlation coefficient for any variables under consideration means a strong direct relationship with each other. In contrast, a low positive coefficient signifies that there hardly exists any direct relationship. A significant negative sign irrespective of the size of the coefficient implies that there exists an inverse relationship. Following [23], Pearson's correlation analysis was undertaken based on the following generic model.

$$r = \left(\frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \sum(y_i - \bar{y})^2}} \right) \quad (1)$$

where r denotes correlation coefficient, x_i represents either of the variables (stringency index, exchange rate, or price) in the sample, $\bar{x}$ is the mean value of either of the above-stated variables, y_i represents the value of either of the above-stated variables in the sample. At the same time, $\bar{y}$ is the mean value of either of the above-stated variables. Given that the analysis entails three variables, the statement "the value of either of the above-stated variables" implies that variables change depending on the linkages being analyzed (See Table 1).

Table 1 Definition of variables

Variable	Definition	Source
Exchange Rate	South Africa's daily real exchange rate against US Dollar (US$)	South African Reserve Bank
Index South Africa	Stringency index for South Africa	Our World in Data
Index US	Stringency index for the United States (US)	Our World in Data
Index Argentina	Stringency index for Argentina	Our World in Data
Index Germany	Stringency index for Germany	Our World in Data
SAFEX YM	SAFEX price for yellow maize at Randfontein (R/ton)	Grain SA
YM parity US	Import parity price for yellow maize from the US (R/ton)	Grain SA

YM parity	Import parity price for yellow maize from Argentina (R/ton)	Grain SA
SAFEX WM	SAFEX price for white maize at Randfontein (R/ton)	Grain SA
WM parity US	Import parity price for white maize from the US (R/ton)	Grain SA
SAFEX Wheat	SAFEX price for wheat at Randfontein (R/ton)	Grain SA
Wheat parity US	Import parity price for wheat from the US (R/ton)	Grain SA
Wheat parity Argentina	Import parity price for wheat from Argentina (R/ton)	Grain SA
Wheat parity Germany	Import parity price for wheat from Germany (R/ton)	Grain SA

However, test the hypothesis to confirm whether governments' strictness affected South Africa's real exchange rate, we employed a Z-test to compare the mean daily exchange rate over 12 months (January - December 2019) before the COVID-19 outbreak in South Africa with the daily mean value for seven months (February 07 – September 25, 2020) after the pandemic was reported in South Africa. A 5% level of significance was used as the basis for comparisons. The Z test was specified as follows [24].

$$z = \left(\frac{x-\mu}{\sigma}\right) \quad (2)$$

X is the population mean, μ is the sample mean, σ is the population's standard deviation. The same test statistic was used to test the other two hypotheses relating to SAFEX prices of wheat and white maize.

According to the daily real exchange data, before the COVID-19 outbreak (January - December 2019), the mean value was R14.45 per US Dollar, with a standard deviation of 0.465. During the pre-COVID-19 period, the mean and standard deviation of the daily SAFEX price of white maize was R2806 per ton and 0.136, respectively. Before the COVID-19 pandemic, wheat's mean daily SAFEX price was R4501 per ton, with a standard deviation of 0.250. As a rule of thumb, the following criterion was used. Reject Ho: if p-value ≤ significance level (5%), and Fail to reject Ho: if p-value > significance level (5%).

3. Results and Discussion

3.1. Descriptive Statistics

Summary statistics for South Africa's Rand against the US Dollar (US$) and the stringency index for South Africa (SA), Argentina (Arg.), Germany (Ger.), and the United States (US) are presented in Table 2. Between February and late September of 2020, the exchange rate was on average R16.26 per US Dollar. During the same period, Argentina imposed the strictest response measures with a mean index of 78.24, followed by South Africa (66.62), while Germany imposed the least strict measures (54.87).

Table 2 Summary statistics for exchange rate and stringency index (February 07 – September 25, 2020)

Description	**Exch. Rate**	**SA Index**	**US Index**	**Arg. Index**	**Ger. Index**
Mean	16.26	66.62	60.15	78.24	54.87
Standard Deviation	1.04	28.19	22.07	29.95	18.63
Minimum	14.76	2.78	5.56	11.11	5.56
Maximum	19.08	87.96	72.69	100.00	76.85
Sample size (n)	165				

Note: Exch. Rate and Ger. denote real exchange rate (R/US$) and Germany, respectively.

Table 3 presents descriptive statistics about the prices of wheat and maize in South Africa. The mean import parity price for white maize (R4090/ton) imported from the US was higher than the import parity prices of yellow maize imported from either the US (R3990/ton) or Argentina (R3860/ton), hence the higher SAFEX price of white maize when compared with that of yellow maize. The higher price of white maize was attributable to the high demand for food items at the start of the lockdown, given that it is used for human consumption, unlike yellow maize, which is used in the manufacturing of animal feeds, as reported by [11] and [10]. The import parity price of yellow maize sourced from the US is attributable to the depreciation of the Rand against the US Dollar, hence the high SAFEX price of yellow maize in South Africa.

Table 3 Summary statistics for wheat and maize prices (February 07 - September 25, 2020)

Description	**Maize price (R'000/ ton)**				
	Yellow Maize			**White Maize**	
	Import Parity			**Import Parity**	
	US	**Arg.**	**SAFEX**	**US**	**SAFEX**
Mean	3.99	3.86	2.74	4.09	2.87
Standard Deviation	0.20	0.20	0.20	0.48	0.37
Minimum	3.64	3.27	2.45	3.43	2.36
Maximum	4.60	4.49	3.31	5.06	5.06
Description	**Wheat price (R'000/ton)**				
	US	Arg.	Ger.	SAFEX	
Mean	5.63	5.83	5.48	5.35	
Standard Deviation	0.32	0.22	0.27	0.38	
Minimum	5.12	5.38	4.99	4.70	
Maximum	6.41	6.39	6.09	6.41	

Note: Sample size (n) for each series was 165 observations.

However, based on the descriptive statistics presented above, while taking cognizant of the fact that countries were imposing various COVID-19 response

measures during the different levels of lockdowns, critical information is relevant for the better understanding of the nexus between the strictness of lockdown measures and the prices of wheat and maize is masked. Thus, graphical illustrations from the periods during which fluctuations in prices and strictness occurred are discussed below. Figure 1 shows the trends for the SAFEX price and import parity price of wheat and the corresponding stringency index for South Africa (SA), Argentina (Arg.), Germany (Ger.), and the United States (US) between early February and late September 2020.

It was observed that all the mentioned countries started imposing very strict COVID-19 response measures during the first two weeks of March 2020. By March 26, all countries had drastically become very strict to the extent that Argentina attained the strictest level (index = 100) while SA, the US, and Germany were at 88.0, 72.3, and 76.9, respectively.

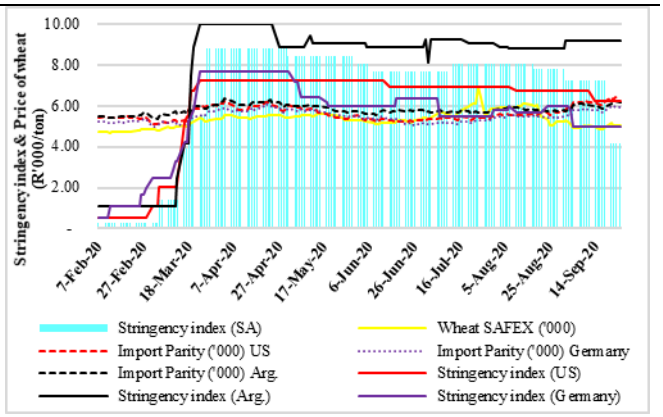

Fig. 1 Strictness by governments during the COVID-19 lockdown and wheat prices

Note: Feb, Mar, Apr, Jun, Jul, Aug, and Sep denote February, March, April, June, July, August, and September, respectively.

The onset of strict lockdown measures in South Africa and other countries coincided with the depreciation of the Rand against the US Dollar (See: Annex 1), thereby suggesting a possible nexus between the two and the prices of wheat and maize. However, the exchange rate fluctuated drastically when government response measures remained stable in South Africa, e.g., between March 26 and April 30. From Figure 1, five-time frames with distinct changes in governments' strictness towards containing the pandemic were in part used as the basis to establish the linkage with prices (Table 4).

Table 4 Effect of governments' strictness during the lockdown on wheat prices in South Africa

Timeframe	**Change in strictness during lockdown**				**SAFEX price change**	**Change in import parity prices**		
	SA	**US**	**Arg.**	**Ger.**	**SA**	**US**	**Arg.**	**Ger.**
Mar 05 – 25	300%	257%	800%	207%	9.8%	13.9%	7.6%	8.8%
May 01 – 30	0.0%	0.0%	2.1%	-22.3%	-1.8%	-9.0%	-5.2%	-6.9%
Jul 13 - Aug 10	0.0%	0.0%	-5.0%	3.4%	7.8%	2.4%	3.7%	6.7%
Aug 10 – 31	-3.5%	0.0%	0.0%	4.9%	-11.0%	3.1%	-2.2%	-0.8%
Sep 01 -25	-42%	-6.9%	0.0%	-17.0%	-4.5%	8.9%	7.2%	8.8%

Note: In some instances, the selected dates coincide with periods during which South Africa's exchange rate showed large fluctuations.

Between March 05 and 25, all the four countries registered significantly high levels of strictness, with Argentina recording an 800% increase, followed by South Africa (300%), the US (257%), and Germany (207%). Correspondingly, the SAFEX price of wheat at Randfontein in South Africa also increased by 9.8% within the same time frame. This increase was largely driven by a 13.9% increase in the import parity price of wheat sourced from the US, followed by Germany (8.8%) and Argentina (7.6%). For May, South Africa's and the United States' levels of strictness remained constant at 84.26 and 72.69, respectively. Conversely, Argentina became stricter by 2.1% (from 88.89 to 90.74), while Germany's stringency reduced by 22.3% from 76.85 (May 01) to 59.72 (May 30). Overall, these changes in strictness during the lockdown can be linked to the 1.8% drop in the SAFEX price of wheat, but largely being driven by declines in the import parity prices of wheat from the US (9.0%), Germany (6.9%) and Argentina (5.2%).

During the third phase (July 13–August 10), stringency levels of South Africa (80.56) and the US (68.98) did not fluctuate, while Argentina's declined by 5% and Germany's increased by 3.4%, but the exchange rate fluctuated considerably. The SAFEX price of wheat increased by 7.8% (to R5 899 per ton as of August 10), and this was largely driven by a 6.7% increase in the import parity price of wheat from Germany, Argentina (3.7%), and the US (2.4%). In September, most countries gradually lifted several lockdown restrictions. The relaxation of lockdown measures in many countries may be attributable to a

decline of 4.5% in South Africa's SAFEX price of wheat, despite an increase in import parity prices for the countries supplying wheat to South Africa as the Rand depreciated further. Therefore, strictness during the lockdown had a direct effect on SAFEX prices of wheat.

In the case of maize, import parity prices available were for the US and Argentina. The trends for the maize prices plotted along with various levels of strictness are shown in Figure 2. Similarly, although slightly different from the case wheat, five-time frames (Table 5) were also used to assess how maize prices were affected by the various levels of strictness imposed during the lockdowns.

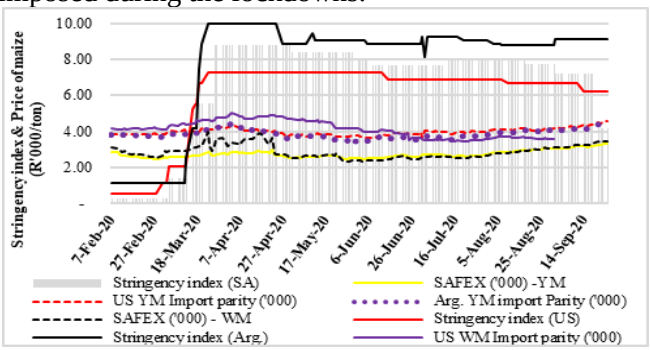

Fig. 2 Strictness by governments during the COVID-19 lockdown and maize prices

During March 02 – 23, South Africa recorded the highest and most drastic increase in strictness in response to the pandemic, followed by Argentina and the US. During this period, South Africa's stringency index rose to 55.56 from a mere 2.78 (an equivalent of a 1 899% increase) while the Rand depreciated by 15% from R15.53 per US$ to R17.81 per US$. White maize was the most affected, unlike yellow maize. SAFEX prices for maize rose by 49.4% for white maize (WM) and 14.9% for yellow maize (YM). Due to Rand's depreciation, the increase in WM SAFEX price was largely driven by a 12.4% upsurge of import parity prices of WM from the US.

In contrast, YM SAFEX prices were mostly influenced by a rise in import parity prices of YM from Argentina. After that, the SAFEX price of WM fluctuated significantly and was much higher than the SAFEX price of YM. However, import parity prices for YM from Argentina and the US showed little variations, suggesting that strictness during the lockdown in Argentina and the US had a more direct impact on WM than YM.

Table 5 Effect of stringency during the lockdown on maize prices in South Africa

Timeframe	**Change in strictness during lockdown**			**SAFEX price change**		**Change in import parity prices**		
				South Africa		**US**		**Arg.**
	SA	**US**	**Arg.**	**WM**	**YM**	**WM**	**YM**	**YM**
Mar 02 – 23	1899%	554%	800%	49.4%	14.9%	12.4%	8.0%	10.7%
Apr 22 -May 22	-4.2%	0.0%	-9.3%	-22.9%	-10.4%	-13.8%	-6.0%	-7.8%
May 25 – August 10	-4.4%	-7.6%	-3.1%	17.5%	13.0%	-11.7%	9.6%	10.6%
June 12 – August 10	4.8%	-7.6%	-1.0%	16.5%	11.7%	-9.2%	60.3%	7.5%
Aug 10 - 31	-3.5%	0.0%	0.0%	10.3%	8.0%	-2.8%	2.5%	4.5%
Sep 01 -25	-42.3%	-6.9%	0.0%	11.2%	8.6%	0.7%	8.9%	6.2%

Note: Arg. denotes Argentina, US denotes the United States of America, SA represents South Africa, WM represents white maize, and YM denotes yellow maize.

For the second time frame (April 22 – May 22), as South Africa and Argentina relaxed the strictness during the lockdowns while the US remained at 72.99 level, the value of the Rand against the US Dollar appreciated by 6%. Appreciation of the Rand led to the drop in maize prices ranging from 7.8% for Argentina's import parity prices of YM to 22.9% for the SAFEX price of WM. The large decline in the SAFEX price of WM was driven by a drop in import parity prices of maize from the US due to the stability in the country's strictness in response to the pandemic. Within South Africa, the decline may be attributable to the consistent assurance by various institutions in the agricultural sector that there was adequate stock of WM, coupled with forecasted bumper harvest for the ongoing production season [25; 26], and appreciation of the Rand against the US Dollar. According to the Crop Estimate Committee, by mid-2020, maize harvest had been forecasted to be more than 15.5 million tons, an equivalent of almost 37% higher than the harvest of the 2019 season, and WM was noted to be the key driver of the overall bumper harvest of the 2020 season [19].

Between May 25 and August 10, the SAFEX price for YM slightly increased above that of WM, largely driven by import parity prices of YM from the US, which increased by 60.3% between June 12 and August 10. In contrast, the import parity price for WM from the US had recorded a decline, despite the more stringent measures imposed in Argentina (See Figure 2). Notably, the Rand appreciated during this time

frame, thus suggesting that the situation in the US played a critical role in influencing the import parity prices of YM and WM. During September, many countries lifted several restrictions imposed during the lockdowns, and the exchange rate fluctuated drastically.

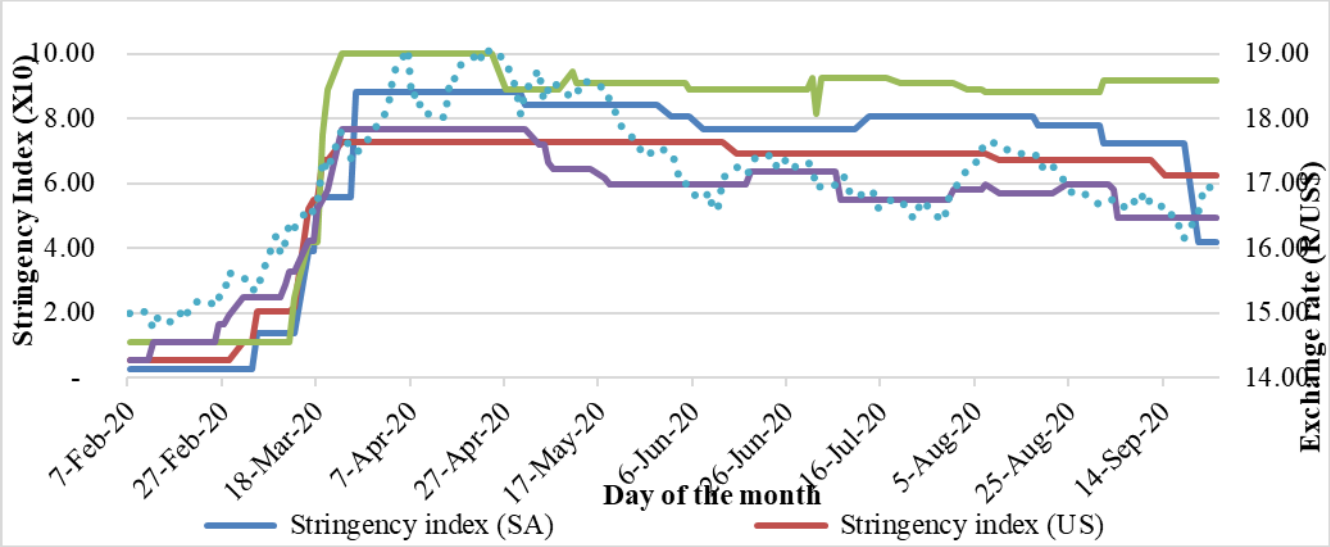

Fig. 3 Strictness by governments during the lockdown and real exchange rate (Authors' compilation based on data extracted from [20, 21])

3.2. Correlation Analysis

The correlation results presented in Table 6 suggest a strong significant and positive relationship between the exchange rate and the level of stringency imposed in each country. For instance, the significant correlation coefficient of 0.811 ($p < 0.05$) exhibited by South Africa means that imposing very strict COVID-19 response measures; hence a high stringency index tends to foster depreciation of the Rand against the US Dollar. Similarly, the results reveal a moderate to a strong positive relationship between South Africa's real exchange rate and the prices of wheat and maize. Wheat prices are the most affected, especially for wheat imported from Argentina. The strong and significant positive correlation coefficient of 0.802 ($p < 0.05$) implies that as South Africa's Rand depreciated against the US Dollar, the import parity price of wheat sourced from Argentina also tended to increase by 0.802 proportions, followed by Germany and the US.

Prices for white maize (WM) were found to be weakly associated with the exchange rate, while for yellow maize, it was only the import parity prices for maize sourced from Argentina that exhibited a weak but statistically significant correlation coefficient (0.154, $p < 0.05$). The weak linkage between the Rand and maize prices was attributable to the fact that South Africa is generally a net exporter of maize, coupled with the fact that the crop estimate committee had forecasted a bumper harvest for the season. Hence, there was no need to panic [19]. However, for the fact that South Africa imports a significant proportion of wheat (42.5%) to the total demand [27], the depreciation of the Rand against the US Dollar inevitably renders wheat to be more expensive.

Results further reveal there is a strong nexus between the levels of strictness imposed by the different countries. The correlation implies that imposing very strict measures in one country stimulates similar measures against COVID-19 in other countries, and the reverse is also true. It is worth noting that the correlation coefficients for the stringency index between all countries were above 0.910 ($p < 0.05$). Concerning the linkage between wheat and maize prices, there is no statistically significant correlation between the SAFEX prices of the two grains. However, results reveal a low to moderate significant positive relationship between the import parity prices of wheat and maize, depending on the country of origin.

3.3. Discussion

The increase in SAFEX and import parity prices of wheat and maize between February and September 2020 is attributable to the imposition of very strict lockdown measures by the various governments to contain the COVID-19 pandemic. In part, due to the strict measures imposed by countries coupled with the junk status rating of the South African economy, the Rand depreciated, thereby rendering the soaring prices of grains (wheat and maize) used as food and raw materials in many food value chains. Even though cargo could be transported within South Africa, there was a slowdown of activities and delays at various harbors, distorting the proper logistical operations, exacerbating the rise in prices of wheat and maize. Moreover, consumers were uncertain of the extreme implications of the pandemic, and many resorted to panic-buying foodstuffs [28; 29].

Given that maize and wheat are used as inputs in several food products, higher prices translate into higher prices paid by consumers. This school of thought concurs with a report by [16] in which relatively high year-on-year price changes in food items derived from wheat and maize are reported. For instance, in July 2020, the price of a 700 grams loaf of

brown bread increased by 6.2%, a 2.5 kg cake flour increased by 16.7%, while one kilogram of super maize meal rose by 7.9%, in comparison with prices in July 2019. Yellow maize prices did not have drastic increases, as was the case of white maize, simply because yellow maize is largely used in the manufacturing of animal feeds, and this was indirectly observed through higher meat prices.

According to the Z-test values presented in table 7, we reject the null hypotheses (Ho) for the real exchange rate, and the SAFEX price of wheat, given that the corresponding p-values are less than the significance level at 5%.

Table 7 Hypotheses test results at 5% significance level

Hypothesis	Z-test	p-value	Decision
Ho: μ ≤ mean daily real exchange rate Ha: μ > mean daily real exchange rate	-3.90	0.0001	Reject Ho
Ho: μ ≤ mean daily SAFEX price WM Ha: μ > mean daily SAFEX price WM	0.53	0.298	Fail to reject Ho
Ho: μ ≤ mean daily SAFEX price wheat Ha: μ > mean daily SAFEX price wheat	3.32	0.0005	Reject Ho

Rejecting the null hypotheses for the real exchange rate and the SAFEX price of wheat implies that governments' imposing of strict COVID-19 response measures influenced the depreciation of South Africa's Rand against the US Dollar and an increase in SAFEX prices of wheat. However, we fail to reject the null hypothesis for white maize since the p-value (29.8%) associated with the z-score is greater than the significance level of 5%. Failure to reject the null hypothesis suggests that governments' implementation of strict COVID-19 response measures did not affect SAFEX prices of white maize in South Africa.

Table 6 Results based on Pearson's correlation analysis

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Exchange Rate	1.000													
Index South Africa	0.811*	1.000												
Index US	0.799*	0.966*	1.000											
Index Argentina	0.767*	0.950*	0.975*	1.000										
Index Germany	0.903*	0.914*	0.927*	0.908*	1.000									
SAFEX YM	0.065	0.163*	0.222*	0.327*	0.139	1.000								
YM parity US	0.039	0.081	0.158*	0.248*	0.143	0.849*	1.000							
YM parity Argentina	0.154*	0.045	0.096	0.187*	0.189*	0.774*	0.890*	1.000						
SAFEX WM	0.173*	-0.002	0.039	0.117	0.176*	0.686*	0.711*	0.845*	1.000					
WM parity US	0.468*	-0.009	-0.033	-0.076	0.253*	-0.331*	-0.21*	0.134	0.302*	1.000				
SAFEX Wheat	0.566*	0.685*	0.638*	0.619*	0.583*	0.001	0.036	-0.047	-0.142	-0.134	1.000			
Wheat parity US	0.463*	0.324*	0.358*	0.458*	0.426*	0.671*	0.645*	0.761*	0.666*	0.277*	0.024	1.000		
Wheat parity Argentina	0.802*	0.627*	0.644*	0.689*	0.735*	0.477*	0.506*	0.594*	0.519*	0.373*	0.340*	0.847*	1.000	
Wheat parity Germany	0.661*	0.466*	0.472*	0.531*	0.548*	0.476*	0.406*	0.567*	0.507*	0.431*	0.144	0.906*	0.891*	1.000

Note: * Significant at 5%; WM stands for White maize, YM represents Yellow maize, parity refers to import parity price. Index refers to stringency index for different countries.

4. Conclusion

The devastating effects of the COVID-19 pandemic are eminent in the various spheres of economies globally. With a particular focus on international trade, many countries responded to the pandemic by imposing temporary trade measures on some agricultural products, maize and wheat included. Even though major suppliers (Argentina, the US, and Germany) of wheat to South Africa did not impose temporary trade measures, other measures imposed by these economies indirectly affected import parity prices in South Africa during the period considered in this paper. As a net exporter of maize, South Africa projected a bumper harvest for the 2020 production season; hence, there was little to worry about maize supplies. Findings might be relevant to policymakers in establishing a balance between imposing very strict COVID-19 response measures and sustaining continuity of economic activities.

Stringent COVID-19 response measures imposed by key trading partner countries like the US and Germany (in the case of wheat), the US for white maize, and Argentina for yellow maize are associated with the significant increase in wheat prices and maize in South Africa. In addition, the imposed COVID-19 response measures are associated with the observed depreciation of the Rand against the US Dollar, which affected the import parity prices of wheat and maize.

Therefore, it is prudent to conclude that stringent measures imposed during lockdowns are directly and indirectly associated with increasing wheat and maize import parity prices. Based on hypothesis test results, governments' stringent COVID-19 response measures were related to the increase in SAFEX price of wheat and the depreciation of the Rand against the US Dollar. Consumers directly bore the increase in SAFEX prices through higher retail prices observed in South Africa between February and September 2020.

The following recommendations are put forward: i) South Africa should consider sourcing wheat and maize from other countries without being restricted to the major suppliers featured in this paper. Diversifying the sources of grains is advantageous given that when the few current suppliers experience shocks, such as the ongoing pandemic, the risk of those countries imposing trade-restrictive control measures that culminate into price spikes would be minimized.

ii) In the event of global shocks such as the COVID-19 pandemic, governments should minimize imposing measures that may not be urgently needed to mitigate the shock. In some instances, the imposed measures are good but may either be misinterpreted or poorly enforced by the concerned institutions at the expense of the intended beneficiaries. It is therefore important to continuously sensitize the masses about the measures in question. Putting in place relevant measures at an apt time frame coupled with continued sensitization of the masses will minimize undesirable spillover effects within and beyond a given country or territory.

iii) In the interest of minimizing price spikes for staple food items (e.g., maize) soon, farmers should be encouraged and supported to produce more maize (both yellow and white) given that there is much uncertainty about how long the pandemic will continue ravaging across countries. However, this also implies that more investment in infrastructure (including storage facilities and access roads) should be made within or nearer to the areas where agricultural production occurs to cater to a likely increase in production.

5. Limitation

Research results are limited to the first eight (8) months into South Africa's lockdown period. Therefore, further analysis should consider a much longer period.

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