NOVATEUR PUBLICATIONS
JournalNX- A Multidisciplinary Peer Reviewed Journal
ISSN No: 2581 - 4230
VOLUME 6, ISSUE 5, May -2020

OPEN DEFECATION IN TOGO: A BOX-JENKINS ARIMA APPROACH

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ABSTRACT:

Based on annual time series data on the number of open defecators in Togo from 2000 – 2017, the study predicts the annual number of people who will still be practicing open defecation over the period 2018 – 2022. The study uses the Box-Jenkins ARIMA approach. The diagnostic ADF tests show that the ODT series under consideration is an I (1) variable. Based on the AIC, the study presents the ARIMA (2, 1, 0) model as the parsimonious model. The diagnostic tests further uncover that the presented model is stable and its residuals are stationary in levels. The results of the study indicate that the number of open defecators in Togo is likely to decline over the period 2018 – 2022, from 47% to 43.32% of the total population. This implies that, open defecation will remain a public health issue in Togo, even after 2022. However, it is possible to end open defecation in Togo, especially if the government is committed to do so. The study suggested a basic two-fold policy recommendation to be put into consideration.

INTRODUCTION:

Open defecation is the disposal of human feces in open areas, such as fields, forests, road side, beaches, and open bodies of water (UN, 2019). Open defecation is widespread in Togo, especially in rural areas. The practice of open defecation is associated with a variety of negative health outcomes such as diarrheal diseases, trachoma, schistosomiasis, child stunting, as well as malnutrition. Given that open defecation directly results in loss of dignity, it is also closely related to psychosocial stress. Therefore, it is important for public health researchers in Togo to model and project the number of people practicing open defecation in order to come up with effective policies to end open defecation. The main goal of this study is to project the number of people practicing open defecation in Togo over the period 2018 – 2022. This study will go a long way in determining if is possible to end open defecation in Togo in the near future.

OBJECTIVES OF THE STUDY:

i. To assess the time series trend of the variable under consideration.
ii. To forecast the number of people practicing open defecation in Togo for the period 2018 – 2022.
iii. To examine the trend of open defecation for the period 2018 – 2022.

LITERATURE REVIEW:

In an African study, Ashenafi et al. (2018) examined the latrine utilization coverage of the kebeles who have already declared open defecation free in Ethiopia. Community-based cross-sectional study design with multistage sampling technique was used. Bivariate and multivariate logistic regression models were applied to identify factors associated with latrine utilization. Their results show that the extent of latrine utilization was high in the community. In an Asian study, Bhatt et al. (2019) explored various motivations of people who practice open defecation in Hattimudha village in Nepal. The maximum variation sampling method was employed to recruit participants for 20 in-depth interviews and 2 focus group discussions. A content analysis approach was applied to analyze data. The study found out that open defecation is either a voluntary choice or a compulsion and that this choice is closely linked with personal preferences, cultural and traditional norms with special concerns for privacy for women and girls in different communities. In another African study, Nyoni & Mutongi (2019) forecasted total population in Togo using the Box-Jenkins ARIMA technique based on annual time series data on total population in Togo from 1960 to 2017. The study presented the ARIMA (3, 2, 0) model and concluded that total population in Togo will continue to rise in the next three decades, thereby posing a threat to both natural and non-renewable resources in the country. This will be a worse threat if the open defecation problem is not addressed given the fact that as total population increases; the number of open defecators is also increasing. In another Asian study, Adhikari & Ghimire (2020) investigated various determinants of open defecation in Nepal. Bivariate analysis was applied to examine the association between dependent variables (toilet status – having and not having toilets in the household) and independent variables (demographic, socio-economic and geographical characteristics) using the Chi-square test. The multivariate logistic regression model was applied to determine significant predictors for a household not having a toilet after controlling other variables. The results of the study indicate that Nepal still has a large number of residences without a toilet. No study has been done so far, in Togo, to model and forecast the number of people practicing open defecation. This study is the first of its kind in the case of Togo, and is expected to significantly reinforce existing policy frameworks in the fight against open defecation in the country.

METHODODOLOGY:

3.1 The Box – Jenkins (1970) Methodology:

The first step towards model selection is to difference the series in order to achieve stationarity. Once this process is over, the researcher will then examine the correlogram in order to decide on the appropriate orders of the AR and MA components. It is important to highlight the fact that this procedure (of choosing the AR and MA components) is biased towards the use of personal judgement because there are no clear – cut rules on how to decide on the appropriate AR and MA components. Therefore, experience plays a pivotal role in this regard. The next step is the estimation of the tentative model, after which diagnostic testing shall follow. Diagnostic checking is usually done by generating the set of residuals and testing whether they satisfy the characteristics of a white noise process. If not, there would be need for model re – specification and repetition of the same process; this time from the second stage. The process may go on and on until an appropriate model is identified (Nyoni, 2018c). This technique will be used to analyze the ODT series under consideration.

3.2 The Moving Average (MA) model:

Given:

$$ODT_t = \sum_{i=1}^{q} \alpha_i L^i \mu_t + \mu_t \ldots\ldots\ldots\ldots [1]$$

where L is the lag operator.

or as:

$$ODT_t = \alpha(L)\mu_t \ldots\ldots\ldots\ldots [2]$$

where:

$$\alpha(L)=\theta(L) \ldots\ldots\ldots\ldots [3]$$

where μ_t is a purely random process with mean zero and varience σ^2. Equation [1] is reffered to as a Moving Average (MA) process of order q, usually denoted as MA (q). ODT is the annual number of people (as a percentage of the total population) who practice open defecation in Togo at time t, α_0 … α_q are estimation parameters, μ_t is the current error term while μ_{t-1} … μ_{t-q} are previous error terms.

3.3 The Autoregressive (AR) model:

Given:

$$ODT_t = \sum_{i=1}^{p} \beta_i L^i ODT_t + \mu_t \ldots\ldots [4]$$

Or that:

$$\beta(L)ODT_t = \mu_t \ldots\ldots [5]$$

where:

$$\beta(L)=\phi(L) \ldots\ldots [6]$$

or that :

$$ODT_t = (\beta_1 L + \cdots + \beta_p L^p)ODT_t + \mu_t \ldots\ldots [7]$$

Where β_1 … β_p are estimation parameters, ODT_{t-1} … ODT_{t-p} are previous period values of the ODT series and μ_t is as previously defined. Equation [4] is an Autoregressive (AR) process of order p, and is usually denoted as AR (p).

3.4 The Autoregressive Moving Average (ARMA) model:

An ARMA (p, q) process is merely a combination of AR (p) and MA (q) processes. Thus, by combining equations [1] and [4]; an ARMA (p, q) process may be specified as shown below:

$$\phi(L)ODT_t = \theta(L)\mu_t \ldots\ldots [8]$$

where $\phi(L)$ and $\theta(L)$ are polynomials of orders p and q respectively, algebraically defined as:

$$\phi(L) = 1 - \beta_1 L \ldots \beta_p L^p \ldots\ldots [9]$$

$$\theta(L) = 1 + \alpha_1 L + \cdots + \alpha_q L^q \ldots\ldots [10]$$

It is quite essential to remember that the ARMA (p, q) model, just like the AR (p) and the MA (q) models; can only be applied for I (0) variables and yet in real life, many time series are not I (0). In fact, in this study, the ODT series has been found to be an I (1) variables (that is, it only became stationary after first differencing). Due to that, ARMA models are not suitable for modeling and forecasting non – stationary time series data. In such instances, the model described below is the one that should ideally be used.

3.5 The Autoregressive Integrated Moving Average (ARIMA) model:

A stochastic process ODT_t is referred to as an Autoregressive Integrated Moving Average (ARIMA) [p, d, q] process if it is integrated of order "d" [I (d)] and the "d" times differenced process has an ARMA (p, q) representation. If the sequence $\Delta^d ODT_t$ satisfies an ARMA (p, q) process; then the sequence of ODT_t also satisfies the ARIMA (p, d, q) process such that:

$$\Delta^d ODT_t = \sum_{i=1}^{p} \beta_i \Delta^d L^i ODT_t + \sum_{i=1}^{q} \alpha_i L^i \mu_t + \mu_t \ldots\ldots [11]$$

where Δ is the difference operator, vector $\beta \in \mathbb{R}^p$ and $\alpha \in \mathbb{R}^q$.

3.6 Data Collection:

This study is based on annual observations (that is, from 2000 – 2017) on the number of people practicing Open Defecation in Togo (ODT), as a percentage of total population. Out-of-sample forecasts will cover the period 2018 – 2022. All the data was gathered from the World Bank online database.

3.7 Diagnostic Tests & Model Evaluation:

3.7.1 Stationarity Tests: Graphical Analysis:

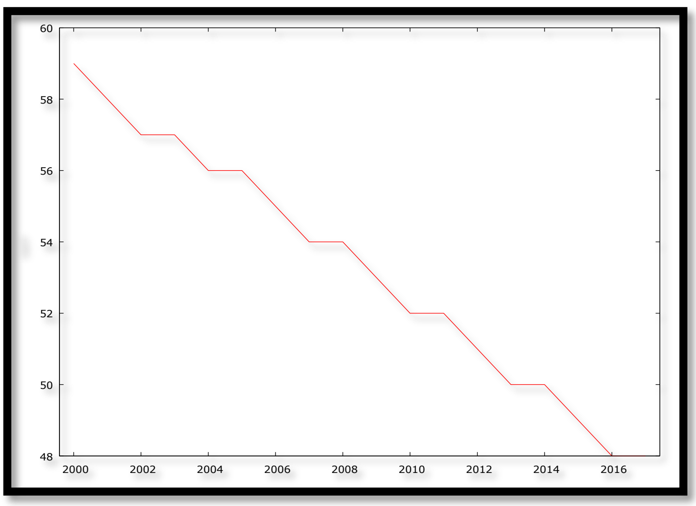

Figure 1

3.7.2 The Correlogram in Levels:

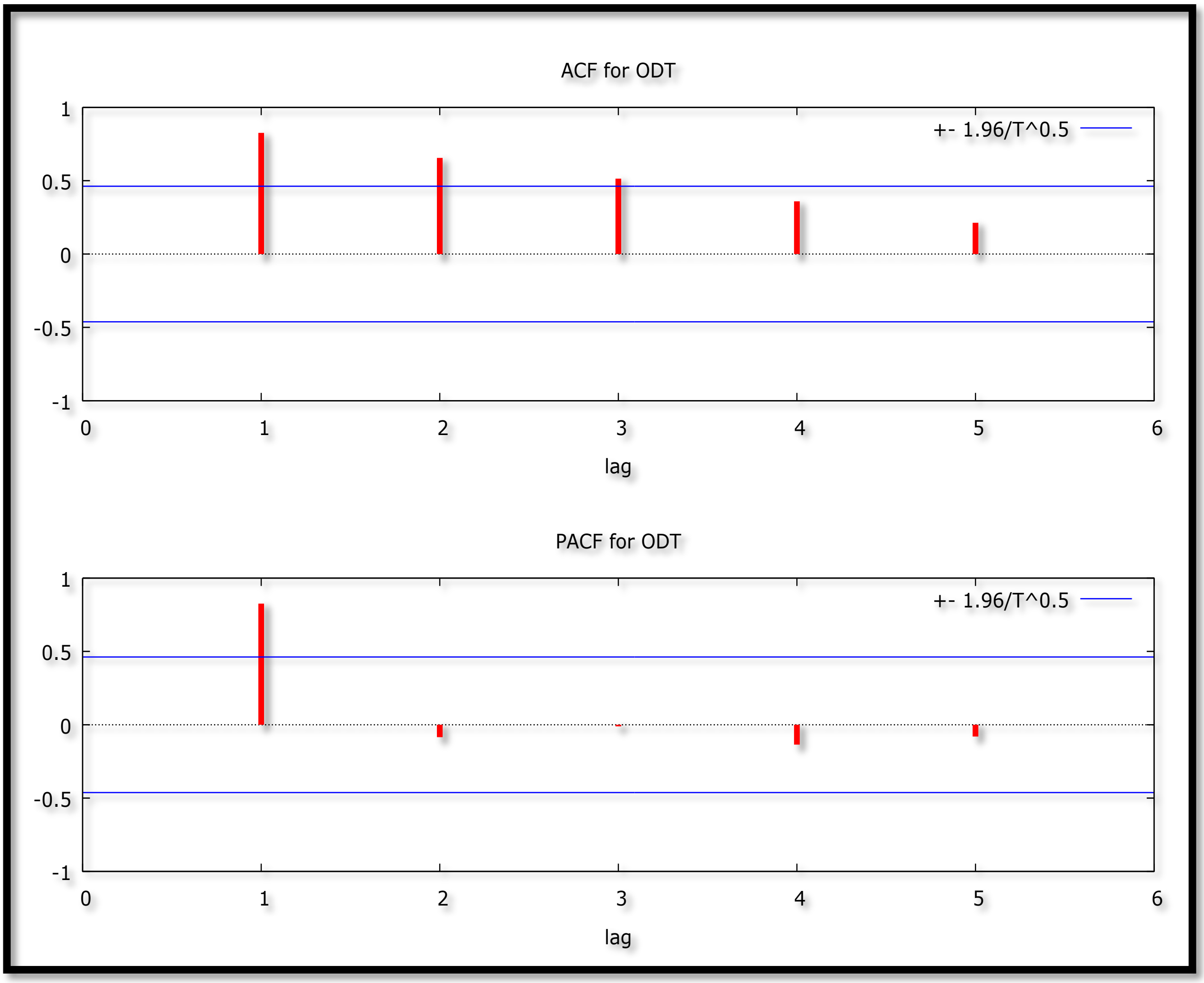

Figure 2: Correlogram in Levels

Figure 1 and 2 show that the ODT series not stationary in levels.

3.7.3 The Augmented-Dickey-Fuller (ADF) Test in Levels:

Table 1: with intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
ODT	1.177211	0.9960	-3.959148	@1%	Non-stationary
			-3.081002	@5%	Non-stationary
			-2.681330	@10%	Non-stationary

Table 2: with intercept and trend & intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
ODT	-1.808015	0.6498	-4.728363	@1%	Non-stationary
			-3.759743	@5%	Non-stationary
			-3.324976	@10%	Non-stationary

Tables 1 and 2 show that OD is not stationary in levels as already suggested by figures 1 and 2.

3.7.4 The Correlogram (at First Differences):

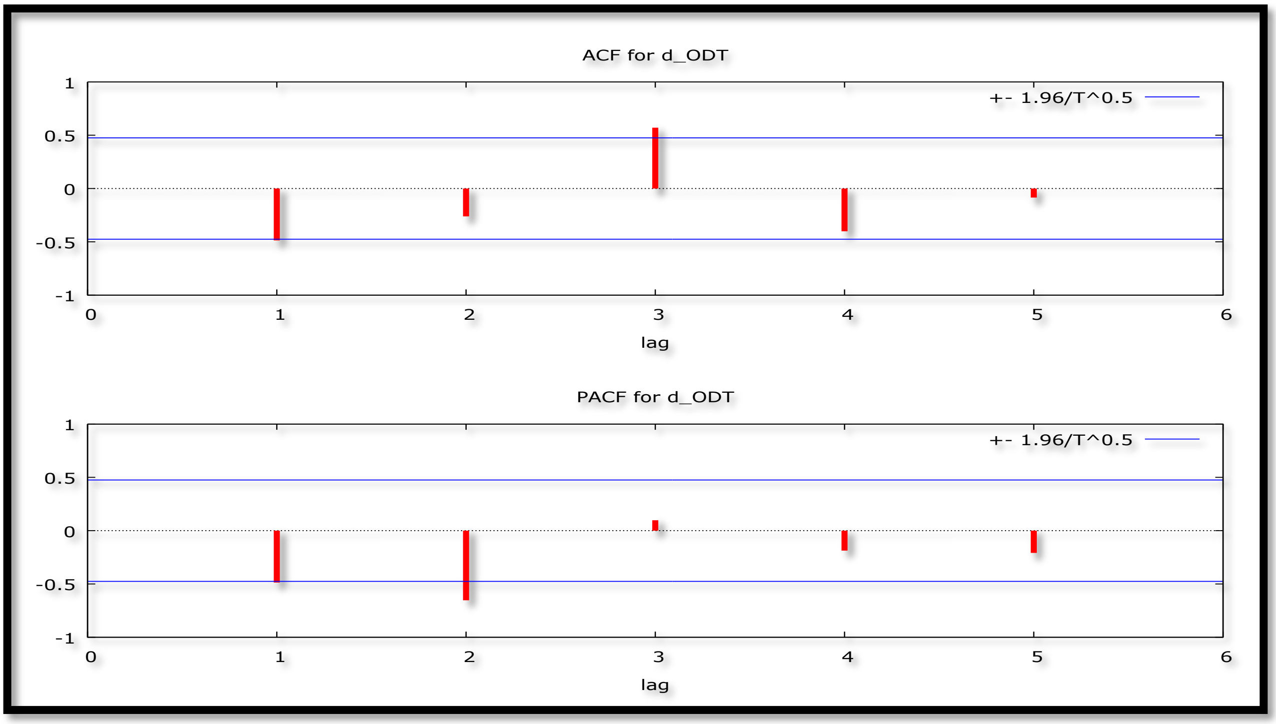

Figure 3: Correlogram (at First Differences)

3.7.5 The ADF Test (at First Differences):

Table 3: with intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
ΔODT	-9.899495	0.0000	-3.959148	@1%	Stationary
			-3.081002	@5%	Stationary
			-2.681330	@10%	Stationary

Table 4: with intercept and trend & intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
ΔODT	-10.19405	0.0000	-4.728363	@1%	Stationary
			-3.759743	@5%	Stationary
			-3.324976	@10%	Stationary

Figure 3 as well as tables 3 and 4, indicate that OD is an I (1) variable.

3.7.6 Evaluation of ARIMA models (with a constant):

Table 5: Evaluation of ARIMA Models (with a constant)

Model	AIC	U	ME	MAE	RMSE	MAPE
ARIMA (1, 1, 0)	24.01056	0.5277	-0.01081	0.34224	0.40944	0.65015
ARIMA (2, 1, 0)	9.429175	0.31596	-0.04556	0.144	0.26878	0.26243
ARIMA (3, 1, 0)	11.42918	0.31596	-0.04556	0.144	0.26878	0.26243
ARIMA (4, 1, 0)	12.59947	0.31067	-0.047264	0.13896	0.26363	0.25448

A model with a lower AIC value is better than the one with a higher AIC value (Nyoni, 2018b) Similarly, the U statistic can be used to find a better model in the sense that it must lie between 0 and 1, of which the closer it is to 0, the better the forecast method (Nyoni, 2018a). In this research paper, only the AIC is used to select the optimal model. Therefore, the ARIMA (2, 1, 0) model is eventually chosen.

3.8 Residual & Stability Tests:

3.8.1 ADF Test (in levels) of the Residuals of the ARIMA (2, 1, 0) Model:

Table 6: with intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
R	-3.489018	0.0228	-3.920350	@1%	Non-stationary
			-3.065585	@5%	Stationary
			-2.673459	@10%	Stationary

Table 7: without intercept and trend & intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
R	-4.193507	0.0288	-4.886426	@1%	Non-stationary
			-3.828975	@5%	Stationary
			-3.362984	@10%	Stationary

Tables 6 and 7 indicate that the residuals of the chosen parsimonious model, the ARIMA (2, 1, 0) model; are stationary. Hence, the model is stable.

3.8.2 Correlogram of the Residuals of the ARIMA (2, 1, 0) Model

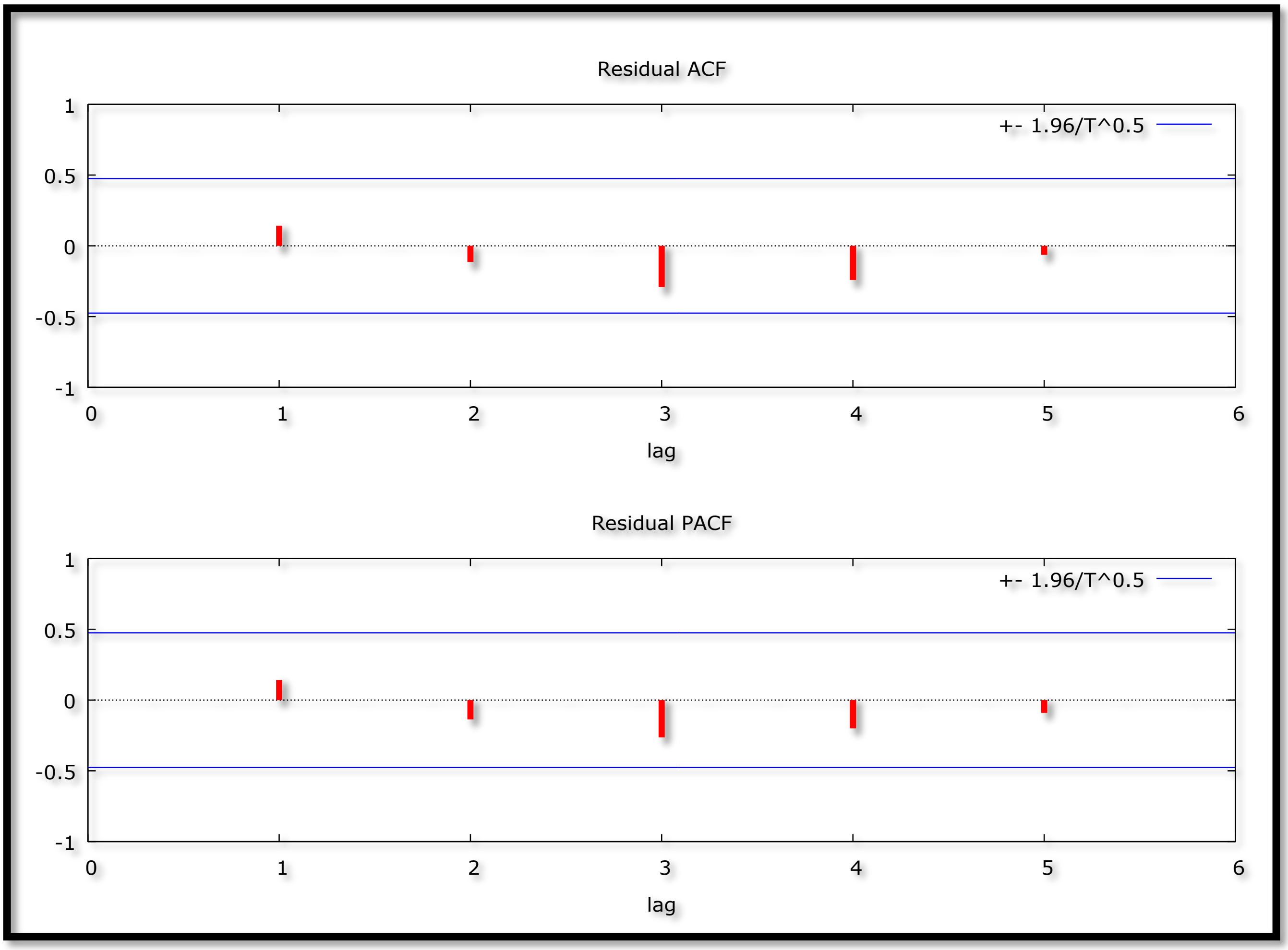

Figure 4: Correlogram of the Residuals

Figure 4 indicates that the estimated ARIMA (2, 1, 0) model is adequate since ACF and PACF lags are quite short and within the bands. This means that the "no autocorrelation" assumption is not violated in this study.

3.8.3 Stability Test of the ARIMA (2, 1, 0) Model

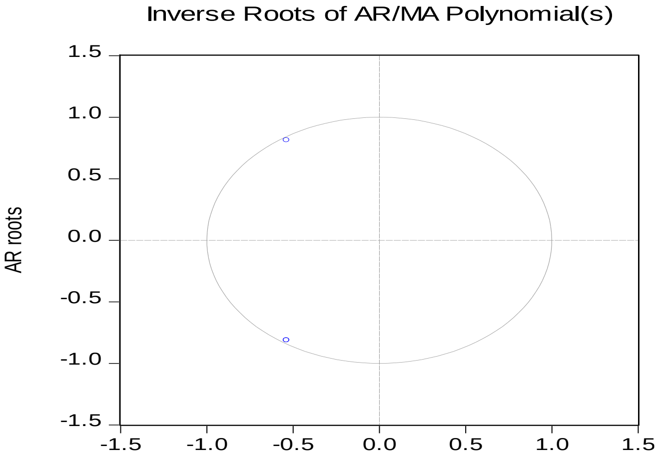

Figure 5: Inverse Roots

Since all the AR roots lie inside the unit circle, it points to the fact that the estimated ARIMA process is (covariance) stationary; thus proving beyond any reasonable doubt that the ARIMA (2, 1, 0) model is really stable and suitable for forecasting annual number of people practicing open defecation in Togo.

FINDINGS:

4.1 Descriptive Statistics:

Table 8: Descriptive Statistics

Description	Statistic
Mean	53.278
Median	53.5
Minimum	48
Maximum	59
Standard deviation	3.4778
Skewness	-0.024072
Excess kurtosis	-1.2023

As shown in table 8 above, the mean is positive, that is, 53.278. This means that, over the study period, the annual average number of people practicing open defecation in Togo is approximately 53% of the total population. This is a warning alarm for policy makers in Togo, especially, with regards to the need to promote an open defecation free society. The minimum number of people practicing open defecation in Togo over the study period is approximately 48% of the total population, while the maximum is 59% of the total population. However, the number of people practicing open defecation in Togo has continued to go down over the years from 59% in 2000 to 48% of the total population in 2017. The skewness is -0.024072 and the most important feature is that it is positive, meaning that the ODT series is positively skewed and non-symmetric. Excess kurtosis is -1.2023; showing that the ODT series is not normally distributed.

4.2 Results Presentation:

Table 9: Main Results

ARIMA (2, 1, 0) Model: Guided by equation [11], the selected optimal model, the ARIMA (2, 1, 0) model can be expressed as follows: $\Delta ODT_t = -0.646016 - 0.997032\Delta ODT_{t-1} - 0.820119\Delta ODT_{t-2} \ldots [12]$				
Variable	Coefficient	Standard Error	z	p-value
constant	-0.646016	0.0212267	-30.43	0.0000***
β_1	-0.997032	0.147451	-6.762	0.0000***
β_2	-0.820119	0.147876	-5.546	0.0000***

Table 9 basically shows the main results of the ARIMA (2, 1, 0) model.

Forecast Graph

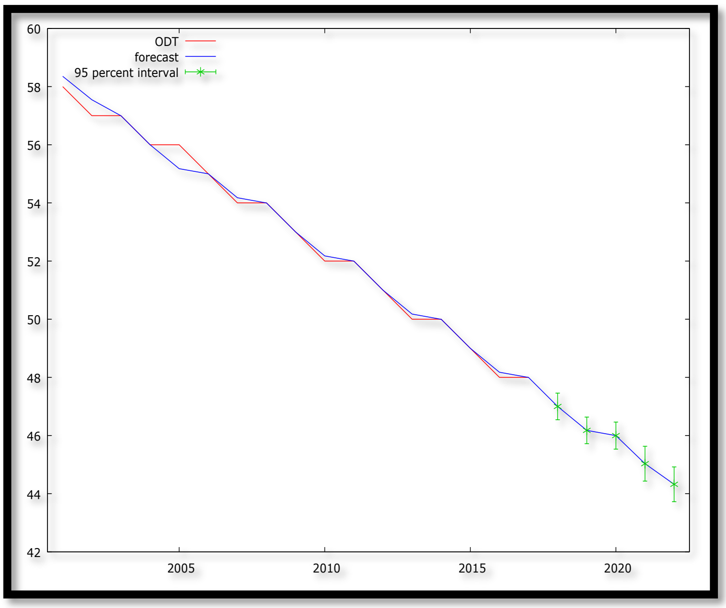

Figure 6: Forecast Graph – In & Out-of-Sample Forecasts

Figure 6 shows the in-and-out-of-sample forecasts of the ODT series. The out-of-sample forecasts cover the period 2018 – 2022.

Predicted ODT – Out-of-Sample Forecasts Only:

Table 10: Predicted ODT

Year	Predicted ODT	Standard Error	Lower Limit	Upper Limit
2018	47	0.234	46.54	47.46
2019	46.18	0.234	45.72	46.64
2020	46	0.237	45.53	46.46
2021	45.03	0.305	44.43	45.63
2022	44.32	0.306	43.72	44.92

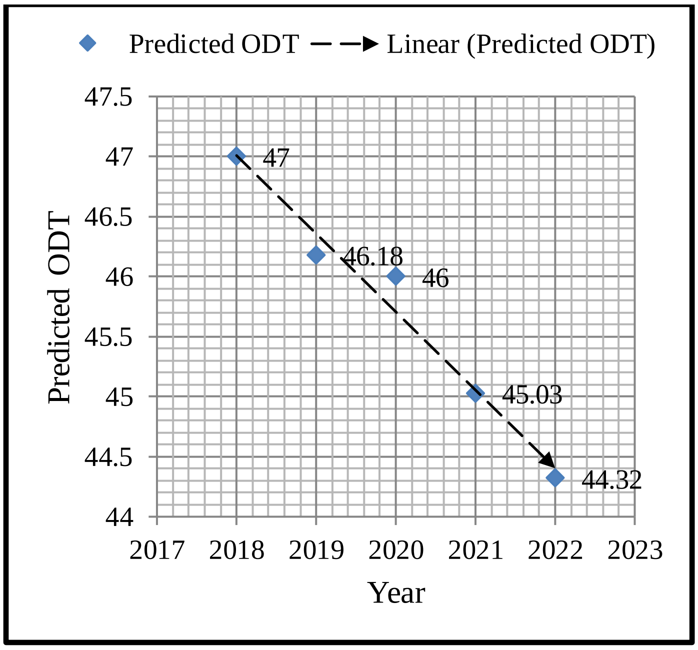

Figure 7: Graphical Analysis of Out-of-Sample Forecasts

Table 10 and figure 7 show the out-of-sample forecasts only. The number of people practicing open defecation in Togo is projected to fall from approximately 47% in 2018 to approximately 44% of the total population by the year 2022. A lot needs to be done, if an open defecation free society is anything to go by in Togo. From our projections, it is now clear that open defecation will not end in the near future in Togo. However, it is imperative for policy makers to consider the policy directions suggested below.

4.3 Policy Implications:

i. The government of Togo must invest more funds in the construction of toilets for people, particularly, for those who live in rural areas. In this regard, there ought to be an intensification if water, sanitation and hygiene initiatives from community to national levels.

ii. There is need to encourage a habit of not defecating in the open in Togo. In this regard, the government of Togo must take a lead in sensitizing the need to preserve the dignity of people by not defecating in the open.

CONCLUSION:

The study shows that the ARIMA (2, 1, 0) model is stable and suitable to forecast the annual number of people practicing open defecation in Togo over the period 2018 – 2022. The model predicts a decrease in the annual number of people practicing open defecation in Togo. These findings are important for the government of Togo, especially when it comes to long-term planning with regards to materializing the much needed open defecation free society.

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