https://dx.doi.org/10.4314/ijs.v26i1.12

A TIME SERIES ANALYSIS OF MONTHLY ISSUANCE OF PLANT IMPORT PERMITS IN NIGERIA

Majebi, O.E.[1,*], Ogunsola, K.E.[2], Kazeem, S. A.[3], and Ogunfunmilayo, A. O.[3]
[1]Federal Cooperative College, Ibadan, Nigeria.
[2]Department of Biological Sciences, Bells University of Technology, Ota, Ogun State, Nigeria.
[3]Post-Entry Quarantine, Surveillance and Diagnostic Station, Nigeria Agricultural Quarantine Service, Moor Plantation, Ibadan, Nigeria.
[*]Corresponding Author's Email: majebi@yahoo.com
(Received: 2nd February, 2024; Accepted: 13th March, 2024)

ABSTRACT

An import permit is issued by the National Plant Protection Organization of each country, known in Nigeria as the Nigeria Agricultural Quarantine Service (NAQS), to allow the importation of pest-free plants and prevent the introduction of quarantine pests or check the entry of regulated non-quarantine pests of imported plant commodities. Issuance of import permits at the Post-Entry Quarantine, Surveillance and Diagnostic Station (PEQDS), Ibadan is mostly for germplasm materials mainly used for cultivation, which poses a high risk of pest introduction. Thus, this study investigated the statistical components of the issuance of import permits at the PEQDS using the Time Series approach to determine the peak period of collection essential for planning phytosanitary activities to mitigate the introduction of foreign pests. The dataset of the monthly issuance of import permits from January 2012 to July 2022 was analysed. From the preliminary study, we observed that the series exhibit seasonal and stationary components with no definite trend pattern, hence we modelled the series using a Seasonal Autoregressive Moving Average (SARIMA) model. Several models were estimated and the best model (SAR(12)) for forecasting the future import permit collectionwas selected based on the forecast accuracy measures. The forecasted values indicated the highest issuance of import permits in May and September, each year and showed a fluctuating movement over time in the future. To further prevent pest incursion and facilitate trade, NAQS needs to operate round-the-clock surveillance, keep its staff on high alert and adequate facilities operational for more effective activities. Other factors responsible for low and fluctuating issuance of import permits should also be investigated.

Keywords: Seasonal Autoregressive Moving Average, Import Permit Issuance, Statistical Components, Post-Entry Quarantine, Quarantine regulations.

INTRODUCTION

The Plant Quarantine Service was established in Nigeria by the Control of Importation Act of 1959 which was later amended with the enactment of the Agriculture (Control of Importation and Exportation) Act of 2004 (Ojuederie, 2004; Awosusi *et al*., 2011; Majebi *et al*., 2023). The Plant Quarantine service of the Federal Department of Agriculture was harmonized with two other existing quarantine units in the Federal Ministry of Agriculture and Rural Development (FMARD) i.e. the National Veterinary Quarantine Service (NVQS) of the Federal Department of Livestock and the National Fisheries inspection and Quality Assurance Quarantine Service (NFIQAQ) of the Federal Department of Fisheries (FDF) to create the Nigeria Agricultural Quarantine Service (NAQS). The harmonization was approved by Federal Executive Council on the 16th of May, 2007 and the Nigeria Agricultural Quarantine Service Establishment Act of 2017 as passed by the National Assembly was assented on the 26th of January, 2018 by the President of Nigeria.

The main mandate of NAQS is to protect the country`s agricultural economy from the introduction, spread and establishment of exotic pests while facilitating trade (Ojuederie, 2004; Awosusi *et al*., 2011; Majebi *et al*., 2023). This service is significant because many dangerous pests could be introduced into Nigeria through unrestricted importation of plants, seeds, livestock, fish and fishery products. These pests could devastate our agricultural produce to the detriment of the agricultural economy of Nigeria.

Importation of agricultural commodities is regulated with the issuance of an import permit to prevent exotic pest introduction with the consignment and promote confidence between trading partners. An import permit is an official document containing the phytosanitary conditions to be fulfilled by the exporting country before the export of agricultural commodity, thus authorizing the importation of a commodity by specified phytosanitary import requirements (ISPM, 2012). This document is issued only by the National Plant Protection Organization (NPPO) of each country as established by the International Plant Protection Convention (IPPC). The NAQS is the NPPO of Nigeria represented by the Plant Quarantine Department (Awosusi *et al.*, 2011).

A plant import permit is usually issued for germplasms, bioagents, commodities in large quantities, and plant materials for research purposes. A phytosanitary certificate issued by the NPPO of the exporting country and consistent with the model certificates of the IPPC, usually accompanies the consignment, indicating that the consignment meets the conditions stated in the import permits (ISPM, 2004; Majebi *et al.* 2023). Imported consignment not covered by an import permit and a phytosanitary certificate stands the risk of being confiscated, destroyed or reshipped at the importer's expense.
The issuance of an import permit after completing an import permit application form would depend on the risk involved. A permit may not be issued if the agricultural material is prohibited or if the country of origin is known to be a high-risk area. In Nigeria, an import permit is issued on the payment of a fee (User Fee) approved by the government for that purpose and it is valid within 12 months in the year of issuance (Unpublished). Further inspection at the importer's field and testing are conducted for germplasms meant for planting. A certificate of release is issued for all imported consignments which comply with the importing conditions (Ojuederie, 2004).

NAQS has quarantine inspectors at the Pre-entry quarantine stations (international airports, seaports, land border crossings and parcel post offices) who ensure compliance with phytosanitary conditions in the import permit. Export/import inspection laboratories, fumigation chambers and incinerators are also provided at designated border stations and at the NAQS Post-Entry Quarantine, Surveillance and Diagnostic Station (PEQSD) to facilitate the enforcement of quarantine regulations (ISPM, 2010; Awosusi *et al.*, 2011).The plant quarantine inspectors at the entry/exit points are provided with regulatory pest identification and management support by the PEQSD at Ibadan, Nigeria, which is common among the NPPO of other countries of the world that are members of IPPC (Ojuederie, 2004; ISPM, 2010; 2012).

The PEQSD mainly issues import permits for planting materials, high-risk crops of economic importance to Nigeria, and microorganisms used as biological agents, and conducts pest risk analysis for preparing conditions in the import permit. It also conducts tests of imported plants for latent pests that may be difficult to detect during the inspection at the points of entry/exit and during planting in the greenhouse before release (Ojuederie, 2004; Awosusi *et al.*, 2011; Ogunsola *et al.*, 2016; 2018). Analysed data on the issuance of import permits usually contain useful information which is very important for strategically-guided phytosanitary decision making and provide information that can be used to identify the strengths and gaps to enhance NAQS operational efficiency in preventing pest incursion and enhance international trade. Time series analysis has been reported as an effective statistical analysis for estimating the future from previously collected data (Eghwerido, 2008). It is a mathematical model largely adopted in economics, physics, engineering, mathematics, and biology to reproduce the behaviour of data series and predict future slopes (Guarnaccia *et al.*, 2014). The aims of this kind of model are to recognize the phenomenon under study using data trend and for periodicity reconstruction and prediction of future values of the time series. The results from such analysis have been used to develop a road map for better operational efficiency and effectiveness (Eghwerido, 2008; Awe *et al.*, 2018). Time series analysis of the issuance of import permits for plants and plant materials is essential for measuring the rate of importation in the country, as well as the level of compliance with the collection of the import permit document. This information will also serve as the basis for policy development toward crop protection as well as surveillance planning, which are essential for preparedness and preventive measures against pest/disease epidemics in the future. Thus, this study evaluated the statistical components of the previously issued import permits from NAQS Post-Entry Quarantine station, Ibadan using the Time Series approach.

MATERIALS AND METHODS

Data collection and statistical analyses

The data on the monthly issuance of import permits were collected from the records of the Import Section of PEQSD. NAQS, Moor Plantation, Ibadan. The data spanned the period from January 2012 to July 2022. The statistical components of the data were examined before further analyses to select the most appropriate model for this study. As shown in Figure 12 we observed a fluctuating movement over the years considered and other preliminary tests were conducted for selecting appropriate analysis model for the data and these are:

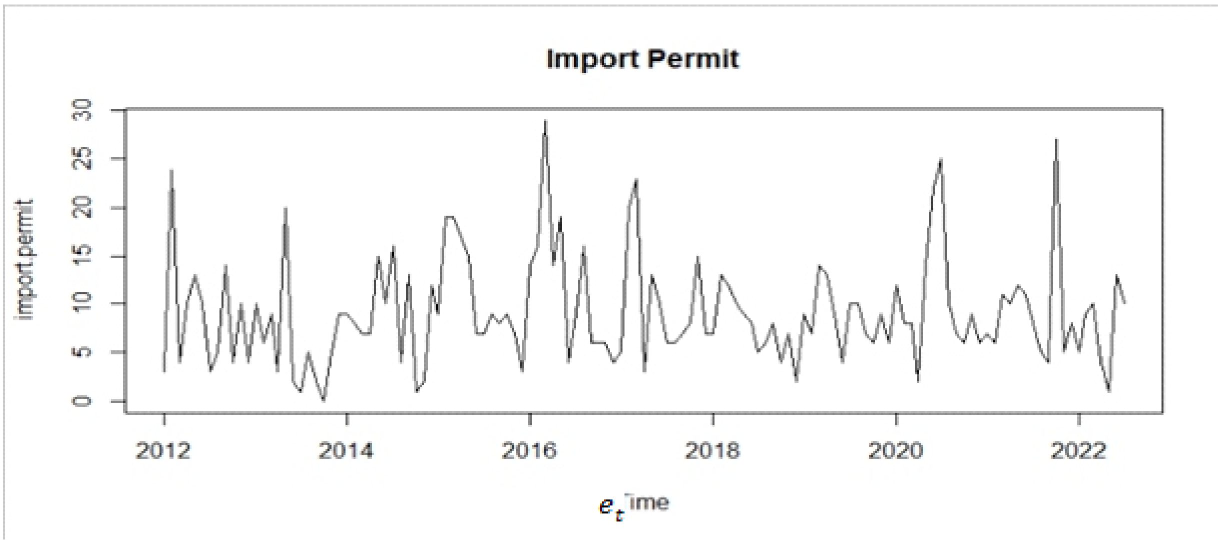


Figure 1: Time Plots of the original series of import permits (January 2012 to July 2022)

The Augmented Dickey-Fuller (ADF) Testing Framework

Augmented Dickey-Fuller (ADF) Testing Framework was used according to Dickey and Fuller (1981). This test shows that the limiting distribution and critical values obtained under the assumption of independent and identical distributed μ_t process are also valid when autoregressive μ_t in the ADF regression is run, assuming the data are generated according to $X_t = \mu_t + \beta X_{t-1}$ with $\beta = 1$ and that

$\mu_t = \theta_1 U_{t-1} + \theta_2 U_{t-2} + ... + \theta_p U_{t-p} + e_t$ (1)

where e_t are *iid*$(0,\sigma^2)$

We considered the regression

$\Delta X_t = \mu_t + \alpha + \beta_t + \varnothing X_{t-1}$ (2)

and tested $H_0: \varnothing = 0$ vs $H_1: \varnothing < 0$.

The ADF tests the null hypothesis that a time series contains a unit root. Depending on which version of the test is performed, the alternative hypothesis is usually stationary or trend steady. The ADF statistic is a negative number. The stronger the rejections of the hypothesis that there is a unit root at whatever level of confidence, the more negative it is. In this study, the test statistic which is defined as:

$$ADF_t = \frac{\hat{\beta}}{SE(\hat{\beta})}$$

where

$$SE(\hat{\beta}) = \sqrt{\sum X^2{}_{t-1}}$$

was computed and compared to the relevant critical value for the Dickey-Fuller test. If the test statistic is less than the critical value, then the null hypothesis, $\beta = 0$ is rejected and no unit root is present. The Augmented Dickey-Fuller (ADF) test is a widely used statistical test to determine whether a unit root is present in a time series dataset. It comes in three standard forms, each representing different models with varying levels of complexity. Here are the equations for each form:

1. ADF Test – Null Hypothesis: The time series has a unit root (non-stationary).

$\Delta X_t = \alpha + \beta_t + \gamma X_{t-1} + \delta_1 \Delta X_{t-1} + \in_t$

2. ADF Test with a constant – Null hypothesis: the time series has a unit root with a constant term.

$\Delta X_t = \alpha + \gamma X_{t-1} + \delta_1 \Delta X_{t-1} + \in_t$

3. ADF Test with a Constant and Trend – Null Hypothesis: The time series has a unit root with a constant and linear trend.

$\Delta X_t = \alpha + \beta_t + \gamma X_{t-1} + \delta_1 \Delta X_{t-1} + \in_t$

ΔX_t = the differenced series at time t

$\propto$ = constant time

β_t = coefficient on the time trend

γ = coefficient on the lagged level of the time series

$_i\delta_i$ = coefficient on the lagged first difference of the time series

$\in_t$ = the error term

The Phillip-Perron (PP) Testing Framework

The Phillip Perron test was also conducted which is a unit root test that is used in time series analysis to test the null hypothesis that a time series is integrated of order 1. It builds on the Dickey-Fuller test of the null hypothesis $\beta = 0$ in

$$\Delta X_t = (\beta - 1)X_{t-1} + \mu$$

where Δ is the first difference operator. The Phillips-Perron test addresses the issue that the process generating data for X_t might have a higher order of autocorrelation than is admitted in the test equation making X_{t-1} endogenous. It makes a non-parametric correction to the t-test statistic. The test is robust concerning unspecified autocorrelation and heteroscedasticity in the disturbance process of the test equation.The test regression for the PP test is

$$\Delta X_t = \mu + \beta X_{t-1} + e_t, \quad e_t \sim l(0) \qquad (4)$$

where we may exclude the constant or include a trend term.

The PP test is correct for any serial correlation and heteroscedasticity in the errors, e_t of the test regression by directly modifying the test statistic $t_\beta = 0$ and T_β. The modified statistics denoted by Z_t and X_β are given as

$$Z_t = \left(\frac{\hat{\sigma}^2}{\hat{\lambda}^2}\right) t_\beta - \frac{1}{2}\left(\frac{\hat{\lambda}^2 - \hat{\sigma}^2}{\hat{\lambda}^2}\right)\left(\frac{T \ x \ SE(\hat{\beta})}{\hat{\sigma}^2}\right)$$

$$Z_\beta = T\hat{\beta} - \frac{1}{2}\left(\frac{T^2 x \ SE(\hat{\beta})}{\hat{\sigma}^2}\right)(\hat{\lambda}^2 - \hat{\sigma}^2)$$

The terms σ^2 and λ^2 are consistent estimates of the variance parameters. They are estimated by

$$\sigma^2 = \lim_{T\to\infty} T^{-1} \sum_{t=1}^{T} E(e_t^2)$$

$$\lambda^2 = \lim_{T\to\infty} \sum_{t=1}^{T} E(T^{-1} S_t^2) = LRV$$

$$S_t^2 = \sum_{t=1}^{T} e_t^2$$

The sample variance of the least squares residual σ^2, and the Newey-West long-run variance estimate of e_t and $\hat{e}_t$ is a consistent estimate of λ^2. Under the null hypothesis that $\beta = 0$, the PP Z_t and Z_β statistics have the same asymptotic distribution as the ADF t-statistic and normalized bias statistics. The test gives the same conclusions as the ADF tests.

Seasonal Autoregressive Moving Average (SARMA) model

Based on the results of the above preliminary tests, we employed the seasonal autoregressive moving average model having observed a seasonal component in the series from the preliminary check on the data. Because the stationarity of the series has been proven at the level (original series), the original series was subjected to modelling. To determine which SARIMA model to use, we estimated 324 SARMA models to find the best model for modelling the import permit.The Seasonal Autoregressive Integrated Moving Average (SARIMA) process is defined as,

$$\Phi_p(B^s)\vartheta_p(B)(1-B)^d(1-B^s)^D X_t = \emptyset_q(B)\ddot{\Theta}_Q(B^s)e_t \qquad (5)$$

where d represents the integrated order (d = 0 in our case), $\vartheta_p(B)$ and $\emptyset_q(B)$ are the autoregressive and moving average polynomials, respectively, defined as,

$$\vartheta_p(B) = 1 - \theta_1(B) - \theta_2(B^2) - \cdots - \theta_p(B^p),$$

$$\emptyset_q(B) = 1 - \varphi_1(B) - \varphi_2(B^2) - \cdots - \varphi_p(B^p),$$

and $\Phi_p(B^s)$ and $\ddot{\Theta}_Q(B^s)$ are the seasonal autoregressive and moving average polynomials, respectively, which are defined as,

$\Phi_p(B^s) = 1 - \Phi_1 B^s - \Phi_2 B^{2s} - \cdots - \Phi_p B^{ps}$

$\ddot{\theta}_q(B^s) = 1 - \ddot{\theta}_1 B^s - \ddot{\theta}_2 B^{2s} - \cdots - \ddot{\theta}_q B^{qs}$,

The residual e_t denotes a white noise process. We can write (5) as, Seasonal Autoregressive Integrated Moving Average (SARIMA)
(p, d, q) x (P, D, Q)s
where
p, d, and q are respectively the autoregressive, differencing, and moving average orders in the non-seasonal part of the model;
P, D, and Q are respectively the autoregressive, differencing, and moving average orders in the seasonal part of the model, and s denotes the data frequency (s = 12 for monthly series) (Yaya and Fashae, 2014)
With d = D = 0, the model becomes the SARMA (p, q) x (P, Q)s process,

$\Phi_p(B^s)\vartheta_p(B)X_t = \emptyset_q(B)\ddot{\theta}_q(B^s)e_t$

which was used to model the import permit series in this study.

Two models:SARMA (2, 2) x $(1, 0)_{12}$ and SARMA (0, 0) x $(1, 0)_{12}$ were considered for modelling the number of import permits. Both were examined and compared to determine the best modelbetween them. Convergence rate and other model criteria were used to diagnose the selected models. By examining the basic statistical features of the models' associated residuals, the two selected models were diagnosed. Various forecast accuracy data were checked and compared for the selected models. In deciding on the best model, parsimony was also put into consideration. The chosen model was used to forecast the monthly Import permits between August 2022 and December 2025.

RESULTS

The ADF and the PP test results on the original Import permit series and the associated first differenced series were presented in Table 1. We considered three regression equations: without a constant and trend, with a constant only and with both constant and trend. The results showed that the import permit series is stationary for all three regression equations and that the differenced series is stationary at all significant levels. Table 2 displays the top 15 models out of 324 estimated. The preliminary best models with the lowest Alkaike Information Criterion (AIC), Bayesian Information Criterion (BIC) and Hannah Quinn (HQ) values were selected and compared in terms of forecast accuracy. SARMA (2, 2) x $(1, 0)_{12}$ appeared to be the best model for modelling the number of import permits, as it has the lowest AIC value, while SARMA (0, 0) x $(1, 0)_{12}$ seemed the most suitable for modelling the number of import permits because of its lowest BIC) and the lowest HQ information Criterion.

Table 1: Results of Unit root tests

Series		None	Intercept only	Intercept and Trend
ADF	Import permit	**-2.629 (.001)**	**-9.748 (.000)**	**-9.708 (.000)**
	D(Import permit)	**-10.014 (.000)**	**-9.971 (.000)**	**-9.929 (.000)**
PP	Import permit	**-3.760 (.000)**	**-9.797 (.000)**	**-9.759 (.000)**
	D(Import permit)	**-51.956 (.000)**	**-51.662 (.000)**	**-50.930 (.000)**

Note: *bolded figures indicate significance at 1% level; p-value in parenthesis*

Table 2: Determination of the optimal model for the Import permit series[a]

Model	LogL	AIC	BIC	HQ
(2, 2)(1, 0)	-389.760132	**6.248191**	6.404957	6.311883
(2, 2)(0, 1)	-390.123201	6.253909	6.410675	6.317601
(0, 0)(1, 0)	-394.265770	6.256154	**6.323339**	**6.283451**
(2, 2)(1, 1)	-389.413871	6.258486	6.437648	6.331277
(0, 0)(0, 1)	-394.542770	6.260516	6.327702	6.287813
(1, 0)(1,0)	-393.714749	6.263224	6.352805	6.299620
(0, 1)(1, 0)	-393.785988	6.264346	6.353927	6.300742
(5, 5)(1, 0)	-384.884335	6.265895	6.557032	6.384181
(1, 0)(0, 1)	-393.906828	6.266249	6.355830	6.302645
(2, 2)(0, 2)	-389.957035	6.267040	6.446201	6.339831
(0, 1)(0, 1)	-393.987828	6.267525	6.357106	6.303920
(3, 0)(1, 0)	-392.073088	6.268868	6.403239	6.323461
(0, 0)(1, 1)	-394.105705	6.269381	6.358962	6.305777
(0, 3)(1, 0)	-392.163138	6.270286	6.404657	6.324879
(0, 0)(2, 0)	-394.214197	6.271090	6.360670	6.307485

[a]AIC, Alkaike Information Criterion; BIC, Bayesian Information Criterion; HQ, Hannah Quinn
Bolded figures denote the best model in terms of the information criterion values

Table 3 and Table 4 contain the SARMA (2, 2) x (1, 0)$_{12}$ and SARMA (0, 0) x (1, 0)$_{12}$ model parameters and other measures, respectively.
The coefficients of the intercept term, autoregressive of orders 1 and 2, and moving average of orders 1 and 2, and the seasonal AR of order 1, as shown in Table 3**,** a were 9.156, 0.652, -0.974, -0.583, 1.000 respectively. The model, SARMA (2, 2) x (1, 0)$_{12}$, had a 12.7% goodness of fit.

Table 3: SARMA (2, 2) x (1, 0)$_{12}$coefficients of import permit series

Coefficients	Constant	??$_1$ AR(1)	??$_2$ AR(2)	??$_1$ SAR(12)	??$_1$ MA(1)	??$_2$ MA(2)
Estimate	9.156 (.000)	.652 (.000)	-.974 (.000)	.299 (.002)	-.583 (.991)	1.000 (.996)
Standard error	.798	.048	.064	.093	52.283	179.247
Loglik = -389.76; adjusted R² = .127; sigma² = 25.868; AIC = 6.248; BIC = 6.405; HQ = 6.311, Convergence rate = 101 iterations;						

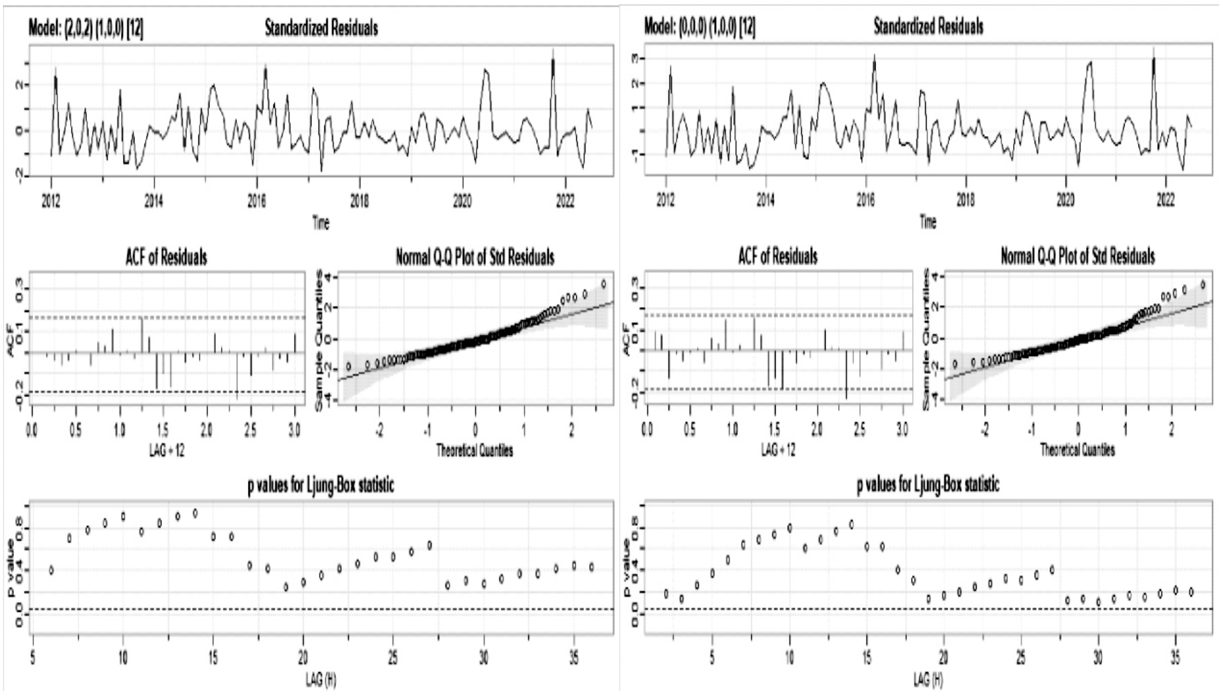
Table 4*:* SARMA (0, 0) x (1, 0)$_{12}$ coefficients of import permit series

Coefficients	Constant	??$_1$ SAR(12)
Estimate	9.131 (.000)	.273 (.001)
Standard error	.793	.083
Loglik = -394.266; adjusted R² = .056; sigma² = 28.896; AIC = 6.256; BIC = 6.323; HQ = 6.283, Convergence rate = 8 iterations;		

Note: p-value in parentheses.

The coefficients of the intercept term and seasonal autoregressive of order 1 are 9.131 and 0.273, respectively. The model, S*ARMA (0, 0) x (1, 0)$_{12,}$* has a 5.6% goodness of fit.

Figure 3 shows the normal Q-Q plot and the autocorrelation plot. For the SARMA (2, 2) x (1, 0)$_{12}$ and SARMA (0, 0) x (1, 0)$_{12}$ models, the autocorrelation plots show that only one of the residuals falls outside of the 95% confidence bound. The Q-Q plots show that the residuals from both models were approximately normally distributed. As observed in the plot, all the p-values for the model are not significant. No evidence of serial correlation was observed. The result of the Ljung–Box test for SARMA (2, 2) x $(1, 0)_{12}$ and SARMA (0, 0) x $(1, 0)_{12}$ in Table 5 showed that the Ljung-Box test for the model SARMA(2, 2) x $(1, 0)_{12}$is 0.8127 are not significant, hence, there was very little evidence for non-zero autocorrelations in the prediction errors at lags 1-24.



SARIMA(2, 2) x $(1, 0)_{12}$ SARMA(0, 0) x $(1, 0)_{12}$

Figure 3: *Residual's diagnostic of model* SARMA (2, 2) x $(1, 0)_{12}$ and SARMA (0, 0) x $(1, 0)_{12}$ *for Import permit Series*

Table 5: Result of Box-Ljung Test for Import Permit

Model	**X-squared**	**Df**	**p-value**
SARMA (2, 2) x $(1, 0)_{12}$	17.797	24	.813
SARMA (0, 0) x $(1, 0)_{12}$	25.357	24	.387

The results of the test to justify the precision of the selected model for the import permit and the forecast accuracy of these models presented in Table 6 showed that SARMA (0, 0) x $(1, 0)_{12}$ is the best model in terms of Root Mean Square error (RMSE), Mean Absolute Error (MAE), Symmetric Mean Absolute Percentage Error (SMAPE), variance proportion, bias proportion, Theil coefficient, BIC measures, and convergence rate, while SARMA (2, 2) x $(1, 0)_{12}$ appears as the best model in terms of adjusted R-squared and AIC measures.

Root Mean Square Error (RMSE):

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}$$

Mean Absolute Error (MAE)

$$MAE = \frac{1}{n}\sum_{i=1}^{n}|y_i - \hat{y}_i|$$

Symmetric Mean Absolute Percentage Error (SMAPE)

$$SMAPE = \frac{1}{n}\sum_{i=1}^{n}\frac{|y_i - \hat{y}_i|}{(|y_i| + |\hat{y}_i|)/2} \times 100\%$$

Where:

y_i represents the observed values.

$\hat{y}_i$ represents the predicted values.

n represents the number of data points.

Table 6: Accuracy measures from model residuals[a]

Models	RMSE	MAE	SMAPE	% Var	% Bias	Thiel coeff.	Adj. R^2	AIC	BIC	Conv. rate
SARMA(2,2)(1, 0)$_{12}$	5.54	4.14	47.09	.85	.00	.28	**.127**	**6.25**	6.41	101
SARMA(0,0)(1, 0)$_{12}$	**5.52**	**4.13**	**46.94**	**.81**	**.00**	**.28**	.056	6.26	**6.32**	**8**

[a]RMSE, Root Mean Square error; MAE, Mean Absolute Error; SMAPE, Symmetric Mean Absolute Percentage Error; Thiel, Adj. R^2, Adjusted R^2;Alkaike Information Criterion; BIC, Bayesian Information;Conv. rate, convergence rate.

Bolded figures denote the best values.

The SARMA (0, 0) x (1, 0)$_{12}$, which is equivalent to SAR(12),for modelling Import permit is given as:

$$IMT_t = 9.131 + 0.273B^{12}\, IMT_t$$

Where:

IMT_t represents the import permit data at time t

B^{12} represents lagging the variable by 12 time periods.

The import permit moves in a nonlinear fashion but yet exhibits a seasonal component. The highest value was recorded in March 2016. The number of import permits depicted a stationary series with no evidence of a trend component. Despite the evidence of the seasonality as displayed on the graph, as a condition for modelling time series dataset, the presence of unit root was tested using Augmented Dickey-Fuller and Phillip-Perron tests.

The future forecasted values of the import permit issuance are presented in Table 7. The number of import permit issuance was forecasted to be about 8, 7, 6, 6 and 5 by the end of September 2022, December 2022, 2023, 2024 and 2025 respectively. According to the forecasted values, the number of import permits will continue to fluctuate through next year, with the tendency to record the highest number of import permits in September 2022, if everything remains the same, May and September have the highest forecast number of import permits issuance in the coming year.

Table 7: Forecast values of import permits from August 2022 to December 2025

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2022	-	-	-	-	-	-	-	5	8	5	5	7
2023	3	6	6	4	8	5	6	4	7	5	6	6
2024	4	6	6	4	6	5	6	5	6	5	6	6
2025	6	5	6	4	5	6	6	6	5	6	6	5

Figure 4 presents the graph of the forecasted values of import permits using the selected model. As shown in the plot, the forecasted values maintain the same movement of the series thereby confirming the precision of the selected model. The selected model provided good predictions.

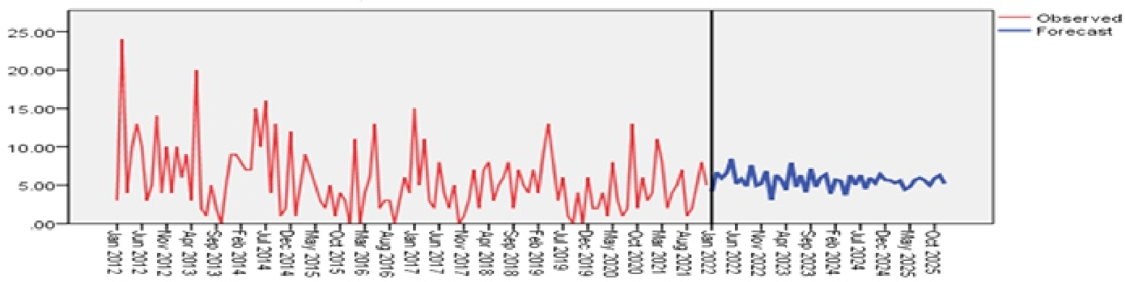


Figure 4: Forecast plot

DISCUSSION

The PEQSD, just like other units of the NAQS, has international and national mandates to prevent the introduction, establishment and spread of pests across national and international boundaries (Awosusi *et al*., 2011). The main strategy involved in quarantine activities is checking human activities that lead to the introduction, establishment and spread of pests across the globe through the movement of goods and articles including plants and plant products that can serve as pathways to dissemination, and where the environment is conducive to their establishment and spread (ISPM, 2012). One of the methods of PEQSD for preventing the introduction of pests into the country is by issuing import permits for plants parts used as planting materials (such as seeds, suckers and corms), biological agents used for biocontrol of crop pests (such as insects, parasitoids, and microbes) after inspection. (ISPM, 2004; 2010).

The frequency of issuance of import permit documents can be used to evaluate the effectiveness of quarantine activities in preventing the introduction of pests into the country through the importation of plant germplasm. Time Series Analysis (TSA) models have been largely adopted in several disciplines and have shown good performances in predictions (Guarnaccia et al., 2014). Analyses and examination of the statistical component of the monthly issuance of import permits for the period of January 2012 to July 2022 and forecasts for the period of August 2022 to December 2025 were investigated using a time series approach. We conducted a preliminary analysis to identify the time series components present in the dataset and observed a seasonal component with no evidence of a trend component. The analysis showed that there was fluctuation in the number of import permit issuance and this was higher in May and September, the coming year. This observation supported the seasonal variation reported by Eghwerido (2008) on import and export activities in the Lagos Port.

We modelled the series using the seasonal autoregressive moving average model and forecasted from August 2022 to December 2025. The goodness and appropriateness of a model is to make a precise/accurate forecast. Based on the forecast measures, SARMA (0, 0) x $(1, 0)_{12}$ was selected as the best model for forecasting the number of import permits evaluated in this study. The fluctuations observed in the series could be associated with the government policy, which usually encourages exportation rather than importation. It might also be due to the NAQS efforts aimed at discouraging the unnecessary importation of plants and plant materials and enhancing the importation of plants that cannot be sourced within the country. The agency has the mandate to prevent repeated importation of agricultural materials which might have already been introduced into the country and thus saves the nations a lot of foreign exchange (Ojuederie, 2004). This is part of its efforts to reduce to the barest minimum, the risk of introducing foreign pests into Nigeria (Awosusi *et al*., 2011). It is on this basis of preventing unnecessary plant importation that the country usually endeavours to maintain germplasm collections of exotic plants of desirable characteristics, such as high yielding, better quality, disease or pest resistance, ecological adaptability and so on and making them available as required for research and agricultural development.

However, beneficial importation of plant germplasm and other biological agents such as parasitoids, predators and other biocontrol agents especially for genetic improvement and other research activities is always encouraged. The observed low issuance of plant import permits in many of the months under study might also be due to illegal importation, perhaps with little awareness of the danger such an act can pose to the agricultural economy of the country. This has resulted in the confiscation of many imported plant materials by the authorized officers. The importers were to ensure obtaining import permits from the quarantine agency from exporting countries before plant materials are brought into the country. It is also suggested that all researchers engaged in germplasm exchange should ensure the involvement of NAQS and compliance with quarantine regulations in their exchange programs (Majebi *et al*., 2023). In addition, more awareness creation is important. NAQS should provide enough information about agricultural quarantine requirements to members of the public especially, international travelers, importers and exporters of plants and plant products. The agency needs to always keep up-to-date records of the import permit issuances since forecast efficiency depends very much on the reliability of data collected. This will provide information that will serve as the basis for improvement on services offered by NAQS if this is strictly adhered to. To enhance efficiency, the government needs to ensure that NAQS officers at various points of entry and exit in the country are given enough authority to carry out their service efficiently and should not be unduly subordinate to other security agencies.

CONCLUSION

In this study, the authors evaluated the statistical components of the issued import permits from NAQS Post-Entry Quarantine Station, Ibadan for the period January 2012 to July 2022 and forecasted the Import permit issuance for the period of August 2022 to December 2025 using a Time Series approach. The analysis showed a decrease and fluctuation in the number of import permits issued which was higher in May and September, the coming year. The observed decrease in the issuance of import permits may be attributed to the Government policy in trying to discourage the importation of goods from abroad, to save the nation by preventing repeated importation of plant materials. This is in consonance with the noble objective of NAQS to reduce to the barest minimum the risk of introducing foreign pests into the country. We recommend that importers ensure obtaining import permits from NAQS in exporting countries before bringing plant materials into the country. Finally, since it is an inescapable duty for NAQS to inform and educate the public on the danger of introducing alien pests into the country, the Nigerian government is advised to increase the budget allocated to NAQS to achieve and enhance the efficiency of services.

ACKNOWLEDGEMENTS

We thank the staff of the Import Section of Post-Entry Quarantine, Surveillance and Diagnostic Station of the NAQS Ibadan, for facilitating provision of import permits data. The statistical analyses were performed by Mr. Olayinka Ahmed Abiola of the Department of Statistics, University of Ibadan, Nigeria.

FUNDING

The authors did not receive support from any organization for this study

CONFLICT OF INTEREST

The authors declare no conflict of interest

AUTHORS' CONTRIBUTIONS

The study was conceived and designed by M.O.E. and O.K.E.; M.O.E., K.S.A. and O.A.O. coordinated the data collection; M.O.E. conducted part of the data analysis and prepared the first draft of the manuscript; O.K.E., K.S.A. and O.A.O. reviewed and edited the manuscript. All authors read and approved the final manuscript.

REFERENCES

Awe, O.O., Akinlana, D.M., Yaya, O.S., Aromolaran, O.2018. Time series analysis of the behaviour of import and export of agricultural and non-agricultural goods in West Africa: A case study of Nigeria. AGRIS on-line Papers in Economics and Informatics; *Research in Agricultural and Applied Economics,*10(2): 15-22. https://ageconsearch.umn.edu/record/276109

Awosusi, O.O., Kazeem, S.A., Ogunfunmilayo, A.O. and Ogunsola, K.E. 2011. Impact of Nigeria Agricultural Quarantine Service on eco-friendly plant protection strategies in Nigeria. *Nigerian Journal of Plant Protection*. 25:13-22.

Dickey, D.A. and Fuller, W.A. 1981. Likelihood ratio statistics for auto regressive time Series with aunitroot. *Econometrica,* 49:1057-1072.

Eghwerido, J.T. 2008. A comparative time series analysis of the total import and export at the Lagos Port complex (1996-2004). A dissertation submitted to the Department of Mathematics, Faculty of Science, Obafemi Awolowo University, Nigeria. 137pp.

Guarnaccia, C., Breton, J.G.C., Quartier, J., Teledyne, C. and Breton, R.M.C. 2014. An Application of time series analysis for forecasting and control of carbon monoxide concentrations. *International Journal of Mathematical Models and Methods in Applied Sciences*. 8:805-815.

ISPM (International Standard for Phytosanitary Measures). 2004. ISPM No.20: Guidelines for a phytosanitary import regulatory system. International Plant Protection Convention (IPPC), FAO, Rome.

ISPM (International Standard for Phytosanitary Measures). 2010. ISPM No. 34: Design and operation of a post entry quarantine station for plants. International Plant Protection Convention (IPPC), FAO, Rome.

ISPM (International Standard for Phytosanitary Measures). 2012. ISPM No. 5, Glossary of phytosanitary terms, International Plant Protection Convention (IPPC), FAO, Rome.

Majebi, O. E., Ogunsola, K. E., Kazeem, S. A., Ogunfunmilayo, A. O. and Ogunsola, J.F.2023. Time series analysis of monthly issuance of phytosanitary certificates for plants and plant materials in Post-Entry Quarantine, Surveillance and Diagnostic Station, in Nigeria. *Nigerian Agricultural Journal*. 54(2): 410-418. http://www.ajol.info/index.php/naj

Ogunsola, K.E., Ogunfunmilayo, A.O., Oluitan, J.A., Kazeem, S.A. Folorunso, D.O. and Ibrahim, S. 2016. Incidence and distribution of roselle (*Hibiscus sabdariffa* L.) diseases of quarantine importance in six northern states of Nigeria. *Nigerian Journal of Plant Protection*, 30: 46-59.

Ogunsola, K.E., Ogunfunmilayo, A.O., Solomon, S., Oluitan, J.A., Kazeem, S.A., Folorunso, D.O. and Ibrahim, S. 2018. Occurrence and population distribution of plant parasitic nematodes associated with roselle (*Hibiscussabdariffa* L.) in Northern Nigeria. *Agro-Science Journal of Tropical Agriculture, Food, Environment and Extension*, 19:18-26.

Ojuederie, B.M. 2004. Phytosanitary concept, principles and methods: Keys to protecting against destructive exotic pests. Spectrum books Ltd. Ibadan. 326pp.

Yaya, O.S., and Fashae, O.A. 2014. Seasonal fractional integrated time series models for rainfall data in Nigeria. *Journal of Theoretical and Applied Climatology*, 120:99-108.