*Journal of Multidisciplinary Modeling and Optimization 4(1) (2021), 1-10.*

# Model for Retail Price Forecast of Thailand Rice In Plateau State Nigeria

O. ADEDIRE*[1], A. J. ANGYAK[2], O. O. ADEDIRE[3], and K. COLLINA[4]

[1]Department of Mathematics,
University of Jos, Jos, Plateau State, Nigeria
dharenss@gmail.com
*ORCID: https://orcid.org/0000-0003-3790-7776*

[1]Federal College of Forestry, Jos, Plateau State, Nigeria,
dharenss@gmail.com

[2]Department of Actuarial Science,
University of Jos, Jos, Plateau State, Nigeria
angyakjonathan@gmail.com
*ORCID: https://orcid.org/0000-0002-6117-1458*

[3]Federal College of Forestry Mechanization, Afaka, Kaduna, Kaduna State, Nigeria,
defemzz@yahoo.com
*ORCID: https://orcid.org/0000-0003-3010-2043*

[4]Federal College of Forestry, Jos, Plateau State, Nigeria,
Talk2nev@yahoo.com
*ORCID: https://orcid.org/0000-0002-3296-4643*

Received: 30.01.2021, Accepted: 23.04.2021, Published: 03.01.2022

**Abstract** — *In this paper, monthly retail prices of imported Thailand rice in Plateau State are analyzed and a model is proposed. Data were collected from major warehouses of businessmen in Plateau State capital and based on the observed pattern in the raw data, time series analysis was employed. Particularly, Seasonal Autoregressive Integrated Moving Average (SARIMA) method is used on the data which covered a period of 156 months (January 2007- December 2019). Results from SARIMA (1, 1, 0)(0,1,1) show Ljung –Box Q statistics value of 30.843 with p value of 0.104 and R-squared value of 0.997 at 95% confidence bound which are all indicative of adequate fitted model for forecast. Hence the developed model from SARIMA (1, 1, 0)(0,1,1) can be used to predict monthly retail prices of Thailand rice in Plateau State Nigeria to aid government policy and enable adequate planning for future changes in retail price of rice.*

**Keywords:** Model, Rice Retail, Price, Forecast.
**Mathematics Subject Classification:** 91B26, 91B60, 91B60, 00A71, 03C30.

Cite as: *O. Adedire, A. J. Angyak, O.O. Adedire and C. Kambai, Model for retail price forecast of Thailand rice in Plateau State, Nigeria, Journal of Multidisciplinary Modeling and Optimization 4(1) (2021), 1-10.*

# 1 Introduction

Rice (Oryza sativa) is a cash crop which is commonly found as a staple food in many households in Plateau State Nigeria. Studies have shown that many rice consumers in Nigeria eat more foreign rice than the domestic rice [1]. One of the reasons being that farmers who are mainly involved in domestic rice production could not meet up with consumption rate due to small-scale farming, terrorist attacks, farmer-herder clashes, consequently increase in prices of foreign food commodity is inevitable [2]. Another reason despite government intervention is presence of small stone particles in some of the domestic rice available due to crude method of processing as only a few number of standard rice processing plants are fully functional. Rice - among other staple foods - take about 6 percent of household expenses in Nigeria [3].

Over the years, people of Plateau State have depended heavily on foreign rice imported from different countries of the world. There are different varieties of rice in Nigeria but rice imported from Thailand is one of the highly desired varieties by the residents of Plateau State. While there are different reasons for consumers' preferences for certain varieties of rice [4], preference of Plateau State residents for Thailand rice could be due to increasing awareness of consumers about quality of rice in West African countries [5].

Many Plateau State residents prefer buying their rice from open markets and from small retail shop outlets than from supermarkets and other formal superstores mainly due to lower prices of the food commodity which supports the findings of Basorun [6]. While some studies exist on heavy and trace elements in some brands of rice consumed outside of Plateau State in Nigeria [7], other studies consider trend, regulation, processing and safety of food [8, 9, 10, 11, 12, 13]. The choice of SARIMA is due to its ability to predict accurately with few numbers of available parameters [14]. It uses lag and shift of historical seasonal data to forecast future outline.

From the foregoing and researches in literature, there has not been a research to model retail price of Thailand rice in Plateau State Nigeria. In this study, our aim is to create a model for retail price forecast of Thailand rice in Plateau State Nigeria to aid government policy and enable adequate planning for future changes in price. The remaining part of this paper is arranged as follows: section 2 centres on the materials and methods which include the study area, data analysis and model specification. In sections 3 and 4, results and discussion are presented and finally conclusion comes up in section 5.

# 2 Materials and Methods

## 2.1 Study Area

The study area for this research is Yan Kwalli market situated in the area of Terminus market in Jos North Local Government Area of Plateau State, Nigeria. It is one of the major markets in Plateau State where all kinds of foreign rice brands are sold. Data for this study were collected from different warehouses and retail prices of Thailand rice were extracted from the records of businessmen in the market (2007-2019). Some of the dealers in the sales of foreign rice did not keep records of their past sales. It should be noted that average retail prices of daily and monthly data are used for this study due to variations in retail prices of foreign rice.

### 2.2 Data Analysis

The data for this study is analyzed using Seasonal Auto-Regression Integrated Moving Average (SARIMA) method of Time Series analysis with aid of Statistical Package for Social Sciences (SPSS). The MAPLE software package is also employed to simplify the series equation.

### 2.3 Specification of the Model

The model for this study is multiplicative seasonal model defined by

$$SARIMA(p,d,q)(P,D,Q)_s \tag{1}$$

where $p$ and $P$ are the number of auto-regressive component of retail price of Thailand rice for both non seasonal and seasonal components respectively. While the parameters d and D are the number of times of differencing the retail prices of Thailand rice for non seasonal and seasonal components respectively, $q$ and $Q$ represent the number of moving average components of the retail price of Thailand rice for non seasonal and seasonal components with s representing the length of the seasonal period. Hence the generalized form of (1) for a series $Y_t$ is given as [15, 16]:

$$\emptyset_p(B)\Phi_P(B^s)\Delta\,\Delta^*Y_t = \theta_q(B)\Theta_Q(B^s)\,\varepsilon_t \tag{2}$$

where $\varepsilon_t$ is white noise, residual or disturbance, $B$ is a backshift operator, $\Delta = (1-B)^d$ and $\Delta^* = (1-B)^d$ are nonseasonal and seasonal differencing operators and

$$\emptyset_p(B) = 1 - \emptyset_1 B - \emptyset_2 B^2 - \cdots - \emptyset_p B^p \tag{3}$$

$$\Phi_P(B^s) = 1 - \Phi_1 B^s - \Phi_2 B^{2s} - \cdots - \Phi_P B^P \tag{4}$$

$$\theta_q(B) = 1 - \theta_1 B - \theta_2 B^2 - \cdots - \theta_q B^q \tag{5}$$

$$\Theta_Q(B^s) = 1 - \Theta_1 B^s - \Theta_2 B^{2s} - \cdots - \Theta_Q B^Q \tag{6}$$

## 3 Results

The results from the analysis of the retail price of Thailand rice in Plateau State covering a period of 156 months from January 2007 to December 2019 are shown in tables and figures below:

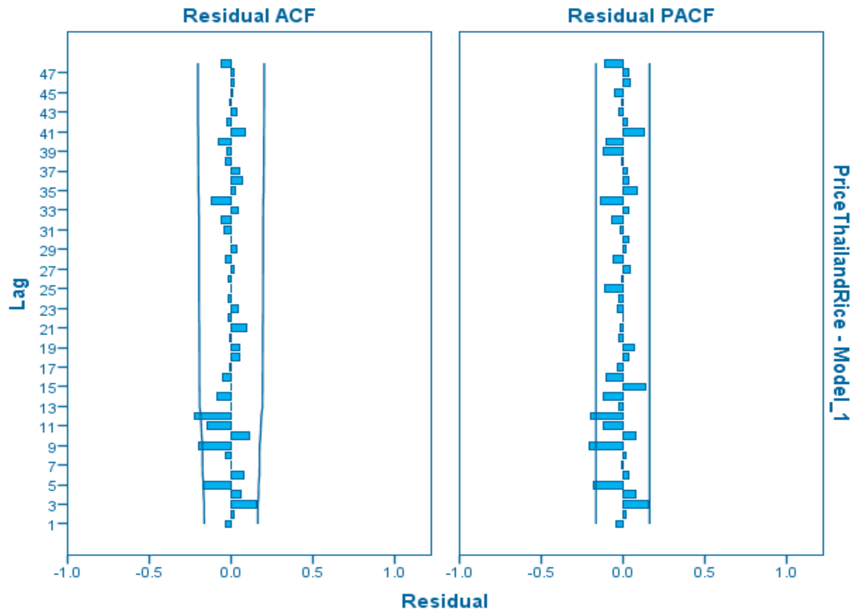


Figure 1: Residual Auto-correlation Function (ACF) and Partial ACF for retail price of Thailand rice (2007-2019) for SARIMA (1, 1, 0) (0, 1, 1) at 48 lags.

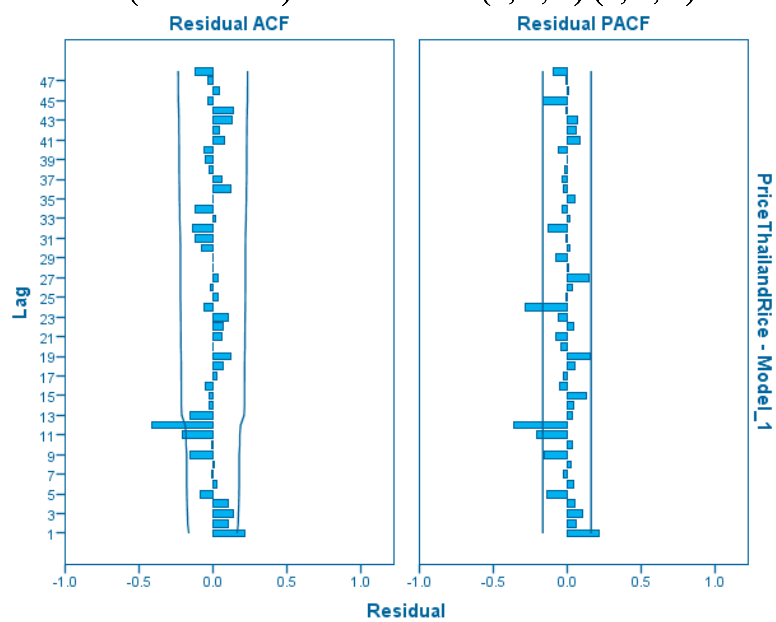


Figure 2: Residual Auto-correlation Function (ACF) and Partial ACF for retail price of Thailand rice (2007-2019) for SARIMA (1, 0, 0) (0, 1, 0) at 48 lags.

Table 1: Fit Statistics of the SARIMA (1, 1, 0) (0, 1, 1) Model of Time Series Analysis.

| Model | Stationary R-squared | R Squared | Root Mean Square Error | Normalized BIC |
|---|---|---|---|---|
| Retail price of Thailand rice (N) | 0.736 | 0.997 | 295.205 | 11.688 |

a. Best-Fitting model according to R-Squared.

Table 2: Fit Statistics of the SARIMA (1, 0, 0) (0, 1, 0) Model of Time Series Analysis.

| Model | Stationary R-squared | R Squared | Root Mean Square Error | Normalized BIC |
|---|---|---|---|---|
| Retail price of Thailand rice (N) | 0.965 | 0.995 | 404.153 | 12.314 |

b. Best-Fitting model according to R-Squared.

Table 3: Ljung-Box parameters of the SARIMA (1, 1, 0) (0, 1, 1) Model of Time Series Analysis.

| Model | Ljung-Box statistics | df | Sig. |
|---|---|---|---|
| Retail price of Thailand rice (N) | 30.843 | 16 | 0.104 |

Table 4: Ljung-Box parameters of the SARIMA (1, 0, 0) (0, 1, 0) Model of Time Series Analysis.

| Model | Ljung-Box statistics | df | Sig. |
|---|---|---|---|
| Retail price of Thailand rice (N) | 57.165 | 17 | 0.00 |

Table 5: Coefficients of SARIMA (1, 1, 0) (0, 1, 1) model for the governing equation for the retail price (in Nigerian Naira N) of Thailand rice.

| SARIMA(1, 1, 0)(0, 1, 1) | Coefficients | SE | t | Sig. |
|---|---|---|---|---|
| AR lag 1 | 0.167 | 0.081 | 2.055 | 0.042 |
| Seasonal MA lag 1 | 0.918 | 0.126 | 7.281 | 0.000 |

Table 6: Comparison of average original retail price (in Nigerian Naira N) with model “fit” price within the period of coverage for the last two consecutive years.

| | Original Retail Price | | SARIMA(1,1,0)(0,1,1) Model Fit Price | |
|---|---|---|---|---|
| Month | 2018 | 2019 | 2018 | 2019 |
| Jan | 18650.00 | 23000.00 | 18647.93 | 23181.17 |
| Feb | 18920.00 | 22500.00 | 18542.62 | 22924.81 |
| Mar | 19610.00 | 23300.00 | 19466.99 | 22933.93 |
| Apr | 19700.00 | 23600.00 | 19873.80 | 23563.54 |
| May | 20590.00 | 23550.00 | 19779.84 | 23801.54 |
| Jun | 20680.00 | 23550.00 | 20919.74 | 23697.40 |
| Jul | 20685.00 | 23200.00 | 20950.38 | 23776.98 |
| Aug | 21650.00 | 23320.00 | 21445.67 | 23261.17 |
| Sep | 21690.00 | 23700.00 | 21611.32 | 23921.45 |
| Oct | 21980.00 | 24400.00 | 22223.95 | 24154.14 |
| Nov | 22200.00 | 24600.00 | 22388.91 | 24857.05 |
| Dec | 23100.00 | 24800.00 | 22632.01 | 25078.81 |

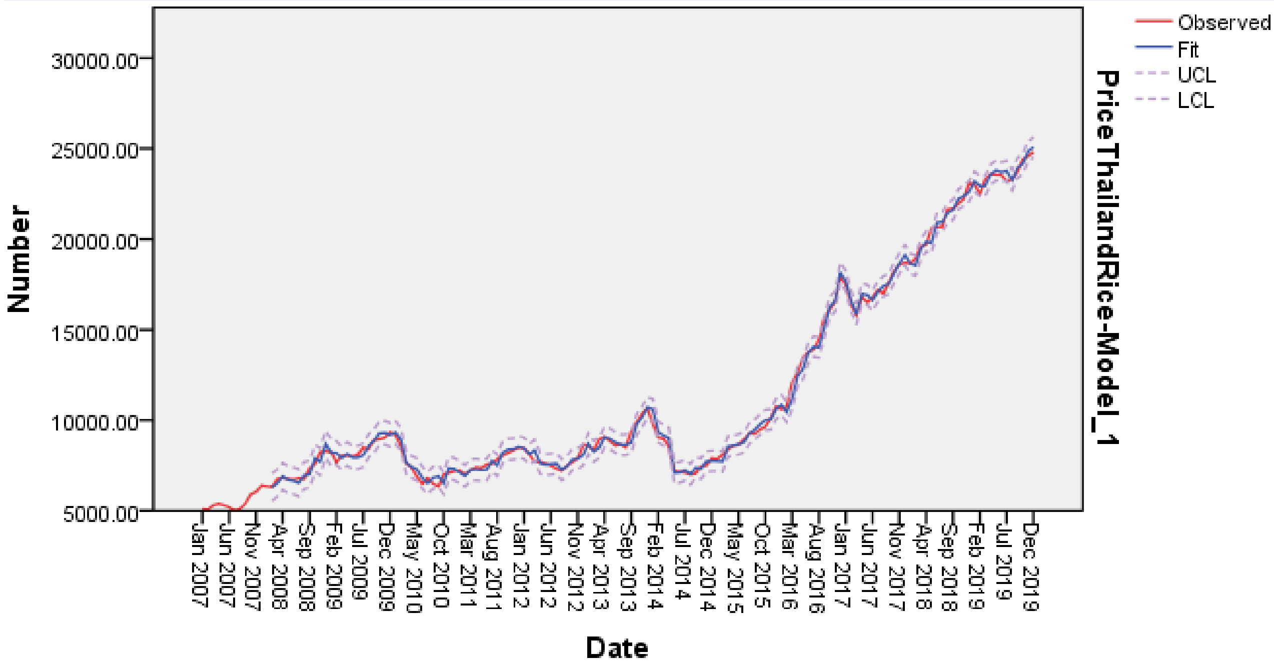


Figure 3: Seasonal ARIMA (1, 1, 0) (0, 1, 1) model chart of the retail price of Thailand rice (2007-2019).

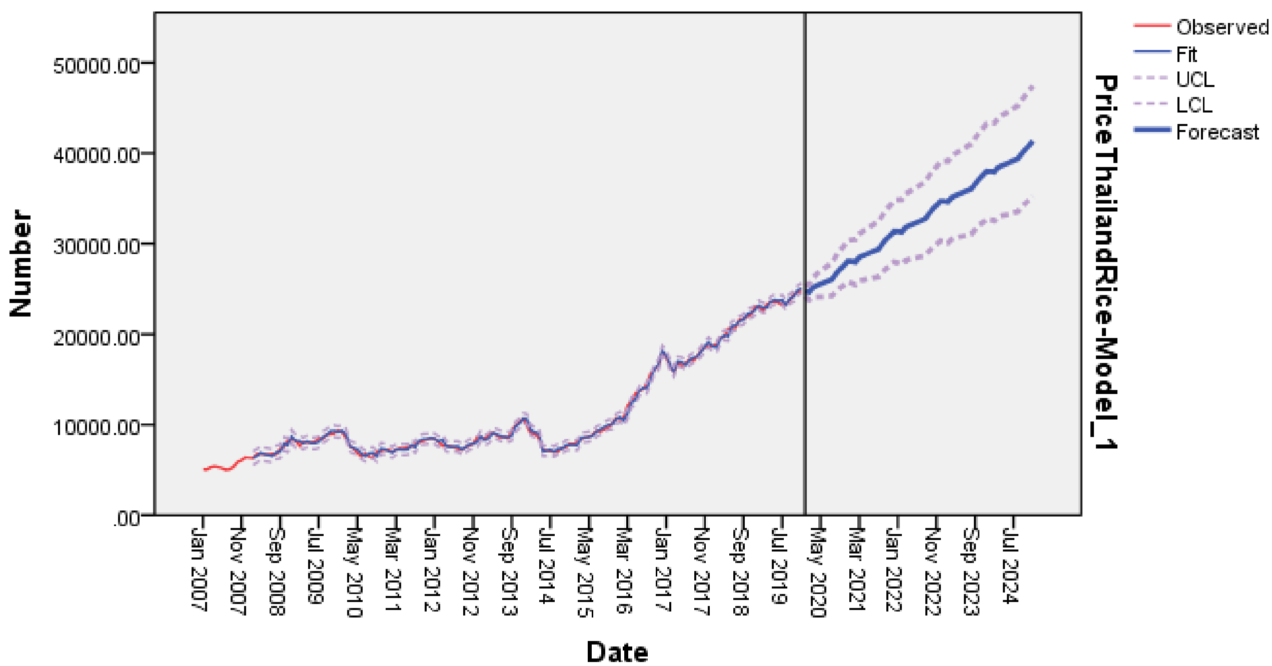


Figure 4: Seasonal ARIMA (1, 1, 0) (0, 1, 1) model chart of the retail price of Thailand rice (2007-2019) with forecast (2020-2024) Plateau State.

Table 7: Forecast (2020 - 2024) of retail price (in Nigerian Naira N) of Thailand Rice using the governing equation (15) for SARIMA (1, 1, 0) (0, 1, 1) .

| Month | Year | | | | |
|---|---|---|---|---|---|
| | 2020 | 2021 | 2022 | 2023 | 2024 |
| Jan | 24745.43 | 28052.98 | 31369.99 | 34687.00 | 38004.01 |
| Feb | 24634.23 | 27949.67 | 31266.67 | 34583.68 | 37900.69 |
| Mar | 25170.52 | 28487.26 | 31804.27 | 35121.28 | 38438.29 |
| Apr | 25393.84 | 28710.80 | 32027.81 | 35344.82 | 38661.83 |
| May | 25556.80 | 28873.80 | 32190.81 | 35507.82 | 38824.82 |
| Jun | 25724.58 | 29041.59 | 32358.60 | 35675.60 | 38992.61 |
| Jul | 25920.36 | 29237.37 | 32554.38 | 35871.38 | 39188.39 |
| Aug | 26078.54 | 29395.55 | 32712.56 | 36029.56 | 39346.57 |
| Sep | 26663.65 | 29980.66 | 33297.66 | 36614.67 | 39931.68 |
| Oct | 27177.19 | 30494.20 | 33811.21 | 37128.22 | 40445.23 |
| Nov | 27576.80 | 30893.81 | 34210.82 | 37527.83 | 40844.84 |
| Dec | 28060.30 | 31377.31 | 34694.31 | 38011.32 | 41328.33 |

## 4 Discussion

Two SARIMA methods of time series analysis are considered. They include SARIMA (1, 1, 0) (0, 1, 1) and SARIMA (1, 0, 0) (0, 1, 0). From the preliminary investigation of the raw data, measure of central tendency show a shift in the mean over time in upward manner. In order to make the non stationary mean steady, differencing of the retail price of Thailand rice was done to remove both the local trend component and seasonal trend component. The model considered that each retail price depends on one previous retail price for nonseasonal component and one random shock for seasonal component. Hence equation (1) for parameters p = 1, d = 1, q = 0, P = 0, D = 1, Q = 1 becomes SARIMA (1, 1, 0) (0, 1, 1) at 95% confidence bounds. The residual Auto-Correlation Functions (ACF) and residual Partial Autocorrelation Function (PACF) for SARIMA (1, 1, 0) (0, 1, 1) at 95% confidence bounds are shown in Figure 1. However, for the alternative SARIMA method of time series analysis, the non stationary mean was made steady by differencing of the retail price of Thailand rice to remove seasonal trend component only without random shock for seasonal component and with consideration of the dependence of each retail price on one previous retail price for nonseasonal component. Hence equation (1) for parameters p = 1, d = 0, q = 0, P = 0, D = 1, Q = 0 becomes SARIMA (1, 0, 0) (0, 1, 0) at 95% confidence bounds. The residual Auto-Correlation Functions (ACF) and residual Partial Autocorrelation Function (PACF) for SARIMA (1, 0, 0) (0, 1, 0) at 95% confidence bounds are shown in Figure 2.

From Tables 1 and 2, the R-squared values are 0.997 and 0.995 for SARIMA (1, 1, 0) (0, 1, 1) and SARIMA (1, 0, 0) (0, 1, 0) respectively which indicate good fitted models such that the models predict the observed values well. Table 3 shows the Ljung-Box Q values of 30.843 with significance $p^* = 0.104$ which indicate that error not explained is merely a random error and that the residuals of the model does not have significant autocorrelation left as shown in Figure 1. Hence we fail to reject null hypothesis which states that there is no significant auto correlation left in the residual of the associated model. On the other hand, Table 4 shows the Ljung-Box Q values of 57.165 with significance $p^* = 0.00$ which indicate that error not explained is a significant random error and that the residuals of the model have significant autocorrelation left as shown in Figure 2. Hence we fail to reject alternate hypothesis which states that there is significant auto correlation left in the residual of the associated model. Furthermore, SARIMA (1, 1, 0) (0, 1, 1) has lower Root Mean Square Error (295.205) compared to SARIMA (1, 0, 0) (0, 1, 0) with RMSE (404.153) as indicated in Tables 1 and 2 respectively. From the foregoing, the SARIMA (1, 1, 0) (0, 1, 1) model is preferable to SARIMA (1, 0, 0) (0, 1, 0) model, hence the focus is shifted to SARIMA (1, 1, 0) (0, 1, 1) in the rest of this analysis.

From Table 5, the results show coefficients of SARIMA (1, 1, 0) (0, 1, 1) model for the governing equation of Thailand rice which indicate that the coefficients are statistically significant and should be retained in the model series equation. Using Table 5 with SARIMA (1, 1, 0) $(0, 1, 1)_s$, the equations (2)-(6) give the following:

$$\emptyset_1(B)\Phi_0(B^s)\Delta\,\Delta^* Y_t = \theta_0(B)\Theta_1(B^s)\,\varepsilon_t \quad (7)$$

$$\emptyset_1(B)\Phi_0(B^s)(1-B)^1(1-B^s)^1 Y_t = \theta_0(B)\Theta_1(B^s)\,\varepsilon_t \quad (8)$$

From equations (4) and (5), $\Phi_0(B^s) = 1$ and $\theta_0(B) = 1$ hence (8) gives

$$\emptyset_1(B)(1-B)^1(1-B^s)^1 Y_t = \Theta_1(B^s)\,\varepsilon_t \quad (9)$$

Application of (3) and (6) on (9) with the aid of Maple software give

$$(1-\emptyset_1 B^1)(1-B)(1-B^s)^1 Y_t = (1+\Theta_1 B^s)\,\varepsilon_t \quad (10)$$

which on expansion becomes

$$[(1-\emptyset_1 B)(1-B^s-B+BB^s)]Y_t = (1+\Theta_1 B^s)\,\varepsilon_t \quad (11)$$

$$[1-B^s-B+BB^s-\emptyset_1 B+\emptyset_1 BB^s+\emptyset_1 BB-\emptyset_1 BBB^s)]Y_t = (1+\Theta_1 B^s)\,\varepsilon_t \quad (12)$$

Expansion of (12) gives

$$Y_t - Y_{t-s} - Y_{t-1} + Y_{t-s+1} - \emptyset_1 Y_{t-1} + \emptyset_1 Y_{t-s+1} + \emptyset_1 Y_{t-2} - \emptyset_1 Y_{t-s+2} = \varepsilon_t + \Theta_1 \varepsilon_{t-s} \quad (13)$$

From Table 5, $\emptyset_1 = 0.167$ and $\Theta_1 = 0.918$

$$Y_t - Y_{t-s} - Y_{t-1} + Y_{t-s+1} - 0.167\,Y_{t-1} + 0.167\,Y_{t-s+1} + 0.167\,Y_{t-2} - 0.167\,Y_{t-s+2} = \varepsilon_t + 0.918\,\varepsilon_{t-s} \quad (14)$$

With the length of the seasonal period $s = 12$ and on further simplification, Eq. (14) gives

$$Y_t = 1.167\,Y_{t-1} - 0.167\,Y_{t-2} + Y_{t-12} - 1.167\,Y_{t-13} + 0.167\,Y_{t-14} + \varepsilon_t + 0.918\,\varepsilon_{t-12} \quad (15)$$

where $Y_t$ is the retail price of Thailand rice at the current time and $Y_{t-i}$ $(i = 1, 2, ...)$ are values of previous retail prices at previous monthly times. The $\varepsilon_t$ and $\varepsilon_{t-i}$ represent random shocks at current times and previous times respectively. Hence equation (15) is the model equation representing the evolution of retail price of Thailand rice in Plateau State. Figure 3 shows the comparison of the fitted model of retail prices of Thailand rice in Plateau State with the actual raw data. Moreover, values for two consecutive years 2018 and 2019 only are displayed in Table 6 to show similarity of fitted model with the actual raw data. It can be seen that the fitted model closely look like the raw data over the number of years covered from January (2007) to December (2019), this is an indication of appropriateness of the model to explain the changes in time series analysis of the retail price of the Thailand rice in Plateau State Nigeria. In Figure 4 and Table 7, five-year forecast of the retail price of the Thailand rice in Plateau State is predicted. A rise in trend of the retail prices is observed over the period of forecast January (2020) - December (2024).

## 5 Conclusion

A SARIMA model was developed to examine the trend in retail prices of Thailand rice in Plateau State, Nigeria. Data which covered a period of 156 months were collected from warehouses of major rice dealers in Yan kwalli market - one of the main markets specialized in sales of domestic and foreign rice - in Terminus area of Jos, the Plateau state capital. After the analysis using SARIMA (1, 1, 0) (0, 1, 1), we derived a model equation which is capable of predicting future changes in retail prices of Thailand rice in Plateau State, Nigeria when existing factors have not significantly changed.

## Conflict of Interest Declaration

The authors declare that there is no conflict of interest statement.

## Ethics Committee Approval and Informed Consent

The authors declare that there is no ethics committee approval and/or informed consent statement.

## References

[1] K. Gyimah-Brempong, M. Johnson and H. Takeshima, The Nigerian rice economy: Policy options for transforming production, marketing and trade, International Food Policy Research Institute (IFPRI), Washington DC, 2016.

[2] H. Takeshima and O. Bakare, Production systems: biophysical and economic environment and constraints. In: Gyimah - Brempong, K., Johnson,M., Takeshima, H. (Eds.), The Nigerian Rice Economy; Policy Options for Transforming Production, Marketing and Trade. University of Pennsylvania Press, Philadelphia, Pennsylvania, 2016.

[3] M. Johnson, H. Takeshima, K. Gyimah-Brempong, O. Kuku-Shittu, X. Diao, P. Dorosh, M. Malek, J. Koo, A. Pradesha and A. Ajibola, Policy options for accelerated growth and competi-

tiveness of the domestic rice economy in Nigeria. International Food Policy Research Institute, Washington DC, 2013.

[4] K. Aoki, K. Akai and K. Ujiie, A choice experiment to compare preferences for rice in Thailand and Japan: the impact of origin, sustainability and taste, Food Qual. Prefer., 56 2017, 274–284.

[5] M. Demont, and M. Ndour, Upgrading rice value chains: experimental evidence from 11 African Markets, Glob. Food Secur., 5 2015, 70–76.

[6] J. Basorun, Empirical analysis of association of rice marketing factors in Igbemo region, Nigeria, Int. J. Bus. Soc. Sci., 3(2) 2012, 296–306.

[7] K. Emumejaye, Heavy and trace elements in some brands of rice consumed in Delta State, Nigeria, IOSRJ. Appl. Phys., 6(2) 2014, 1–5.

[8] J. Ezirigwe, Much Ado about food safety regulation in Nigeria, J. Sustain. Develop. Law Policy, 9(1) 2018, 109–132.

[9] H.H. Jensen and J. Zhou, Food safety regulation and private standards in China. In: Hammoudi, A., Grazia,C., Surry,Y., Traversac,J.B. (Eds.), FoodSafety, Market Organization, Trade and Development. Springer, Cham, 2015.

[10] M. Johnson and A. Ajibola, Post-harvest processing, marketing and competitiveness of domestic rice. In: Gyimah-Brempong, K., Johnson, M.,Takeshima,H.,Gyimah-Brempong, K., Johnson, M., Takeshima, H. (Eds.), The Nigerian rice economy : Policy options for transforming production, marketing and trade. University of Pennsylvania Press, Philadelphia, 2016.

[11] M. Nguyen, M. Demont, E. Vanloo, A. deGuia, P. Rutsaert, T. Huutuan and W. Verbeke, What is the value of sustainably-produced rice? Consumer evidence from experimental auctions in Vietnam. Food Policy, 79, 2018, 283–296.

[12] R. Oginyi, O. Mbam, C. Abojei and O. James, Assessment of occupational health hazard and the use of safety measures among rice mill workers in Ebonyi state, Nigeria, World Appl . Sci. J., 35 (7) 2017, 1133–1141.

[13] D. Ray, N. Mueller, P. West and J. Foley, Yield trends are insufficient to double global crop production by 2050. PLoSOne 8(6) 2013, e66428.

[14] M.O. Thomas, Short Term Forecasting, an introduction the Box Jenkins Approach, John Wiley and Sons, 1983.

[15] G. E. P. Box, G. M. Jenkins and G. C Reinsel, Time Series Analysis: Forecasting and Control. John Wiley & Sons Inc., San Francisco, 2013.

[16] J. D. Cryer and K. –S. Chan, Time Series Analysis: with Applications in R. Springer, New York, 2008.