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Analysing the relationship between load shedding and chicken meat prices in South Africa during the intense load-shedding period (2014–2023)

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Abstract: Since 2008, South Africa has experienced frequent electricity outages, referred to as load shedding, which have severely disrupted energy-intensive agricultural industries such as the poultry industry due to its heavy reliance on electricity for broiler production, slaughtering, refrigeration, and cold storage throughout the value chain. Based on this, this study investigates the relationship between load shedding and chicken meat prices in South Africa from 2014 to 2023. For the analysis, monthly secondary time-series data on chicken meat prices were obtained from the South African Poultry Association, while load shedding data were sourced from the Council for Scientific and Industrial Research. Descriptive statistics, trend analysis, Johansen's cointegration test, and a simple linear regression model were employed to analyse the underlying patterns and relationships between load shedding and chicken meat prices. Descriptive statistics revealed that the average monthly load shedding was 238.08 GWh, with a range from 0.000 GWh to 2667 GWh, whereas wholesale IQF chicken meat prices averaged R22.29 per kilogram, with a minimum of R14.13 per kilogram and a maximum of R32.41 per kilogram. Trend analysis showed that both load shedding and chicken meat prices increased over the study period, with notable spikes in load shedding during 2022–2023. Johansen's cointegration test showed no evidence of a long-term equilibrium relationship. Nonetheless, results from the simple linear regression exhibited a statistically significant positive relationship, with a one-unit increase in load shedding associated with R0.09 rise in chicken meat prices. However, the model accounted for only 37.5% of the variability. These findings imply that although load shedding influences short-term price increases, other factors also affect chicken meat prices in South Africa. Consequently, policy strategies should focus on mitigating immediate price pressures, while broader interventions addressing additional cost drivers within the value chain are equally essential to promote sustained price stability.

Keywords: chicken meat prices, load shedding, nexus, regression analysis, and South Africa

Introduction

Since 2008, South Africa has faced ongoing electricity outages, known as load shedding (Klishi, 2024). Load shedding involves the deliberate and controlled interruption of electricity supply to specific areas to prevent the entire national grid from failing due to limited generation capacity (Erero, 2023). This recurring problem, especially since 2010, has caused considerable economic and social impacts. The poultry industry, which is highly energy-dependent, is among the most affected sectors. Meat production relies heavily on electricity for broiler houses, slaughterhouses, cold storage facilities, and refrigeration and logistics across the entire supply chain (Kuka, 2025).

The sector's reliance on electricity makes it particularly vulnerable to supply disruptions, which raise operational costs, reduce productivity, and hinder profitability.

Chicken meat serves as a fundamental protein source for the population of South Africa, which is also the largest poultry producer on the continent, accounting for approximately 20% of Africa's total output (Govoni et al., 2021). The sector makes substantial contributions to the national gross domestic product and employment levels (Mashapu & Mathaba, 2024). Load shedding causes disruptions to essential operations, including feed and water supply, ventilation, as well as heating and cooling systems, thereby elevating production costs that are subsequently transferred to consumers (Pooe, & Tazvivinga, 2024; Siankwilimba, 2019). Additionally, power outages adversely affect growth rates and production volumes, leading to increased mortality rates and diminished yields. Such disruptions can result in supply shortages and price increases, disproportionately impacting low-income households that depend on affordable protein sources. Considering the electricity crises confronting the poultry industry and the consequent operational and cost-related pressures, this study investigates the relationship between load shedding and chicken meat prices in South Africa.

Theoretical underpinnings of the study

The relationship between load shedding and chicken meat prices in South Africa can be examined through theories of supply and demand, cost-push inflation, and household food security. These frameworks highlight the complex and far-reaching impacts of unreliable electricity supply on the poultry industry. The supply and demand theory explains that the prices of commodities, including chicken meat, are primarily driven by the balance between supply and demand. Load shedding hampers the chicken meat supply chain by causing production delays, reducing the availability of poultry products, and increasing operational costs for farms and processing facilities. As Baxevanou et al. (2017) observe, poultry farms require energy for essential operations such as heating, cooling, and processing; load shedding disrupts these activities, leading to reduced output capacity. Consequently, when the supply of chicken meat decreases while demand remains constant or increases, the price of chicken meat tends to rise. The disruption in supply, coupled with an inability to meet consumer demand, swiftly results in price hikes, which disproportionately affect low-income households that rely on chicken as an affordable source of protein (Dewa et al., 2020).

In the realm of cost-push inflation, load shedding acts as a key factor that increases production costs. Businesses forced to invest in backup generators and adopt costly alternative energy options to keep operations running during power outages pass these extra expenses along the supply chain. Poultry farms and processing plants, already operating with slim profit margins, bear the burden of rising fuel, maintenance, and operational costs. The cost increases, driven by the need for energy security during load shedding, lead to higher prices for chicken meat. The cost-push inflation theory suggests that rising production costs force companies to raise prices to maintain profitability, thereby raising consumer prices across various sectors, including food (Goldberg, 2015; Arikan et al., 2022).

Furthermore, the influence of load shedding on poultry meat prices markedly impacts household food security within South Africa. Chicken meat constitutes an essential source of affordable protein, forming a staple component of numerous households' diets, particularly in low-income communities. Volatile chicken prices, precipitated by supply disruptions, may render this vital aliment less accessible, thereby exacerbating food insecurity. The escalation in prices can disproportionately affect vulnerable households, impairing their capacity to secure adequate nutrition and thus directly threatening their food security. Price fluctuations within the poultry sector underscore the interconnection between energy infrastructure and household nutrition, emphasising the critical need for a reliable electricity supply to ensure food security (Akin et al., 2020; Dewa et al., 2020). In conclusion, the relationship between load shedding and chicken meat prices in South Africa is intricate, shaped by supply disturbances, increased production costs, and broader socio-economic impacts on food security.

South Africa's electricity market has experienced structural changes, tariff increases, and recurring load shedding, which have heightened pressure on energy-intensive sectors like poultry (Chan & Delina, 2023; Cloete et al., 2023; Ngoepe-Ntsoane, 2025). From 2008 to 2022, above-inflation tariff hikes combined with periodic load shedding events (2014, 2020) have greatly affected the cost structures and market prices of chicken (Jacobs, 2023; SU Bureau for Economic Research, 2023; Energy Finance, 2024). Although extensive global research exists on energy prices and food costs, there is limited study on country-specific, energy-intensive commodities and how recurring structural shifts in electricity supply influence food prices in developing economies.

In response to this gap, the current study examined the relationship between load shedding and chicken meat prices in South Africa from 2014 to 2023. Specifically, trend analysis was conducted to determine whether observed price increases coincide with periods of intensified load shedding. The Johansen cointegration test was employed to investigate the long-term relationship, while the simple linear regression model was utilised to quantify the magnitude of the short-term relationship. By doing so, this study addresses the gap in the literature on country-specific, energy-intensive commodities and the long-term effects of recurring electricity disruptions.

Methodology

Research design

This study used a quantitative time-series research design with secondary monthly data to examine the relationship between load shedding and wholesale chicken meat prices in South Africa. Wholesale chicken meat portion prices were obtained from the South African Poultry Association (SAPA), which maintains industry-verified monthly price statistics. Average monthly load shedding data were collected from the Council for Scientific and Industrial Research (CSIR), known for its comprehensive energy-sector reporting and national load shedding monitoring. Therefore, the analysis was based on data from two reputable and sector-specific sources. The study spanned ten years (2014–2023), including both 2014 and 2023, resulting in a total of 120 observations, calculated as follows:

n = number of years × number of months per year = 10 × 12 =120

Justification of the study period

The period from 2014 to 2023 (10) which is the sample size of this study was deliberately selected as it signifies the most critical phase of South Africa's electricity supply crisis. Although isolated load shedding incidents commenced in 2012, it was only from 2014 onward that load shedding was systematically implemented and maintained, marking the onset of an intense and prolonged electricity crisis within the country. Consequently, the timeframe of 2014–2023 encapsulates both the institutionalisation and escalation of load shedding, rendering it highly pertinent for analysing its economic ramifications. By 2023, South Africa experienced unprecedented levels of load shedding, with approximately 6,948 hours and 24,869 GWh of electricity shed (CSIR, 2024). This decade-long interval provides a coherent and data-rich period for evaluating the dynamic impact of electricity disruptions on energy-intensive industries, such as the poultry sector.

While early 2024 data indicate a modest improvement, with approximately 1,656 hours and 4,126 GWh shed by March 2024 (CSIR, 2024), these observations represent incomplete and potentially transitional dynamics. To avoid structural breaks and enhance model accuracy, 2024 and 2025 were excluded to ensure that the econometric estimations reflect a consistent phase of intensive load shedding. Similarly, years prior to 2014 were omitted, as they do not reflect a continuous or systematic load shedding regime and could therefore distort the trend analysis.

Analytical techniques

To accomplish the objectives of this study, a sequential analytical methodology was adopted, as delineated below. Descriptive statistics, including the mean, maximum, minimum, and standard deviation, alongside graphical trend analysis, were utilised to furnish preliminary insights into fluctuations in prices and electricity disruptions throughout the study period. Subsequently, unit root tests, specifically the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests, were conducted to verify the stationarity of the time series data, an essential prerequisite for reliable econometric modelling. Upon confirmation of stationarity, the Johansen cointegration test was implemented to assess whether chicken meat prices and load shedding exhibit a long-term equilibrium relationship, thereby establishing potential persistent associations between energy disruptions and food prices. Ultimately, a simple linear regression model was employed to quantify the short-term impact of load shedding on monthly wholesale chicken meat prices, with the coefficient denoting the magnitude and direction of the effect. By integrating these analytical techniques, the study offers a comprehensive examination of both the long-term and short-term relationships between load shedding and chicken meat prices, thus fulfilling the research objectives.

Descriptive and trend analyses

Descriptive statistics were used to summarise and analyse the trends of load shedding and chicken meat prices in South Africa from 2014 to 2023. Specifically, they outlined the mean, minimum, maximum, and standard deviation of monthly wholesale prices for frozen chicken meat portions, as well as the average monthly load shedding. Trend analysis, supported by graphical representations, was employed to visualise fluctuations and patterns throughout the study period, providing a comprehensive overview of the variations in load shedding and chicken meat prices time.

Unit root testing

To ensure the suitability of the data for econometric modelling, unit root tests were performed using the Augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) tests. The ADF test addresses serial correlation by including lagged differences of the series, while the PP test adjusts for heteroskedasticity and autocorrelation through non-parametric methods (Hamilton, 1994; Enders, 2014). The ADF regression is specified as (Dickey and Fuller, 1979):

$$\Delta Y_t = \alpha + \beta_t + \gamma Y_{t-1} + \sum_{i=1}^{\rho} \Delta Y_{t-1} + \varepsilon_t \quad (1)$$

where: $\triangle Y_t =$ the first difference of the time series (y_t–y_{t-1}); α = the constant (intercept term; β_t = optional deterministic trend; γ = coefficient of the lagged level; δ_i = the coefficients of the lagged differences; *p* = the number of lags; and ε_t = the error term (Enders, 2014). The PP test is expressed as:

$$\triangle Y_t = \alpha + \beta_t + \gamma y_{t-1} + \varepsilon_t \quad (2)$$

where ΔY_t is the first difference, α is a constant, βt is the trend term, γ is the coefficient of the lagged level, and ε_t is the error term (Enders, 2014).

The utilisation of both the Augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) tests to evaluate stationarity was imperative in this study to secure dependable estimates of the relationship between load shedding and chicken meat prices. Each test addresses specific statistical concerns: the ADF accounts for serial correlation through the inclusion of lagged differences, whilst the PP test adjusts for heteroskedasticity and autocorrelation via non-parametric methods. The employment of both tests consequently enhanced the robustness and reliability of the findings. Establishing stationarity was of paramount importance, as non-stationary data can lead to spurious correlations induced by trends or structural shifts rather than genuine associations. Confirming that both variables were stationary, or appropriately differenced to attain stationarity, ensured that subsequent Johansen cointegration and regression analyses accurately reflected the true long-term and short-term dynamics between electricity disruptions and poultry price fluctuations in South Africa (Enders, 2014; Greene, 2018).

Cointegration testing

Once stationarity was confirmed using the Augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) tests, the Johansen cointegration test (Johansen, 1991) was employed to determine whether load shedding and chicken meat prices share a long-term equilibrium relationship. Unlike the Engle–Granger method, which is limited to a bivariate framework, the Johansen approach can be used for both two-variable and multivariate systems, enabling the simultaneous estimation of one or more cointegrating relationships and thus enhancing analytical robustness and accuracy (Enders, 2014; Greene, 2018). The test is based on the following vector autoregressive (VAR) representation:

$$\Delta Y_t = \prod Y_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \, \Delta Y_{t-1} + \varepsilon_t \quad (3)$$

where Y_t is a vector of endogenous variables (chicken meat prices and load shedding), Π indicates the long-run matrix that captures the cointegration relationship, and Γ_i represents short-term adjustments. In the context of this study, identifying cointegration would imply that, despite short-term fluctuations, chicken meat prices and load shedding move together over time toward a stable long-run equilibrium. This finding provides evidence that persistent electricity disruptions have a structural influence on poultry prices in South Africa, offering policy insights into the long-term vulnerability of the agri-food system to energy instability.

Regression analysis

After determining whether a long-term relationship exists between load shedding and chicken meat prices, a straightforward linear regression model was applied to measure and quantify the short-term impact of load shedding on chicken meat prices in South Africa from 2014 to 2023. This model investigates the direct link between the independent variable (monthly average load shedding) and the dependent variable (wholesale monthly prices of frozen chicken meat portions), thereby estimating how fluctuations in load shedding influence price movements. The regression assumes linearity, independence of errors, and homoscedasticity, which were tested and verified to ensure the reliability of the results (Gujarati & Porter, 2009). The coefficient β_1 represents both the direction and magnitude of the effect of load shedding on chicken meat prices. The general model is specified as:

$$Y_t = \beta_0 + \beta_1 X_t + \varepsilon_t \quad (4)$$

The general model was transformed into a specific model as:

$$Pc_t = \beta_0 + \beta_1 Ld_t + \varepsilon_t \quad (5)$$

where Pc_t= monthly wholesale prices of frozen chicken meat portions; Ld_t= monthly average load shedding, β_0= intercept; β_1= regression coefficient quantifying the effect of load shedding, and ε_t = random disturbance term. A simple linear regression model allows the study to quantify the extent of short-term price fluctuations caused by electricity disruptions, complementing the long-term relationship examined by the Johansen cointegration test.

Table 1: Description of variables used in the study model

	Variable code	Variable name	Unit of measurement
		Dependent variable	
Y	P_C	Average monthly prices of wholesale frozen chicken meat portions	South African Rands per kilogram (R/Kg)
		Independent variable	
X_1	L_D	Average monthly load shedding	Gigawatt hour (GWh)

Source: Authors' compilation

Results and discussion

This section presents and discusses the results of the empirical analysis based on the study's aim of exploring the relationship between load shedding and chicken meat prices in South Africa. It begins with descriptive statistics that summarise the main features and variability of the data series. This is followed by a trend analysis showing the changes in chicken meat prices and electricity disruptions over time, offering initial insights into their possible co-movements. To confirm the data's suitability for econometric modelling, the results of the stationarity tests namely, the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests are then presented. Next, the Johansen cointegration test results are shown to determine if a long-term equilibrium relationship exists between the two variables. Finally, the section ends with the findings from a simple linear regression model, which estimates the short-term impact of load shedding on wholesale chicken meat prices. These analytical stages collectively offer a detailed framework for understanding how fluctuations in electricity supply affect both the long-term stability and short-term dynamics of chicken meat prices in South Africa.

Descriptive results

The empirical analysis commences with a detailed discussion of the descriptive statistics for the data series employed in this investigation. These statistics furnish a comprehensive summary of the principal characteristics of each variable, including the mean, median, minimum, maximum, and standard deviation. Such measures provide an overview of central tendency, dispersion, and the data range, thereby establishing the foundation for understanding variability and distribution patterns prior to conducting further econometric analysis. Table 2 exhibits these descriptive statistics for the two primary variables under examination, namely, average monthly load shedding and wholesale chicken meat prices.

Table 2: Results of the descriptive analysis

	L_D	P_C
Mean	238.08	22.29
Median	26	22.08
Minimum	0.00	14.13
Maximum	2667	32.41

Standard deviation	434.17	4.86

Note: All figures were rounded to two decimal places

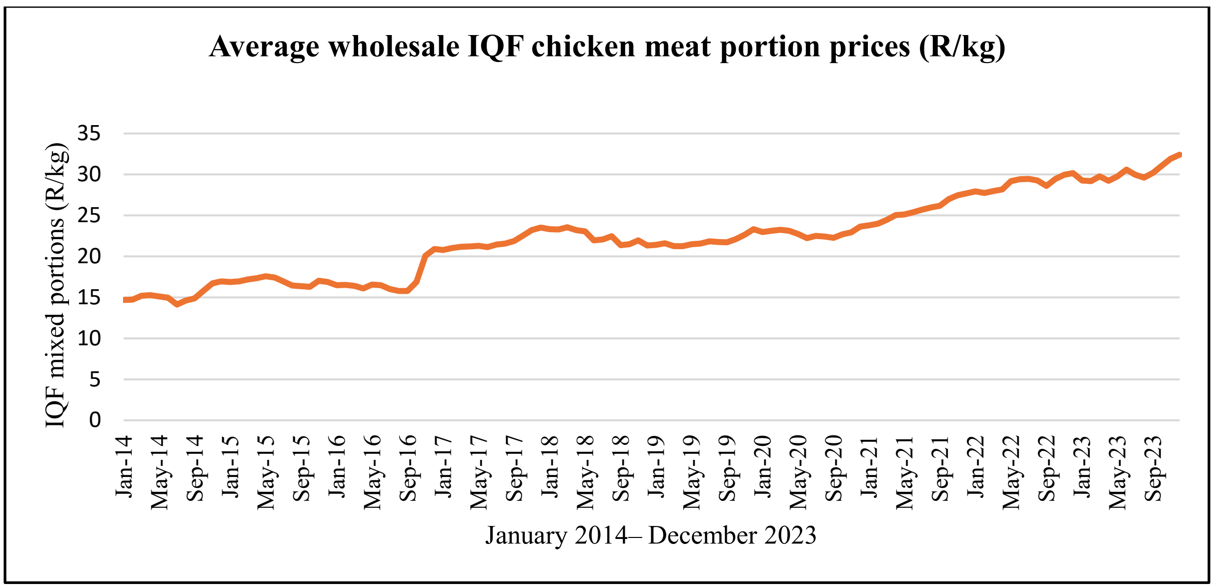
Source: Authors' compilation (2023)

The findings indicate that the average monthly load shedding and wholesale prices of individually quick-frozen (IQF) mixed chicken portions in South Africa from 2014 to 2023 were 238.08 GWh and R22.29 per kilogram, respectively. The comparatively low average wholesale price reflects the exclusion of retail markups from the dataset. The wholesale price of IQF chicken portions ranged from R14.13 to R32.41 per kilogram, demonstrating significant price variability throughout the period. The standard deviations for load shedding and wholesale prices were 434.17 GWh and R14.13 per kilogram, respectively. The elevated standard deviation of load shedding indicates considerable fluctuations around the mean, whereas the lower standard deviation of wholesale prices suggests a more consistent distribution of price values over time.

Trend analysis results

This section presents the results of the trend analysis, highlighting the temporal dynamics of wholesale prices of individually quick-frozen (IQF) mixed chicken portions and average monthly load shedding in South Africa between 2014 and 2023. The analysis unfolds in three stages. First, the movement and fluctuations of wholesale prices of IQF mixed chicken portions are examined over the study period. Second, the temporal patterns of average monthly load shedding are highlighted, showing periods of high and low electricity disruptions. Third, the co-movement between load shedding and chicken meat prices is explored to provide a descriptive understanding of potential associations between electricity supply variability and price dynamics. Figure 1 displays the results of the trend analysis of wholesale prices for IQF chicken meat portions in South Africa from 2014 to 2023.

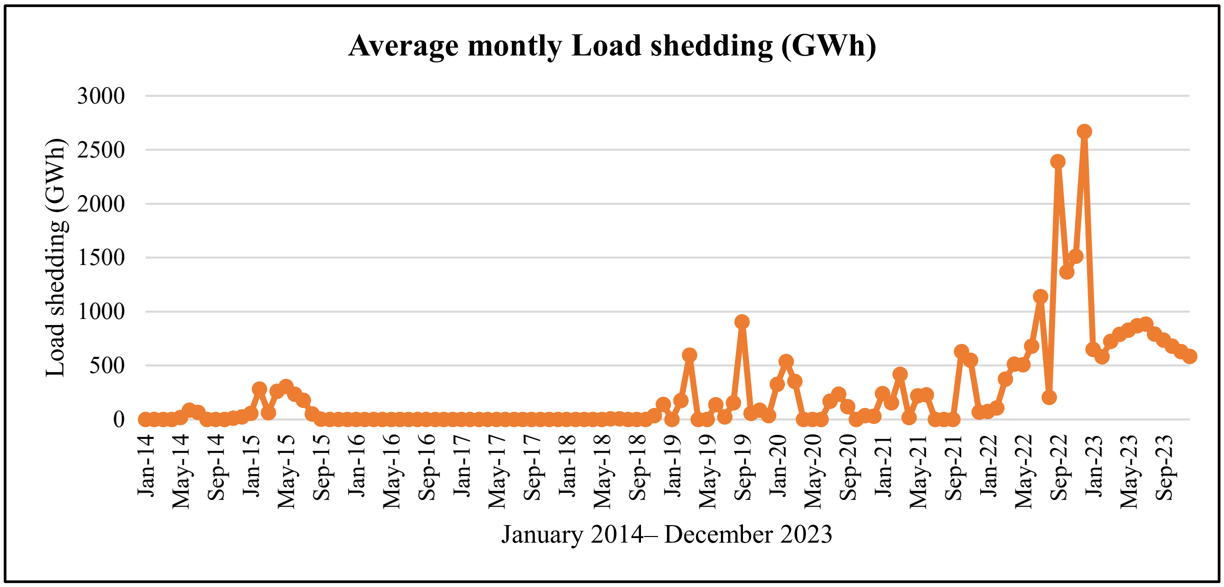
Figure 1: Prices of IQF chicken meat portions in (R/kg)



Source: Authors based on SAPA (2023) data

The trend analysis indicates that wholesale prices of individually quick-frozen (IQF) mixed chicken portions were initially below R15 per kg from January to September 2014, representing the lowest price levels during the study period. From June to December 2014, prices increased by an average of R2.57 per kg, showing early signs of upward pressure. A more significant rise occurred between September 2016 and January 2018, with an average increase of R7.72 per kg, roughly three times greater than the increase seen in 2014. Conversely, a slight price decline was recorded from April 2018 to May 2019. However, from September 2020 onwards, prices generally resumed an upward trend, reaching above R30 per kg by the end of 2023. This period coincides with record-level load shedding in South Africa, suggesting a possible link between increased electricity disruptions and rising wholesale chicken prices. Despite occasional short-term decreases, the overall trend points to a consistent rise in IQF chicken prices over the study period. These patterns imply the presence of market shocks, underscoring the need for further analysis to determine whether fluctuations in electricity supply, especially load shedding, have contributed to the observed price trends. Figure 2 displays the average monthly load shedding in South Africa from 2014 to 2023.

Figure 2: Average monthly load shedding in South Africa



Source: Authors based on CSIR (2023) data

The trend analysis indicates that from January to April 2014, there was no load shedding. Then, in May 2014, load shedding began with an average of 19 GWh, escalating to 85 GWh in June 2014. In contrast, September and October 2014 saw no load shedding. However, between November 2014 and September 2015, South Africa experienced significant load shedding, peaking at 306 GWh in May 2015, marking the first major peak in the country. After this period, load shedding stopped from October 2015 to October 2018, reflecting a three-year phase of relative grid stability. Nevertheless, from November 2018 onwards, load shedding returned and intensified rapidly, with the 2019–2021 period characterised by intermittent but increasing disruptions, with notable spikes over 900 GWh in October 2019 and repeated surges throughout 2020 and 2021. The severity escalated sharply in 2022 and 2023, recording the highest levels of load shedding in South Africa to date. Major peaks were observed in June 2022 (around 1,100 GWh), October 2022 (more than 2,300 GWh), and February 2023 (approximately 2,650 GWh), which stands out as the single highest month of load shedding across the entire 2014–2023 period. These steep and sustained rises highlight the worsening energy crisis, as also noted by Naidoo (2023).

Electricity supply is a vital factor affecting productive activities and overall economic growth (Dewa et al., 2020). Therefore, the observed fluctuations and sustained increases in load shedding over the study period indicate a strong potential for direct impacts on economic activities, including those in the agricultural and food sectors. This highlights the importance of analysing the relationship between electricity disruptions and wholesale chicken meat prices, as increasing load shedding may lead to higher production costs and market price volatility. Figure 3 compares the trends in monthly movements of load shedding and IQF chicken prices across the study period from 2014 to 2023

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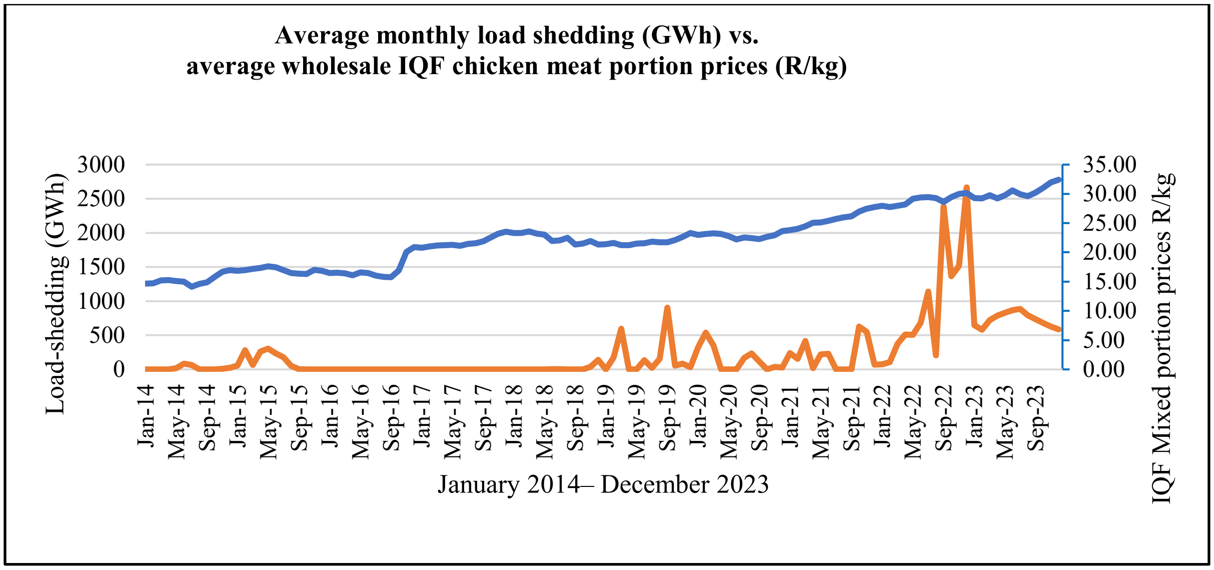
Figure 3: Mixed portion prices (R/kg) of IQF vs. load shedding (GWh)



Source: Authors based on data SAPA (2023) and CSIR (2023) data

The comparative analysis indicates that, overall, both variables showed an upward trend, with IQF chicken prices rising from R14.69/kg in January 2014 to around R31.00/kg by December 2023, while load shedding increased from 0 GWh to a peak of about 2,650 GWh in February 2023. Notably, in June 2014, a slight dip in chicken prices (from R14.96/kg to R14.13/kg) coincided with a reduction in load shedding (from 85 GWh to 69 GWh). Conversely, during the extended period from October 2015 to October 2018, when no load shedding occurred, chicken prices continued to increase steadily, reflecting additional factors unrelated to electricity disruptions.

Subsequently, as load shedding sharply increased from November 2018 through 2023, reaching unprecedented levels in 2022 and 2023, IQF chicken prices also showed corresponding upward trends. Although the rises in chicken prices were more gradual and less volatile than the spikes in load shedding, their timing, especially during periods of severe energy shortages, indicates a possible link between escalating electricity disruptions and rising wholesale poultry prices. Overall, the patterns observed suggest that both IQF chicken prices and load shedding rose over the study period, with coinciding increases highlighting a potential connection between electricity supply fluctuations and wholesale chicken meat prices. This paves the way for further econometric analysis to measure the strength and significance of this relationship.

Unit root test results

This section shows the results of unit root tests conducted to evaluate the stationarity of the time series data. Testing for stationarity was crucial in this study because the subsequent Johansen cointegration test assumes that the variables are integrated of the same order. Therefore, the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests were used to formally examine whether the series displayed stochastic trends or fluctuated around a constant mean, establishing a basis for the cointegration analysis. Table 3 displays the results of the ADF unit root test. The results of the ADF test for Pc (wholesale IQF chicken prices) and Ld (average monthly load shedding) are shown in Table 3.

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Table 3: Results of the ADF unit root test

Variable	Test equation	Test for unit root	ADF statistics	Test critical value at 5%	Probability Value	H_0 results
Pc	Trend and intercept	Level	-2.45	-3.44	0.3509	Fail to reject
		First difference	-8.18	-3.44	0.000	Rejected
Ld	Trend and intercept	Level	-3.44	-3.44	0.0507	Fail to reject
		First difference	-13.09	-3.44	0.000	Rejected

Note: Mackinnon (1996) one-sided p-values

Source: Authors' compilation (2023)

The Augmented Dickey-Fuller (ADF) test assesses whether a time series is stationary by testing the null hypothesis that a unit root exists (meaning the series is non-stationary) against the alternative hypothesis of stationarity. The null hypothesis is rejected if the absolute value of the ADF test statistic exceeds the critical value and the p-value is below the selected significance level (usually 5%). The ADF results show that both series are non-stationary in their level forms. Specifically, the ADF test statistic for Pc (wholesale IQF chicken prices) at the level was -2.45, which is smaller in magnitude than the critical value of -3.44, with a p-value of 0.35. Likewise, Ld (average monthly load shedding) had a test statistic of -3.44, surpassing the critical value of -3.449, with a p-value of 0.0507.

In both cases, the null hypothesis of a unit root could not be rejected, indicating that the series are non-stationary in levels. However, after first differencing, both Pc and Ld became stationary. The ADF test statistic for the first-differenced Pc was -8.18 (p-value = 0.000), and for Ld it was -13.09 (p-value = 0.000), both surpassing the critical values at the 5% significance level. This shows that both series are integrated of order one, I(1), reaching stationarity after first differencing. Overall, the ADF results confirm that wholesale chicken prices and load shedding data are non-stationary at the level but stationary after first differencing, fulfilling a key precondition for the subsequent Johansen cointegration test.

The Phillips-Perron (PP) test was employed in conjunction with the Augmented Dickey-Fuller (ADF) test to provide a robust assessment of stationarity. While both tests evaluate the presence of a unit root, the PP test differs from the ADF test in its approach to correcting for serial correlation and heteroskedasticity in the error terms without adding lagged difference terms, making it a complementary method for verifying stationarity (Afriyie et al, 2020; Verma et al., 2022). As with the ADF, the PP test evaluates the null hypothesis that a time series is non-stationary against the alternative hypothesis of stationarity. The null hypothesis is rejected if the absolute value of the PP test statistic exceeds the critical value and the p-value is below the chosen significance level (commonly 5%). The results of the PP test for Pc (wholesale IQF chicken prices) and Ld (average monthly load shedding) are presented in Table 4.

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Table 4: Results of the PP unit root test

Variable	Test equation	Unit root test	PP test statistics	Critical test Value at 5%	Probability Value	H_0 results
Pc	Trend and intercept	Level	-2.01	-3.44	0.5871	Fail to reject
		First difference	-7.95	-3.44	0.000	Reject
Ld	Trend and intercept	Level	-6.70	-3.44	0.000	Failure to reject
		First Difference	-73.55	-3.44	0.0001	Reject

*Mackinnon (1996) one-sided p-values

Source: Authors' compilation (2023)

The PP test results indicate that both Pc and Ld were non-stationary in their level forms. Specifically, the PP test statistic for Pc was -2.01 (p-value = 0.5871), and for Ld it was -6.70 (p-value = 0.000), indicating a failure to reject the null hypothesis of non-stationarity. However, after first differencing, both series became stationary, with Pc showing a PP statistic of -7.95 and Ld -73.55, both with p-values of 0.000, surpassing the 5% critical value. These results confirm that both series are integrated of order one, I(1), satisfying a key assumption for the subsequent Johansen cointegration analysis.

Johansen cointegration test results

Following the descriptive, trend, and unit root analyses, the study conducted the Johansen cointegration test to determine whether a long-term equilibrium relationship exists between wholesale IQF chicken prices (Pc) and average monthly load shedding (Ld). The unit root tests (ADF and PP) confirmed that both variables are integrated of order one, I(1), fulfilling the necessary condition for Johansen's cointegration test. Since Pc and Ld are integrated of order one, I(1), the Johansen cointegration analysis is suitable for examining whether the two variables move together over the long term. The Johansen test uses two complementary statistics, namely the trace statistic and the maximum eigenvalue statistic, to identify the number and existence of cointegrating relationships between the variables, thus offering a reliable framework for assessing the long-term dynamics indicated by the descriptive and trend analyses. Table 5 shows the results of the Johansen cointegration test for wholesale IQF chicken prices (Pc) and average monthly load shedding (Ld).

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Table 5: Johansen cointegration results for Pc and Ld

Unrestricted Cointegration Ranking Test (Trace)				
Hypothesized No. of CE(s)	Eigenvalue	Trace statistic	0.05 Critical value	Prob.**
None.	0.073379	8.783210	15.49471	0.3858
At most 1	0.000166	0.019037	3.841465	0.8902
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen-Statistic	0.05 Critical Value	Prob.**
None*	0.073379	8.764173	14.26460	0.3063
At most 1	0.000166	0.019037	3.841465	0.8902

Notes: The trace test indicates that there is no cointegration at the 0.05 level.

The Max-Eigenvalue test indicates 1 cointegrating equation at the 0.05 level.

* Denotes the rejection of the hypothesis at the 0.05 level.

**Mackinnon-Haug-Michelis (1999) p-values

Source: Authors' compilation (2023)

The results of the trace test indicate that the null hypothesis of no cointegration cannot be rejected. Specifically, the trace statistic for no cointegration was 8.783, which is less than the critical value of 15.495, with a p-value of 0.3858. Furthermore, for at most one cointegrating equation, the trace statistic was 0.019, below the critical value of 3.841. These findings imply that there is no evidence supporting a long-term equilibrium relationship between Pc and Ld based on the trace statistic, suggesting that the series do not converge over the long term.

Conversely, the Max-Eigenvalue test indicates that the null hypothesis of no cointegration is not rejected at the 5% significance level, with a Max-Eigen statistic of 8.764, which is below the critical value of 14.264 (p-value = 0.3063). For at most one cointegrating vector, the Max-Eigen statistic was 0.019, also below the critical value of 3.841, signifying the absence of additional cointegrating relationships. Collectively, the results from the trace and Max-Eigen tests offer mixed evidence; however, there is no substantial indication of a stable long-term relationship between load shedding and wholesale IQF chicken prices. This implies that short-term factors or shocks, rather than enduring long-term equilibrium dynamics, predominantly influence the observed co-movements between electricity supply disruptions and chicken meat prices. Consequently, a straightforward linear regression model was employed to estimate the short-term impact of load shedding on wholesale chicken meat prices.

Simple linear regression model results

A simple linear regression model was employed to estimate the short-term impacts of load shedding (Ld) on wholesale IQF chicken prices (Pc), building on the earlier Johansen cointegration results that showed no evidence of a stable long-term relationship between the two variables. Since both Pc and Ld were found to be stationary after first differencing (integrated of order one, I(1)), analysing their first differences enables a meaningful evaluation of short-term effects without breaching stationarity assumptions. Therefore, this study used a straightforward linear regression model on the differenced series to examine the immediate impact of changes in load shedding on wholesale chicken meat prices, offering insights into short-term price responsiveness that complement the descriptive and trend analyses presented earlier.

Table 6: Estimated regression results

Variable	Coefficient	Std. Error	t-statistics	Prob.
C	2.688868	0.077721	34.59646	0.000
D(LD)	0.089872	0.014268	6.299038	0.000
R-squared	0.375461			
Adjusted R-squared	0.365998			
F-statistics	39.67788			
Prob (F-statistics	0.000000			
AIC	-0.601272			
SIC	-0.535992			
HQ	-0.575406			
DW	0.421700			

Source: Authors' compilation (2023)

The results of the simple linear regression model, presented in Table 6, examine the short-term effect of load shedding (D(Ld)) on changes in wholesale prices of IQF chicken portions (D(Pc)). The estimated model is:

$$D(Pc_t) = 2.689 + 0.0899\ D(Ld_t) + \varepsilon_t \quad (6)$$

where $D(Pc_t)$ and $D(Ld_t)$ represent the first differences of wholesale chicken prices and load shedding, respectively, and ε_t is the error term.

The regression results indicate a statistically significant relationship between load shedding (D(Ld)) and changes in wholesale chicken meat prices (D(Pc)). The coefficient of D(Ld) is 0.0899, suggesting that a one-unit increase in load shedding is associated with a R0.09 rise in the wholesale price of chicken meat portions, ceteris paribus. This finding aligns with previous studies (Naidoo, 2023; Goldberg, 2015) linking energy supply disruptions to higher operational costs and consumer prices in the food sector. Recent evidence further highlights the specific mechanisms through which load shedding affects food systems. For instance, Maré (2023) reported that load shedding in South Africa caused interruptions in poultry production, failures of electrically irrigated crops, and delays in processing fresh produce due to reliance on an unstable electricity supply. These disruptions increase operational costs, reduce the supply of certain commodities, and create upward pressure on food prices. Similarly, SAICA (2024) noted that the reliance of food processors and retailers on diesel generators results in additional costs, which are subsequently passed on to consumers. Finally, Ngoepe-Ntsoane (2025) demonstrated that power outages affect poultry production, cold-chain logistics, and overall food system resilience, further contributing to higher consumer prices. Together, these studies provide empirical support for the observed relationship between load shedding and increases in wholesale IQF chicken prices in this study.

Despite the statistical significance, the explanatory power of the model remains modest. In particular, the R^2 of 0.375 indicates that load shedding explains only 37.5% of the variation in wholesale chicken prices, while the adjusted R^2 of 0.366 further highlights that much of the variation remains unaccounted for. This suggests that other factors, such as feed costs, fuel prices, inflation, and seasonal or market-specific shocks, probably play a prominent role in determining chicken meat prices. Nevertheless, model diagnostics demonstrate reasonable reliability. Specifically, the Durbin-Watson statistic of 0.422 indicates limited concern about first-order autocorrelation. Additionally, the relatively low AIC (-0.601), SIC (-0.536), and HQ (-0.575) values imply an acceptable model fit, although these criteria are more meaningful when comparing alternative models.

Building on these results, several implications for short-term price movements in the poultry sector can be identified. The positive and significant coefficient of load shedding shows that wholesale chicken prices respond quickly to electricity disruptions, reflecting the immediate sensitivity of the poultry sector to energy supply shocks. However, although load shedding has a measurable impact on prices, the low R^2 and adjusted R^2 indicate that electricity disruptions alone cannot fully explain the variation in chicken meat prices. Additionally, the remaining variability suggests that other factors, such as feed costs, fuel prices, inflation, seasonal effects, and market-specific shocks, also influence short-term price fluctuations. Moreover, the findings highlight how electricity disruptions lead to increased operational costs, which are rapidly reflected in wholesale prices, revealing the vulnerability of poultry production to energy supply instability. Lastly, diagnostics confirm that the model is relatively robust, with no evidence of first-order autocorrelation, supporting the validity of the short-term relationship observed. Overall, these findings clearly demonstrate that while load shedding contributes to short-term price increases in the poultry sector, other structural and operational factors also play vital roles.

Conclusions

This study investigated the relationship between load shedding (Ld) and wholesale IQF chicken meat prices (Pc) in South Africa from 2014 to 2023, employing descriptive statistics, trend analysis, unit root tests, Johansen cointegration, and a straightforward linear regression model. The combined results from the descriptive, trend, and cointegration analyses indicate that although both Pc and Ld show variability and upward trends throughout the period, there is limited evidence of a long-term equilibrium relationship between the two series. Descriptive statistics demonstrated significant variation in both variables, while trend analysis identified periods of price increases that aligned with fluctuations in load shedding. Unit root tests (ADF and PP) confirmed that both series are integrated of order one, fulfilling the prerequisites for cointegration analysis. Nonetheless, the Johansen test results revealed that wholesale chicken prices and load shedding do not converge in the long run, implying that short-term factors or shocks, rather than enduring long-term equilibrium dynamics, primarily influence the observed co-movements between electricity supply disruptions and chicken meat prices. Regression analysis additionally indicated a statistically significant positive short-term effect of load shedding on chicken meat prices, with a one-unit increase in load shedding linked to an approximate R0.10 rise in wholesale prices.

Building on these results, five key implications can be identified for understanding short-term price movements in the poultry sector. First, the positive and significant coefficient of load shedding indicates that, in the absence of a long-term equilibrium relationship, wholesale chicken prices respond to electricity disruptions in the short term, highlighting the immediate responsiveness of prices to energy supply shocks. Second, the modest explanatory power of the model ($R^2 = 0.375$, adjusted $R^2 = 0.366$) suggests that while load shedding has a measurable effect, much of the variation in chicken prices remains unexplained, indicating that electricity disruptions alone are not enough to fully explain price fluctuations. Third, the residual variation implies that other factors, such as feed costs, fuel prices, inflation, seasonal effects, and market-specific shocks, likely play a significant role in determining prices, emphasising the importance of including multiple factors in future analyses. Fourth, from a policy and managerial perspective, the findings highlight that short-term operational costs, and therefore wholesale prices, are sensitive to electricity supply variability, emphasising the need for contingency planning, investment in backup power, and energy-efficient production to reduce these price shocks. Fifth, the study showcases the usefulness of combining econometric results with sector-specific insights, suggesting that future research should develop more comprehensive models with multiple predictors to better capture both short-term and structural influences on poultry prices.

Despite these insights, the study has several limitations that require further examination, as outlined. The analysis, covering the period from 2014 to 2023, while informative, may not identify long-term trends or structural changes in the electricity supply and poultry markets. Moreover, the current models do not test for structural breaks, which could result from policy shifts or major energy supply shocks and might influence the stability of relationships over time. Additionally, using a simple linear regression restricts the ability to detect potential nonlinearities, dynamic effects, or interactions among multiple variables. Given these limitations, future research should (1) expand the analysis over a longer timeframe to identify potential structural adjustments, (2) implement structural break tests to account for sudden shifts in the relationship between load shedding and poultry prices, and (3) adopt more sophisticated econometric models such as vector error correction models (VECM), time-varying parameter models, or nonlinear regression techniques to better capture both short-term dynamics and long-term interactions in the poultry sector

References

[1] Afriyie, J. K., Twumasi-Ankrah, S., Gyamfi, K. B., Arthur, D., & Pels, W. A. (2020). Evaluating the performance of unit root tests in single time series processes. *Mathematics and Statistics*, *8*(6). doi:10.13189/ms.2020.080605

[2] Akin, A. C., Arikan, M. S., Çevrimli, M. B., & Tekindal, M. A. (2020). Assessment of the effect of beef and mutton meat prices on chicken meat prices in Turkey using different regression models and the decision tree algorithm. *Kafkas Üniversitesi Veteriner Fakültesi Dergisi*, *26*(1). doi: 10.9775/kvfd.2019.22195

[3] Arikan, M. S., Çevrimli, M. B., Polat, M., Mat, B., Akin, A. C., Özel, Z., & Tekindal, M. A. (2022). Analyzing the Factors Affecting the Price of Broiler Chicken in Turkey Using the Boosting Regression Method. *Brazilian Journal of Poultry Science*, *24*(4). https://doi.org/10.1590/1806-9061-2021-1618

[4] Baxevanou, C., Fidaros, D., Bartzanas, T., & Kittas, C. (2017). Energy consumption and energy saving measures in poultry. *Energy and Environmental Engineering*, *5*(2).doi: 10.13189/eee.2017.050201

[5] Chan, C., & Delina, L. L. (2023). Energy poverty and beyond: The state, contexts, and trajectories of energy poverty studies in Asia. *Energy Research and Social Sci*ence, *10(2)*. https://doi.org/10.1016/j.erss.2023.103168

[6] Cloete, K., Pienaar, L., & Van der Merwe, M. (2023). Is persistent "loadshedding" pulling the plug on agriculture in the Western Cape, South Africa?. *Agrekon*, *62*(3-4). https://doi.org/10.1080/03031853.2023.2269185

[7] Council for Scientific and Industrial Research. (2024). *CSIR releases statistics on power generation in South Africa for 2024*. https://www.csir.co.za/media-hub/media-room/csir-releases-statistics-on-power-generation-in-south-africa-for-2024

[8] Dewa, M. T., Van Der Merwe, A. F., & Matope, S. (2020). Production scheduling heuristics for frequent load-shedding scenarios: a knowledge engineering approach. *South African Journal of Industrial Engineering*, *31*(3). https://doi.org/10.7166/31-3-2422

[9] Dickey, D. A., & Fuller, W. A. (1979). Distribution of the Estimators for Autoregressive Time Series with a Unit Root. *Journal of the American Statistical Association*, *74*(366). https://doi.org/10.2307/2286348

[10] Enders, W. (2014). Applied econometric time series fourth edition. New York (US): University of Alabama, 30.

[11] Energy Finance, (2024). Addressing Eskom's Rising Tariffs and Chronic Load Shedding. *Enfin*. https://enfin-energy-finance.co.za/addressing-eskoms-rising-tariffs-and-chronic-load-shedding.

[12] Erero, J. L. (2023). Impact of loadshedding in South Africa: A CGE analysis. *Journal of Economics and Political Economy*, *10*(2). doi: 10.1453/jepe.v10i2.2443

[13] Goldberg, R. (2015). The economic impact of load shedding: The case of South African retailers (Doctoral dissertation, University of Pretoria).

[14] Govoni, C., Chiarelli, D. D., Luciano, A., Ottoboni, M., Perpelek, S. N., Pinotti, L., & Rulli, M. C. (2021). Global assessment of natural resources for chicken production. *Advances in Water Resources*, *154*, 103987. https://doi.org/10.1016/j.advwatres.2021.103987

[15] Greene, W. H. (2018). Econometric analysis (8th ed.). New York. Pearson.

[16] Gujarati, D. N., & Porter, D. C. (2009). Basic econometrics (5th ed.). McGraw-Hill/Irwin.

[17] Hamilton, J. D. (1994). Time series analysis*.* Princeton University Press. Princeton.

[18] Jacobs, S. (2023). Eskom hiked prices 450% since load-shedding began. *Daily investor*. https://dailyinvestor.com/energy/29549/eskom-hiked-prices-450-since-load-shedding-began.

[19] Johansen, S. (1991). Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models. *Econometrica*, *59*(6). https://doi.org/10.2307/2938278

[20] Klishi, K. (2024, September). Power Outage Perils: Assessing the Impact of Load-Shedding on SMEs in Enoch Mgijima Local Municipality, South Africa. In *European Conference on Innovation and Entrepreneurship*, 339-346. Academic Conferences International Limited. doi: 10.34190/ecie.19.1.2476

[21] Kuka, M. G. K. (2025). Establishing a resilient meat value chain in northern Nigeria for sustainable economic growth. *Journal of Emerging Trends in Economics and Management Sciences*, *16*(3), 85-93.

[22] Mashapu, L.D., & Mathaba, T.N. (2024). The Economic Impact of Load Shedding in Industry: A South African Case Study. *2024 International Conference on Electrical, Computer and Energy Technologies (ICECET*, 1-6. doi:10.1109/ICECET61485.2024.10698523

[23] Maré, F. (2023, March 14). *What monsters lurk in the dark? The impact of loadshedding on food systems in South Africa.* https://www.ufs.ac.za/templates/news-archive/campus-news/2023/march/what-monsters-lurk-in-the-dark-the-impact-of-loadshedding-on-food-systems-in-south-africa

[24] Naidoo, C. (2023). The Impact of Load Shedding on the South African Economy. *Journal of Public Administration*, *58*(1), 7–16. https://hdl.handle.net/10520/ejc-jpad_v58_n1_a2

[25] Ngoepe-Ntsoane, M. (2025). Navigating the effects of load shedding on agricultural productivity and food security: a case study of South Africa. *International Journal of Business Ecosystem & Strategy (2687-2293)*, *7*(4).https://doi.org/10.36096/ijbes.v7i4.881

[26] Palachy, S. (2019). Detecting stationarity in time series data. *Medium Toward Data Science*, *9*, 53. https://www.kdnuggets.com/2019/08/stationarity-time-series-data.html

[27] Pooe, D., & Tazvivinga, K. (2024). Building Resilient FMCG Supply Chains in South Africa Amid Prevailing Load-Shedding Challenges. *African Journal of Inter/Multidisciplinary Studies*, *6*(1), 1-13.https://doi.org/10.51415/ajims.v6i1.1315

[28] Sekwati, D., & Dagume, M. A. (2023). Effect of unemployment and inflation on economic growth in South Africa. *International Journal of Economics and Financial Issues*, *13*(1). doi: 10.32479/ijefi.13447

[29] Siankwilimba, E. (2019). Effects of climate change-induced electricity load shedding on small holder agricultural enterprises in Zambia: The case of five southern province districts. *Journal of Agriculture and Research*, 5(8). https://doi.org/10.53555/IJRDO/3184

[30] South African Institute of Chartered Accountants. (2024, February 22). *How load-shedding affects food prices – through diesel*. https://www.saica.org.za/news/how-load-shedding-affects-food-prices-through-diesel

[31] Stellenbosch University Bureau for Economic Research. (2023). Economic Prospects: Economic activity expected during 2023 and 2025. *BER: Economic Prospects: Full Survey*, *38*(4), 1-36.

[32] Surbhi, S. (2014). Differences between price, cost, and value. *Key difference*. https://keydifferences.com/difference-between-price-cost-and-value.

[33] Verma, S., Sharma, P. & Sam, D. (2022). Stationarity and cointegration in time-series analysis. *Statistical Methods Journal*, *45*(1), 105–120.