THOMAS ADEWUMI UNIVERSITY, OKO, KWARA STATE
Science | Technology | Medicine

Thomas Adewumi University
Journal of Innovation,
Science and Technology (TAU-JIST)

ISSN: 3043-503X

RESEARCH ARTICLE

MODEL ANALYSIS FOR NIGERIA RICE PRICE FORECAST: AN IMPLICATION FOR FOOD SECURITY

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ARTICLE DETAILS

Article History:
Received 02 July 2024
Accepted 05 October 2024
Available online 10 December 2024

ABSTRACT

This study highlights the specific and accurate methods for forecasting prices of local and imported rice in Nigeria based on data from January 2017 to February 2024. Different models that include autoregressive integrated moving average (ARIMA), Naïve, Holts, Mean and exponential smoothing were used to forecast the sample price data.. The result indicated that Holt is the best applicable model for imported rice while exponential smoothing is best applicable model for local rice. The study forecasted the prices of both local and imported rice for 26month using different models. The result showed varying prices for both local and imported rice for the various models used. None of the models used showed reduction in the prices of the two types of rice forecasted by 2026. This study recommended that production of local rice should be made consistent in Nigeria in order to ascertain its availability, also, addressing the underlying causes of price volatility and promoting sustainable agricultural development are essential for enhancing food security and improving the well-being of the populace.

KEYWORDS

Rice, forecasting, Holt model, ETS, Nigeria

Introduction

Rice is a highly strategically and prioritized commodity for food security in Africa. It is one food commodity that is most promptly expanding both in consumption and production in sub-Saharan Africa (SSA). Its consumption is reported to be more than tripled from 9.2 Mt to 31.5 Mt from 1990 to 2018 in SSA (USDA, 2018). The per-capita consumption of rice is estimated at 24.8 Kg/annum in Nigeria, which represent is 9% of total caloric intake (USDA, 2018). According to Onu *et al.* (2015), population growth and urbanization are the principal factors that are driving consumer's preference towards rice in Nigeria. Rice has taken over the place of cassava, yam and sorghum in the average household changing it from luxury to staple food. Studies have shown that many rice consumers in Nigeria eat more foreign rice than the domestic rice Gyimah-Brempong *et al.* (2016) which result to Billions of Naira been spent on annual basis to import rice despite the fact that rice is grown on approximately 3.7 million hectares of land in Nigeria, covering 10.6 percent of the 35 million hectares of land under cultivation; out of a total arable land area of 70 million hectares. Cadoni and Angelucci(2013) Four types of rice are locally produced majorly in Nigeria Agricultural production systems namely; upland rice, lowland rice, irrigated rice and mangrove/deep water rice production systems Ogunsimi (2013), yet the production has not kept pace with demand of the populace. USDA (2018). The reason for this could be because farmers who are mainly involved in domestic rice production could not meet up with consumption rate due to small-

Quick Response Code	Access this article online	
	Website: https://journals.tau.edu.ng/index.php/tau-jist	**DOI:** https://doi.org/10.5281/zenodo.15002996

Cite the Article: *Ajala, A.K. , Ajetomobi, J.O., Fajobi, D.T, & Olarinre, A.A. (2024). Model Analysis For Nigeria Rice Price Forecast: An Implication For Food Security*

scale farming, terrorist attacks, farmer-herder clashes, consequently increase in prices of rice is inevitable Takeshima and Bakare (2016). However, an increase in rice prices in Nigeria can have significant implications on food security, affecting various aspects of the population's access to an adequate and nutritious diet to mention a few (Amolegbe *et al.* 2021).

Although price forecasting is a dicey venture because of several unseen factors which could render the forecast invalid (Jadav *et al.*, 2017), food price-forecasting model is developed to provide information about how changes in the quantities of food use affect consumer food prices. Generally, when price increases, a household will spend more of its disposable income on food compared with the income spent before the price increase (Van Wyk & Dlamini, 2018)

Forecasting assists policy makers in making timely decisions when faced with an uncertain future as witnessed globally in current times. This study therefore aims at employing different models to forecast the price of local rice and imported rice in Nigerian for 26 month based on monthly time series data from January 2017 to February 2024. The Data on prices used in this study were obtained from the National Bureau of Statistics (NBS) in Nigeria; the data is available on request and also available on the bureau website. These prices were collected from states across the nation, and it reflects the actual household prices.

Methodology

This study covers the price of Local and imported in Nigeria. Nigeria is bordered to the west by Benin, to the northwest and north by Niger, to the northeast by Chad and to the east by Cameroon, while the Atlantic Ocean forms the southern limits of Nigerian territory. Land cover ranges from thick mangrove forests and dense rain forests in the south to a near-desert condition in the north eastern corner of the country. Total cultivable area is estimated at 61 million ha, which is 66% of the total area of the country. Several researchers have predicted the future price, yields, production, outputs of different rice and using several forecasting techniques (Belete & Shoko, 2018; Darekar & Reddy, 2017; Esther & Magdaline, 2017; Jimoh *et al.*, 2016; *Panasa et al*., 2017; Sharma *et al*., 2013; Verma, 2018*)*,

In this study, five common forecasting techniques were estimated in the process of generating a meaningful forecast for imported, local rice and comparing different models. The methods used are: exponential smoothing, naïve, holts, mean and auto-regressive integrated moving average (ARIMA) models because they have the ability to generate accurate forecast (Ajetomobi and Olaleye, 2019; de Oliveira and Oliveira, 2018; Kriechbaumer *et al*., 2014). The forecast performance of the models was based on the following measures of accuracy – MAPE, MAE and RMSE. The use of forecast package in R software were used to estimate all the models and measures of accuracy while summary tools and ggplot2 packages were used to draw tables and graphs. Below are the mathematical formulations for each of the forecasting techniques:

Naïve Method

The naïve approach is based on the assumption that the rice j in year t+1 is equivalent to its immediate price in year t

$Y_{jt+1} = Y_{jt}$

Where;

Y_{jt+1} is the forecast price of rice j in year t and Y_{jt} is the actual price of rice j in year t

Exponential Smoothing

Exponential smoothing involves the process of decomposing a time series into two components, namely, a level and a residual component (Ghysels and Marcellino, 2018). When the level at the end of the estimation sample, say Y_T^L, is reached, it can be used to forecast Y_{T+h} with h > 1. If the time series y_t is independent and identically distributed with a non-zero mean, Y_T^L can be estimated as the sample mean of y. In case y_t is consistent, then more weight should be given to the more recent observations such that

$$Y_T^L = \sum_{t-1}^{T-1} \alpha(1-\alpha)^t \ Y_{T-t}$$

Where, α represents the smoothing parameter. Generally, $0 < \alpha < 1$ and $Y_{T+h} = Y_T^L$

Since $(1-\alpha)Y_T^L = \sum_{t-1}^{T-1} \alpha(1-\alpha)^{t+1} \ Y_{T-t-1}$.

The equation the becomes, $Y_T^L = \alpha Y_T + (1-\alpha)Y_{T-1}^L$.

The starting condition is $Y_1^L = Y_1$. The larger the α, weight given to the most recent observations. In the limiting case of $\alpha = 1, Y_T^L = Y_T$.

HOLT-

Winters procedure is the more elaborate extension of the simple exponential smoothing where

$Y_i^L = \alpha Y_t + (1-\alpha)(Y_{t-1}^L + Y_{t-1})$

$T_t = c(Y_t^L - Y_{t-1}^L) + (1-c)T_{t-1}$

Given that 0 < a< 1 the starting condition $T_2 = Y_1 - Y_1$ and $Y_2^L - Y_2$ and $Y_{T+h} = Y_T^L + h_{T_t}$

The coefficients α and c are the parameters to control the smoothness of Y_T^L. Y_T^L Becomes smoother as the coefficients gets smaller,

In this study, Y_T^L is the price of the rice while Y_{T+h} is the forecast value of each of them. The state space framework for automatic forecasting with exponential smoothing in forecast package in R software (Hyndman et al., 2002) was employed in this study.

Arima Model

A univariate economic time series such as Y_T contains a data generating procedure which belongs to the category of Autoregressive Integrated Moving Average (ARIMA) models. An ARIMA model is usually specified by three order parameters, termed, p, d, q. The autoregressive part of the model uses historic values to foretell the observed values. The autoregressive parameter, p, represents the number of lags allowed in the model. Take for example, ARIMA$(n, 0, 0)$ is represented by;

$Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \alpha_2 Y_{t-2} + \ldots. + \alpha_n Y_{t-n} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots(1)$

where α_0 to α_n are the model parameters.

The d component of the model shows the degree of differencing $(I(d))$ in the integrated component. The moving average component of the model, q indicates the residual of the model as a function of previous residual terms.

$Y_t = \beta_0 + \beta_1 \varepsilon_{t-1} + \beta_2 \varepsilon_{t-2} + \ldots. + \beta_n \varepsilon_{t-n} + e_t \ldots\ldots\ldots\ldots\ldots(2)$

Combining the three models, the ARIMA model can be written in linear form as

$$Y_t = c + \alpha_1 Y_{dt-1} + \alpha_2 Y_{dt-2} + \ldots. + \alpha_n Y_{dt-n} + \beta_0 + \beta_1 \varepsilon_{t-1} + \beta_2 \varepsilon_{t-2} + \ldots. + \beta_n \varepsilon_{t-q} + e_t$$

There are two alternative process of setting up an ARIMA model (Box and Jenkin 1976). The first procedure involves

a) plotting the data and checking for outliers, stationarity and/or the need for variable transformation.
b) Differencing the variable till it stationary.
c) Finding appropriate p and q ARIMA parameters by using differenced series. Fitting the appropriate ARIMA (p, d, q) to the original data
d) Confirming that the best available model has been estimated.
e) Forecast

The scond alternative routes to be taken include:

i. using an iterative automated algorithm with as many different models as possible and later identifies the best model with appropriate information criteria.

ii. Fitting the ARIMA (p, d, q) to the original data

iii. Ascertaining that the best available model has been estimated.

iv. Forecast

This study followed second approach using the automated algorithm in forecast package in R software.

Measures of Accuracy

Let Y_t to be tth observation and ht the forecast, where $t = t\ 1,2,\ldots\ldots, n$ to assess the forecast performance of the models used in this study, the following measures of accuracy were used

$MAE = n^{-1} \sum_{t=1}^{n} |Y_t - h_t|$

$MAPE = 100n^{-1} \sum_{t=1}^{n} (\frac{|Y_t - h_t|}{|Y_t|}))$

$RMSE = \sqrt{n^{-1} \sum_{t=1}^{n} (|Y_t - h_t|)^2}$

Where MAE is the mean absolute error, MAPE is the mean absolute percentage error and RMSE is the Root Mean Square Error.

Results and Discussion

Trend of Price of Local and Imported rice from January 2017 to February 2024

Figure 1 shows the trend of the price of local rice and imported rice in Nigeria from 2017 to 2024. The price for local rice and imported rice was less than ₦500 in 2017, and the price is over ₦1500 and ₦1250 for imported rice and local rice respectively in February 2024. The price of local rice in Nigeria is often affected change in climate, management practises, irrigation facilities and also the price of imported rice. . However, the price of imported rice is often affected by several government policies, and exchange rate.

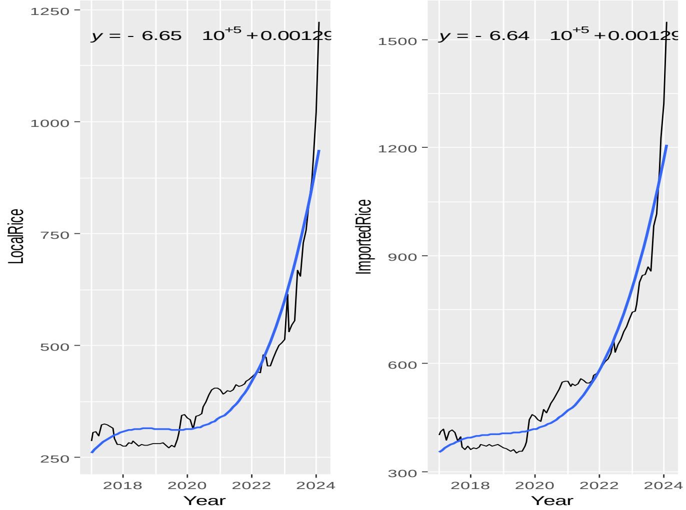

Figure 1: Trend of price of Local rice and imported rice in Nigeria from 2017- 2024

Relating MAEs of ARIMA, HOLT, MEAN, NAÏVE and ETS Models

This section presents the empirical results of the models used for forecasting the price of local rice, and imported rice using five approaches: the ARIMA, HOLT, MEAN and NAIVE and ETS models. To compare the performance of the models through the two datasets. Forecasting accuracy measure MAE was used over the forecasting period for each model. Smaller values of MAE indicate higher forecasting accuracy. Table 1 lists the complete empirical results for ARIMA, HOLTS, MEAN, ETS (Exponential smoothing), NAIVE models. The forecasting model is chosen based on the forecasting criterion MAE, the efficiency ratio defined is used for this selection. The corresponding MAE of ARIMA, HOLT, MEAN, NAÏVE and ETS models for Imported rice equals 17.69, 14.59, 165.17, 19.37, and 14.85 respectively, while the corresponding MAE of ARIMA, HOLT, MEAN, NAÏVE and ETS models for Iocal rice equals 16.84, 14.9, 120.97, 17.32, 14.7, contrary to some literature, Ajetomobi et al (2022) this study shows that Holt model is more efficient compared with ARIMA for imported rice, while Exponential smoothing model is more efficient in forecasting the price for Local maize compared with ARIMA that is recently commonly used.

Table 1: MAEs of ARIMA, HOLT, MEAN, NAÏVE and ETS models

Dataset	Statistics	ARIMA	HOLT	MEAN	NAIVE	ETS
Imported Rice	RMSE	31.33	25.65	231.67	37.95	26.66
	MAE	17.69	14.59	165.17	19.37	14.85
	MAPE	2.92	2.48	30.02	2.85	2.45
Local Rice	RMSE	33.49	28.55	177.78	35.49	29.02
	MAE	16.84	14.9	120.97	17.32	14.7
	MAPE	3.28	3.20	28.49	3.23	3.05

Source: Authors' Computation

This study used different forecasting models to exploit the capabilities of ARIMA, HOLTS, NAÏVE, MEAN and ETS to forecast the price of Local rice and imported rice for the next 26months. Comparing the forecasting performance on the basis of the residual, the best techniques was used for each type of rice. These results show that there is no universally suitable technique for two types of rice; rather, the forecast of each rice performs better with a specific model. Using the best model (Holt and ETS) for Imported and local rice respectively, both imported and local rice show a stable increase in price trend for the forecast.

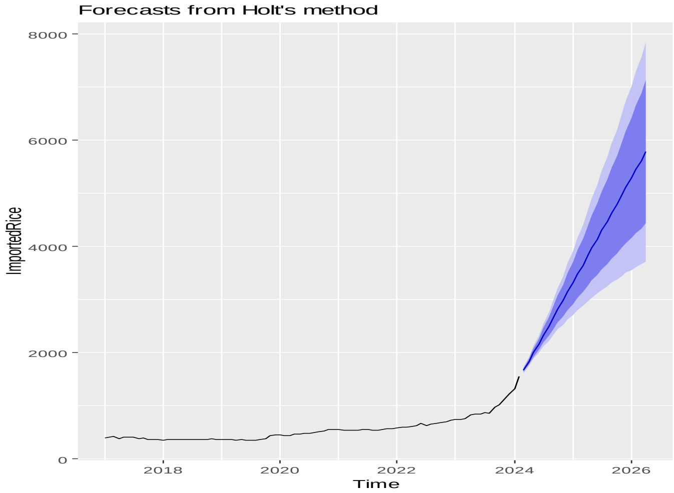

Figure 2: Forecast for Imported Rice in Naira/Kg Using Holt method

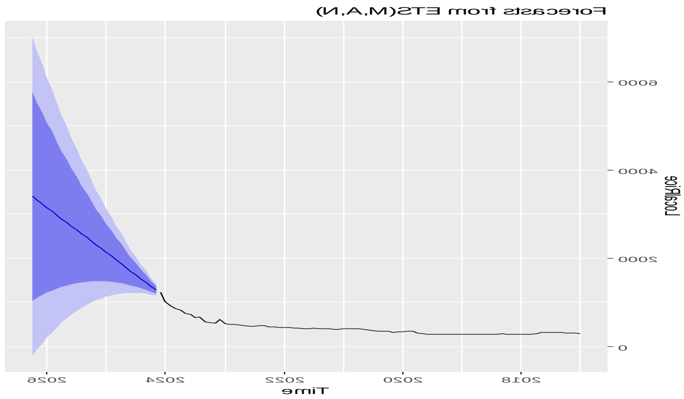

Figure 3: Forecast for Local Rice in Naira/Kg Using Exponential Smoothing Method

Figure 4 and 5 shows the result of price forecast for imported rice and Local rice using the different forecast models selected for this study. The forecast models predicted different prices for the rice varieties for from 2024 to 2026..

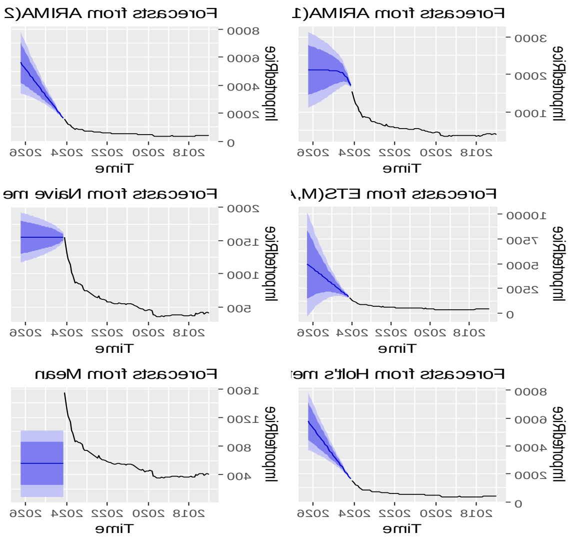

Figure 4: Forecast for Imported Rice in Naira/Kg Using different forecast Models

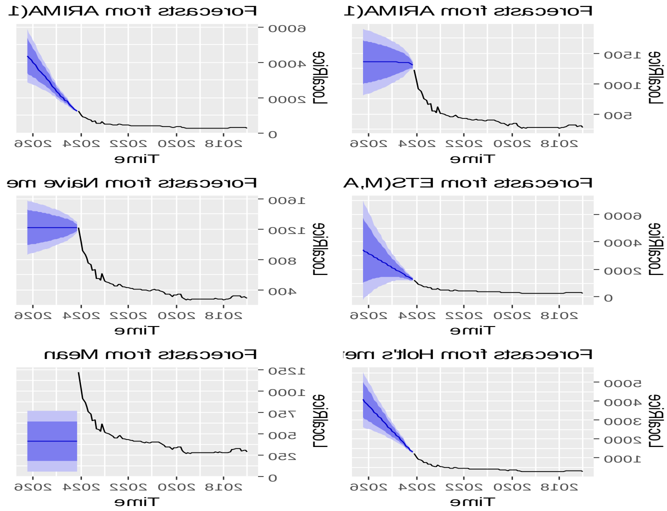

Figure 4: Forecast for Local Rice in Naira/Kg Using different forecast Models

Conclusion

The main objective of this study is to forecast the price local and imported rice in Nigeria. Based how important rice is to the country, and current hike in the price of rice the forecast analysis was conducted on local rice and imported rice. Based on the forecast accuracy measures (MAE, RMSE and RMSE), Holt outperformed the other three alternatives (Arima, mean, naïve and exponential smoothing methods) for imported rice while exponential smoothing method out performed others for local rice. The study used secondary data on Nigerian food prices from January 2017 to February 2024 that was retrieved from the NBS website. Software for R statistics was employed to investigate the data. The study forecasted the price of rice from 26 months and the results for the two rice type indicated that the price for both Imported and Local rice will not improve significantly by 2026. This study therefore calls for policies aimed at availability of high yielding and drought tolerant rice varieties to be made available to the farmers at affordable prices. The farmers should be properly advised on best management practices such as efficient application of fertilizer, pesticides and irrigation facilities. The government should review the import policies on the rice to promote local production and processing. Also, the ban of rice importation should be reviewed to prevent the deliberate hiking in price imposed on the imported rice the illegal rice importers. In essence, an increase in rice prices in Nigeria can have wide-ranging implications for food security, affecting affordability, nutrition, poverty alleviation, food access, social stability, and policy responses. Addressing the underlying causes of price volatility and promoting sustainable agricultural development are essential for enhancing food security and improving the well-being of the population.

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Cite the Article: *Ajala, A.K. , Ajetomobi, J.O., Fajobi, D.T, & Olarinre, A.A. (2024). Model Analysis For Nigeria Rice Price Forecast: An Implication For Food Security*

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