



**INTERNATIONAL JOURNAL OF SCIENCE FOR GLOBAL SUSTAINABILITY**  
**A Model for Forecasting Inmate Population in Correctional Centres**  
**Using Time Series**

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Received on: August, 2020

Revised and Accepted on: September, 2020

Published on: October, 2020

**ABSTRACT**

The rising urge by the government in maintaining law and order to reduce or prevent crime has led to the need to get accurate data on all crimes for assessment. This will guide the government and policy formulators on the status of crime. In this study, a time series model for forecasting prison inmates' population using data from Idah zonal correctional centre, Kogi State, Nigeria is presented. The result shows a relatively downward trend for awaiting inmate and on average, a linear trend for convicted inmates.

Keywords: crime, correctional service, forecast, trend, arima

## 1.0 INTRODUCTION

There is no society without a prison (correctional centre) system and prisons have existed in different civilizations in ancient times. It included short-term detention facilities for the confinement of persons waiting trial, sentencing, execution, deportation (transportation to other countries as punishment) whipping or some other form of corporal punishment. (Reid, 2012, Shajobi-Ibikule 2014). The Primary mandate of the prison is confinement (Bamgbose, 2003). As succinctly put, the mission of the correctional centre is to keep prisoners safe, busy and to do it with fairness without undue suffering and as efficiently as possible. A recurring problem in the correctional centres worldwide is that of overcrowding and congestion. The ripple effect of congestion in most correctional centre are manifested in non-classification of inmates, inadequate beddings, sickening, physical condition, poor feeding, inadequate staffing, bad state of prisoners health, and increased rate of recidivism (see, Bamgbose, 2003). His paper also examined the genesis of privatization as one of the methods for tackling growing problem of prisons crowing and congestion, debates and controversies on its introduction into prison system and lessons for the Nigerian government from global experience.

One of the most daunting challenges is misconduct in correctional facilities which can create problems both for the other inmates and staff. Identifying of individuals at increased risk of violence in prison

and quantifying the probability of such assaultive misconduct are obviously important issues for prison administrators and public policy makers (see, Arbach-Luconi and Garcia, (2014), Sorensen and Cunningham, 2007). Szifris, *et al.* (2018), articulated the theory of prison education, offering a new insight into the relevance of desistance theory and understanding of Prison Sociology to the lives of men engaged in education whilst in prison.

Many researchers have focused on indicators of risk of prison violence, especially in the United States. Little is known about this question in Nigeria despite the fact that the country has crowded prison system. In this study, time series model is employed to forecast inmate population using data from Idah zonal correctional centre, Kogi State, Nigeria.

Barnett (1987) proposed a method for forecasting prison populations under a variety of assumptions about sentencing policy and demographic structure. His approach builds on a familiar stochastic model of the individual criminal career. Lin *et al.* (1986) presented a study of a time-series model for predicting Louisiana's prison population using the iterative Box-Jenkins modelling methodology. Time series forecast were contrasted with results of regression models and an experimental smoothing model. It was observed that when compared with actual data the prediction appeared sufficiently adequately to meet the needs of the correctional

system for short-term period planning. Anthanasopoulos and weatherburn (2018), reported on how to generate point and interval forecasts for the monthly average male and female, prison population in New South Wales (NSW). Separate ARIMA and Exponential Smoothing Over the long term, the forecasts from the two models began to diverge. Mohammed *et al.* (2019) in their work, used the ARIMA model to predict the monthly average solar radiation with seasonal lag and mimic the seasonality and monthly cyclic nature of solar radiation in Seoul, South Korea. They found that the ARIMA model can potentially and effectively make daily and monthly prediction because of its convenience and accurate prediction, low data input requirement, and simple computational process. Martinez (2008), gave a methodology to apply the laws and policies regulating release from prison and to project the prison population that results from offenders newly admitted into the prison system. He gave other models for forecasting such as the flow, stochastic, auto regression integrated models, and micro-simulation. Also, Martinez (2009), presented a model for forecasting correctional admissions. He points out that the prison population in the United States continues to increase despite generally declining crime rates. He maintained that there is a need for a model that simulates how offenders are admitted to prison, how they are move in and out of the prison system.

As a result of the rapid population growth in correctional facilities, forecasting have become an

(ETS) models were fitted to data on the daily average number of male and female prisoners held in NSW correctional centres. It was shown that over the short term, both classes of model returned fairly accurate forecasts for both male and female prisoners.

Important component of a country and prison administration planning. Hence in this study, a time series model for forecasting prison population using data from the Nigerian correctional facility, Idah, Kogi State is presented. The main advantages of the time series models are that short-term forecasts produced by method are usually more accurate than those produced by any other methods, that is the forecasts are minimum mean square error, the technique allows for a wide range of possible models for the data and provides a strategy for selecting a model from that class which best represents the data. Also, all available information is used, including characteristics of residual as well as trend and seasonality, and the model is conceptually superior to the other traditional models (see Lin *et al.*, 1986)

## 2.0 METHODOLOGY

The Data used in this study was collected from Nigerian correctional centre, Idah Kogi State for the period of twenty (20) years. The data consists of 375 awaiting trial inmates and 756 convicted inmates. The methodology used is descriptive Statistics and Time Series Analysis using Microsoft Excel and R Statistical packages.

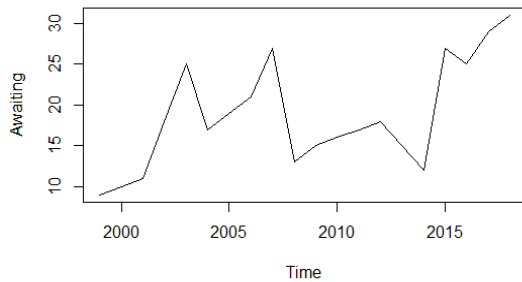
## 3.0 RESULTS

### 3.1 Descriptive Statistics

Table 3:1: Descriptive Statistics of Inmates from 1998 - 2018

	Total	Minimum	Maximum	Mean	Std. Dev.	Skewness
Awaiting inmate	375	9	31	18.75	6.60	0.37
Convicted inmate	756	15	60	37.8	9.61	-0.37

The table 3.1 above reveals the yearly average number of inmates awaiting trial is about 19 while



**Figure 3.1: Line Chart showing the trend of awaiting inmates from 1998 – 2018**

Figure 3.1 depicts the oscillating pattern of the trend of inmates awaiting trial, as it generally shows an upward trend.

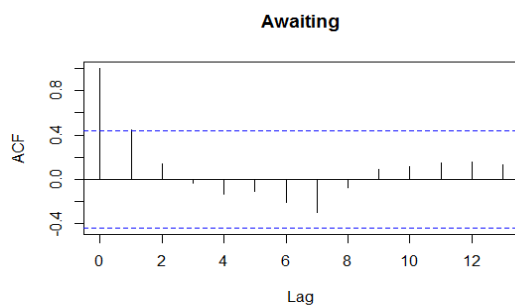
### 3.2 Test of Hypothesis

Hypothesis 1

Ho: the series of awaiting inmates is non-stationary  
Augmented Dickey Fuller (ADF) test was performed on the data set using R and results obtained are as follows

$$\text{Dickey Fuller} = -1.8204, \quad \text{Lag order} = 2, \\ \text{P-value} = 0.04408.$$

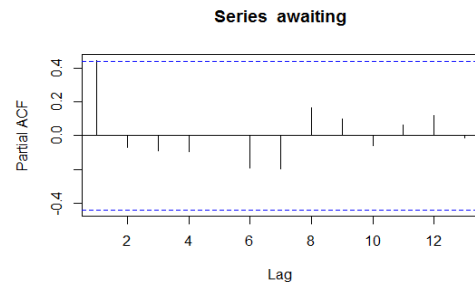
Since the P-value (0.04408) < 0.05, the null Hypothesis of non-stationarity is rejected hence, conclude that the series is stationary.



**Figure 3.2: An Autocorrelation function plot for Awaiting Inmates data**

The figure above shows the Auto Correlation Function of the data obtained on awaiting inmates. The image shows stationarity as the bars are within the limit (dotted blue lines). The single bar exceeding the limit shows sign of auto regression.

the yearly average number of convicted inmates is about 38.



**Figure 3.3: A Partial Autocorrelation function plot for Awaiting Inmates data**

In like manner to the ACF, the PACF also depicts stationarity in the data.

### 3.3.1 Model Fit for Awaiting Inmates Data

The *auto.arima* function were used to generate the best ARIMA model for the time series data. The best model was found to be ARIMA (1, 0, 0) which implies that the data is not differenced due to the fact that it was stationary all along. The model follows the pattern of an autoregressive model of order 1 with AIC = 131.15 and BIC = 134.14. The significant estimated parameter is  $\alpha_1 = 0.5833$  with  $\mu = 18.9028$  standard error 0.2109. The arima (1, 0, 0) is expressed as

$$x_t = \mu + \alpha_1 Y_{t-1}$$

After fitting the model, the following mathematical expression is obtained.

$$x_t = 18.9028 + 0.5833Y_{t-1}$$

### 3.3.2 Forecasting for Awaiting Inmates

The obtained model was used to forecast for five (5) years values of awaiting inmates. This was carried out using *forecast* package in R studio environment.

**Table 3.2: Five-year Forecast of Awaiting Inmates**

Year	Forecast	Lower boundary	Upper boundary
2019	26	15	37
2020	23	10	36
2021	21	8	35
2022	20	6	34
2023	19	5	33

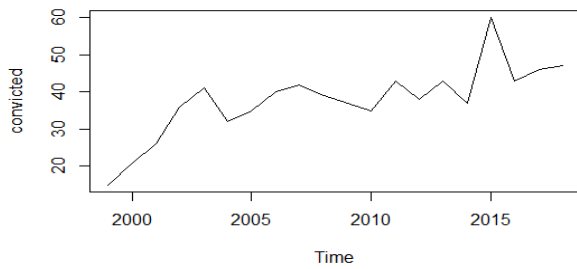


Figure 3.4: Time plot for the forecast of Awaiting inmate

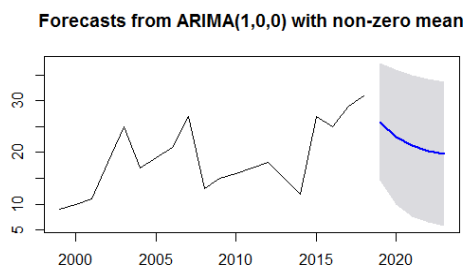


Figure 3.5: Time plot for Convicted Inmates data

The figure 3.5 shows an upward trend which indicates that the data is not stationary and need to be differenced hence proceed to test for stationarity using the ADF, ACF and PACF.

**Hypothesis 2**

Ho: the series of convicted inmates is non-stationary

In addition, we used Augmented Dickey Fuller test to further assess the stationarity of the data on convicted inmates using R package and the results obtained are as follows

Dickey Fuller = -4.0142, Lag order = 2, P-value = 0.02276.

Since the ADF produced a p-value  $0.02276 < 0.05$ , thus the null hypothesis is rejected. Hence, we conclude that the data is stationary. However, the time plots showed non stationarity, again we carry out the ACF and PACF.

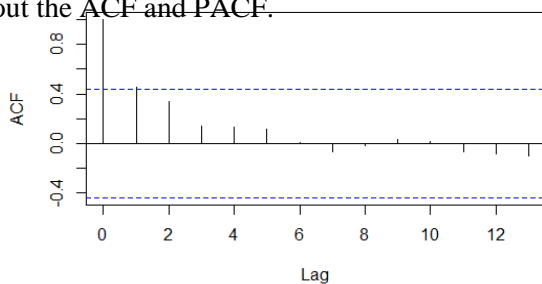


Figure 3.6: An autocorrelation function plot for convicted inmate.

The figure 3.6 shows the Auto Correlation Function of the data obtained on awaiting inmates. The graph shows no stationarity as the second bar tends to exceed the confidence limits.

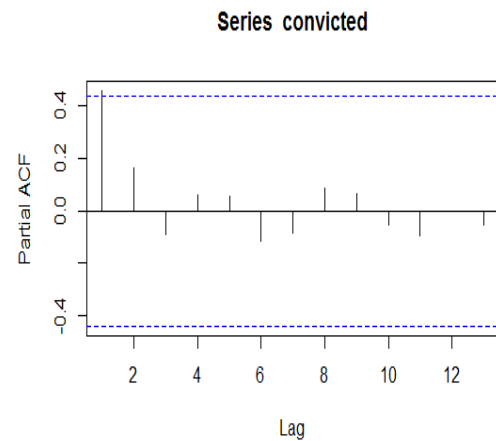


Figure 3.7: A Partial autocorrelation function plot for convicted inmate

**3.3.3. Model Fit for Convicted Inmates**

The auto arima function was used to generate the best ARIMA model for the time series data. The best model was found to be ARIMA (1, 1, 0) which implies that the data was differenced due to the fact that it was not stationary and the model follows the pattern of an autoregressive model of order 1 with  $AIC = 133.73$  and  $BIC = 135.62$ . The significant estimated parameter is  $\alpha_1 = 0.4518$  with mean  $\mu = 0$  and standard error 0.1981. The ARIMA (1, 1, 0) is given as

$$x_t = \mu + Y_{t-1} + \alpha_1(Y_{t-1} - Y_{t-2})$$

After fitting the model, we obtained

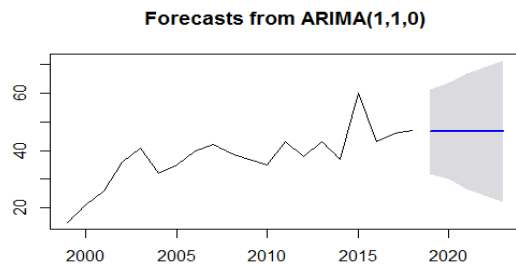
$$x_t = Y_{t-1} + 0.4518(Y_{t-1} - Y_{t-2})$$

**3.3.4 Forecast for Convicted Inmates**

The obtained model is used to forecast for awaiting inmates for five years using R package as:

Table 3.3: Five-year Forecast of Convicted Inmates

Year	Forecast	Lower boundary	Upper boundary
2019	46	31	61
2020	47	29	63
2021	47	26	66
2022	47	24	69
2023	46	22	71



**Figure 3.8:** Time plot for the forecast of convicted inmate

Figure 3.8 shows the five year forecast of the convicted inmates.

#### 4.0 DISCUSSION

This research work assessed data of the awaiting and convicted inmates from Idah zonal correctional centre, Kogi State, Nigeria. From the analysis, the population structure of inmates in Kogi State was found to be stationary. The model parameters were estimated using autoarima function from the R software. Models obtained were ARIMA (1,0,0) and ARIMA(1,1,0) for awaiting and convicted inmates series respectively. The model was examined for adequacy using various standard statistical techniques. The forecast of period of five (5) years were presented for each group. Also, the model for estimation and forecasting was found to be very adequate.

#### 5.0 CONCLUSION

Expert agree that predicting correctional Centre's population is not an exact science as it is a combination of facts and probabilities (Martinez, 2009). Although the "state of art" prison population forecast might not exist. In this study, the data collected has been used to forecast for five (5) years period. Appropriate methodologies were applied and the best model was identified and selected. The resulting forecast shows a relatively downward trend for awaiting inmate and on average, a linear trend for convicted inmates. This gives a clearer picture of how the total population of inmates in Idah correctional centre, Kogi State will be over the time period. Correctional centre's population forecasts are essential for correctional administrators and policy makers to make management and budget decisions.

#### 6.0 RECOMMENDATION

The findings from this research are very helpful to correctional administrators to successfully manage

the correctional centres. It is recommended that correctional administrators should have control over the number of inmates remanded in custody or sentenced to prisons. Also, correctional centres are meant to correct inmates for the purpose of reformation, rehabilitation and reintegration of deviant offenders and not to punish alone, therefore, serving as a correctional institution.

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