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TREND ANALYSIS AND FORECASTING OF COWPEA (*Vigna unguiculata* L) PRICES IN YOBE STATE, NIGERIA

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Abstract

In order to aid players in the cowpea industry in making timely decisions in the face of unclear future prices of cowpea, this study's primary goal was to determine the trend and predict future cowpea prices in Nigeria's Yobe State. The National Bureau of Statistics (NBS) database provided secondary data on the monthly price of cowpea in the study area between January 2016 and May 2023. The analysis was conducted using the Box-Jenkins methodology's ARIMA model and descriptive statistics. The outcome showed that cowpea price trend in January 2016 was at ₦229.05/kg and fluctuated upwards and downwards until December 2020. However, the trend continue rising in January 2021 at ₦243.01/kg and continuously increasing without typically declining up to May 2023. And with respect to the Forecasting, the data' stationarity was tested using graphical and formal tests, and found out that the data was not stationary at level but series remained stationary after applying first order difference. Model selection criteria proved that ARIMA (1.1.0) was the best model for the process. Diagnostic test confirm ARIMA (1.1.0)'s suitability for the forecasting. Seven months projected cowpea market prices were done. The trend and projected cowpea price were in continues increase. In view of these government should implement appropriate measures such as restricting cowpea export and eliminating import taxes of cowpea product in order to stabiles the price.

Key words**:** *cowpea, forecasting, trend, price, Yobe State, Nigeria*

INTRODUCTION

Most of cowpea production occurred in Africa especially in Niger, Nigeria, Burkina Faso, Mali, and Senegal [16]. [24] asserted that cowpeas are produced in all nations in sub-Saharan Africa, Asia, South America, Central America, the United States, and the region surrounding the Mediterranean Sea in tropical and subtropical zones. However, marketing is a process of satisfying human needs by bringing products to people in the proper form and at a proper time and place [3]. They added that marketing has economic value because it gives form, time, place, utility to products and services. [1] affirmed that cowpea storage methods are very important on the product chain in Nigeria. [20] evaluated the cowpea productivity when tillage practices are implemented aiming to assure soil conservation and increase product quality.
[26] pointed out that understanding agricultural commodity price trends is essential for producers, marketers, consumers, and policymakers to prevent inefficiency in agricultural markets due to poor market knowledge and structural imperfections [17], [9]. [8] stated that farmers' 40% share in food crop retail pricing is low, with price swings due to harvest gluts and offseason shortages. Moreover, production of agricultural goods is largely influenced by price changes and directly depends on natural environment, therefore market conditions must be continuously analysed always to be ready, and future situation evaluations must be done in order for producers and marketers to survive and adapt to the price changing conditions for

their respective decision marking [7]. However, farmers face a significant difficulty in developing effective production and marketing strategies to reduce risks due to the price instability and uncertainty. [10] mentioned that price forecasting is essential for facilitating effective decisions and will be crucial in coordinating the supply and demand of agricultural products. Therefore, anticipating agricultural prices will be helpful to producers, consumers, processors, planners for rural development, and other market participants. [7] highlighted that Producers and marketers rely on historical market pricing for their respective choice. Nonetheless, time series analysis is a stochastic modelling technique that aids in forecasting future occurrences by utilizing data from past periods. It finds application in a number of domains, including geophysics, meteorology, finance, business, statistics, and agriculture [4]. Time series analysis, according to [12], is widely utilized by marketers to look at the long-term trends in their entire sales.

[6] sustains that one of the most effective methods for forecasting is ARIMA, which is typically used in financial time series. The ARIMA model just requires historical time series data for the variables which are forecasted [22].

In Turkey, [18] has successfully used ARIMA methods for predicting sugar price.

Sales analysis is important for businesses to predict sales trends, forecast personnel and goods needs, and predict seasonal and annual sales [12]. Hence understanding cowpea price trend and forecasting will help consumers, government organizations, producers, marketers, and non-governmental organizations make well-informed decisions about cowpea prices in the study area. Therefore, the main objectives of this study were to ascertain the cowpea price trend and forecast future prices in the study area.

MATERIALS AND METHODS

The Study Area

Yobe State was carved out of Borno State on 27 August 1991. It borders Bauchi, Borno, Gombe, and Jigawa, while to the north it borders the Republic of Niger. The state is primarily a rural state, majority of the population lives in rural settlements, and its economy is agricultural-based, comprised mostly of livestock, crops, horticultural production and fisheries, gum arabic and palm trees [25]. The state is located in the North-eastern geopolitical zone of Nigeria between latitudes 10º and 14º North and longitude 11º 30′ to 14°45′East [23]. The state experiences hot, dry weather for the majority of the year, with temperatures between 300 and 420 degrees Celsius. The north typically receives more rainfall than the south, with 400 to 500 millimetres falling in the north and 600 to 1,000 millimetres in the south. [11] and major crops grown in the state include: millet, sorghum, cowpea, rice, maize, sesame, wheat and groundnuts while livestock kept include sheep, cattle and goat [11].

Source and Method of Data Collection

National Bureau of Statistics (NBS) database was used to access monthly cowpea prices in the study area from January 2016 to May 2023.

Methods of data analysis

The trend of cowpea prices in the study area was ascertained using descriptive statistics (graph), as employed by [5] The future price of cowpea in the study area was estimated using the ARIMA model (Box-Jenkins methodology). The Box-Jenkins approach forecasted the price of cowpea and identified the appropriate ARIMA (p, d, and q) model parameters [21].

Test of stationarity

Graphical and format test Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root test were employed to test the stationarity of the data at 0.05 level of significant. Adopted from [6].

Type of ARIMA Model for the Study

The study considered three type of ARIMA models, each capable of forecasting future cowpea price values in the study area, based on adequacy tests.

(1)**AR (p) Model**

AR (p) model is concerned with the actual data.

$Y_t = \varphi_0 + \varphi_1 Y_{t-1} + \varphi_2 Y_{t-2} + \varphi_3 Y_{t-3} + \ldots . \varphi_p Y_{t-p} + \varepsilon_t$ ----------equation (1)

where:

Y_t= Response variable (price of cowpea) at time t

Y_{t-1} Y_{t-2}, Y_{t-3} …… Y_{t-p} is the respective variables (price of cowpea) at different time lags

φ_0, = constant,φ_1, φ_2, φ_3 ……..φ_p are the coefficients

ε_t is the error term

(2) **MA(q) Model**

MA (q) model is concerned with the error term.

$Yt = \mu_0 + \partial_1\epsilon_{t-1} + \partial_2\ \epsilon_{t-2} + \partial_3\ \epsilon_{t-3} + \partial_q\ \epsilon_{t-q} + \epsilon_t$ ----------equation (2)

where:

μ_0 = constant mean of the series

$\partial_1, \partial_2, \partial_3$ ……..∂_q = coefficients of estimated error term, ϵ_t = error term

(3) **ARMA (p, q) model**

The combination of equation (1) and (2) give ARMA (p, q) model with general form:

$Y_t = \varphi_0 + \varphi_1 Y_{t-1} + \varphi_2 Y_{t-2} + \varphi_3 Y_{t-3} + \varphi_p Y_{t-p} + \varepsilon_t + \mu_0 + \partial_1\epsilon_{t-1} + \partial_2\epsilon_{t-2} + \partial_3\epsilon_{t-3} + \partial_q\epsilon_{t-q} + \epsilon_t$ ----------equation (3)

Adopted from [2].

ARIMA Model Building

The Flow Diagram in Figure 1 illustrates how the ARIMA model using Box–Jenkins method was built for the study.

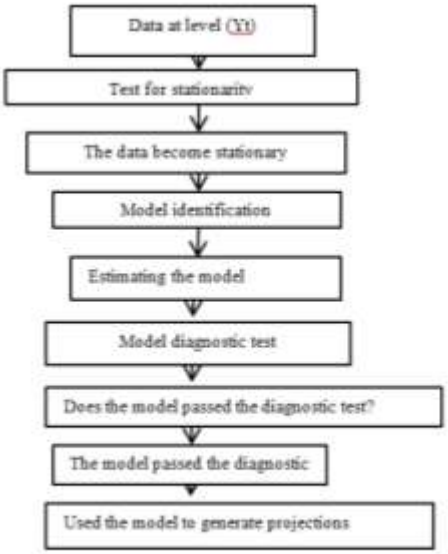

Fig. 1. Building ARIMA model using box-jenkins methodology
Source: Adapted from [14]

Forecasting accuracy

Mean Absolute Percentage Error (MAPE) was used to test the accuracy power of the ARIMA model selected for the forecasting.

$MAPE = \frac{1}{n}\sum_{t=1}^{n}\left|\frac{\hat{Y}\,t - Yt}{Yt}\right| x100$ ---------- ----------equation (4)

where:

Yt = Actual price of cowpea,

$\hat{Y}\,t$ = Forecasted price of cowpea,

n = Total number of observations

Adopted from [10], [21].

Forecasting

ARIMA model, which offers the highest estimated accuracy, was used to estimate cowpea prices in the study area on a monthly basis for seven months, from June 2023 to December 2023.

RESULTS AND DISCUSSIONS

Price trends for cowpea in the study area from January 2016 to May 2023

A monthly trend of cowpea prices in Nigeria's Yobe state, expressed in naira per kilogram (kg), from January 2016 to May 2023 is depicted in Figure 2. The cowpea price trend was at ₦229.05 per kilogram in January 2016. From the January 2016, the price trend continued to fluctuate upward and downward until June, when it was at ₦220.56/kg. In July of 2016, the price trend increased to ₦267.26/kg. And in August, the price trend goes down to ₦233.06/kg. After that, the trend fluctuated downward and upward until December of 2016 where price was at ₦258.58/kg. The price trend of cowpeas was at ₦244.92 in January 2017 but it continued to fluctuate, reached its peak at ₦324.32 in September and goes down to ₦292.26 in December. In January 2018 the price was ₦311.13/kg it later drops down to ₦297.19, ₦294.88, ₦226.25, ₦274.73 and ₦262.25 in February, March, April, May and June 2018 respectively. In July 2018 the cowpea price trend was at ₦301.84/kg and decrease to ₦288.14 in August and keeps up increasing in September, October and November the same year and later declined to ₦279.31/kg in December 2018.Similar pattern of fluctuations in cowpea prices trend was observed in the

study area in 2019. In January 2019 the price was at₦259.71/kg; it increased to ₦270.57 in February and decreased to ₦261.87 in March. The price trend move upwards to ₦271.92, ₦274.22 and ₦299.89 in April, May and June 2019 respectively and later fluctuated downwards to ₦255.00, ₦220.00, ₦246.43, ₦210.00, ₦215.71 and ₦213.17 in July, August, September, October, November and December 2019 respectively. The cowpea price trend was at ₦198.31/kg in January 2020, but it was quickly drop to the lowest value in the study's period to ₦148.69, ₦149.49 and ₦150.84 in March, April and May, 2020 respectively. And then the price trend jump up to ₦208.68 in June, then it kept going upward until December 2020, when it was at ₦ 239.66/kg. Then cowpea prices trend began to move upward in January 2021 when it was at ₦243.01/kg and remained rising until the end of the year without customarily falling. The price trend of cowpea in the study area was at ₦485.87/kg in May 2023, having risen steadily since January 2022 until the end of the investigation. This may be explained by the general increases in the cost of food commodities in Nigeria as a result of the country's rising fuel pump prices brought on by the Nigerian government's elimination of the fuel subsidy.

At first, the study's findings were comparable, but from January 2021 to May 2023, they diverged from those of [5]. Who looked at cowpea integration and price trends in the Biu and Miringa markets in Borno State, Nigeria's Biu Local Government area, using a graphical representation of the price data, they described the trend of cowpea price variation from 2016 to 2018 and discovered both upward and downward trends in cowpea prices in the Biu and Miringa markets during that time.

Estimated Cowpea Prices in the Study Area from June 2023 to December 2023

The steps involved in projecting cowpea using the Box-Jenkins's Methodology are model identification, model estimation, diagnostics checking and forecasting.

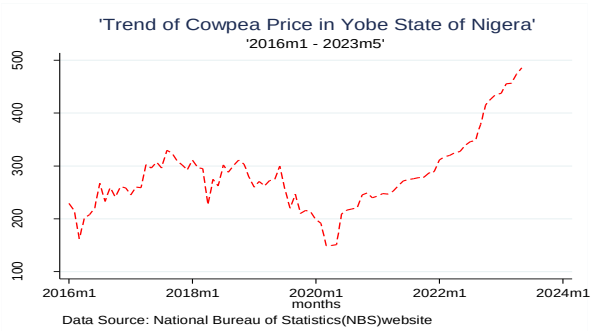

Fig. 2. Cowpea price trend in Yobe state, Nigeria, 2016 m1 - 2024 m1.
Source: Own design based on the data from National Bureau of Statistics, NBS [15].

Model identification

Stationarity and determining the order of p, d, and q in an ARIMA model are two aspects of model identification.

Stationarity

The stationarity of the Cowpea price series was tested using the graphical and formal tests, the Augmented Dickey-Fuller (ADF) and the Phillips-Perron test for unit root, in this analysis.

Graph of cowpea price

The series' up-and-down trend on the graph in Figure 3 indicates that it is not stationary.

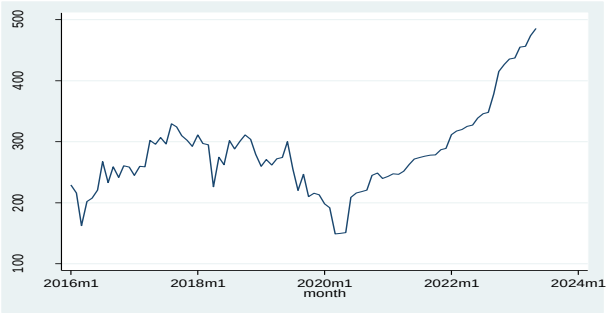

Fig. 3. Cowpea price in Yobe state, Nigeria, 2016 m1 - 2024 m1.
Source: Own design based on the data from National Bureau of Statistics, NBS [15].

The preliminary understating of time series data indicates that there is no consistency in the variables over a specified period of time. Figure 3 shows that cowpea price is a non-stationary variable, requiring for the use of differencing.

Graph of cowpea price at first difference

Figure 4 graph revealed that series become stationary after applying the first difference. The plot indicates non-seasonality, the time series has a constant mean, and the

observations fluctuate horizontally as indicated by the pattern of fluctuation.

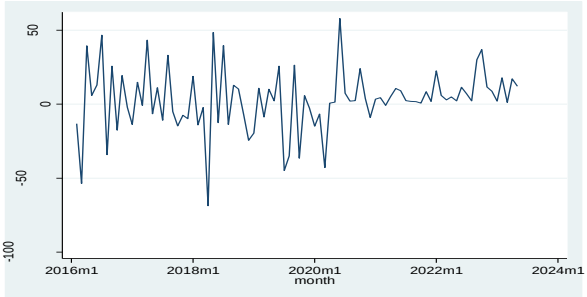

Fig. 4. Graph of cowpea price at first difference
Source: Own design.

Correlogram of autocorrelation of cowpea price

Correlogram Figure 5 also shows that the series is non-stationary at level; there is slow decay in ACF which was die down quickly, which suggested that, the series was non-stationary.

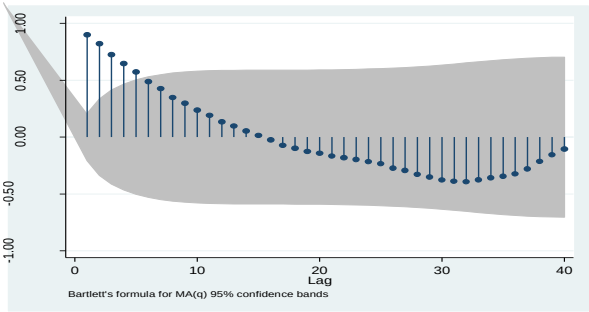

Fig. 5. Correlogram of autocorrelation of cowpea price
Source: Own design.

Correlogram of partial autocorrelation

Correlogram of partial autocorrelation in Figure 6 shows spike suggested that the series was not stationary at level.

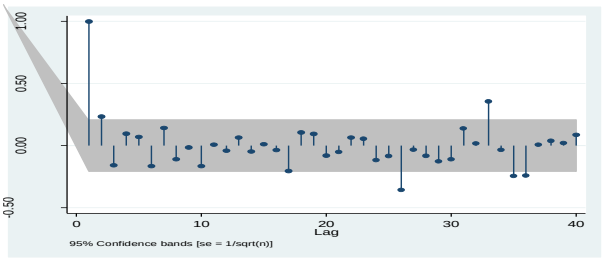

Fig. 6. Correlogram of partial autocorrelation of cowpea price
Source: Own design.

Formal test

Two formal tests were used to determine whether the series was stationarity: the Phillips-Perron test (PP) and the Augmented Dicky Fuller test (ADF). The Augmented Dicky fuller test at level revealed a p-value of 0.9697 which is greater 0.05, this means that the series has a unit root, therefore it is non-stationary. Likewise the Phillips-Perron test at level revealed a p-value of 0.9835 this shows that the series has a unit root, therefore it is non-stationary. In addition the trend and the constant are also not significant. Since the series has a unit roots and is it non-stationary, then the series was transformed by taking the first order difference.

First order differences

Dickey-Fuller test for unit root revealed a p value of 0.000, which is less than 0.05; this showed that after applying the first difference, the series is now stationary. The null hypothesis that the series has a unit root is now rejected because the Phillips-Perron test for the unit root also showed that the series is stationary with a p-value of 0.0000. Since the series become stationary after the first order difference, ARIMA (p.d.q) model was used for the study. This is in conformity with [6] who used the Box Jenkins Methodology for Estimation and Forecasting Models in Higher Education in Athens to model the proportion of 18-19 year olds enrolled in higher education. An Autoregressive Integrated Moving Average (ARIMA) model was created to fit the previous time series. The study found the process was not stationary and needed differentiation. The ADF test and PP tests confirm that the higher education enrolment series was not stationary (ADF p-value of 0.3745, PP test p-value of 0.3753) as indicated by the p-value greater than 0.05%. He further stated that the series was not stationary, according to both Autocorrelation Function (ACF) and Partial Auto Correlation Function (PACF). However, he further reported that data transformation confirms the ARIMA model's stationary assumption, and the time series on higher education enrolment was stationary after the first order difference with a p-value for the ADF test of 0.0000.

Determining the order of p.d.q in ARIMA models

The order of p.d.q. in the ARIMA models was ascertained by using the Autocorrelation

function (ACF) and the Partial Autocorrelation function (PACF) in order to identify possible ARIMA candidates for further process.

Autocorrelation function (ACF)

The Autocorrelation function plot presented in Figure 7 indicates that lag number one is the best value of q (q = 1), as ACF shows exponential decay at lag 1.

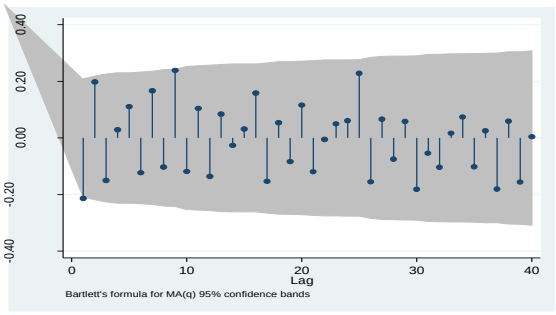

Fig. 7. Autocorrelation function (ACF) plot
Source: Own design.

Function of partial autocorrelation (PACF)

One lag from Figure 8's Partial Autocorrelation Function stood out as being just above the cut off. Since the PACF exhibits exponential decay at lag1, this lag was selected as the optimal value of p, i.e., p = 1.

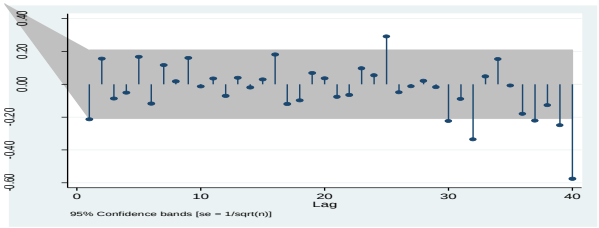

Fig. 8. Partial autocorrelation function (PACF) plot
Source: Own design.

From the use of the partial autocorrelation and autocorrelation functions there were three potential models found: ARIMA (1.1.1), ARIMA (0.1.1), and ARIMA (1.1.0). According to [20], the models' auto-regression and moving average orders are actually determined using the ACF and PACF.

Models estimation

The following estimates were made for the three identified ARIMA candidates: ARIMA (1.1.1), ARIMA (0.1.1), and ARIMA (1.1.0):

ARIMA (1.1.1) model

The estimate for the ARIMA (1.1.1) model was shown in Table 1.

Table 1. Estimated ARIMA (1.1.1) Model

D.cp	Coefficient	Std. Err	Z	P>|z|
Constants	2.896541	2.070816	1.40	0.162
AR L1	-.6225263	.3344268	-1.86	0.063
MA L1	.4174488	.3698285	1.13	0.259
SigmaSQ	20.72324	1.241937	16.69	0.000

Log Likelihood = -391.657
p-value =0.0040

AIC = 791.3141

BIC = 801.2234

Source: National Bureau of Statistics (NBS) [15].

Model: ARIMA (0.1.1)

Table 2 displayed the estimate for the ARIMA (0.1.1) model.

Table 2: ARIMA (0.1.1) Model Estimate

D.cp	Coefficient	Std. Err	Z	P>|z|
Constants	2.942809	2.017398	1.46	0.145
MA L1	-.16696	.0978899	-1.71	0.088
SigmaSQ	21.06451	1.226133	17.18	0.000

Log Likelihood = -393.0686
p-value = 0.0881

AIC = 792.1373

BIC = 799.5693

Source: National Bureau of Statistics (NBS) [15].

Model: ARIMA (1.1.0)

Table 3 displayed the ARIMA (1.1.0) model's estimated values.

Table 3: ARIMA Model Estimate (1.1.0)

D.cp	Coefficient	Std. Err	Z	P>|z|
Constants	2.932958	1.975713	1.48	0.138
AR L1	-.212745	.0977985	-2.18	0.030
SigmaSQ	20.94895	1.212561	17.28	0.000

Log Likelihood = -392.5836
p-value = 0.0296

AIC = 791.1672

BIC = 798.5992

Source: National Bureau of Statistics (NBS) [15].

Model selection criteria

According to Table 4, model C was the best model based on the number of significant variables, while model A is the best based on the smallest sigma square. Additionally, because model A had a larger log likelihood, it is also the best based on log likelihood. Model C is the best model based on Akaike's (AIC) value because it was the lowest. Similarly, due to its lowest BIC value, model C remains the best model based on the Bayeseian (BIC) algorithm. In summary,

model C is the recommended model for residual checking (diagnostics).

Table 4. Model selection criteria

Criteria	Model			Best model
	Model A	Model B	Model C	
	ARIMA (1.1.1)	ARIMA (0.1.1)	ARIMA (1.1.0)	
No. of sig. variables	0/3	0/2	½	C
Sigma sq	20.72324	21.06451	20.94895	A
Log likelihood	-391.657	-393.0686	-392.5836	A
Akaike (aic)	791.3141	792.1373	791.1672	C
Bayesian (bic)	801.2234	799.5693	798.5992	C
Best model				C

Source: National Bureau of Statistics (NBS) [15].

Diagnostic

Diagnostic checking is required to make sure the identified model is suitable for analysis or not. In reality, it involves carrying out diagnostic testing on the residual term that was derived from the ARIMA model, to verify whether the model's residuals are stable (white noise). The residual plot, portmanteau test and Inevitability test AR root graph were used to confirm this.

Residual plot

The residual plot presented in figure 9 confirmed that the residuals estimated from the chosen model (ARIMA (1.1.0)) are white noise, meaning that the error revolves around the mean. This suggested that there was no evidence of error autocorrelation in the model. Therefore the model is fit for forecasting the future values of cowpea prices in the study area.

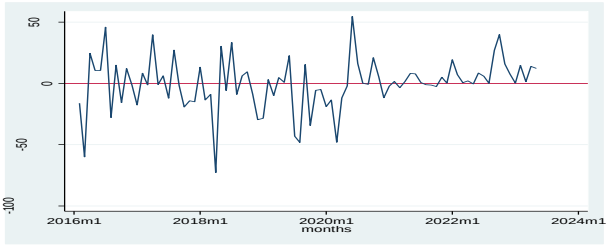

Fig. 9. Residuals plot
Source: Own design.

Portmanteau test

The portmanteau test revealed a p-value of 0.1091 which was greater than 0.05, therefore the null hypothesis that the residual are white noise cannot be rejected. In this case the residuals are stable. Hence the ARIMA (1.1.0) model chosen is fit for forecasting the future price of cowpea in the study area.

Inevitability test (AR Roots graph)

From figure 10 AR root had lie inside the unit circle, this confirmed that the residuals are white noise and the process was stable. And this suggests that the selected ARIMA model was capable of predicting the future cowpea prices in Nigeria's Yobe state.

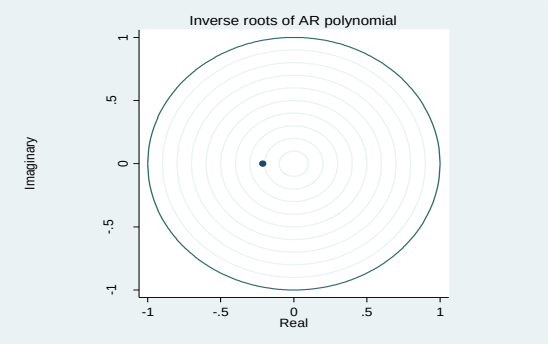

Fig. 10. AR Root
Source: Own design.

The future value of cowpea prices in the study area could be accurately predicted by the ARIMA (1.1.0) model, since the residual plot, portmanteau test and AR root graph both demonstrated that the residuals are white noise (stationary).

Forecasting

Seven Month of forecasted cowpea price was presented in Table 5 provided the predicted value of cowpea price. However, this forecast was based on the past values of the cowpea price in Yobe state. The anticipated cowpea price indicated that the price of cowpeas in the study area would continue to rise in the upcoming months. The findings of the study were consistent with those of [13], who carried out research on the forecasting of cowpea prices in Adamawa state, Nigeria, and discovered that there will be upward trend of cowpea prices in Adamawa State in February and October - November in the year 2018. However, the finding of this study was contrary to the findings of [19] who study Agricultural Production Forecasting the Box-Jenkins (ARIMA) model was used to forecast paddy production in southern India. Their research showed that future years will see

both an increase and a decrease in rice production.

*Table 5. Forecasted Cowpea Price from June, 2023 to December, 2023 in Yobe State

Month	Forecasted cowpea price (FCP) in Naira/kg
June	486.83
July	490.18
August	493.03
September	495.98
October	498.91
November	501.84
December	504.77

Source: National Bureau of Statistics (NBS) [15].
*The forecasted prices could fluctuate within ± 5% due to lack of price control system in place.

Forecasting Accuracy

Graph and Mean Absolute Percentage Error (MAPE) were employed to assess the model's forecasting accuracy.

Graphical presentation of actual and forecasted cowpea price

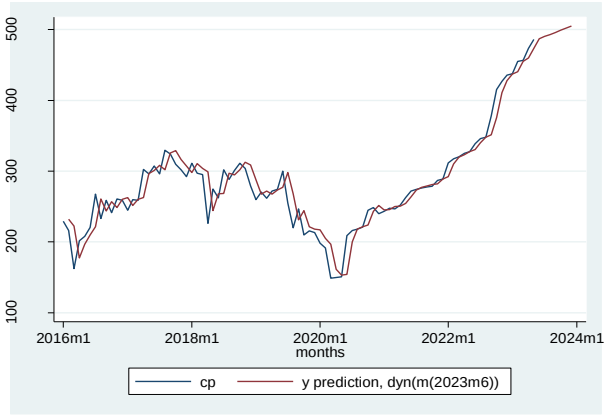

Fig. 11. Graph of actual and forecasted cowpea price
Source: Own design.

The red line on the graph in Figure 11 represents the forecasted cowpea price, while the blue line represents the actual cowpea price. The graph showed that there is a positive correlation between the actual cowpea price and forecasted price.

Mean absolute percentage error (MAPE)

5.86% was the mean absolute percentage error (MAPE) of the forecasted cowpea price in the study area. This demonstrates how well the ARIMA (1.1.0) model predicted the future value of cowpea prices in the study area. This was based on [21] scale of judgment for forecasting accuracy, which indicated that a forecast is highly accurate if the MAPE is less than 10%.The study's findings were in consistent with that of [21], who examined the Box-Jenkins ARIMA model for S&P BSE stock index trend detection and stock price forecasting. Due to random stock price behaviour, they discovered a positive correlation coefficient between the predicted and actual stock prices as well as a MAPE of 8.65, which indicates the model's accuracy and suitability for future forecasting.

CONCLUSIONS

Up until the conclusion of the investigation in May 2023, the price of cowpea in the study area fluctuated between up and down trends before finally rising. This demonstrates that the cowpea price trend in the research area was unstable. A seven-month cowpea price projection was made using the Box-Jenkins's Methodology and the cowpea price proved non stationary at level but it remained stationary at first difference. ARIMA (1.1.0) model was identified for the forecasting process and the projected cowpea prices were estimated from June – December 2023 with highly accurate forecast.

In order to stabilize cowpea price instability and allow stability in trend movement of cowpea prices in the study area, to help cowpea producers, marketers, consumers and policymakers in making their respective decisions, government should implement appropriate measures such as restricting cowpea produce exports and eliminating import taxes on cowpea product. In addition more research should be done to forecast the price of other crops using Box-Jenkins's Methodology, as this will assist government organizations, farmers, traders, and consumers in making their appropriate decisions.

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