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THE EFFECT OF SELECTED MACROECONOMIC POLICIES ON CITRUS PRICE VOLATILITY IN SOUTH AFRICA: A REFLECTION ON EXPERIENCES OF FARMER SUPPORT

Joseph Sello Kau[1]✉, Victor Mmbengwa[2], Jan Swanepoel[1]

[1]University of Free State, South Africa
[2]University of Limpopo, Central University of Technology of Free State, South Africa

Abstract. The macroeconomic policies enacted by the South African government after democracy and their effects on the welfare of resource-poor farmers remains a subject of scholarly interest. It is not known if farmers are cushioned against exogenous macroeconomic shocks. The aim of this study was to analyse citrus price volatility in National Fresh Produce Markets and to study the effects of macroeconomic policy shocks. Secondary data for prices was sourced from the Johannesburg National Market. GARCH was employed as an empirical model to estimate price volatility. According to the results, price volatility for lemon and soft citrus is statistically insignificant. Price volatility for oranges was statistically significant at a 99% persistence level ($\alpha = 0.39$, $p = 0.0030$) and ($\beta = 060$, $p = 0.0000$). The exchange rate ($\alpha = 0.05$, $p = 0.0000$), CPI ($\alpha = -0.26$, $p = 0.0035$) and prime lending rates ($\alpha = 0.12$, $p = 0.0026$) were significant in explaining price volatility in oranges. Added values of the coefficient of α and β for Grapefruit amounted to 1.1, which means the price volatility was explosive. High levels of price volatility mean farmers are faced with the difficulty of projecting expected levels for farm income and profitability. The results provide insights into farm planning and decision making. It is recommended that the government provide farmers with resources that can cushion against price instability and enable them to access export markets.

Keywords: resource-poor, farmers, price, volatility, macroeconomic policies

INTRODUCTION

As a result of democratic dispensation, which culminated in the lifting of trade sanctions and the pursuit of the reintegration of the economy into global markets, the South African government introduced sweeping policy reforms. For the purposes of this study, important policies that were introduced include the Land Restitution and Redistribution Act, deregulation of agricultural markets, trade liberalization and inflation targeting. To address the socioeconomic challenges faced by resource-poor farmers that benefited from the Land Reform programme, such as lack of skills and poor access to resources (i.e., markets, farm inputs, technology, farm credit and information), between 2004 and 2009, the South African government introduced a number of farm support programmes. These included the Comprehensive Agricultural Support Programme (CASP), Ilima-Letsema (meaning cooperatives in English), the Micro Agricultural Financial Institution of South Africa (MAFISA), Fetsa Tlala Integrated Food Production initiative, Land Care programme and Recapitalization and Development Programme (RADP). While these different programmes had different delivery mandates, the overriding goal was to enhance successful implementation of the Land Reform programme through realisation of optimal farm-level productivity and commercialization of agricultural outputs (Cousins, 2016). Historically, the

✉Joseph Sello Kau, Agricultural Research Council of South Africa, South Africa, e-mail: kauj@arc.agric.za, https://orcid.org/0000-0001-6939-0797

prevalent feature for most of these farmer support programmes is the provision of fertilizer, seeds, infrastructure equipment and other planting material.

With regard to marketing, the deregulation of agricultural markets, which culminated in the abolishment of agricultural subsidies and marketing boards, was reported as per the literature (Bernstein, 2013. It was noted that market liberalization harmonised trade tariffs, thereby making it easy for other countries to export their agricultural products into South Africa (Erten et al., 2019). In 2000, to bring about price and currency stability, the South African Reserve Bank promulgated a new macro-economic policy dubbed inflation targeting (SARB, 2011). Under the inflation targeting regime, the repo rate, which is the interest rate with which the SARB borrows money from commercial banks, became an instrument for stabilising inflation and the value of the exchange rate. By adopting a free-floating exchange rate, the value of the Rand would be determined by the forces of demand and supply (Miyajima, 2020). This development ushered in a new era for the independence of the SARB, where henceforth it could separate its functions from those of politicians (e.g., job creation) and focus mainly on the maintenance of price stability. Kydland and Prescott (1997) and Barro and Gordon (1983) believed that the independence of Central Banks would result in lower inflation and good prospects for economic growth (Aguir, 2017).

These policy reforms delivered a mix of results. According to Sihlobo and Qobo (2021), deregulation of agricultural markets and trade liberalization worked in favour of the established commercial agricultural sector. The commercial sector achieved growth in productivity and increased export competitiveness, but these results were not achieved among resource-poor farmers. As of 2017, 80% of the total value of agricultural output was produced by just a few commercial farmers (i.e., 40122 individuals), and less than 20% was produced by 2 million smallholder farmers (StatsSA, 2020). On the question of whether the farmer support programmes are effective, recent studies by several researchers, namely Maka and Aliber (2019) and Rusenga (2020), Mncina and Agholor (2021) and Zantsi et al. (2021), have painted a bleak picture. They posit that these programmes to a large extent are poorly designed and not fit for purpose as they do not address the needs of resource-poor farmers. Most of the farmer support programmes are poorly coordinated and there is late delivery for some of the services (Mncina and Agholor, 2021), whereas a high number of farmers struggle to access markets, especially export markets (Rusenga, 2020). Specifically for citrus, Bitzer and Buman (2014) posit that the support programmes designed for resource-poor citrus producers were not efficient to enable them to meet the stringent quality requirements of export markets. The researchers further caution that the existing strategic partnership models (this being a sub programme under RADP), where white commercial farmers assist black farmers to access export markets, are not sustainable as they create a dependency syndrome (Bitzer and Buman, 2014). Genis (2018), in the study where he looked into the transferred land reform projects in South Africa, reported that resource-poor citrus farmers struggle to access export markets and that they rely on local markets. A recent study involving field research conducted between September 2020 and May 2021 in four provinces, namely Gauteng, Limpopo, Mpumalanga and KwaZulu-Natal, among 40 vegetable producers operating small-scale (0.25ha to 5ha) and medium scale (5ha to 50ha) operations had discovered that these farmers did not have access to export markets (Wegerif, 2022). The important market facilities for these farmers included municipal fresh produce markets used by more than 50% of interviewed farmers, informal bakkie traders (12%) and retail supermarkets (30%) (Wegerif, 2022). Farmers far away from Gauteng province, by almost 496 kilometres (such as those of Vhembe district in Limpopo), among others, supplied their produce to the Joburg market (Wegerif, 2022).

The situation is different to other countries in sub-Saharan Africa, where small-scale farming (from as small as 0.25ha in extent) remains the lifeblood of the economy (FAO, 2015). A number of innovative strategies, such as contract-grower schemes and public-private partnerships (e.g., in Mozambique) (Mangeni, 2019), cooperative schemes (e.g., in Kenya) (FAO, 2015) and advanced telecommunications technologies (e.g., in Ghana) (Wyche and Steinfield, 2016), are effective for accessing export markets.

With regard to the inflation-targeting policy framework, among others, the important channels through which this policy manifests itself in the economy include movements in exchange rates, interest rates and consumer price inflation (Oladipo, 2017). In a study by Aye and Odhiambo (2021) based on 39 developing countries that adopted inflation targeting, it is said that when inflation in these countries exceeded the threshold of 5.9%, growth in the agricultural sector declined, and there was an acceleration of inflation in these countries. These macroeconomic factors can serve as exogenous factors that can give rise to price instability in local markets. The implications are that, while resource-poor farmers are already struggling because of poor farmer support programmes, they are also facing the risk of price uncertainty in local markets. In this study, we analyse citrus price volatility as citrus is of strategic significance to the economy. During the 2017/18 season, the citrus industry was responsible for R19 billion, South African currency, that was contributed to the total gross value of agricultural production in South Africa (NAMC, 2020). Citrus commodities in South Africa are some of the few export-orientated commodities that can be grown in almost all of the provinces (eight out of nine) (CGA, 2022) and carries high potential for development. In the world at large, price volatility in the agricultural sector remains an area of interest as it affects long-term planning (FAO, 2011).

LITERATURE REVIEW

The global food crises of 2007–2008 brought the issue of food price volatility into policy discourse (Lang, 2010). This food crisis resulted in social unrest across the world, and this has since triggered renewed interest in research into the area of food price volatility (Tadesse et al., 2016). A study that looked into the price volatility of selected grain crops in Germany discovered that, among other factors, macroeconomic factors such as petrol price volatility and exchange rate were important (Ott, 2014). In Africa, food price volatility is said to be the major cause of household food insecurity, and it has the potential to incite political instability and attacks on civilians by insurgent groups (Rezaeedaryakenari et al., 2020). Tadesse et al. (2016) have since formulated three major categories for the causes of food price volatility. These include root causes (e.g., weather and macroeconomic shocks), conditional causes (e.g., high market concentration) and internal drivers (e.g., market speculation and trade bans) (Tadesse et al., 2016). Perhaps the category for root causes, of which one of the examples is macroeconomic factors, requires more attention because if not addressed, its effects can be systematic and end up creating a vicious cycle.

Figure 1 shows that key macroeconomic indicators, e.g., CPI, interest rate and exchange rate, for the period of 2010 to 2022 have been unstable (see Fig. 1). It can be seen that in January 2010, May 2014, February 2016 and January 2017, the CPI exceeded the SARB's target band of 3 to 6% (see Fig. 1). Since 2014, both the Rand and the prime lending rate have exhibited an upward trajectory, with the Rand losing value against the dollar for most of that time. For almost a decade, i.e., December 2012 to January 2020, the prime lending rate followed in the same direction as the movement of the Rand, and this is because it is used as an instrument to limit the supply of money into the economy. The spikes that are

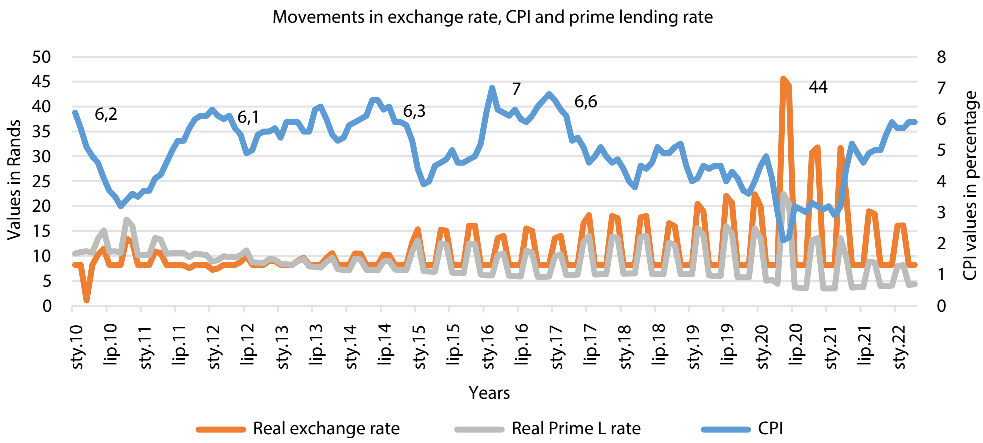

Fig. 1. Trends in the movements of exchange rate, CPI and prime lending rates (2010 to 2022)
Source: data sourced from StatsSA (www.statssa.gov.za) and SARB (www.resbank.co.za)

showing in May 2020 are because of the covid-19 pandemic. These factors can have adverse effects on the prices of agricultural produce. In a study that covered the period 1984 to 2014, Mazorodze and Tewari (2018) posited that, during this period, the undervalued Rand boosted growth in agricultural exports.

As the Rand weakens, locally produced goods and services become cheaper to international buyers (Mazorodze and Tewari, 2018). Aye and Odhiambo (2021) posit that there is a need to balance currency undervaluation and control of inflation. In an environment where key farm inputs (e.g., fuel and machinery) are imported from abroad, which is the case in South Africa, a weaker rand means that these items are more expensive, and this can lead to high inflation. The effects of interest rates on resource-poor farmers have been studied already. In the work of Chisasa and Makina (2012), it is said that in South Africa, due to upward movements of interest rates, the ratio of credit for small-scale farmers to total private sector credit declined from 18% in 1986 to 1% in 2009.

Based on the available literature, a number of studies in South Africa that looked into price volatility paid more attention to grain crops. Sayed and Auret (2020) recently looked at the volatility transmission of white maize from other countries to South Africa. In South Africa, there has never been a study looking into price volatility for citrus, and this constitutes a knowledge gap. Based on the above discussion, this study attempts to study citrus price volatility in the South African National Fresh Produce Markets, this being the single most important marketing facility for resource-poor farmers, and also to reflect on how macroeconomic factors, namely interest rates, exchange rates and inflation, affect citrus price volatility. GARCH is employed as an empirical model to study citrus price volatility. Akaike Info Criterion was used to select the best GARCH type model, and the Wald test was used for validating causality. To deliver on this, the remainder of the study comprises sections dealing with study methods, empirical results, discussion and conclusion and recommendations.

STUDY METHODS

Study area

Figure 2 shows the regions in South Africa where citrus is produced. According to CGA (2022), citrus is produced in eight out of nine provinces, with Limpopo

Fig. 2. Growing areas of citrus in South Africa
Source: CGA, 2020.

province constituting the biggest area (40 383ha) cultivated at 40%, followed by Eastern Cape (25%), Western Cape (19%), and Mpumalanga (8%). Orange Free State and North West provinces have the lowest number of hectares cultivated. Ironically, while Gauteng province does not have a high share of agricultural production, the biggest local fresh produce market is situated in this province. The Joburg market remains the biggest fresh produce market in South Africa, with approximately 42% of the market share amongst fresh produce markets, valued at around R20 billion. Given its dominance in terms of share of the fresh produce market industry, the Joburg Market serves as a barometer for fresh produce prices (Joburg Market, 2021).

Sampling technique

Based on the availability of data, secondary monthly data from January 2010 to April 2022 spanning a period of 12 years and constituting 147 observations was sourced from the Johannesburg Fresh Produce Market, which is owned by the South African government. Data on Consumer Price Index and exchange rates were sourced from StatsSA and the South African Reserve Bank respectively. By comparison, a study by Tirno et al. (2021) employed GARCH on a monthly series constituting a sample of 132 observations to study price volatility, and thus this gives confidence for our own sample size.

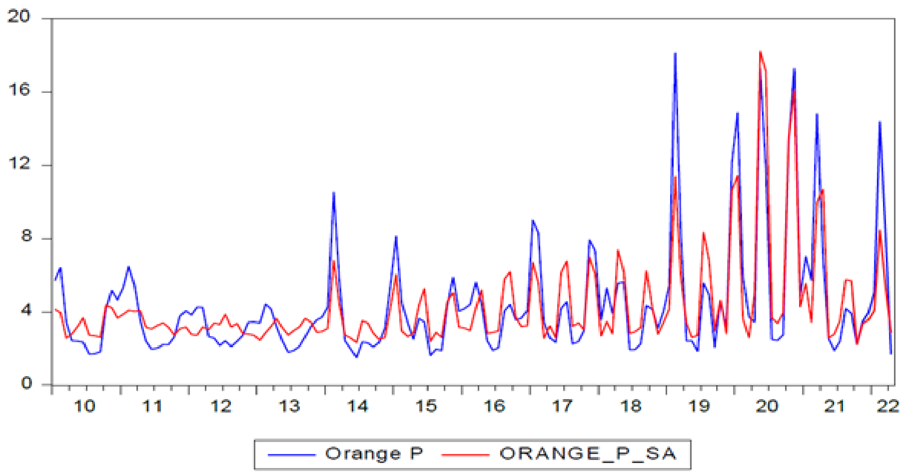

Fig. 3. Eviews seasonally adjusted orange price series
Source: Eviews output with data from Joburg market.

Data Handling and Management

Eviews was employed to generate a new series (denoted Orange_P_SA) that is seasonally adjusted, and in figure 3, the new series is presented together with the initial raw data series.

One of the important steps before testing for stationarity using the unit root test is to address the influence of the predictable components of price movements, such as the effects of seasonality, inflation and trends, as they should not be considered part of price volatility. Seasonality should be removed, leaving only the unpredictable or stochastic component for further analysis (Shi et al., 2014).

Using descriptive analysis, the seasonality of orange prices was analysed. With 2010 set as a base year, the effect of inflation was removed by deflating the nominal prices with the CPI.

Basic Procedures for building GARCH model

The approach for studying price volatility can be complex as a number of invisible market factors overshadow the movements of real prices. These include the stochastic nature of prices, the influence of the lag period on movements of prices and the influence of externalities such as policies, weather etc. The conditional variance is not constant over time. In the conditional variance, the underlying stochastic process is conditionally heteroscedastic. In the face of many competing econometric models, such as the ARIMA, Error Correction Model (VCM) traditionally used for modelling time series relationships and for forecasting, the GARCH model is found to be suitable for analysing price volatility. This is because, unlike these other models, GARCH has the capacity to address heteroscedasticity (Hsu Ku et al., 2007).

The Eviews software package 2009 was employed to run the analysis. Before a GARCH model is built, a number of steps must be followed. This includes the need to establish clustering volatility and to test for unit root test and ARCH effects. To test for stationarity, a Dickey Fuller Test was employed, and the series was found to be non-stationary at its own level. Only when differenced at first order did it become stationary. To test for ARCH effects, using Eviews software, a residual diagnostic test was employed, followed by a heteroscedasticity test.

MODEL SPECIFICATION

Conditional Mean Models

Some models are not capable of considering the lag effects of past relationships in a series. The Box-Jenkins approach considers past relationships and the effects on a time series and considers the autoregressive nature of a time series (Box-Jenkins, 1970). An Autoregressive (AR) Model is one in which we use the statistical properties of the past behaviour of variable to predict its future behaviour. An autoregressive model with p lags, is given by

$$Y_t = \mu + \varnothing_1 Y_{t-1} + \varnothing_2 Y_{t-2} + \ldots + \varnothing_p Y_{t-p} + \varepsilon_t = \mu + \sum_{i=1}^{p} \varnothing_1 Y_{t-1} + \varepsilon_t \quad (1)$$

Where ε_t = the white noise error, μ is the mean, $\varnothing$ is the weight and Y_{t-1} is the value y at t-1 periods ago. Moving Average (MA) Models: a time series is said to be in a moving average (MA) process if the current time series is a linear combination of current and finite number of previous shocks. The j^{th} order MA process can be expressed as

$$Y_t = \mu + \varepsilon_t + \varnothing_2 \varepsilon_{t-1} + \varnothing_2 \varepsilon_{t-2} + \ldots + \varnothing_2 \varepsilon_{t-q} = \mu + \sum_{i=1}^{p} \varnothing_j \varepsilon_{t-j} + \varepsilon_t \quad (2)$$

Where ε_t and ε_{t-1} are the previous white noise disturbance term and the current disturbance terms respectively t, σ is the MA parameters which describes the effect of the past error on Y_t.

Autoregressive Integrated Moving Average (ARIMA) models are the most general class of models for forecasting a time series, which can be stationary by transformations such as differencing and lagging. Mathematically, it can be expressed as:

$$Y_t = \mu + \sum_{i=1}^{p} \varnothing_1 Y_{t-1} + \sum_{i=1}^{p} \varnothing_{j1} \varepsilon_{t-j} + \varepsilon_t \quad (3)$$

Conditional Variance Model

ARCH Models were introduced by Engle (1982). The ARCH (q) regression model can be expressed as $U^2{}_t$ in terms of past values of $U^2{}_t$.

That is,

$$U^2{}_t = \mathrm{W} + \sum_{i=1}^{q} \sigma_i U^2{}_{t-1} \quad (4)$$

GARCH Models are those that are mainly used to model volatility. GARCH models generalize the ARCH model in the same sort of way that an ARMA model generalizes an MA model. The GARCH (p,q) model can be expressed as:

$$h_t = \mathrm{W} + \sum_{i=1}^{q} \alpha_i u^2{}_{t-1} + \sum_{j=1}^{p} B_j h_{t-j} \quad (5)$$

With the constraints w > 0, $\alpha > 0$, i = 1,., q and $B_j > 0$, J = 1, … p. For instance, GARCH (1,1), GARCH (1,2), GARCH (1,3) and GARCH (2,1) models are displayed as follows:

$$r_t = \mu + \mu_t,\ \mu_t \sim \mathrm{N}(\mathrm{O}, \sigma^2)$$
$$\text{GARCH (1,1)} : h_t = \mathrm{w} + \alpha_1 U^2{}_{t-1} + B_1 h_{t-1}$$
$$\text{GARCH (1,2)} : h_t = \mathrm{w} + \alpha_1 U^2{}_{t-1} + \alpha_2 U^2{}_{t-2} + B_1 h_{t-1} \quad (6)$$
$$\text{GARCH (1,3)} : h_t = \mathrm{w} + \alpha_1 U^2{}_{t-1} + \alpha_2 U^2{}_{t-2} + \alpha_2 U^2{}_{t-3}\ B_1 h_{t-1}$$
$$\text{GARCH (2,1)} : h_t = \mathrm{w} + \alpha_1 U^2{}_{t-1} + + B_1 h_{t-1} + B_2 h_{t-2},$$

Selection of explanatory variables

Data from StatsSA (2010 to early 2022) shows that transport, food inflation and electricity were important contributors to headline inflation. Learning from the work of Akram (2009) and Duverall et al. (2013), three macroeconomic variables, namely exchange rate, interest rate and inflation are considered to be explanatory variables. There are other macroeconomic variables, such as tariffs, income tax policies and so forth, but in order to focus, the three important ones mentioned are considered. MoroŞan and ZubaŞ (2015) caution that these variables may be correlated. This means if considered into a model, they may lead to a multi-collinearity problem, and the results may be spurious. To address this problem, using E views software, a standard correlation model was run. The results of this correlation point to prime lending rate being correlated with exchange rate at a coefficient of 0.70, whereas other variables, e.g., CPI and exchange rate, are negatively correlated with a low coefficient value of -0.38. CPI is also negatively correlated with prime lending rate, with a coefficient of -0.25. Because of these results, in specifying the GARCH model, the prime lending rate was paired with CPI, and CPI was paired with exchange rate.

Combined mean and variance model

In Eviews, GARCH was estimated by setting the equation for the mean and variance jointly.

The equations for the four dependent (Y) variables under consideration, i.e., the prices of the four species, were set separately, exploring different GARCH formations and types (i.e., GARCH (1,1), (1,2), (1,3) and (2,1)). Based on the results of the correlation, two exogenous variables, namely exchange rate and CPI, were held as explanatory variables in the first approach, and in the second approach, it was CPI and prime lending rate. Five different error distribution criteria were set. These included the normal (Gaussian) distribution, Student's t, Generalised Error (GED), Student's t with fixed df and GED with fixed parameter. After modelling the mean and variance equations, a model significance test using the Wald Statistics test was applied, followed by serial correlation test (i.e., ARCH LM test and Correlogram). The lowest value of the Akaike Info Criterion was used to determine the best type model for GARCH.

The following hypotheses were set

H_0: The four citrus species under study do not have persistent price volatility.

H_a: The four species under consideration have persistent price volatility.

A representative equation for each of the species can be represented as follows:

$$\text{GARCH} = C(4) + C(5)^*\text{Resid}(-1)^{\wedge 2} + C(6)^*\text{GARCH}(-1) + C(7)^*D(\text{CPI}) + C(8)^*D(\text{Exh\_Rate}) + C(9)^*D(\text{prime lending rate}) + \varepsilon_t \quad (7)$$

Where the independent variable, GARCH, represents the price volatility, and in the case of orange, is expressed as D(Orange_P_SA), which is the seasonally adjusted price in its first difference form. C(4), is the constant and C(5)*Resid represents the ARCH effects in the lagged form, whereas C(6)*GARCH (–1) is the previous month's price volatility. In the results, Resid will be denoted as Alpha (α), whereas GARCH will be denoted as Beta (β).

RESULTS AND DISCUSSION

Stationary in time series, Dickey Fuller Test results

Table 1 provides a summary of the results. At their own level, the variables were found not to be stationary. As can be seen in the table, all variables have a P value of less than 5%, and thus the hypothesis is rejected, meaning the variables are now stationary at the first difference. Furthermore, for all the six variables, the t statistics are more than the critical value. These results provided the basis for modelling both the ARCH and GARCH equations.

To establish if there is clustering volatility, the mean equation for each of the four citrus prices in their difference forms were computed in Eviews, after which a residual was plotted. Figure 4 presents the clustering volatilities.

By establishing the existence of clustering volatility and the ARCH effects, a condition for running the GARCH was fully met. For each of the prices of the four species, an episode of low volatility is often followed by an episode of high volatility. The different spikes in the graph, shows different socio-economic shocks. The period constituting the last part of 2018 up to end of 2021, shows similarities among the clustering volatilities of the four species, and this is probably due to the effect of Covid 19. To test for the ARCH effects, using E views software residual diagnostic test was employed, followed by heteroscedasticity test. The results for testing the ARCH effects shows that both the P value for the F-statistics and for the Observed R square, are less than 5 percent and therefore the null hypothesis is rejected, meaning that there exists ARCH effects.

Table 1. Dickey Fuller Test results, at the first difference

	Test Equation	ADF test statistics	P value
Orange Price	With intercept	–7.31	0.0000
	With intercept and trend	–7.28	0.0000
	None	–7.3	0.0000
Soft citrus price	With intercept	–7.32	0.0000
	With intercept and trend	–7.29	0.0000
	None	–7.31	0.0000
Grapefruit price	With intercept	–18.6	0.0000
	With intercept and trend	–18.6	0.0000
	None	–18.6	0.0000
Lemon Price	With intercept	–7.3	0.0000
	With intercept and trend	–7.4	0.0000
	None	–7.4	0.0000
Exchange rate	With intercept	–7.4	0.0000
	With intercept and trend	–7.4	0.0000
	None	–7.4	0.0000
CPI	With intercept	–9.0	0.0000
	With intercept and trend	–10	0.0000
	None	–10	0.0000
Prime Lending rate	With intercept	–7.88	0.0000
	With intercept and trend	–7.85	0.00000
	None	–7.78	0.0000

Source: data used sourced from Joburg Market (2010–2022).

Price volatility (variance) estimation results

Table 2 presents the results for the variance model based on the lowest Akaike Info criterion established across

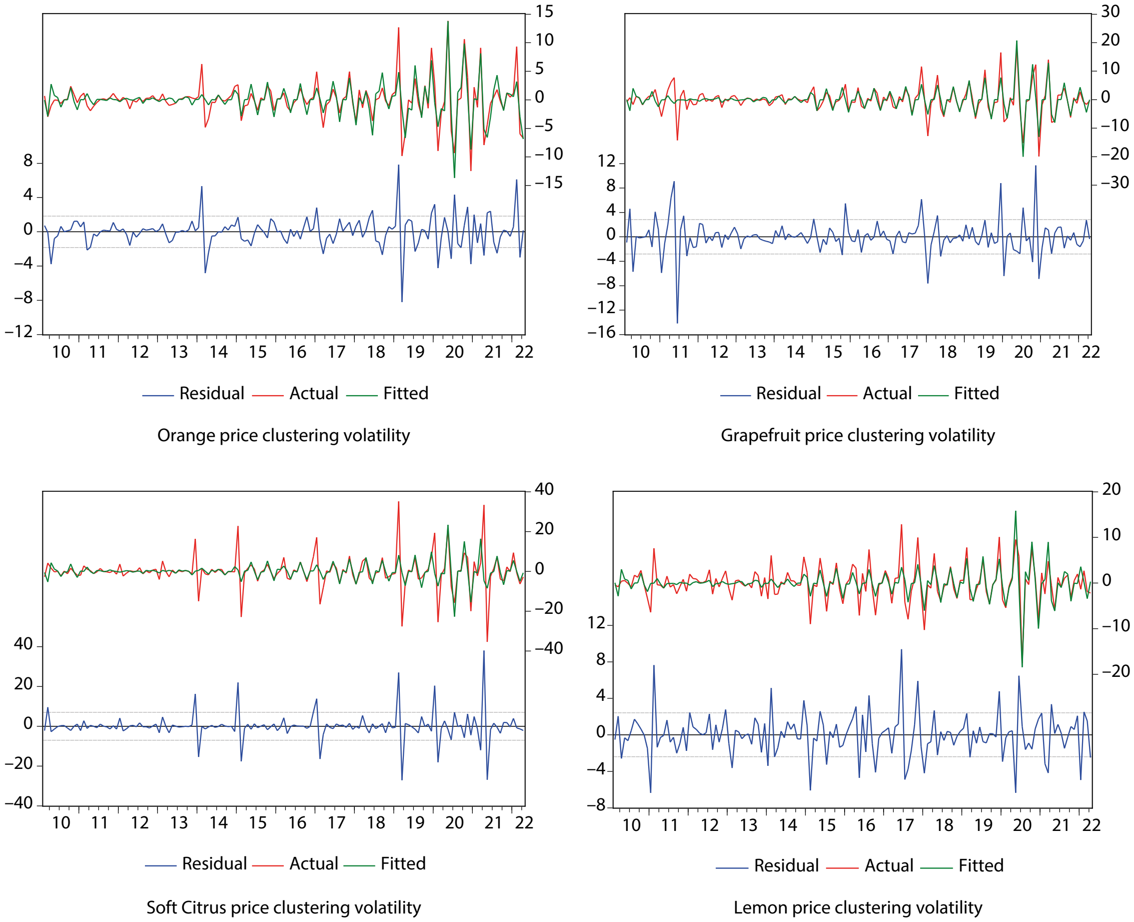

Fig. 4. Clustering volatilities for the four citrus species in South Africa
Source: data used sourced from Joburg Market (2010–2022).

the five error distribution methods. For Lemon, the lowest value for Akaike Info Criterion is 4.47 under GED and GARCH (1,1), yet the P value for Resid (-1) is more than 5%, and in terms of the Correlogram and ARCH LM test, the model does have ARCH effects and serial correlation, and the model is not accepted. Price volatility for Lemon is statistically insignificant. Soft citrus had the lowest Akaike Info value of 5.05 under student t. Both the residual and GARCH in their lagged form had a p value of more than 5%, and therefore are not statistically significant to explain price volatility for soft citrus. The Wald test results also show that the explanatory value, i.e., exchange rate, CPI and prime lending rate, with a p value of more than 5% are statistically insignificant to explain price volatility for soft citrus.

The implications are that everything remaining constant, farmers who are risk averse are likely to include soft citrus and lemon in their crop mix.

Regarding price volatility for oranges, the results with the lowest value for Akaike Info Criterion of 2.52 are found in GARCH (1,1) under GED, where the added values of coefficients yields a figure of 0.99, which indicates that price volatility for oranges is persistent. The *p* values are less than 5%, suggesting that the previous month's residual and the previous month's GARCH are statistically significant in explaining next month's orange price volatility. These explanatory variables serve as internal shocks.

The diagnostic testing results (Correlogram and ARCH LM test) are statistically significant, showing

Table 2. Summary of price volatility among the four species

Variance output		Lemon	Soft citrus	Orange	Grapefruit
GARCH Type		GARCH (1,1)	GARCH (1,1)	GARCH (1,1)	GARCH (1,3)
Error Distribution Method		GED	Student t	GED	GED
Lowest Akaike Info		4.47	5.05	2.52	4.21
Resid^2 (–1) or *Alpha*		–0.005 (0.9652)	358.3 (0.9951)	0.39 (0.0030)	0.26 (0.0197)
GARCH (–1) or *Beta*		0.58 (0.2170)	0.002 (0.7850)	0.60 (0.0000)	0.84 (0.0000)
Alpha + Beta		0.58	358.3	0.99	1.1
CPI		–7.59 (0.1443)	684.5 (0.9951)	–0.26 (0.0035)	–1.18 (0.1097)
Exchange rate		0.02 (0.9585)	76.8 (0.9951)	0.05 (0.0000)	0.40 (0.0159)
R squared		0.62	0.29	0.84	0.66
Correlogram Squared (p value)		Less than 5%	More than 5%	More than 5%	More than 5%
ARCH LM Test	Prob. F(1,44)	0.0000	0.7035	0.75	0.25
	Prob. Chi-square	0.0000	0.7012	0.75	0.24
Histogram	Jarque-Bera Stat	27.5	1905	102.4	31.6
	Histogram P value	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Wald test (p values)					
		Lemon	Soft citrus	Orange	Grapefruit
Ho: C(5) = 0	t statistic	(0.3986)	(0.9951)	(0.0036)	0.4832
	f statistic	(0.3986)	(0.9951)	(0.0036)	0.4832
	Chi square	(0.3971)	(0.9951)	(0.0030)	0.4820
Explanatory variables (p values)					
		Lemon	Soft citrus	Orange	Grapefruit
C(6) = C(7) = C(8) = C(9) = 0	t statistic	n/a	n/a	n/a	n/a
	F statistic	(0.0000)	(0.9993)	(0.0000)	(0.0000)
	Chi square	(0.0000)	(0.9993)	(0.0000)	(0.0000)

Source: data used sourced from Joburg Market (2010–2022).

that there are no ARCH effects, and there is no serial correlation. The Wald test results are also statistically significant at less than 5%. The exogenous factors, exchange rate and CPI with coefficient values of 0.005 and -0.26 respectively and *p* values of less than 5% are significant in explaining orange price volatility. For the CPI, the negative sign suggests that a unit increase in inflation will decrease orange price volatility at a factor of 0.26%. With regard to prime lending rate, the only instance in which it is statistically significant in explaining price volatility for one of the species (which is orange) is in GARCH (1,1) under GED, with the lowest value of Akaike Info Criterion of 2.53. It carries a coefficient of 0.12 and a *p* value of less than 5% (See Annexure A).

The theoretical explanation for the effects of exchange rate and CPI on orange price volatility can be found in the work of Aye and Odhiambo (2021), where it is purported that a weaker exchange rate can make imported agricultural inputs more expensive and stimulate high inflation. According to CGA (2020), as of 2019, oranges accounted for the largest area cultivated with citrus at 48%, followed by soft citrus at 25%, lemon at 19% and grapefruit at 9%, and by virtue of volume, is the biggest species to be exported. Incidentally, whenever the currency is weak, farmers will supply oranges to export markets, and this will affect local prices. Madito and Odhiambo (2018), Ngarava (2021) and Habanabakize and Dickason-Koekemoer (2021) have highlighted that inflation in South Africa is constituted by the following parameters: transport, electricity, fuel and labour. Thus, inflation is one of the channels that may hamper resource-poor farmers from supplying citrus products to local markets. The channel for the movement of exchange rate and interest rates can be linked to the mandate of SARB. To demonstrate this, normally, when the Rand depreciates, the SARB acts by increasing the repo rate. An increase in repo rate normally leads to an increase in the prime lending rates; a situation that results in farmers not being able to qualify for loans and credit.

Lack of access to credit normally leads to low volumes of citrus supplied to the market ceteris paribus. This must be read against the backdrop of a poor farmer support policy framework in South Africa. To improve on the policy framework, regarding farmer support programmes, South Africa can exploit policy provisions of the World Trade Organization, which are prescribed in the Green Box policy framework. The Green Box provides a broader framework outside restrictions for subsidies and tariffs on how the government can manoeuvre to make resource-poor farmers competitive and able to access export markets (IMF et al., 2022).

Some of the inflation contributing resources, such as the cost of diesel and electricity, can be included as part of the support structures for the farmers. Mpandeli and Maponya (2014) believe the South African government can include transport and accessibility to markets as other important farmer support services for resource-poor farmers.

Coming to the price volatility of grapefruit, in table 2, where the lowest Akaike Info value was established in GARCH (1,3) under GED, with added values for the residual and for the GARCH, yielding a figure of 1.1, it can be seen that its price volatility is not just persistent, but explosive. However, the Wald test results show that in terms of the t statistics, F statistics and the Chi square, the residual is not statistically significant in explaining grapefruit price volatility. The exogenous factors, CPI and exchange rate are statistically significant. The other results for the other different error distribution methods are presented in Annexure A to Annexure D. The previously mentioned annexures also contain the results of other exogenous variables, namely for prime lending rate paired with CPI.

CONCLUSION AND RECOMMENDATIONS

Using data derived from the Johannesburg Fresh Produce Market spanning a period of 12 years, GARCH was employed as an empirical model to study citrus price volatility. This is the first study of its kind in South Africa. The results show that price volatility is persistent for oranges at a 99% level and persistent for grapefruit at a 110% level. Due to the high levels of volatility, making projections for expected farm income and profitability may remain a difficult task for resource-poor farmers, and thus make it difficult to plan business expansion. The effects on selected macroeconomic variables were studied. The results show that interest rate, inflation and exchange rate were significant in explaining orange price volatility, whereas for grapefruit, it was only exchange rate and inflation. Since in South Africa, inflation targeting is the main economic policy framework for stabilising prices, and given the independent mandate of the SARB, the studied macroeconomic parameters may move in any direction at any point in time. Just as what happened during the crisis period of Covid-19, where the SARB increased the repo rate on more than 5 different occasions, it is clear that the government has no control over these parameters. As a recommendation, there is scope for the government to exploit the provisions of the Green Box programme of the WTO by providing farmers with resources that are susceptible to movements in exchange rate, interest rate and inflation. As examples, such resources could be diesel and transport. Assisting farmers to diversify their market accessibility with exports being a priority could be another key strategy for dealing with the effects of high price volatility in local markets.

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REFERENCES

Aguir, A. (2018). Central Bank Credibility, Independence and Monetary Policy. J. Centr. Bank. Theory Pract., 3, 91–110.

Akram, F. (2009). Commodity prices, interest rates and the dollar. Energy Econ., 32(6), 838–851.

Aye, G.C., Odhiambo, N.M. (2021). Threshold effect of inflation on Agricultural Growth: Evidence from Developing countries. Adv. Decis. Sci. Taich., 25(2), 1–2.

Barro, R.J., Gordon, D.B. (1983). A positive theory of monetary policy in a Natural Rate Model. J. Polit. Econ., 91(4), 589–610.

Bernstein, H. (2013). Commercial Agriculture in South Africa since 1994: Natural, Simply Capitalism. J. Agrar. Change, 13(1), 23–46.

Bitzer, V., Buman, J. (2014). Old Oranges in New Boxes? Strategic Partnerships between Emerging farmers and Agribusinesses in South Africa. J. South. Afr. Stud., 40(1), 167–183.

Chisasa, J., Makina, D. (2012). Trends in Credit to Smallholder Farmers in South Africa. Int. Bus. Econ. Res. J., 11(97), 771–784.

Citrus Grower Association (CGA). (2020). Key Industry Statistics for Citrus Growers, 2019 Export Season. Retrieved from https://www.google.co.za//Citrusgrowerassociation+key+industry+for+citrus+grower+2019

CGA (Citrus Grower Association). (2022). 2022 Industry Statistics: 2021 Export Season. Retrieved from: https://www.cga.co.za

Cousins, B. (2016). Land reform in South Africa is sinking. Can it be saved? A Commisison of Enquiry report compiled by the Research Chai on Poverty, Land and Agrarian Study, University of the Western Cape. The report sponsored by Mandela Foundation. Hanns Spidel Foundation and ouncil for the advancement of the South African Constitution.

DAFF (Department of Agriculture Forestry and Fisheries). (2020). The State of National Fresh Produce Markets (NFPMs) in South Africa. A presentation to the Portfolio Committee on Agriculture, Land Reform and Rural Development, 02 March 2020. Directorate Marketing. The Republic of South Africa.

Duverall, D., Loening, J.L., Birru, Y.A. (2013). Inflation dynamics and food prices in Ethiopia. J. Dev. Econ., (104), 89–106.

Engle, R.F. (1982). Autoregressive Conditional Heteroscedasticity with estimates of the variance of United Kingdom Inflation. Econometrica, 54(4), 987–1007.

Erten, B., Leight, J., Tregenna, F. (2019). Trade Liberalization and Local Labor Market Adjustment in South Africa. J. Int. Econ., 118, 448–467.

FAO (Food and Agriculture Organization of the United Nations). (2011). Price volatility in Food and Agricultural Markets: Policy Responses. FAO with contributions from IFAD, IMF, OECD, UNCTAD, WFP, the World Bank, the WTO, IFPRI and the UN HLTF. Retrieved from https://www.fao.org

FAO (Food and Agriculture Organization of the United Nations). (2015). The Economic Lives of Smallholder Farmers: An analysis based on household data from nine countries. Report compiled by George Rapsomanikis. Rome.

Genis, A.J. (2018). Oranges and labourers: The potential for job creation in the Citrus Sub-sector of South Africa. Working Paper 54. Institute for Poverty, Land and Agrarian Studies, University of Western Cape, South Africa.

Habanabakize, T., Dickason-Koekemoer, Z. (2021). Production and sales risks in the manufacturing sector: The role of electricity supply, inflation and fuel price volatility. Int. J. Econ. Fin. Iss., 11(6), 24–31.

Hsu Ku, Y., Chen, H., Chen, K. (2007). On the application of the dynamic conditional correlation model in estimating optimal time-varying hedge ratios. Appl. Econ. Lett., 14(7), 503–509.

IMF, OECD, WTO, World Bank. (2022). Subsidies, Trade and International Cooperation. Washington DC. Retrieved from https://www.wto.org/english/news_e/news22_e/igo_22apr22_e.pdf

Joburg Market (2021). Business Plan – 2020/2021: Implementing the People Centric Market of the Future. Retrieved from https://www.joburg.org.za/documents/Business%20Plans/Annexure_A6_2021-22_JoburgMarket

Kydland, F.E., Prescott, E.C. (1977). Rules rather than discretion: The inconsistency of optimal plans. J. Polit. Econ., 85(3), 473–491.

Lang, T. (2010). Crisis? What crisis? The normality of the current food crisis. J. Agrar. Change, 10(1), 87–97.

Madito, O., Odhiambo, N.M. (2018). The main determinants of inflation in South Africa: An empirical investigation. Org. Market. Emerg. Econ., 9(2), 212–232.

Maka, L., Aliber, M.A. (2019). The role of mentors in Land Reform projects supported through the Recapitalization and Development Programme: finding from Buffalo City Metropolitan Municipality, South Africa. South Afr. J. Agric. Exten., 47(2), 37–45.

Mangeni, B. (2019). The role of Public-Private Partnerships (PPPs) in ensuring technology access for farmers in sub-Saharan Africa. Afr. J. Food Agric. Nutr. Dev., 19(1), 14137–14155.

Mazorodze, B.T., Tewari, D.D. (2018). Real Exchange Rate undervaluation and sectoral growth in South Africa. Afr. J. Econ. Manag. Stud., 9(4), 462–476.

Miyajima, K. (2020). Exchange rate volatility and passthrough to inflation in South Africa. Afr. Dev. Rev., 32(3), 404–418.

Mncina, S.D., Agholor, A.J. (2021). Comprehensive Agricultural Support Programme as the prime mover of agricultural development agenda in South Africa. South Afr. J. Agric. Exten., 49(1), 122–140.

MoroŞan, G., ZubaŞ, I.M. (2015). Interest rates, exchange rate and inflation in Romania, correlates and interconnection. J. Publ. Admin. Fin. Law, 8, 146–160.

Mpandeli, S., Maponya, P. (2014). Constraints and Challenges facing Small-Scale farmers in Limpopo Province, South Africa. J. Agric. Sci., 6(4), 135–143.

NAMC (National Agricultural Marketing Council). (2020). SA Fruit Trade Flow. Issue 40. Markets and Economic Research Centre. Pretoria-South Africa.

Ngarava, S. (2021). Long-term relationship between food, energy and water inflation in South Africa. Water-Energy Nexus, 4, 123–133.

Oladipo, O. (2017). Inflation targeting and exchange rate passthrough to domestic prices: evidence from South Africa. J. Econ. Fin. Stud., 5(5), 1–11.

Ott, H. (2014). Extent and possible causes of intra-year agricultural commodity price volatility. Agric. Econ., 45, 2225–2252.

Rezaeedaryakenari, R., Landis, T.S., Thies, C.G. (2020). Food price volatilities and civilian victimization in Africa. Confl. Manag. Peace Sci., 32(2), 193–214.

Rusenga, C. (2020). Setting them up to fail: enforcement of the agribusiness model on land reform projects in South Africa. Rev. Afr. Polit. Econ., 47(165), 382–398.

Sayed, A., Auret, C. (2020). Volatility transmission in the South African White Maize Futures Market. Eurasian Econ. Rev., 10, 71–88.

Shi, G., Guo, J., Huang, W., Williams, B.M. (2014). Modelling seasonal heteroscedasticity in vehicular traffic condition series using a seasonal adjustment approach. J. Transport. Eng., 140(5), 04014012.

Sihlobo, W., Qobo, M. (2021). Addressing constraints to South Africa's agriculture inclusiveness. Black Economic Empowerment Project – SCIS Working Paper No. 26. University of the Witwatersrand, Johannesburg and Southern Centre for Inequality Studies.

SARB (South African Reserve Bank). 2011. SARB monetary policy in the decade 1989 to 1999: SARB 90th Anniversary. South Africa-Pretoria. Retrieved from: https://www.resbank.co.za

SARB (South African Reserve Bank). (2022). Monetary Policy Review-October 2022. Retrieved from: https://www.resbank.co.za/sarb/publications/monetary-policy-review/2022

StatsSA (2020). Census of Commercial Agriculture 2017: Financial and Production Statistics. Report No. 11-02-01 (2017), embargoed until 24 March 2020. Department Statistics South Africa-Republic of South Africa-Pretoria.

Tadesse, G., Algieri, B., Kalkuhl, M., von Braun, J.V. (2016). Drivers and triggers of international food price spikes and volatility. In: M. Kalkuhl, J. von Braun, M. Torero (Eds.), Food price volatility and its implications, for food security and policy (pp. 59–82). Springer, Cham.

Tirno, D., Gardachw, W., Addeye, N. (2021). Price Volatility for Selected Agricultural Commodities in Ethiopia: Evidence from GARCH models. WSEAS Trans. Bus. Econ., 18, 1380–1388.

USDA (United States Department of Agriculture). (2020). South African Citrus exports expected to reach record levels amid Covid-19. GAIN report number: SF2020-0054.

Wegerif, M. (2022). The impact of Covid-19 on black farmers in South Africa. Agrekon, 61(1), 52–66.

Wyche, S., Steinfield, C. (2016). Why don't farmers use cell phones to access market price? Technology Affordances and barriers to market information services adoption in rural Kenya. Inf. Technol. Dev., 22(2), 320–333.

Yu, X., Liu, C., Wang, H., Feil, J. (2020). The impact of Covid-19 on food prices in China: evidence of four major food products from Beijing, Shandong and Hubei Provinces. China Agric. Econ. Rev., 12(3), 445–458.

Zantsi, S., Mulanda, S., Hlakanyane, L. (2021). Small-scale agriculture, land reform and government support in South Africa: Identifying moral hazard, opportunistic behaviour and adverse selection. Int. J. Afr. Renais. Stud. Mult. Inter. Transdisciplin., 16(2), 119–144.