

## EXAMINING THE REGIONAL, SEASONAL, AND TEMPORAL VARIABILITY IN PALM OIL PRICES: EVIDENCE FROM SELECTED MARKETS IN NIGERIA

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### ABSTRACT

*Palm oil is a critical agricultural commodity in Nigeria, used broadly for food, industry, and biofuel. Its price dynamics have major implications for inflation, rural livelihoods, and food security. This study examines the regional, seasonal, and temporal variability in palm oil prices in Nigeria, 2022 - 2024. Data were collected monthly from markets in both marginal (North) and major (South) palm-oil-producing areas. Analyses were conducted using descriptive statistics, seasonal index, and the Cuddy-Della Valle Instability Index (CDI). Results show that palm oil prices increased substantially over the period. Mean prices in the South were ₦1,015,591 (2022), ₦1,096,576 (2023), and ₦1,348,767 (2024); in the North, they were ₦1,491,736 (2022), ₦1,579,271 (2023), and ₦1,920,538 (2024). Seasonal analysis identified four distinct price periods: a Low-Price Period (March–July), a Price Recovery Period (August–September), a Peak Price Period (October–December), and a Transition Price Period (January–February). Price stability analysis reveals low instability in 2022 and 2023 (CDI  $\approx$  2.7% and 6.5%, respectively), while 2024 exhibits moderate instability with a CDI of 13.6%. The study concludes that there were significant regional variations between the North and South, and that price instability increased in 2024. To stabilize prices in the coming years, policy recommendations include investing in local production through access to quality seedlings, enhancing processing facilities, providing financial support to smallholder farmers, improving infrastructure and promoting value chain coordination.*

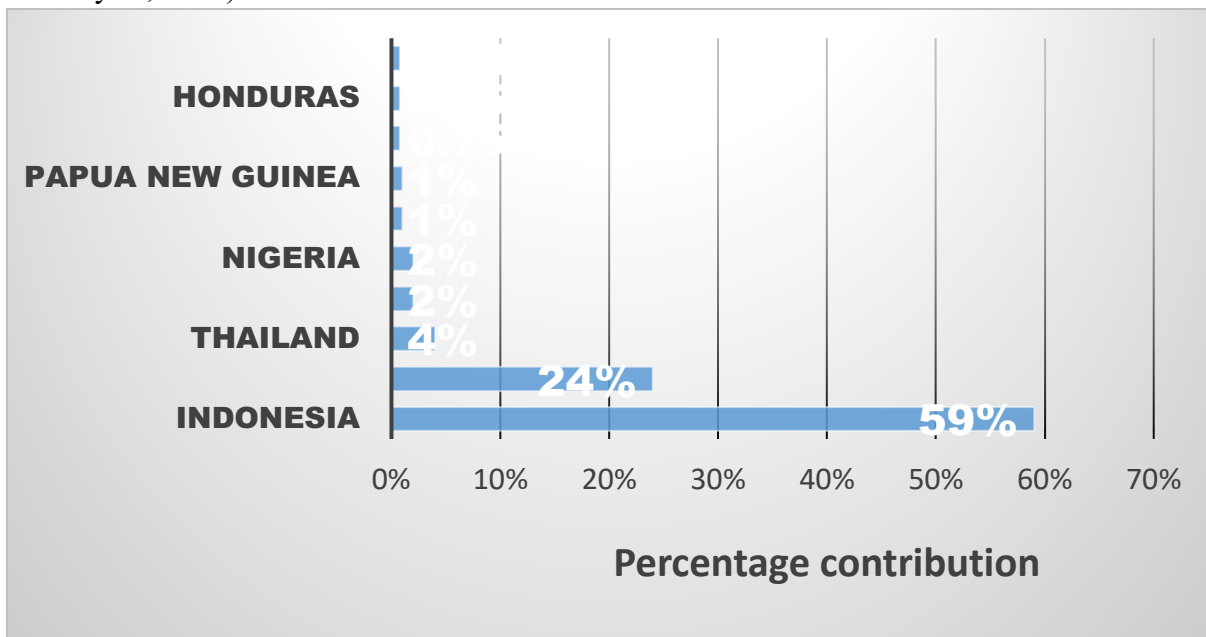
**Keywords:** palm oil, price variability, seasonal index, regional price differential, Nigeria, market

### INTRODUCTION

The agricultural sector was the backbone of Nigeria's economy in the 1960s, contributing about 60% of the Gross Domestic Product (GDP), more than 70% of total export earnings, and providing employment for roughly 70% of the labor force (Oyejide et al., 2003, as cited by Abah, 2020). By 2020, however, agriculture's share had declined to around 22% of GDP (Taiwo, 2020). Despite this decline, Nigeria's diverse agro-ecological zones remain highly suitable for oil palm cultivation, although domestic production continues to fall short of national demand. The country currently produces about 1.5 million metric tons of palm oil annually (USDA, 2025). Oil palm contributes significantly to Nigeria's economy through its impact on GDP, job creation, industrial raw material supply, and export revenues (NIFOR, 2021; Sabo, 2021). It is estimated that palm oil production supports the livelihoods of nearly 5 million Nigerians, including farmers, traders, and processors involved in both crude and refined palm oil production for local consumption and export (FAO, 2020).

Globally, palm oil is the most traded edible oil commodity, with Indonesia and Malaysia accounting for over 85% of total world production (USDA, 2024; Rahman et al., 2023). Oil palm is also the most productive oil-bearing crop, requiring just 0.26 hectares of land to produce one ton of oil, compared with 2.2, 2.0, and 1.5 hectares for soybean, sunflower, and rapeseed, respectively (Yusoff, 2020). Importantly, the crop produces two distinct oils (palm oil from the mesocarp and palm kernel oil from the seed) that further enhance its economic and industrial value (Rahman et al., 2023). Nigeria ranks as the fifth-largest palm oil producer globally (see Figure 1), and the commodity remains deeply embedded in the nation's economy, culture, and diet. The palm oil industry has far-reaching social, economic, and environmental implications, particularly in the context of Nigeria's agricultural development (PIND Foundation, 2021; FAO, 2020). Moreover, palm oil holds strategic global importance as it is used in the production of more than half of supermarket goods worldwide, with Nigeria recognized as the largest consumer of palm oil in Africa (World Bank, 2018).

Agricultural markets in developing economies, however, are characterized by significant price instability. This volatility is often driven by weak storage infrastructure, limited access to market information, and inefficiencies in supply chains, which increase the vulnerability of both producers and consumers (Abdulai, 2012; Oguntade et al., 2020). Price analysis, therefore, plays a vital role in evaluating the welfare implications of government policies such as subsidies, tariffs, and buffer stock schemes, while also facilitating value chain coordination and strengthening food security (Minot, 2014). Through the application of econometric approaches, scholars have provided evidence on the dynamics of price transmission and volatility spillovers across domestic and international markets (Nazlioglu and Soytaş, 2012).



**Figure 1: Global percentage share. Source USDA, 2024.**

Palm oil is a critical agricultural commodity in Nigeria, yet its market is characterized by pronounced price fluctuations with far-reaching implications for farmer incomes, consumer welfare, and food security. These price movements are uneven across regions, reflecting differences in production levels, transportation costs, and local demand pressures. Seasonal patterns further compound this challenge, with harvest periods often leading to temporary surpluses and price declines, while lean seasons trigger sharp price increases. Broader macroeconomic factors such as inflation, currency depreciation, and global market shocks have also intensified volatility in recent years. Despite the importance of these dynamics, limited research has systematically explored the combined regional, seasonal, and temporal variability of palm oil prices in Nigeria. Existing studies tend to focus on generalized assessments of price instability without adequately disaggregating by location or time dimension. This knowledge gap restricts the design of effective policy and market interventions aimed at stabilizing prices, improving value chain coordination, and enhancing food security through greater predictability in palm oil markets. This present study aims to fill this gap. Its main objective is to examine the regional, seasonal, and temporal variability in palm oil prices in Nigeria. Specifically, the study seeks to:

1. Analyze regional differences in palm oil prices between Northern and Southern markets in Nigeria.
2. Examine seasonal patterns in palm oil price fluctuations.
3. Assess the degree of price variability in Nigeria's palm oil market.

To facilitate empirical testing, this study formulated the following hypotheses:

**Null hypothesis ( $H_0$ ):** The true mean difference in palm oil prices between Northern and Southern markets is zero (i.e., no regional difference).

**Alternative hypothesis ( $H_1$ ):** The true mean difference in palm oil prices between the two regions is nonzero.

## **METHODOLOGY**

### **Study area**

The study was conducted in Nigeria, one of the largest countries in Africa, which lies wholly within the tropics along the Gulf of Guinea on the West coast of Sub-Saharan Africa. Nigeria lies between 40 and 140 North of the equator and between longitudes 30 and 150 east of Greenwich. Nigeria has a total land area of 923,768.622 km or about 98.3 million hectares, and a current population estimated at 215,175,364 people by Worldometer elaboration from the United Nations database (Buari 2022).

### **Source of Data**

Primary data was used for this study. Monthly palm oil market prices were collected over a 36-month period, from January 2022 to December 2024. Data were obtained from markets in the following northern states: Jigawa, Niger, Nasarawa, and Kogi, which represent marginal production regions, and from Edo, Akwa Ibom, and Enugu in the southern region, known for high palm oil production. Palm oil volumes were expressed in metric tons, with 1,125 liters of palm oil being equivalent to one ton (Omofonmwan et al, 2025).

## Descriptive statistics

Descriptive statistics, such as mean, percentage and table were used.

## Diagnostic test.

It was important to examine the time series data for the existence of a unit root. The test for Stationarity was conducted using the Augmented Dickey-Fuller (ADF) test. Following Gujarati (2004), two hypotheses were set up: Null Hypothesis ( $H_0$ ) (the data is non-stationary (has a unit root)) and the alternative Hypothesis ( $H_1$ ) (the data is stationary). If the p-value is greater than 0.05, we fail to reject  $H_0$ , meaning the data is non-stationary. The Stationarity test results (ADF Test) show that in 2022, the Data is non-stationary ( $p > 0.05$ ). First difference applied. 2023: Data is non-stationary ( $p > 0.05$ ). First difference applied. 2024: Data is non-stationary ( $p > 0.05$ ). First difference applied. The overall ADF Statistic = 0.0843 and p-value = 0.9650. Since the p-value is greater than 0.05 ( $p > 0.05$ ), we fail to reject the null hypothesis ( $H_0$ ), meaning the data is non-stationary. However, non-stationarity was corrected by first-order differencing ( $X_t - X_{t-1}$ ) and a retest for stationarity was carried out. The test after differencing yielded an ADF Statistic of -2.8710 and a p-value of 0.0488. Since the p-value was now  $< 0.05$ , we reject the null hypothesis ( $H_0$ ), meaning the differenced data is now stationary.

## Pair t statistic

The pair t t-statistic was used to test the significance of the average difference between Northern and Southern and across the pooled period. A paired t-test was the appropriate statistical method to compare the mean price differences between the Southern and Northern regions because the data used consists of paired observations from the same months across three years. It was estimated as:

$$t = \frac{\bar{d} - 0}{sd/\sqrt{n}} \dots\dots\dots 1a$$

$$sd = \sqrt{\frac{1}{n-1} \sum_{i=1}^n (d_i - \bar{d})^2} \dots\dots\dots 1b$$

Where

Sd= sample standard deviation

n = sample size

$\bar{d}$  = Mean of differences

## Seasonal Index

To determine the seasonal variations in price trends of palm oil in Nigeria, the **Seasonal Index (SI)** was computed using the **Seasonal Ratio (SR)** and **Moving Average (MA)** method. This approach is commonly used in time series analysis to measure periodic fluctuations, as described by Makridakis et al. (1998) and Hyndman and Athanasopoulos (2018). The seasonal index was estimated as;

## The Seasonal Ratio (SR)

The seasonal ratio helps identify seasonal fluctuations. The SR for each observation was calculated using the equation:

$$SR_i = \frac{X_i}{MA_i} \times 100 \dots\dots\dots(2a)$$

Where;

$SR_i$  = seasonal ratio for month i

$X_i$ = actual observed price for month i

$MA_i$ = moving average of prices for month i.

### Average Seasonal Ratio (ASR)

The **Average Seasonal Ratio** reduces variability and ensures stability in the seasonal pattern over multiple years, thereby reducing noise. The **Average Seasonal Ratio (ASR)** for each month was calculated by averaging the seasonal ratios over multiple years:

$$ASR_m = \frac{SR_{m,t}}{N} \dots\dots\dots(2b)$$

Where;

$SR_{m,t}$  = Seasonal ratio for month m in year t

N = Number of years in the dataset.

$$SI_m = \frac{ASR_m}{100} \dots\dots\dots(2c)$$

Where;

$SI_m$  = seasonal index for month m

$ASR_m$  = average seasonal ratio for month m

A seasonal index greater than 1 indicates a period with a higher-than-average price, while an index below 1 signifies a lower-than-average price.

### Instability Index (Cuddy-Della Valle Index)

The palm oil price volatility was estimated using the **Instability Index (Cuddy-Della Valle Index)** which adjusts the Coefficient of Variation (CV) by removing the effect of long-term trends (via  $\sqrt{1 - R^2}$ ) in price data was used and it was estimated following Rani et al 2022, Sihmar (2014), Kumar et al 2023), **Bhatta, and Doppler (2010)**. The Cuddy-Della index (CDI) was calculated as follows:

$$CDI = CV\sqrt{1 - R^2} \dots\dots\dots(3a)$$

Where;

CV = coefficient of determination

$$CV = \frac{\sigma}{\mu} \times 100 \dots\dots\dots(3b)$$

$R^2$  = Coefficient of determination (from a regression trend line) =

$\sigma$  = Standard deviation of palm oil prices

$\mu$  = Mean (average) palm oil price.

To measure the trend effect, a linear regression was performed:

$$P_t = \alpha + \beta t + \varepsilon_t \dots\dots\dots(3c)$$

Where:

$P_t$  is the palm oil price at time  $t$ ,  $\alpha$  is the intercept,  $\beta t$  is the trend coefficient, and  $\varepsilon_t$  is the error term

The **R<sup>2</sup> (coefficient of determination)** from this regression tells us how much of the price variation is explained by the trend.

Following Cuddy and Della (1978), Bhatta, and Doppler (2010), the ranges of Cuddy Della Valle index (CDVI) are given as follows in Table 1.

**Table 1: Grouping of Instability Level**

| Instability Index (%) | Instability Level | Remark                                             |
|-----------------------|-------------------|----------------------------------------------------|
| < 10%                 | Low               | suggests prices are fairly stable around the trend |
| 10 - 20%              | Moderate          | noticeable fluctuations but not extreme            |
| > 20%                 | High              | high instability (serious price volatility)        |

Source: Bhatta and Doppler (2010).

## RESULTS AND DISCUSSION

### Regional Disparities in Nigeria's Palm Oil Market (2022–2024)

The result in Table 2 shows that in 2022, the Northern price was almost **47% higher** than the Southern mean. The relative gap **declined slightly** over time (44% in 2023, 42% in 2024), even though the absolute naira gap grew. This suggests that while both regions experienced rising prices, Southern prices grew faster proportionally, narrowing the relative difference. The paired  $t$ -test results are presented in Table 3. The analysis revealed a consistent and statistically significant disparity between Southern and Northern palm oil prices during the 2022–2024 period. In 2022, the mean price difference was ₦476,145 (SD = ₦60,165), with a  $t$ -value of 23.75 ( $p < 0.001$ ), showing that Northern prices were markedly higher. A similar pattern was observed in 2023, with the mean difference widening to ₦482,694 (SD = ₦147,846), also highly significant ( $t = 11.30$ ,  $p < 0.001$ ). By 2024, the gap had further increased to ₦571,771 (SD = ₦173,586), reflecting intensifying regional price divergence ( $t = 11.42$ ,  $p < 0.001$ ). Confidence intervals for each year confirm that the disparity is stable and persistent, supporting the conclusion that structural regional factors, rather than short-term market shocks, underpin these differences.

The pooled analysis for 2022–2024 shows an average North–South price gap of ₦513,300 (SD = ₦117,900) with a narrow 95% confidence interval (₦471,400–₦555,200) and a very large effect size, highlighting that the disparity is both statistically robust and economically significant. These results suggest that higher Northern prices may reflect supply shortages due to lower regional production and high energy costs required to transport from Southern surplus zones. This persistent gap underscores inefficiencies in palm oil market integration and suggests the need for targeted interventions, such as improved logistics, storage facilities, and infrastructure to reduce transaction costs. This result agrees with Seiyefa and Eguruze (2024), who reported significant price differences between urban and rural markets, influenced by factors such as transportation costs and market accessibility.

**Table 2: Regional Palm Oil Price Gap Analysis (2022–2024)**

| Items                      | 2022      | 2023      | 2024      | Pooled    |
|----------------------------|-----------|-----------|-----------|-----------|
| <b>Southern Market</b>     |           |           |           |           |
| Mean (A)                   | 1,015,591 | 1,096,576 | 1,348,767 | 1,176,278 |
| Std Dev.                   | 144,877   | 101,045   | 409,172   | 279,805   |
| Min (₦)                    | 804,375   | 905,625   | 945,000   | 804,375   |
| Max (₦)                    | 1,207,081 | 1,239,000 | 2,070,000 | 2,070,000 |
| <b>Northern Market</b>     |           |           |           |           |
| Mean (B)                   | 1,491,736 | 1,579,271 | 1,920,538 | 1,689,578 |
| Std Dev.                   | 155,802   | 97,952    | 517,351   | 482,046   |
| Min (₦)                    | 1,213,750 | 1,458,333 | 1,475,625 | 1,213,750 |
| Max (₦)                    | 1,732,500 | 1,732,500 | 3,078,750 | 3,078,750 |
| Mean Difference, A – B (₦) | 476,145   | 482,694   | 571,771   | 513,300   |
| % Gap                      | 46.9      | 44.0      | 42.4      | 43.6      |

Source: Computed from NIFOR monthly data, 2022 – 2024.

**Table 3: Summary of Paired t-Test Results on Regional Palm Oil Price Differences (Southern vs Northern, 2022–2024)**

| Year   | Mean Diff (₦) | SD of Diff (₦) | t-value | p-value | 95% CI for Mean Diff (₦) |
|--------|---------------|----------------|---------|---------|--------------------------|
| 2022   | 476,145       | 60,165         | 23.75   | < 0.001 | 429,905 – 522,385        |
| 2023   |               | 147,846        | 11.30   | < 0.001 | 388,730 – 576,658        |
|        | 482,694       |                |         |         |                          |
| 2024   | 571,771       | 173,586        | 11.42   | < 0.001 | 461,597 – 681,945        |
| Pooled | 513,300       | 117,900        | –       | < 0.001 | 471,400 – 555,200        |
|        |               |                | 20.45   |         |                          |

Source: Computed from NIFOR monthly data, 2022 – 2024.

#### Seasonality Analysis of Palm Oil Prices in Nigeria (2022 -2024)

The seasonal analysis of the palm oil price is presented in Table 4. Seasonal index was computed to help identify recurring patterns in palm oil prices across different months. The computed seasonal indices were based on a **12-month moving average (12-MA)**. The seasonal index values indicate the relative strength of palm oil prices in different months compared to the annual average. An index **above 1.0000 (>1)** indicates that prices are higher than the annual average for that month, while an index **below 1.0000 (< 1)** suggests lower-than-average prices. From the result, the price of palm oil was divided into four seasons: Low-Price Period (March–July), Price Recovery Period (August–September), Peak Price Period (October–December), and Transition Price Period (January-February).



The low-price period (March – July) marks the lowest palm oil prices of the year, with April (0.8969) being the cheapest month. During this period, Prices remain below 1.0000 from March to July, suggesting an oversupply in these months. This period coincides with peak production and harvesting season, leading to increased market availability and lower prices. The second phase, the Price Recovery period, was August (1.0425) and September (1.0279). This period marked the season where Palm oil prices were slightly above the annual average, indicating increasing demand or reduced supply.

The Peak Price Period occurs during the months of October–December. Analysis of the index indicates that this period had the highest seasonal indices. The result shows that October (1.0799), November (1.0830) and December (1.0961). This period marked the most expensive time for palm oil, with December (1.0961) recording the highest price of the year. The reasons for this high price could be Festive Season Demand, Supply Constraints (Production levels are lower as most palm oil mills operate at reduced capacity after the peak harvest),

Transition period (January- February) with seasonal index of 0.9969 and 0.9879, which was slightly below 1.0000, indicating that palm oil prices remain slightly lower than the yearly average, though not as low as the coming months (March–July). This month is a transition because it follows the festive season, during which household and industrial consumption slightly declines, resulting in reduced buying pressure. This period marks early Signs of Increased Production as oil palm trees begin fruiting, leading to the first signs of supply recovery, although full-scale harvesting is still months away. This study agrees with Adewale et al (2024), who analyzed data from 2016 to 2022, identified seasonal trends in palm oil prices in Nigeria, and attributed them to fluctuations in factors like production cycles, demand patterns, and climatic conditions.

**Table 4: Seasonal Index for palm oil price (2022-2024)**

| Month     | Average Seasonality Ratio<br>(12-MA) | Seasonal Index (12-<br>MA) |
|-----------|--------------------------------------|----------------------------|
| January   | 99.70                                | 0.9969                     |
| February  | 98.79                                | 0.9879                     |
| March     | 93.70                                | 0.9370                     |
| April     | 89.69                                | 0.8969                     |
| May       | 90.29                                | 0.9029                     |
| June      | 94.42                                | 0.9442                     |
| July      | 96.35                                | 0.9635                     |
| August    | 104.25                               | 1.0425                     |
| September | 102.80                               | 1.0279                     |
| October   | 107.99                               | 1.0799                     |
| November  | 108.30                               | 1.0830                     |
| December  | 109.61                               | 1.0961                     |

Source: Computed from NIFOR monthly price report data, 2022- 2024.



### Stability Analysis of Palm Oil Prices in Nigeria

The analysis in Table 5 provides a breakdown of palm oil price stability in Nigeria over three years (2022–2024) using three key metrics: Coefficient of Variation (CV),  $R^2$  (Trend), and the Composite Deviations Index (CDI), which determines the level of price instability. The instability analysis of palm oil prices in Nigeria reveals clear spatial and temporal differences across the South and North. In 2022 and 2023, both regions exhibited relatively low instability, with CDI values well below 10 percent, indicating that prices were stable around their underlying trend. The pooled national measure also reflected low instability in 2022 and 2023, confirming that the national market was largely resilient to sudden shocks during this period. However, the analysis of the year 2024 showed a turning point with a significant escalation in price volatility in both the South and North, as well as in the pooled series. CDI values rose above 13 percent in each case, placing instability in the moderate category. This sharp increase points to a heightened level of market uncertainty, likely driven by a combination of production shortfalls, inflationary pressures, and supply chain disruptions. The higher CV in 2024, particularly in the South (30.34 percent), underscores the widening variability in monthly prices and the potential vulnerability of producers and consumers to sudden price movements. However, analysis across the full 2022–2024 period showed that instability increased with years in both regions and at the pooled level, with CDI values ranging from 17 to 19 percent. This suggests that Nigerian palm oil prices are anchored by long-term trends but are increasingly susceptible to short-term fluctuations.

**Table 5. Instability Analysis of Palm Oil Prices in Nigeria (2022–2024)**

| Region | Year          | CV<br>(%) | $R^2$<br>(Trend) | CDI<br>(%) | Instability<br>Level |
|--------|---------------|-----------|------------------|------------|----------------------|
| South  | 2022          | 14.27     | 0.972            | 2.38       | Low                  |
| South  | 2023          | 9.21      | 0.495            | 6.55       | Low                  |
| South  | 2024          | 30.34     | 0.752            | 15.10      | Moderate             |
| South  | 2022–<br>2024 | 25.29     | 0.440            | 18.93      | Moderate             |
| North  | 2022          | 10.44     | 0.910            | 3.13       | Low                  |
| North  | 2023          | 6.20      | 0.066            | 5.99       | Low                  |
| North  | 2024          | 26.94     | 0.762            | 13.15      | Moderate             |
| North  | 2022–<br>2024 | 22.03     | 0.402            | 17.03      | Moderate             |
| Pooled | 2022          | 12.40     | 0.950            | 2.7        | Low                  |
| Pooled | 2023          | 7.70      | 0.280            | 6.5        | Low                  |
| Pooled | 2024          | 28.80     | 0.760            | 13.6       | Moderate             |
| Pooled | 2022–<br>2024 | 23.00     | 0.430            | 17.3       | Moderate             |

**Source: Computed from NIFOR monthly price report data, 2022– 2024.**

## CONCLUSION AND POLICY RECOMMENDATIONS

The study revealed that between 2022 and 2024, palm oil prices in Northern Nigeria consistently exceeded those in the South. The absolute price gap widened over time, even as the relative percentage difference showed a slight decline. The Seasonal analysis indicated distinct cyclical price patterns across the year. While price volatility remained relatively low during 2022–2023, there was a marked increase in instability in 2024, indicating growing susceptibility to supply disruptions, inflationary pressures, and broader market shocks. The study recommends increased investment in local production through improved access to quality seedlings, financial support for smallholder farmers, and upgrading transport and logistics infrastructure. Furthermore, strengthening value chain coordination and investing in processing capacity (notably in surplus southern zones) will reduce costs, smooth seasonal swings, and boost national food security.

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