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Time Series Analysis of Monthly Issuance of Phytosanitary Certificates for Plants and Plant Materials in Post-Entry Quarantine, Surveillance and Diagnostic Station, in Nigeria

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Abstract
Nigeria Agricultural Quarantine Service (NAQS) has the sole national mandate to carry out phytosanitary activities at various points of entry into Nigeria. It is the competent authority that issues Plant Health or Phytosanitary Certificates (PC) to prevent the introduction of foreign pests to other countries through the export of plant materials. However, there is limited information on the trend of issuance of PCs essential for informed decisions in planning for improving the efficiency of PCs in mitigating foreign pests across countries. This study examined the issuance of PCs at the Post-Entry Quarantine, Surveillance and Diagnostic Station (PEQSDS), NAQS Ibadan, using a Time Series method. The monthly PC issuance dataset spanning January 2012 to July 2022 was analysed, and the ARIMA model was fitted. Based on the results of the forecast measures of the study, ARMA (5, 8) was selected as the best model for forecasting the number of PCs. Monthly fluctuation of issued PCs was observed. The forecasted values indicate that the number of issued PCs will fluctuate throughout the subsequent years. Investigation into the causes of the erratic issuance of PCs is necessary. The study recommends among others, the need for NAQS to maintain constant surveillance, keep employees on high alert and consider the electronic phytosanitary certification process for more productive phytosanitary activities to reduce pest incursion and facilitate trade.
Keywords: Autoregressive Integrated Moving Average, plant export, issuance, plant quarantine, and quarantine regulations

Introduction

Nigeria Agricultural Quarantine Service (NAQS) is an internationally recognized body charged with the responsibility of preventing the introduction of foreign pests into the country as well as preventing the exportation of indigenous pests through agricultural materials. It is expected to promote international agricultural trade by permitting only entry of clean agricultural materials and export of certified ones thus enhancing the credibility of national agricultural products and ensuring that the country's agricultural interests are not jeopardized (Awosusi *et al*., 2011). The inherent ability of plants, especially seeds, to serve as carriers of pests and the risk of transboundary spread along with their movement present a high-risk factor for international germplasm distribution activities. NAQS is the National Plant Protection Organization (NPPO) of Nigeria responsible for the issuance of Phytosanitary Certificates (PC) for agricultural products meant for export (Ogunsola *et al*., 2016). The agency serves as the only competent authority in certifying that all agricultural products from the country are pest-free thus protecting the exporters from avoidable losses resulting from the rejection or confiscation of consignments.

The major export crops in Nigeria include cashew, cocoa, maize, leafy vegetables and cassava products, among others. An exporter of agricultural products of plant origin requires a PC for the commodity. The PC is required by the importing countries but issued by the exporting countries as stipulated by the International Plant Protection Convention (IPPC) (ISPM 12, 2017; FAO, 2022). The importing countries use the certificate as proof that export inspection and certification of the commodity have been duly conducted and the phytosanitary document indicates the type of examination and treatments carried out on the consignment (ISPM 7, 2016). The PC is a document stating that the commodity is free of a list of regulated pests stipulated by the importing countries.

To facilitate the export of plants and plant products across international borders, the establishment of a Pest-free area (PFA) for a particular cash crop is important. The PFA is an area in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained (Ogunsola *et al*., 2016; 2018; FAO, 2017). In a situation where PFA is not yet available, a smaller area referred to as a Pest-free place of production (PFPP) or Pest-free production site (PFPS) can be established. This PFPS is the portion of a place of production in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained for a defined period and is managed as a separate unit in the same way as a PFPP (FAO, 1999). Such establishment and use of a PFA or PFPS by an NPPO provides for the export of plants, plant products and other regulated articles from one country (exporting country) to another (importing country) without the need for application of additional phytosanitary measures when certain requirements are met. Thus, the pest-free status of an area may be used as the basis for the phytosanitary certification of plants and plant products for the stated pest(s) (Ogunsola *et al*., 2018; FAO, 2022). An example of introduced pests that caused epidemics and pandemics with disastrous consequences for food production, livelihoods, and environmental biodiversity is the Irish potato famine in the 1840s caused by *Phytophthora infestans*, which was introduced from Central America into Ireland (Klinkowski, 1970; Kumar *et al*., 2019). A more recent example is the fall armyworm (*Spodoptera frugiperda*) outbreak in Africa and Asia caused by the likely introduction of the insect pest from the Americas (Goergen *et al*., 2016) and which was first detected in Nigeria in 2016 (Kumar *et al*., 2021; Ogunfunmilayo *et al.*, 2021).

Some of the NAQS export inspection (inspection of exportable plants) procedures (Figure 1) include: 1) Sampling, 2) Field Inspection during active growth (Vegetative, flowering and fruiting stage), 3) Sourcing plant material from pest-free area or production site, 4) Warehouse inspection, 5) Laboratory diagnosis (seed health testing, etc.) 6) Growing-on test in screen houses 7) Point of exit inspection before export, 8) Treatment (fumigation, seed dressing, etc.) 9) packaging/transportation 10) issuance of PC (Awosusi *et al*., 2011; FAO, 2022). Since the importance of import and export to a nation's economic growth and development cannot be over-emphasized, such national services of NAQS require occasional strategic planning and evaluation to ensure higher efficiency of performance. This assessment of performance required an adequate record of activities as well as an analysis of the trend of issuance of the certificates. This might be a measure of compliance by the exporters and the rate of exportation of agricultural commodities. Such information will also serve as a means of monitoring the introduction and emergence of new pests among nations thus contributing to the protection of the agricultural economy at both national and global levels.

Time series methodologies have been used to analyze agricultural data in several studies Emokaro and Adetoyinbo, 2014; Ayinde *et al*. 2015). For instance, Syed *et al*. (2015) analyzed the impact of agricultural exports on the macroeconomic performance of Pakistan using secondary data for the period 1972-2008. Similarly, the relationship between exchange rate volatility and agricultural imports in Nigeria was analyzed using annual data covering the period from 1970 to 2015. Their co-integration and Granger Causality test revealed the presence of a long-run relationship between exchange rate volatility and agricultural imports and that exchange rate does not Granger-cause the movements in agricultural imports (Uduakobong and Williams, 2017). However, there is limited information in Nigeria on the trend of issuance of PCs essential for informed decisions in planning and evaluation to improve the efficiency of PCs in enhancing trade and mitigating foreign pests across countries. This study evaluated the issuance of PC at the Post-Entry Quarantine, Surveillance and Diagnostic Station (PEQDS) of NAQS Ibadan, using a Time Series method.

Materials and Methods

The records of issuance of monthly PCs at the Export Certification section of PEQSD, NAQS, Moore Plantation, Ibadan for the years between January 2012 and July 2022 were used in this study. Since the dataset is a time series, the statistical components were first examined. In this study, the time series analysis was carried out using a time plot, the unit root test, model identification using Autoregressive Integration Moving Average (ARIMA) models, model parameter estimation, Autocorrelation and Ljung – Box Test and forecast accuracy measure. A time plot was carried out to study the trend of issuance of phytosanitary certificates and to determine whether the series was stationary, a unit root test was performed. So, it is crucial to test for unit roots and determine the order of stationarity to prevent erroneous results. Although there are various ways to check for unit roots, the Augmented Dickey-Fuller (ADF) test is the most frequently employed. The ADF test corrects any potential serial correlation in the series. It is described as the regression of the time series' initial difference versus a series that has lagged by a fixed amount of time. The autocorrelation and partial autocorrelation plots were used to determine which ARIMA model should be utilized.

Dickey-Fuller Test

Given the mode $y_t = \theta y_{t-1} + \varepsilon_t$ .....(1)

Where is a constant and is a white noise process. By subtracting y_{t-1} from both sides we have:

$$y_t - y_{t-1} = \theta y_{t-1} - y_{t-1} + \varepsilon_t$$

$$\Rightarrow \Delta y_t = (\theta - 1) y_{t-1} + \varepsilon_t$$

$$\Delta y_t = \delta y_{t-1} + \varepsilon_t \text{ ..... (2)}$$

Testing for $\theta = 1$ is equal to testing for $\delta = 0$

Dickey and Fuller (1979) consider the regression equation1

$\Delta y_t = \delta y_{t-1} + \varepsilon_t$ ...... (i)

$\Delta y_t = \alpha + \delta y_{t-1} + \varepsilon_t$ ...... (ii)

$\Delta y_t = \alpha + \delta y_{t-1} + \alpha_2 t + \varepsilon_t$ ...... (iii)

Equation (i) contains a pure random walk model, equation (ii) contains an intercept or drift term and equation (iii) contains both the drift and linear time trend.

ARIMA

Autoregressive Integrated Moving Average (ARIMA) model is a combination of the differenced autoregressive model with the moving average model. It is

$y^1{}_t = I + \alpha_1 y^1{}_{t-1-} + \alpha_2 t^1_t{}_2 + ... + \alpha_p y^1_p + e_t + \theta_1 e_{t-1} + \theta_2 e_{t-2}\ \varepsilon_t$ 3

Where α and θ are autoregressive and moving average parameters, and the part of ARIMA shows that the data values have been replaced with differenced values of d-order to obtain stationary data. Furthermore, Eviews 10's automatic ARIMA forecasting feature was utilized to estimate 81 ARIMA models to find the best model for modelling the phytosanitary certification frequency. The best model was chosen using the Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and Hannah Quinn information criteria (HQ). 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, ARMA (5, 8) for the number of PCs, was used to forecast the monthly certificates between August 2022 and December 2023.

Results and Discussion

A varying movement was observed in the years under consideration as presented in Figure 2. The phytosanitary certificates developed nonlinearity but still have a seasonal element. The most significant figure was noted in January 2013. A stable series without any indication of a trend component might be seen in the number of phytosanitary certificates. The graph of the original series of the PC shows that there is a fluctuating movement over the years considered. The number of certificates issued moves in a nonlinear fashion. Between the periods of January 2012 and around December 2013, the PC number moved in an upward and downward manner, with the highest values recorded within those periods. The number of these certificates depicts a downward trend from May 2016 until July 2022. It is evident that the number of plant health certificates changes over time. The plot of the original series as well as the different series show evidence of stationarity.

The ADF and the Phillip-Perron (PP) test results on the original Phytosanitary series and the associated first differenced series were presented in Table 1. Three regression equations were considered: no constant and trend, with constant, and with constant and trend. Each test's statistic and p-value (in parenthesis) are listed in Table 1. The results demonstrate that the Phytosanitary series is stationary for the three regression equations and the differenced series is also stationary at all significant levels. Because the series' stationarity was established to be stationary at order 1(original series), the original series was used for further analysis.

Table 2 shows the top 15 ARIMA among the 81 models examined. ARMA (5, 8) appears to be the best model for modelling the number of certificates, as it has the lowest Alkaike Information Criterion (AIC) value, while ARMA (3, 3) appears the best model for modelling the number of these certificates issued because of its lowest Bayesian Information Criterion (BIC) and the lowest Hannah Quinn (HQ) Information Criterion. Both ARMA (5, 8) and ARMA (3, 3) were considered for modelling the number of PCs and examined to determine the best model between the two. Forecast accuracy, convergence rate, and other model diagnostic criteria were used to diagnose the selected models.

The coefficients of the intercept term, autoregressive of order 1 to 5, and moving average of order 1 to 8, as shown in Table 3, are 44.806, 0.619, 0.066, 0.654, -0.754, 0.296, -0.587, 0.300, -0.738, 1.117, -1.019, 0.245, -0.372, and 0.665, respectively. The AR (1), AR (3), and AR (4) coefficients were significant, while the other coefficients were not. The model has a 43.3% goodness of fit. The ARIMA model for modelling Phytosanitary is given as:

$$
\begin{aligned}
Phy_t = 44.806 &+ 0.619Phy_{t-1} + 0.066Phy_{t-2} + 0.654Phy_{t-3} - 0.754Phy_{t-4} + 0.296Phy_{t-5} \\
&- 0.587e_{t-1} + 0.300e_{t-2} - 0.738e_{t-3} + 1.116e_{t-4} - 1.019e_{t-5} + 0.245e_{t-6} \\
&- 0.372e_{t-7} + 0.665e_{t-8}
\end{aligned}
$$

The coefficients of the intercept term, autoregressive of order 1 to 3, and moving average of order 1 to 3, as shown in Table 4, are 46.426, 0.156, 0.579, -0.340, -0.045, -0.284, and 0.762, respectively. The AR (2), and AR (3) coefficients were significant, while other coefficients were not significant. The model has a 30.4% goodness of fit. The ARIMA model for modelling PC is given as:

$$
\begin{aligned}
Phy_t = 46.426 &+ 0.156Phy_{t-1} + 0.579Phy_{t-2} - 0.340Phy_{t-3} - 0.045e_{t-1} + 0.284e_{t-2} \\
&+ 0.762e_{t-3}
\end{aligned}
$$

For the PC series, the correlogram and Ljung-Box test of ARMA (5, 8) and ARMA (3, 3) models' residuals were presented in Figure 2. For ARMA (5, 8), only one of the residuals falls out of the 95% confidence bound. However, for ARMA (3, 3), two of the residuals fall out of the 95% confidence bound. As observed in the plot, all the p-values for the model were not significant. No evidence of serial correlation was observed.

Since the correlogram shows that only one of the sample autocorrelations for lags 1-24 surpasses the significance bounds, and the p-value for the Ljung-Box test for the models ARMA (5, 8) is 0.716 (Table 5). This implies that there is very little evidence for non-zero autocorrelations in the prediction errors at lags 1-24. In addition, the correlogram showed that two of the sample autocorrelations for lags 1-24 surpass the significance bounds, and the p-value for the Ljung-Box test for the models ARMA (3, 3) is 0.298 as shown in Table 5. This is an indication that there is very little evidence for non-zero autocorrelations in the prediction errors at lags 1-24.

Table 6 shows the measures of accuracy from residuals generated from the selected models. Based on the results in the table, comparing the values between the two models, ARMA (5, 8) appears as the best model in terms of Root Mean Square error (RMSE), Mean Absolute Error (MAE), Symmetric Mean Absolute Percentage Error (SMAPE), Theil U, Theil coefficient, adjusted R-squared, and AIC measures, while ARMA (3, 3) appears as the best model in terms of BIC measures, Bias proportion, and convergence rate. The goodness and appropriateness of a model is to make a precise or accurate forecast. Based on the forecast measures presented in Table 6, ARMA (5, 8) was selected as the best model for forecasting the number of certificates.

The number of the PC was forecasted to be about 36, 12 and 37 by August 2022, December 2022, and December 2023, respectively, according to the projected values in Table 7. According to the forecasted values, the number of these certificates will continue to fluctuate through next year, if everything remains the same. The result is similar to that of export values of red chilli in India over a period from 1980-1981 to 2016-2017 which faced some instability, initially showing an increase but which later decreased (Muthupandi *et al*., 2018). The projected fluctuation in the trend of the number of certificates issued, rather than an increasing trend, signifies a lack of improvement in the future issuance of the certificates, which implies low export of agricultural commodities for trade. This has great adverse effects on the nation's economic development through foreign exchange earnings. Agricultural trade in Nigeria, just like non-agricultural trade, also influenced the Nigerian exchange rates movement (Awe *et al*., 2018). The agricultural sector has been considered the second largest export earner after crude oil and the largest employer of rural labour in Nigeria hence, it is ranked a key contributor to wealth creation, poverty reduction and food security in the country (Awe *et al*., 2018).

This study also indicated records of monthly issuance of PCs by the PEQDS of NAQS. This might have resulted from the decentralization of NAQS phytosanitary certification with the presence of some other NAQS stations in different regions of the country where the certificates can also be obtained by the exporters. However, it might also be due to the low export of agricultural commodities by the country. Although Nigeria has been regarded globally as the highest producer of several food crops such as cassava, cowpea, melon seeds, etc., it is also the greatest consumer of most of the crops due to the teeming population (FAO, 2020; Ogunsola *et al*., 2022; Ogunsola and Ogunsola, 2022). Thus, high imports with low exports of commodities will impair the nation's balance of trade with negative consequences on economic growth.

Poor compliance with the phytosanitary measures may also be responsible for the low trend of the number of PCs issued in Nigeria. On the part of the public, there is the need for the exporters to ensure that plant products are certified pest-free and PCs are issued for any of such commodities leaving the borders of Nigeria (Awosusi *et al*., 2011). The importers of such commodities should also ensure that the PC of the exporting country is duly collected together with the import permit documents from Nigeria to ensure that all movement of plant germplasm is certified to be of good phytosanitary status. Compliance with these is important for any nation to fully achieve the desired purpose of phytosanitary certification for improved global trade for national growth and development. The phytosanitary measures of most countries are not always stringent however, many exporters, especially in the developing nations, refuse to show compliance. A study has revealed that cocoa export in Cameroon between 2001 and 2017 was not influenced by the sanitary and phytosanitary measures in major importing countries (Assoua *et al*., 2022). Most of these measures are not hindrances to trade yet there is poor compliance. Electronic Phytosanitary Certification (ISPM 7, 2017) will assist in improving the compliance level through ease of the application and certification process, prevent forgery and enhance record keeping.

Given the crucial role played by NAQS in the agricultural economy and food security, a deliberate and concerted effort must be made to improve public perception of the agency. For the nation to benefit maximally from the activities of the services, NAQS officers need to contribute positively to the upliftment of the service by discharging their duty humanly and selflessly. If the present generation leaves a more secure food situation, the generations to come will inherit invariably a more prosperous nation where people will desire to emigrate as opposed to the practice today where many citizens want to leave the shores of the nation. Officers of NAQS at the entry/exit points do interact with people of different cultures, nationalities, trades and professions, especially with importers and exporters of agricultural commodities as well as researchers and policymakers. The agency, therefore needs to secure cooperation and voluntary compliance from these stakeholders. Also, there is a need for adequate staff capacity building and the use of modern facilities to improve phytosanitary certification. This is important because the effectiveness of phytosanitary procedures depends on the knowledge of pest distribution, availability of diagnostic tools for seed health testing, qualified operators and procedures for inspection (Kumar *et al*., 2021).

Conclusion

In conclusion, NAQS is advised to ensure adequate documentation of PC issuances since forecast efficiency depends very much on the reliability of the data collected. If this is adhered to, it will serve as a basis for an improvement in the efficiency of Services. Similarly, bearing in mind the crucial roles of Nigeria Agricultural Quarantine Service in protecting the nation's agricultural products from ravaging by foreign pests coupled with its mandate to facilitate trade and certify its nation's agricultural exports pest-free, the following are thereby recommended:

(1) All importers should ensure that import permits from NAQS and phytosanitary certificates from exporting countries are obtained before plant materials are brought into the country.

(2) NAQS should, as a matter of facilitating ease of doing business in Nigeria, key into the IPPC's e-phyto Hub for electronic phytosanitary certification processes.

(3) All research scientists engaged in germplasm exchange should ensure that phytosanitary activities are duly carried out in their exchange program.

(4) All other government and private agencies at various entry points should ensure that Quarantine officers are invited when inspecting any consignments that fall within NAQS's jurisdictions.

(5) NAQS publicity and machinery should provide enough information about plant quarantine requirements to members of the public especially international travellers, importers and exporters of plants and plant products.

(6) NAQS staff must be properly and regularly trained, equipped with modern facilities and fitted to operate as a disciplined and efficient outfit.

(7) 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 government is therefore advised to increase the budget allocated to NAQS to enhance the efficiency of the services.

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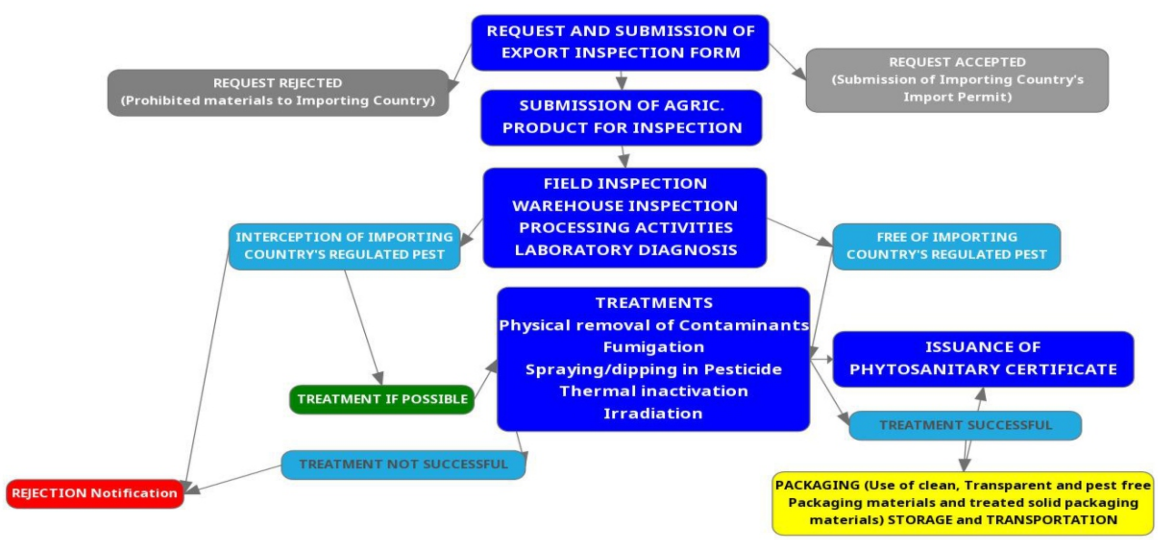

Figure 1: Export inspection procedure

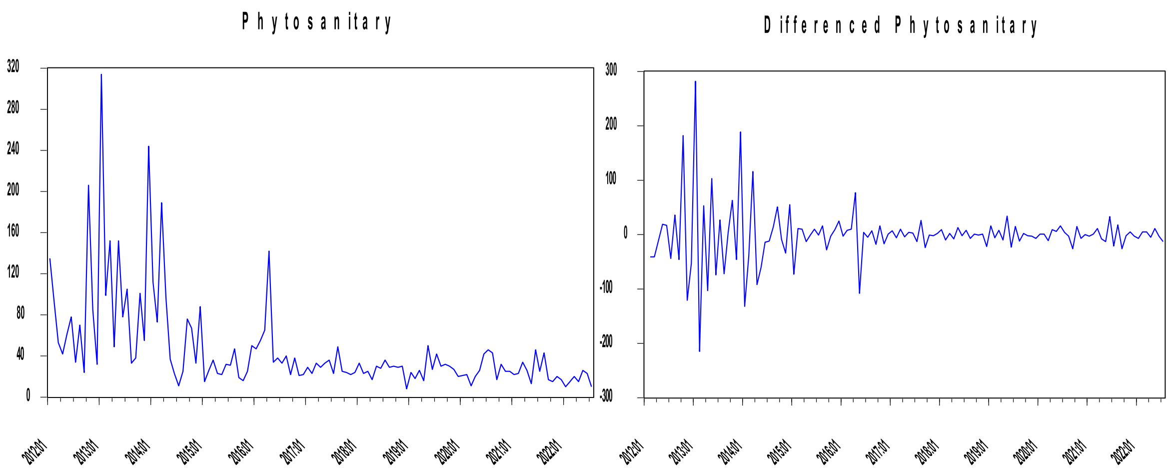

Figure 2: Time Plots of original and first difference series of phytosanitary certificates (Jan 2012 to July 2022)

Table 1: Results of ADF Unit root test

Series		**None**	**Intercept only**	**Intercept and Trend**
	Phytosanitary	-3.000 (.003)	-4.544 (.000)	-5.906 (.000)
ADF	D(Phytosanitary)	-5.792 (.000)	-6.090 (.000)	-6.210 (.000)
	Phytosanitary	-5.668 (.000)	-9.115 (.000)	-10.589 (.000)
PP	D(Phytosanitary)	-36.696 (.000)	-36.758 (.000)	-36.543 (.000)

Source: Extracted from EViews result output; bolded figures indicate significance at 5%

Table 2: Determination of the optimal model for Phytosanitary series

Model	LogL	AIC*	BIC	HQ
(5,8)	-88.379797	**1.628028**	1.963956	1.764512
(5,5)	-91.972328	1.637359	1.906102	1.746546
(7,7)	-88.125790	1.639776	1.998099	1.785358
(3,3)	-96.230442	1.641424	**1.820586**	**1.714215**
(6,8)	-88.282669	1.642247	2.000570	1.787829
(5,7)	-90.645044	1.647953	1.961486	1.775338
(7,8)	-87.777953	1.650047	2.030764	1.804728
(6,7)	-90.204215	1.656759	1.992687	1.793243
(6,4)	-93.303418	1.658322	1.927064	1.767508
(7,4)	-92.416763	1.660106	1.951244	1.778392
(6,5)	-92.915576	1.667962	1.959099	1.786247
(5,6)	-92.948772	1.668485	1.959622	1.786770
(7,5)	-92.037903	1.669888	1.983421	1.797273
(5,2)	-97.058860	1.670218	1.871775	1.752108
(8,5)	-91.361368	1.674982	2.010910	1.811466

Source: Extracted from EViews result output

Table 3: ARMA (5, 8) coefficients of phytosanitary certificate series

Convergence achieved after 579 iterations				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	44.80587	19.49898	2.297858	0.0234
AR(1)	0.618899	0.144694	4.277296	0.0000
AR(2)	0.065722	0.160714	0.408941	0.6834
AR(3)	0.653946	0.093815	6.970563	0.0000
AR(4)	-0.753993	0.143060	-5.270456	0.0000
AR(5)	0.296412	0.178582	1.659807	0.0998
MA(1)	-0.586730	31.48183	-0.018637	0.9852
MA(2)	0.299713	23.17362	0.012933	0.9897
MA(3)	-0.737566	60.74843	-0.012141	0.9903
MA(4)	1.116521	65.91365	0.016939	0.9865
MA(5)	-1.018813	64.38018	-0.015825	0.9874
MA(6)	0.245183	30.29480	0.008093	0.9936
MA(7)	-0.372362	35.71478	-0.010426	0.9917
MA(8)	0.664681	91.55867	0.007260	0.9942
SIGMASQ	1059.131	78111.12	0.013559	0.9892
R-squared	0.496089	Mean dependent var		45.85827
Adjusted R-squared	0.433100	S.D. dependent var		46.02720
S.E. of regression	34.65514	Akaike info criterion		10.15534
Sum squared residual	134509.6	Schwarz criterion		10.49127
Log-likelihood	-629.8643	Hannan-Quinn criterion		10.29183
F-statistic	7.875829	Durbin-Watson stat		1.899553
Prob(F-statistic)	0.000000			
Inverted AR Roots	.91	.46-.36i	.46+.36i	-.60+.77i
	-.60-.77i			
Inverted MA Roots	.90-.25i	.90+.25i	.51-.86i	.51+.86i
	-.42-.76i	-.42+.76i	-.70-.71i	-.70+.71i

Source: Extracted from EViews result output

Table 4: ARMA (3, 3) coefficients of phytosanitary certificate series

Convergence achieved after 140 iterations				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	46.42626	13.12500	3.537238	0.0006
AR(1)	0.156377	0.158282	0.987961	0.3252
AR(2)	0.579135	0.111425	5.197550	0.0000
AR(3)	-0.340189	0.133203	-2.553906	0.0119
MA(1)	-0.045246	50.99320	-0.000887	0.9993
MA(2)	-0.283586	39.03177	-0.007266	0.9942
MA(3)	0.761647	309.6953	0.002459	0.9980
SIGMASQ	1381.182	60990.01	0.022646	0.9820
R-squared	0.342865	Mean dependent var		45.85827
Adjusted R-squared	0.304209	S.D. dependent var		46.02720
S.E. of regression	38.39316	Akaike info criterion		10.22016
Sum squared resid	175410.1	Schwarz criterion		10.39932
Log-likelihood	-640.9803	Hannan-Quinn critter		10.29295
F-statistic	8.869855	Durbin-Watson stat		1.927512
Prob(F-statistic)	0.000000			
Inverted AR Roots	.53+.31i	.53-.31i	-.90	
Inverted MA Roots	.52-.70i	.52+.70i	-1.00	

Source: Extracted from EViews result output

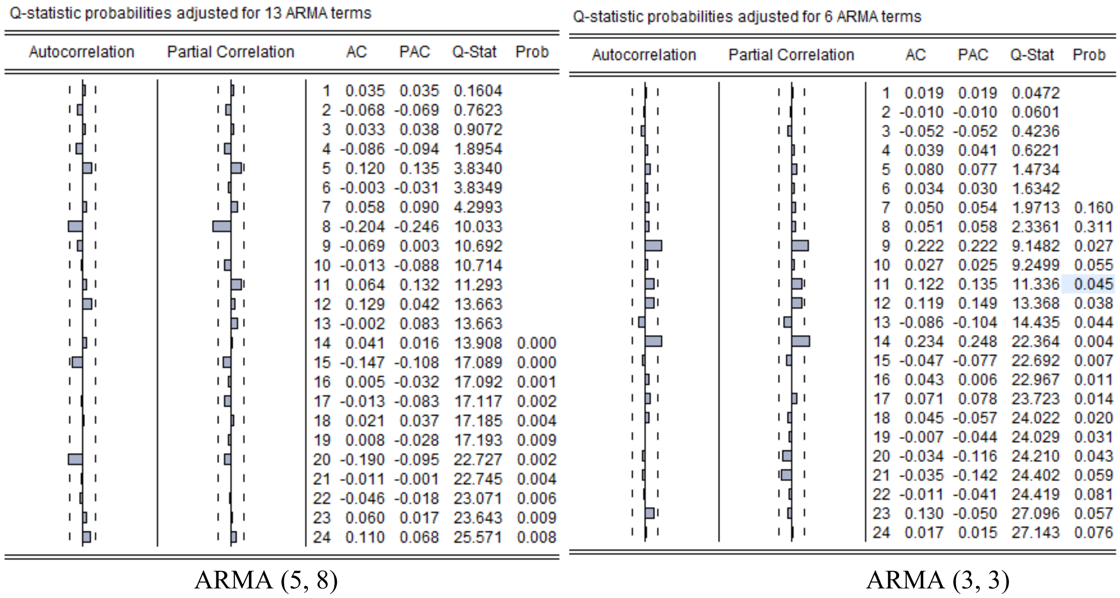

Figure 3: Correlogram of Residuals of model ARMA (5, 8) and ARMA (3, 3) for Phytosanitary Series#

Table 5: Result of Box-Ljung Test for Phytosanitary Certificates

Model	X-squared	Df	p-value
ARMA (5, 8)	19.659	24	0.716
ARMA (3, 3)	27.144	24	0.298

Source: researcher's estimation

Table 6: Accuracy measures from model residuals

Models	RMSE	MAE	SMAPE	Theil U	% Bias	Thiel coeff.	Adj. R^2	AIC	BIC	Conv. Rate
ARIMA (5, 8)	**42.91**	**27.58**	**56.95**	**1.01**	0.3	**0.39**	**0.43**	**10.16**	10.49	579
ARIMA (3, 3)	45.68	28.72	58.47	1.10	**0.2**	0.41	0.30	10.22	**10.40**	**140**

Source: Extracted from EViews result output; bolded figures denote the best values

Table 7: Forecast values of the phytosanitary certificate from August 2022 to December 2023

	2022	2023
Jan	-	24
Feb	-	28
Mar	-	18
Apr	-	37
May	-	33
Jun	-	26
Jul	-	42
Aug	36	32
Sep	23	31
Oct	32	44
Nov	38	32
Dec	12	37

Source: Extracted from Eviews result output