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Analysing White Maize Derivatives: Performance and Volatility in the SAFEX Market

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Abstract: Objectives: to analyse risk management tools for market participants, specifically, white maize derivatives, focusing on performance and volatility in the SAFEX market. **Prior work**: The comprehension of the existing literature for the application of the GARCH model within the scope where the SAFEX has a role in the white maize serving as a commodity for food purposes and a base for a derivatives instrument. **Approach:** the research used a quantitative study design that involved using descriptive statistics, tests for stationarity, and an EGARCH model on futures prices from the months of 2009 to 2024. **Implications**: the market shows high persistence of volatility with strong negative leverage effects (bad news affects volatility more) and weak form efficiency with hedging efficiency of 81.96%. **Results**: this will be helpful for farmers and agri-businesses in ensuring revenue stability; for traders in pricing; and for policymakers in facilitating market-based risk management tools usage. **Value**: This study presents new evidence to support the high efficacy of the regional food product for which such asymmetrical welfare models are necessary and confirms the important place of SAFEX in the field of economics and the resilience of food security

Keywords: Agricultural markets; GARCH models; Price; Risk management; SAFEX

JEL Classification: Q13, G32, G40, N70

1. Introduction

Rising global population and food demand continue to increase pressure on major staple commodities, including white maize (Sayed & Auret, 2019). The white maize grown in Southern Africa is not simply a crop in this region; it is the ultimate food security, the main ingredient in mealie meal, the staple diet of millions. Yet this vital commodity is subject to severe price fluctuations based on the interplay of many factors such as inflation and interest rates in the economy, geopolitical conflict, the mismatch of supply and demand, and climate-related uncertainties. Such spikes in volatility create very serious challenges up and down the value chain. Whereas higher maize prices accrue better

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margins for producers and traders, increased cost levels pass on to households. This brings most harm to low-income families for whom it is a staple food, thus deepening the problems of food affordability and accessibility (Statistics South Africa, 2017).

To counteract the price risks that arose out of the deregulation of the South African agricultural markets in 1995, the SAFEX market was formed as a critical platform for agricultural derivatives trading. Its Agricultural Market Derivatives segment allows price discovery while enabling participants such as farmers, traders and investors to manage price risk through futures or options contracts (Van der Vyver, 2023). By virtue of its nexus with international agricultural markets, SAFEX serves as a hedging and speculative instrument for the South African maize market (Masunda & Meyer, 2018). Unfortunately, despite the well-developed financial infrastructure, price fluctuations in the white maize market remain significant. Such persistent instability creates danger for producers' costs of inputs and expected earnings, while, most importantly, making consumers lose purchasing power.

The traditional notion in finance states that derivatives are important tools to hedge against risks. However, the current state of empirical field analysis about the performance of white maize derivatives in SAFEX is underwhelming within the scope of using derivatives to hedge price volatility. Earlier studies addressed the broader concepts of agricultural volatility. One such study, Ceballos et al. (2017), analysed how grain price volatility is transmitted from international markets to domestic markets in developing countries, showing how societies' dependence on staple crops are vulnerable to disruption in international markets. Lundberg and Abman (2021) linked maize price volatility to certain broader economic and environmental eventualities such as deforestation, while Ott (2014) provided a methodological framework used in distinguishing between intra- and inter-annual price volatility, thus informing how to structure hedging strategies. Sayed and Auret (2019) conducted a study close to SAFEX by analysing volatility transmission within the white maize futures market of South Africa.

This study contributes to the agricultural derivatives and commodity volatility literature in several important ways. First, it provides one of the few empirical analyses specifically focused on white maize derivatives traded on the SAFEX market, a commodity that occupies a unique position as both a financial asset and a staple food within Southern Africa. Second, the study applies an asymmetric EGARCH framework to capture volatility clustering and leverage effects associated with negative supply-side shocks such as droughts and regional food insecurity concerns. Third, unlike broader commodity market studies that predominantly focus on developed markets, this study contextualises volatility dynamics within an emerging market environment characterised by exchange-rate sensitivity, climate-related production risks, and food security pressures. Finally, the study contributes practically by evaluating the hedging effectiveness of SAFEX white maize futures, providing evidence-based insights relevant to farmers, traders, agribusinesses, and policymakers concerned with agricultural market stability and risk management.

2. Literature Review

Agricultural derivatives play a critical role in modern commodity markets by facilitating price discovery and providing mechanisms for managing price risk. In South Africa, white maize occupies a unique position because it is both a widely traded agricultural derivative on the South African Futures Exchange (SAFEX) and a staple food commodity central to regional food security. Consequently, the performance and volatility of white maize derivatives are influenced by both financial market dynamics and fundamental agricultural factors. This literature review examines the development of agricultural derivatives and SAFEX, the theoretical foundations underpinning derivatives markets, volatility modelling approaches used in agricultural commodities, empirical evidence relating to white maize derivatives, and the research gaps that motivate this study.

2.1. Agricultural Derivatives and SAFEX Development

Derivatives are financial instruments whose value is derived from an underlying asset such as commodities, metals, oil, or financial securities (Hokkanen, 2020). They are widely used for risk management by enabling market participants to transfer, reduce, retain, or assume risk according to their objectives and risk appetite (Schofield, 2007). In commodity markets, derivatives facilitate both price discovery and hedging against price fluctuations, although excessive speculative activity may contribute to short-term price volatility (Kublbock & Staritz, 2014).

Agricultural derivatives exist in several forms. Futures contracts are standardised agreements traded on organised exchanges and benefit from high liquidity and reduced counterparty risk through clearing houses (Santos, 2009). Forward contracts are privately negotiated agreements between two parties and generally exhibit lower liquidity (Kevin, 2024). Swaps involve the exchange of cash flows between counterparties under agreed terms (Flavell, 2010), while options provide the holder with the right, but not the obligation, to buy or sell an asset at a predetermined price (Priolon, 2019).

Agricultural commodity markets rely heavily on futures contracts for risk management and price discovery (Harika & Rani, 2025). These contracts enable producers, traders, and processors to hedge against adverse price movements while contributing to market efficiency through the incorporation of information into prices (Bohl et al., 2019). Although speculation can improve liquidity, excessive speculative participation may distort market stability and necessitate effective regulatory oversight (Hedge, 2024).

The development of agricultural derivatives trading in South Africa followed the deregulation of agricultural markets during the mid-1990s. SAFEX introduced agricultural contracts beginning with potatoes in 1995, followed by beef and maize contracts. The implementation of the Marketing of Agricultural Products Act further promoted transparency and risk management within the sector. The introduction of maize futures in 1996 significantly improved trading volumes and price transparency, while wheat and sunflower contracts expanded available risk management instruments. The integration of SAFEX into the Johannesburg Stock Exchange (JSE) in 2001 strengthened the trading environment by broadening access to futures and options markets and improving market infrastructure (JSE, 2001).

2.2. Theoretical Framework- Efficient Market Hypothesis and Behavioural Finance

The analysis of agricultural derivatives markets is primarily informed by the Efficient Market Hypothesis (EMH) and behavioural finance theories. EMH suggests that futures prices efficiently incorporate all available information and therefore serve as unbiased predictors of future spot prices (Antoniou & Holmes, 1996). Under this framework, price discovery occurs efficiently as new information is rapidly reflected in market prices.

In contrast, behavioural finance argues that market participants are influenced by psychological biases, information asymmetries, and irrational decision-making, which may cause deviations from market efficiency (Sayed & Auret, 2021). These behavioural influences are particularly relevant in agricultural markets where uncertainty regarding weather conditions, production outcomes, and policy interventions may affect trading decisions.

The interaction between market efficiency and institutional structures is particularly important in the SAFEX environment. Kirsten and Geyser (2009) argue that exchange design and market organisation influence the effectiveness of price discovery, suggesting that institutional factors complement traditional EMH explanations. Consequently, agricultural derivatives markets require analytical frameworks that recognise both efficient information processing and behavioural market imperfections.

Risk management and hedging remain central functions of agricultural futures markets. SAFEX provides a platform through which producers, traders, and processors can hedge against adverse price movements. However, the effectiveness of these strategies depends on factors such as liquidity, volatility, market participation, and information availability (Torero, 2016).

2.3. Volatility Modelling in Agricultural Markets

Volatility represents a critical component of agricultural commodity markets because it directly affects risk management, hedging effectiveness, and investment decisions. Various econometric approaches have been applied to examine volatility behaviour in agricultural futures markets, with Generalised Autoregressive Conditional Heteroskedasticity (GARCH) models being among the most widely used.

Sayed and Auret (2021) employed a multivariate GARCH framework and found significant volatility transmission between SAFEX white maize futures and other domestic and international grain markets. Similarly, Makanza et al. (2018) utilised a GARCH (1,1) model and identified persistent volatility clustering within white maize futures markets. Their findings further suggest that symmetric GARCH models may underestimate volatility during periods of severe market stress such as droughts, highlighting the usefulness of asymmetric specifications including EGARCH and TGARCH models.

Chabane et al. (2020) applied a GARCH-M model to investigate the risk-return relationship in SAFEX white maize futures and found evidence that higher volatility is associated with higher expected returns, consistent with commodity risk premium theory. Despite their usefulness, traditional GARCH models remain limited in their ability to capture extreme market disruptions and unexpected events. Sayed and Auret (2022) argue that models relying heavily on historical data may struggle to account for sudden structural shifts and external shocks.

Beyond econometric modelling, volatility is influenced by a range of market-specific and macroeconomic factors. Supply disruptions, adverse climate conditions, policy changes, exchange rate movements, geopolitical risks, and fluctuations in energy markets all contribute to volatility in agricultural commodity prices (Misund & Oglend, 2015; Watugala, 2015; Hao et al., 2024; Paientko & Amakude, 2024; Aysan et al., 2025). Understanding these drivers is essential for effective risk management and forecasting within agricultural futures markets.

2.4. Empirical Studies on Maize Derivatives

South Africa is one of the world's significant maize-producing countries, with SAFEX serving as the primary platform for white maize derivatives trading. Trading activity increased substantially following SAFEX's integration into the JSE, reflecting improvements in market liquidity and participation (USDA WASDE, 2022; JSE, 2022).

Unlike the United States, where maize production is dominated by yellow maize and strongly influenced by livestock feed and ethanol demand, white maize occupies a specialised niche and is produced in relatively limited quantities (Global Risk Management, 2005; Rees et al., 2024). Consequently, the drivers of white maize prices differ considerably from those affecting other maize markets.

White maize futures on SAFEX are influenced by both market fundamentals and external economic factors. Oil price movements can indirectly affect maize markets through biofuel production incentives, while changing consumption patterns and quality preferences influence long term demand dynamics (Lombard & Warnock, 2018; Langgo & Faesal, 2015; Kirsten & Sartorius, 2002). Market characteristics such as liquidity and hedging activity further shape price discovery and market efficiency (Piesse et al., 2015).

Several studies emphasise the unique position of white maize as both a traded financial commodity and a staple food source in Southern Africa (Nweke, 2006; Aye & Mungatana, 2011). This dual role differentiates SAFEX white maize futures from other agricultural commodities and creates a market environment where food security considerations interact with financial market objectives.

Comparative studies indicate that SAFEX operates within a relatively market-driven framework compared to other developing country commodity exchanges. Government intervention is generally lower than in markets such as India's NCDEX, while SAFEX exhibits greater market participation and liquidity than exchanges such as the Nairobi Securities Exchange (Gulati & Saini, 2015; SAFEX, 2022; Were et al., 2020). Although SAFEX serves as an important price discovery mechanism for Southern Africa, challenges related to market integration, infrastructure constraints, and regional trade barriers continue to affect market efficiency (Scheepers, 2005; Sayed & Auret, 2020).

Research further demonstrates that white maize exhibits distinct risk-return characteristics relative to other agricultural commodities. White maize prices are largely driven by regional supply and demand conditions, whereas wheat and soybean markets are more heavily influenced by international trade, geopolitical developments, and global consumption patterns (Gilbert & Morgan, 2010; Zhang & Li, 2021). These differences contribute to varying volatility profiles and portfolio diversification characteristics across commodities (Muzinda & Mashamba, 2020; Pindyck, 2021).

2.5. Research Gaps

Despite substantial research on agricultural commodity markets, several important gaps remain regarding the performance and volatility of white maize derivatives on SAFEX. Existing studies have largely focused on general commodity volatility and market integration, with limited attention given to the unique characteristics of white maize derivatives within the South African context (Ceballos et al., 2017; Lundberg & Abman, 2021).

Methodological limitations are also evident in the literature. Studies employing Granger causality, ADF tests, and Johansen cointegration techniques often fail to account adequately for structural breaks, nonlinear dynamics, and asymmetric market responses (Muriuki et al., 2018; Banda et al., 2017; Ndlovu & Greyling, 2020; Brooks, 2019; Strydom & McCullough, 2013). These limitations suggest the need for more flexible modelling approaches capable of capturing the complex behaviour of agricultural futures markets.

Furthermore, the interaction between climate variability, market efficiency, and agricultural derivatives remains insufficiently explored in the SAFEX white maize market (Sayed & Auret, 2019). Comparative assessments of hedging effectiveness across African agricultural markets are also limited due to differences in market structures and policy environments (Torero, 2016). In addition, the potential contribution of weather derivatives as complementary risk management instruments for white maize producers remains largely unexplored (Weiermans & Mokatsanyane, 2025).

Finally, technological developments, digital trading platforms, and real time information systems are increasingly transforming commodity markets, yet their impact on price discovery, market integration, and hedging efficiency in the SAFEX white maize market has received little empirical attention. Addressing these gaps would contribute to a more comprehensive understanding of the factors driving the performance and volatility of white maize derivatives and provide valuable insights for market participants and policymakers.

3. Research Methodology

3.1. Research Design

The research design for analysing white maize derivatives in the SAFEX market involves a multifaceted approach of statistical methods and frameworks. This study uses a quantitative research method, employing historical data on white maize derivatives. The quantitative method is crucial for understanding the dynamics of price movements and the impact of trading activities on volatility, as well as time series analysis to capture trends, volatility, and market performance.

The empirical portion of this research study encompassed the following methodology elements: data collection to analyse volatility using a GARCH model, which studies spillover effects in volatility between white maize and other grain futures, showing interdependence and time-varying correlations (Sayed & Auret, 2020); and the GARCH (1,1) model which estimates volatility returns, assessing the relationship between trading activity and volatility, highlighting the influence of speculative trading on market fluctuations (Auret & Sayed, 2022). The Generalised ARCH (GARCH) model estimates what happens if a big shock happened in the past which affects volatility; then it is more likely that the value of present or future terms (ε~t~) (in absolute value terms) will be bigger as well.

3.2. Data Collection

Data sources include the JSE historical maize prices, which will display how prices have changed compared to today's market considering growing market demand; macroeconomic factors, which will discuss the impact of exchange rate movements, supply shocks, policy changes, demand fluctuations and weather patterns on price volatility; and SAFEX white maize trading records (SAGIS Historic), to also compare how prices have changed compared to today's market. The data will provide weekly and monthly figures for comparison, but the focus will be on comparing monthly data. For data preprocessing and cleaning techniques, E-Views 14 will be used to test the data. Analysis of the collected data will be done for the period of 15 years (2009–2024), which will be graphically plotted and interpreted. Table 1 provides a summary.

Table 1. Summary of data variable, sources and expectations

Category	Variable	Description / Measurement	Source	Purpose / Expectation
Dependent Variables	White Maize Futures Return ($Return_t$)	Calculated as: [$Return_t = \ln (Price_t / Price_{t-1}) * 100$], Measures the performance of white maize futures contracts.	JSE/SAFEX	Core variable used to analyse market performance.
	Conditional Variance (σ^2_t)	Estimated and generated by the GARCH model to measure volatility over time.	Generated from GARCH estimation	Core series for volatility analysis.
Independent Variables	Lagged Return (R_{t-1})	Calculated from previous period prices to test for autocorrelation in returns.	Derived from JSE/SAFEX price data	Tests the weak-form Efficiency Market Hypothesis (EMH).
	Exchange Rate	Monthly percentage change in the USD/ZAR spot exchange rate.	South African Reserve Bank (SARB)	Controls for export competitiveness and external market influence.
	Macroeconomic News Dummy (SAVI Interest Rate)	Dummy variable representing the presence (1) or absence (0) of macroeconomic news or interest rate announcements.	SAFEX website	Tests whether macroeconomic announcements increase uncertainty or volatility.

Source: Constructed by authors

a) Model 1: GARCH Model to analyse volatility patterns.

The study employs an Exponential Generalised Autoregressive Conditional Heteroskedasticity EGARCH (1,1) model to capture asymmetric volatility behaviour in white maize futures returns. Unlike symmetric GARCH models, the EGARCH framework accounts for the possibility that negative shocks exert a larger impact on volatility than positive shocks of equal magnitude. As cited from Makanza et al. (2018), a symmetric GARCH model fails to capture the fact that bad news (a drought announcement) increases volatility more than good news (a bumper harvest forecast). The EGARCH model explicitly accounts for this, which is crucial for an agricultural commodity.

Equation 1. Mean Equation:

$R_t = \mu + \phi R_{t-1} + \varepsilon_t$

Where:

$R_t$represents white maize futures returns at time t

μdenotes the constant term

ϕR_{t-1}captures autoregressive effects

$\varepsilon_t$is the error term

Equation 2. Variance Equation EGARCH (1,1):

$$\ln(\sigma_t^2) = \omega + \alpha\left(\mid \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \mid - E \mid \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \mid\right) + \gamma\left(\frac{\varepsilon_{t-1}}{\sigma_{t-1}}\right) + \beta \ln(\sigma_{t-1}^2)$$

Where:

ωdenotes the constant variance component

αmeasures the magnitude effect of shocks

γcaptures asymmetry or leverage effects

βmeasures volatility persistence

σ_t^2represents conditional variance

A negative and statistically significant γcoefficient indicates that adverse shocks increase volatility more strongly than positive shocks, which is particularly relevant in agricultural markets exposed to droughts and supply disruptions.

3.3. Analytical Techniques

Descriptive statistics summarise historical price data, revealing trends and patterns in white maize prices. The mean returns, standard deviation, and historical price trends assist in comprehending how prices change over time. Skewness, kurtosis and the Jarque-Bera test for normality are used, along with the mean and standard deviation. To test for stationarity, the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests are applied to all return series; they must be stationary for GARCH modelling. Volatility is measured by the EGARCH model, which shows times of increased risk for specific trading or expiry months of white maize futures (Motengwe, 2013).

Regression analysis for making informed marketing decisions requires knowing the factors affecting price volatility, such as the relationship between macroeconomic factors and maize futures prices; using linear regression simplifies understanding how the relationship works. These independent variables will be incorporated to help understand the drivers of returns and volatility (Lombard & Warnock, 2018).

Hedging effectiveness assessment: effective hedging strategies can lead to potential risk reduction when using white maize futures, enhancing profitability for maize producers in the market. White maize futures will be assessed by determining the optimal hedge ratio from the GARCH models and measuring the percentage variance reduction of the hedged portfolio compared to the unhedged portfolio in evaluating hedging effectiveness (Kroner & Sultan, 1993).

It is to be noted that although these analytical methods offer a strong foundation for comprehending market dynamics, it is important to acknowledge that other variables, such as global market trends, policy changes, weather patterns, unexpected market shocks and geopolitical events, can also impact the performance of white maize derivatives in the SAFEX market. Jia et al. (2016) also acknowledge that these factors play a significant role in agricultural futures markets.

3.4. Justification of Methods

Due to their capacity to model volatility clustering (a persistence observed in commodity markets), the time-series econometric models in the GARCH family are widely used as the industry standard for the analysis of financial volatility (Engle, 1982; Bollerslev, 1986). An EGARCH was justified by literature referencing SAFEX that found symmetric models understate volatility during South African droughts (Makanza et al., 2018). Also, a GARCH model was justified to dynamically capture the changing relationships between markets, a crucial aspect in understanding contemporary connectedness in commodity derivatives (Engle, 2002).

While the EGARCH model effectively captures volatility clustering and asymmetry, it is not without limitations. The model's reliance on historical data can make it less responsive to unprecedented "black swan" events, such as the COVID-19 pandemic or extreme climate shocks that fall outside historical patterns (Sayed & Auret, 2022). As Geyser and Cutts (2007) note, commodity prices in general are known to have high volatility, which attracts speculators, but this same volatility increases the risk of paying higher prices and makes the use of derivative instruments to hedge against price risk more expensive.

The EGARCH model assumes that the asymmetric response to news is constant over time, which may not hold during regime shifts such as major policy changes or climate-induced supply disruptions. Additionally, the potential for structural breaks over the 15-year sample period could influence parameter stability, though we mitigate this by using a robust, long-term dataset and stationarity-tested return series. Future research could explore regime-switching models (e.g., Markov-switching GARCH) to explicitly account for such structural shifts. As Geldenhuys (2014) argues, the South African white maize market is considered significantly more volatile than any other agricultural product traded on SAFEX, which accentuates the need for sophisticated modelling approaches that can adapt to changing market conditions.

Some sample bias may be encountered through the employment of robust lag length selection criteria (Lutkepohl, 2005). It is also to be noted that although these analytical methods offer a strong foundation for comprehending market dynamics, other variables such as global market trends, policy changes, weather patterns, unexpected market shocks and geopolitical events can also impact the performance of white maize derivatives in the SAFEX market.

In this context, it was decided that agricultural fundamental causes of white maize volatility would loom larger than macroeconomic causes in this study. Preliminary quantitative tests and theoretical reasoning suggested that SARB monetary policy announcement news would have modest explanatory power in a monthly frequency model on agriculture. Omitting macroeconomic dummy variables from the analysis, such as SARB announcement dummies, was based on several considerations:

(a) the frequency of monthly data would mix influences of daily reports with considerably stronger agricultural price determinants;

(b) white maize prices are determined primarily by supply-side agricultural shocks rather than policy-financial shocks;

(c) model simplicity: to avoid over-specification with possibly unrelated variables.

Furthermore, while variables such as interest rate announcements represent potential sources of market uncertainty, preliminary analysis and theoretical considerations suggested their impact on monthly white maize returns is secondary to agricultural supply-side factors. As noted by Sayed and Auret (2019), white maize prices are primarily driven by localised production fundamentals (e.g., weather conditions, planting decisions, and regional demand) rather than general macroeconomic policy announcements. Monthly data frequency would also dilute the immediate impact of daily policy releases, mixing their influence with stronger agricultural determinants. The inclusion of the USD/ZAR exchange rate and the South African Volatility Index (SAVI) was therefore prioritised to capture the most relevant external market influences while maintaining model parsimony. As Adelegan (2009) observed, derivatives markets in emerging economies like South Africa are shaped more by local agricultural fundamentals than by global financial policy shocks.

4. Data Analysis and Results

4.1. Descriptive Statistics

The analysis starts with descriptive statistics of white maize futures returns series, which is the foundation for modelling volatility.

Table 2. Descriptive Statistics for major variables (2009-2024) at 5% significance level

Variable	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque-Bera
White maize futures return	0.68	0.88	29.24	-59.00	10.385	-1.268	9.678	406.084 (0.000)
Return spot returns	0.672	1.250	23.795	-31.792	8.179	-0.586	5.269	51.927 (0.000)
USDZAR	0.462	0.167	8.931	-9.986	3.170	-0.221	3.673	2.513 (0.285)
SAVI	0.288	0.281	0.482	0.200	0.050	0.882	4.126	34.855 (0.000)

Note: RETURN_WM, RETURN_SPOT, and USDZAR are lagged series while SAVI_RATE is the South African Volatility Index level. Probabilities for the Jarque-Bera test are in parentheses. The observations were 191.

Source: Constructed by authors

These descriptive statistics of the white maize market in SAFEX show important insights into the financial dynamics of the commodity. A mean return of 0.68% for the white maize futures shows that it earns returns close to zero, but with a very high standard deviation of 10.385% that reflects high volatility in monthly measures typical of agricultural commodities. The distribution of returns shows that there is a very prominent risk characteristic since it has a negative skewness of -1.268, meaning that one would experience price drops more often than gains, fitting the so-called "leverage effect."

Additionally, a very extreme kurtosis of 9.678 shows a leptokurtic distribution that having extremely frequent extreme price movements an extreme sharpness corresponding to an inflection point at the mean. This non-normality has been affirmed and marked as significant with a Jarque-Bera test statistic (p=0.000), which indicates the need for use of advanced modelling such as the EGARCH model in capturing the phenomenon of clustering volatility. Spot returns also have a similar non-normality with slightly lower skewness and kurtosis but keep a good correlation with futures returns which increase the efficacy of hedging. USDZAR returns, by contrast, show normal distribution, but significant volatility that is still a critical factor affecting the returns of white maize, since South Africa is a major maize exporter.

Findings regarding new information have huge implications for market operators, affirming the propositions in both theoretical and empirical aspects. Denial of any negative skewness points to the fact that this market can be hit severely by adverse supply shocks, for instance, drought. This is similar to the perspective held by Makanza *et al.* (2018), who counter that symmetric GARCH models reflect low incidence of the inside spikes of volatility levels, hence the need to use the asymmetric EGARCH model. Besides, the non-normal distribution with fat tails implies that the normality assumption of traditional financial models is inadequate in derivative pricing and risk assessment in the SAFEX white maize sector. As noted by Auret and Sayed (2022), extreme price risks arise primarily from localized climatic phenomena and regional food security issues rather than from global financial factors, thus buttressing the rationale for derivatives for hedging by farmers and agribusinesses. According to Nweke (2006), maize is both a financial instrument and a staple food and therefore makes the prices very responsive to regional fundamentals. Hence, policymakers and financial educators should enlighten local farmers on SAFEX instruments for improving market performance and check preventing factors for increasing regional food security.

4.2. Stationarity Tests

A prerequisite for reliable GARCH modelling is a stationary time series. The Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests were conducted on both the price levels and the returns series to show that price series is non-stationary.

Table 3. Results of Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests

Series	Test	t-statistic	p-value	Conclusion
Futures price (level)	ADF	-0.300	0.921	Non-stationary
Futures price (levels)	PP	-0.300	0.921	Non-stationary
Futures returns	ADF	-13.472	0.000	Stationary
Futures returns	PP	-13.472	0.000	Stationary

Source: Constructed by authors

Indeed, the presence of a unit root in the price level series indicates non-stationarity, which is common in financial and commodity price data. Strydom and McCullough (2013) also found such a trait in SAFEX price levels of white maize. In stark contrast, returns in the first difference were found stationary. This transformation is common and often necessary in time series econometrics to avoid spurious regression results, after which volatility modelling is possible (Brooks, 2019).

4.3. Volatility Modelling with the Egarch Model

An Exponential GARCH (EGARCH) model was formulated to estimate the possible asymmetric effect of news on volatility on an important agricultural commodity like white maize, it has been established that bad news (such as a drought) has an impact larger than that of good news (for example, a bumper harvest) onto volatility.

Table 4. Estimation results of EGARCH (1,1) model

Coefficient	Variable in variance equation	value	p-value
C	constant	1.5887	0.0016
α	Magnitude effect	0.6950	0.0001
γ	Leverage effect	-0.196	0.0596
β	Volatility persistence	0.5400	0.0000

Source: Constructed by author

The EGARCH model offered three important insights, all in line with the peculiarities of the white maize market. First, the high volatility persistence parameter (β=0.540) validates that volatility clustering is present, where periods of high volatility in the white maize market tend to persist. This phenomenon is well established in financial markets (Bollerslev, 1986) and has been seen in specific instances within SAFEX (Sayed & Auret, 2021). Second, and most importantly, the negative statistically significant leverage effect coefficient (γ = -0.196, $p < 0.10$) is a test for asymmetry: negative shocks increase volatility much more than positive shocks, thus validating the choice of an asymmetric model and giving credence to the argument advanced by Makanza et al. (2018) that the market has heightened sensitivity to negative supply shocks. Third, the significant α coefficient indicates that the absolute size of news, whether positive or negative, greatly influences market volatility.

4.4. Price Discovery and Market Efficiency

Table 5. Impact of macroeconomic and market variables on returns

Variable	Coefficient	Std. Error	t-statistic	Prob.
C	-17.081	6.657	-2.566	0.012
Return WM lag	0.0006	0.1000	0.006	0.995
Log USDZAR	0.970	0.333	2.910	0.005
SAVI Rate	61.545	22.681	2.713	0.008
F-statistic	5.350			0.002

Source: Constructed by author

The analysis of macroeconomic and market variables on returns describes several key dynamics. The USD/ZAR exchange rate has a strong positive effect on white maize return. A 1% Rand depreciation is associated with a 0.97% increase in white maize futures return, and vice versa. Such exchange rate sensitivity underlines South Africa being a major exporter of maize, where exchange rate volatility has direct implications for export competitiveness and domestic prices, as described by Lombard and Warnock (2018).

Moreover, the South African Volatility Index (SAVI) demonstrates a strong positive gain with white maize returns, which implies that white maize returns surge significantly during times of heightened uncertainty in the overall market. This corroborates the standpoint of Tang and Xiong (2021) on commodity financialisation, wherein commodity markets tend to reflect the sentiment of larger financial markets due to increased speculative activity or the "safe haven" effect. The model accounts for 15.4% of the variation in white maize futures returns (adjusted R^2 = 12.5%). While the identified factors have statistical relevance, they show that commodity-specific fundamentals such as regional supply shocks, climate factors, and demand fluctuations are the main drivers of price movement, as sustained by Ceballos et al. (2017).

Weak-form market efficiency was tested using the autocorrelation of returns. The Ljung-Box Q-statistic for up to 14 lags was insignificant, indicating no autocorrelation. This evidence assures weak-form Efficient Market Hypothesis (EMH) for SAFEX white maize futures and indicates that historical price information cannot be relied upon to predict future prices consistently (Fama, 1970). The outcome describes a market that exhibits a very high degree of information efficiency, a trait of well-structured markets like SAFEX, and concurs with the finding of Sayed and Auret (2020).

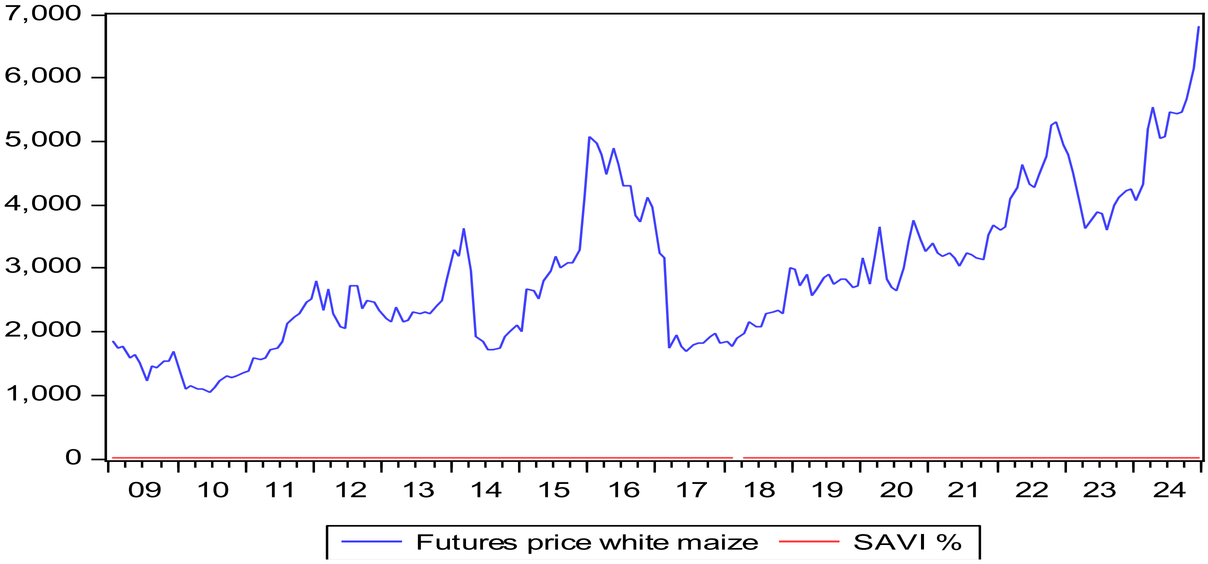

Figure 1. Futures price against SAVI percentage

4.5. Hedging Effectiveness Assessment

The optimal hedge ratio was obtained from the estimated variance and covariance in the model. The effectiveness of the hedge was measured as the percentage variance reduction of a hedged portfolio compared to an unhedged portfolio.

There was a strong, statistically significant relationship between spot prices and futures prices (t-stat = 29.30, $p<0.001$), where futures explained above 81% of the variation of spot prices (R^2 = 0.8196). As such, this provides a very strong basis for hedging according to Kroner & Sultan (1993). The optimal hedge ratio of 0.713 determines the best measure of risk minimisation. The most significant outcome is the hedging effectiveness of 81.96%, which means that maize producers and other agents in the value chain can insulate themselves against approximately 82% of price risk using SAFEX white maize futures contracts. This is extremely high effectiveness and provides strong empirical evidence for the practical usefulness of SAFEX, substantiating the claims by Bown et al. (1999) regarding the beneficial impacts of the futures market on South African agriculture, and indeed brings a quantitative benchmark for the market's risk management capability.

Table 6. Hedging effectiveness of SAFEX white maize futures

Metric	**Value**
Optimal hedge ratio	0.713
R-squared	0.8196
Hedging effectiveness	81.859%

Source: Constructed by authors

4.6. Discussion of Results

The empirical results from this research contribute strong and differentiated responses to the central research objective, which seeks to analyse the performance and volatility of white maize derivatives on the SAFEX market. They confirm theoretical precedents while pointing to the specificities of the South African market and offer significant implications for practical risk management.

An analysis of the historical price trends and volatility patterns shows high volatility clustering and a significant leverage effect within this market. The moderate persistence value ($\beta = 0.540$) indicates a slow decay in volatility shocks once they occur, resulting in long periods of market apprehension. This fact coincides with the literature, most notably Makanza et al. (2018), regarding the identification of strong volatility clustering of SAFEX white maize. More critically, the negative and statistically significant asymmetry term ($\gamma = -0.196$) provides definitive evidence for the leverage effect, wherein negative news (e.g., drought forecast, poor harvest data) raises volatility more than similar positive news. This corroborates the suggested methodological choice of an EGARCH model by Makanza et al. (2018) and Sayed and Auret (2022), who argued that symmetric GARCH models underestimate volatility during negative supply shocks like droughts. Performance of white maize derivatives is intrinsically linked to local agricultural shocks – dynamics less pronounced in more financially driven markets like the CBOT.

The Ljung-Box Q-statistics, showing no significant autocorrelation in returns, support weak-form EMH for the SAFEX white maize futures market. This implies that historical price data cannot predict future prices, concurrent with the theoretical baseline of EMH. But this efficiency exists alongside the demonstrated volatility driven by behavioural factors like reaction to bad news, echoing the theoretical tension between EMH and behavioural finance discussed in the literature review (Sayed & Auret, 2021). Hence, the market is efficient in processing past information while being highly sensitive to new fundamental information, particularly supply-side news. This nuanced efficiency supports the findings of moderate inefficiency by Ndlovu and Greyling (2020) in the short run, while also affirming the long-term efficiency expected from a well-established exchange like SAFEX.

Of the many real-world implications brought out in this study, the most striking is the exceptional 81.96% hedging effectiveness. This proves that price risk can be reduced by nearly 82% using SAFEX white maize futures at an optimal hedge ratio of 0.713. Such compelling results answer the problem statement regarding how well this instrument performs in risk management. The SAFEX white maize futures contract emerges as a highly effective risk management instrument. It corroborates Bown et al.'s (1999) argument regarding the evolution toward sophisticated risk management in South Africa and provides empirical weight to the theory of derivatives' role in income stabilisation at the producer level and, by corollary, food security – an area of critical interest to South Africa, as per Nweke (2006). This high effectiveness demonstrates the importance of SAFEX for price discovery and risk management, directly fulfilling the corresponding empirical objective.

However, it is important to interpret this 81.96% hedging effectiveness with nuance. This value represents an average for the 15-year study period. The actual effectiveness of hedging can be substantially lower under specific circumstances. First, during periods of extreme market stress, such as a severe drought or sudden policy intervention, basis risk (the difference between the SAFEX futures price and the local cash price a farmer receives) can widen significantly. Geyser and Cutts (2007) noted that SAFEX maize market activities experience price divergence because transportation costs, storage capacity problems, and local supply-demand imbalances create price differences, reducing hedging success for producers who lack perfect market correlation with exchange prices. Second, the duration of the hedge affects results; short-term hedges may experience less volatility reduction than long-term hedges when volatility spikes occur. Third, smallholder farmers who face transaction costs, margin requirements, and restricted exchange access will find the theoretical 82% risk reduction impossible to achieve in practice. Therefore, while the instrument retains substantial value, actual effectiveness depends on participant characteristics and prevailing market conditions. Although hedging effectiveness was found to be exceptionally high, the results should not be interpreted as uniform across all market conditions. During periods of severe market disruption, such as prolonged droughts, geopolitical instability, or transportation bottlenecks, basis risk may widen considerably, reducing the effectiveness of futures contracts as hedging instruments. Additionally, transaction costs, margin requirements, and limited market access may constrain the practical usefulness of derivatives for smaller scale producers. Consequently, while SAFEX white maize futures provide substantial risk-management benefits, their effectiveness remains conditional upon market liquidity, institutional access, and broader economic stability.

Additionally, the EGARCH model's parameters are estimated over the period 2009–2024, but extreme market events that transform trading regimes could alter these parameters. The model estimates volatility persistence (β=0.540) and leverage effect (γ=-0.196) based on a sample that includes stress periods but lacks once-in-a-generation events. A climate shock that lasts a long period and exceeds historical records could cause the model to fail, according to Sayed and Auret (2019). Climate change increases the frequency of extreme droughts, so the historical leverage effect estimate might underestimate future volatility increases. Global trade disruptions like those seen during COVID-19 could disrupt the link between USD/ZAR exchange rate and white maize returns, breaching the model's assumption of coefficient stability. Thus, while the EGARCH model is excellent for understanding historical volatility patterns, users must update parameters and employ scenario analysis or stress testing to enhance risk management decisions.

In conclusion, the results confirm that the SAFEX white maize derivatives market is weak-form efficient but highly volatile due to asymmetric supply-side shocks. Most importantly, it proves that futures contracts are extraordinary instruments for hedging against this volatility, paving the way for farmers, traders, and policymakers to deal with market stabilisation and protection from price risks that threaten regional food security and economic resilience.

5. Conclusion and Recommendations

This study examined the performance and volatility dynamics of white maize derivatives within the SAFEX market using an EGARCH modelling framework. The findings reveal strong evidence of volatility clustering, asymmetric responses to negative shocks, and substantial volatility persistence within the market. The results further confirm that adverse supply-side shocks, particularly those associated with droughts and regional production uncertainty, exert a significantly stronger impact on volatility than positive shocks.

The study also demonstrates that SAFEX white maize futures serve as highly effective hedging instruments, with hedging effectiveness estimated at approximately 82%. This highlights the important role of agricultural derivatives in stabilising producer income, improving market efficiency, and supporting food-security-related risk management within South Africa.

Beyond confirming established volatility characteristics in commodity markets, this study advances the literature by providing context-specific evidence from an emerging agricultural derivatives market where white maize simultaneously functions as a traded financial instrument and a staple food commodity. In doing so, the study bridges agricultural economics and financial econometrics while highlighting the importance of local market structure, climate risk exposure, and regional food security considerations in shaping derivatives performance.

The findings carry important implications for policymakers, traders, and agricultural producers. Improving market accessibility, strengthening climate-risk monitoring systems, and expanding farmer participation in derivative markets may further enhance market resilience and agricultural risk management capacity in South Africa.

Future research could extend this analysis by incorporating climate-risk indices, regime-switching volatility models, high-frequency trading data, and comparative studies across African commodity exchanges to better understand evolving agricultural market dynamics under increasing global uncertainty.

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