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Time series analysis of crime deterrence on drug abuse in Jalingo Local Government Area, Taraba State, Nigeria

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Abstract

Time Series on crime deterrence on drug abuse was carried out in order to determine the trend and tendency of crime and the effect of drug abuse, unemployment, and number of arrest on crime. After careful analysis, it was discovered that in the year 2017, the number of crime reported is 291 which was less than other figures used in the analysis and more forecast for subsequent years 2018, 2019 and 2020 with reported forecast rising to a high level of 414, 484 and 454 respectively. 77.3% on the variation in the crime was explained by the number of arrest, unemployment rate and drug abuse cases. The coefficients indicate that drug abuse cause increase in crime while previous arrest cause decrease in crime rate. This could be as a result of using previous information.

Keywords: autocorrelation; forecast; arrest; drug-abuse; unemployment.

1 Introduction

One of the continuous problems that have bedeviled the existence of mankind is crime. Since early days of man's existence, crime had been a disturbing threat to personality, property and lawful authority [1]. The relationship between crime and evolution of mankind is considered a historical one as Cain (first son of Adam and Eve) committed the first violent crime when he murdered his brother Abel because of jealousy [2]. Today, in the modern complex world, the situation is most highly disturbing. It started in the primitive days as a simple and less organized issue, and ended today as very complex and organized. Due to the complex nature of the subject of crime, its causes and consequences, various academic disciplines such as criminology, sociology, geography, psychology and demography study it from their own perspective [3].

The aim of this research is to determine the trends in crime rate in Taraba state and forecast the future possible crime rate in the state. To determine the trend of crime rate in Taraba State
With a view to see the impact of drug abuse, unemployment rate, and number of arrests on crime rate. This research was carried out in Taraba state, and it is a secondary data on crimes provided by the Taraba State Police Divisional Head Quarters, Jalingo, from 2000 to 2016.

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2 Research methodology

To realise the objectives of this research, simple time domain techniques (ARIMA model) O.I. The work in [10] will be used to forecast and to determine the trend of crime rates. The Multiple Linear Regression Analysis will also be performed in order to determine the impact of drug abuse, unemployment rate, and the number of arrests. SPSS version 20 and E-views shall be used to carry out all the analysis. The ARIMA encompass three components, AR, MA, and integrated series. AR stands for the autoregressive model i.e. regressing the dependent variable with linear combination of its past values or lagged values [4], MA stands for moving average model i.e. regressing the dependent errors with linear combination of its past error or lagged error or innovation and I stands the differencing order, that is number of difference applied on the stochastic process before attaining stationary [9]. Hence, the mathematical form of the model with the parameters is:

$$Crime = Cons\tan t + \beta_1 * Arrest + \beta_2 * Unemp + \beta_3 * Drug + \beta_4 * \Pr ev.Arrest.$$

There are steps we will take to achieve our aims and these are listed below: Model Estimation, Model Identification, Model Diagnostic and Forecasting Accuracy.

2.1 Model estimation

We estimate the parameters of ARIMA model using Statistical Package for social sciences (SPSS).

2.2 Model identification

The major thing to do here is to test for stationarity of the series using the approach of Phillips-Perron test statistic [6].

2.3 Model diagnosis

If we fit the model, the model diagnosis will aid us to know the forecasting, reliability, accuracy ability which will be judge under the coefficient of determination or through the use of the smallest mean square error or other smallest measurement tools like MAE (Mean Absolute Error), MAPE (Mean Absolute Percentage Error), RMSE (Root Mean Square Error), MSE (Mean Square Error). Box and Jenkin [5] model building strategy entails a diagnosis of the adequacy of the model. More importantly, it is necessary to ascertain in what way a model is adequate or inadequate. And this entails being sure that;

- The model converged upon minimum sum of square error
- The sum of square error (residuals) should be quite small so that R^2 of the model could be quite large [8].

3 Data analysis and interpretation

3.1 Time series analysis

Table 3.1 Minimization phase section

Itn No.	Error Sum of Squares	Lambda	AR(1)	AR(2)	MA(1)	MA(2)
0	264452	0.1	0.1	0.1	0.1	0.1
1	169655	0.1	-0.2273186	-5.678551E-02	0.4330371	0.2286701
2	1.329453E+15	0.04	5.681635E-02	0.4535415	0.9430795	0.7431056
3	1.881917E+07	0.4	-0.2168886	0.1127902	0.6257304	0.520533
4	161098.2	4	-0.2458111	-5.257529E-02	0.4841563	0.2917979
5	160097.9	1.6	-0.2662098	-4.102172E-02	0.5505252	0.3357024
6	157076.8	0.64	-0.2816789	-5.006321E-02	0.5395117	0.3182929
7	156547.3	0.256	-0.2935411	-6.232658E-02	0.5448436	0.2975857
8	155869.4	0.1024	-0.2564089	-7.762863E-02	0.5881894	0.2610659
9	153828.9	0.04096	-0.1462758	-0.1128353	0.6924632	0.173146
10	146632.2	0.016384	0.1247474	-0.1988176	0.9505295	-4.271355E-02
11	348883.9	0.0065536	0.630744	-0.377059	1.469549	-0.4616326
12	140005.8	0.065536	0.2199221	-0.3662845	1.024166	-8.783563E-02
13	128638.5	0.0262144	0.4119723	-0.4661938	1.229158	-0.2448201
14	7.40718E+14	1.048576E-02	0.4711801	-0.258344	1.823251	-0.1722613
15	6.844108E+12	0.1048576	0.4453836	-0.3274333	1.718337	-0.1312337
16	4.772269E+08	1.048576	0.4053402	-0.4492193	1.457659	-0.1190874
17	118132.7	10.48576	0.4084557	-0.4678892	1.273622	-0.2139967
18	116883.2	4.194304	0.4086467	-0.4698515	1.280031	-0.210033
19	115139.2	1.677722	0.409653	-0.4749367	1.289584	-0.205186
20	112053.4	0.6710886	0.4117909	-0.4835263	1.310181	-0.1966075

The above table displays the algorithms progress toward a solution. The Error Sum of Squares presents the sum of the squared residuals. This is the value that is being minimized by the algorithm. Lambda is the value of Marquart's lambda parameter. AR(1), AR(2), MA(1) and MA(2) are the values of the autoregressive and moving average parameters.

Table 3.2 Model description section

Series	Crime rate-MEAN	
Model	Regular(2,1,2)	Seasonal(No seasonal parameters)

Mean	409.8
Observations	15
Iterations	20
Pseudo R-Squared	19.897974
Residual Sum of Squares	112053.4
Mean Square Error	11205.34
Root Mean Square	105.8553

Table 3.2 displays summary information about the solution. The series shows the name of the variable being analyzed, which is crime rate. The Model contain the phrase *Regular (p,d,q)* gives the highest order of the regular ARIMA parameters. The *Seasonal (P,D, Q)* gives the highest order of the seasonal ARIMA parameters, if they were used (SARIMA is not used in this work), where;

2 is the highest order auto regression parameter in the model.
1 is the number of times the series was differenced.
2 is the highest order moving average parameter in the model.

The mean is the average of the series, which is 409.8 crimes per year. Observations is the number of observations (rows) in the series. Iterations is the number of iterations before the algorithm converged or was aborted. Pseudo R-Squared is the value that generates a statistic that acts like the R-Squared value in multiple regression, a value near zero indicates a poorly fitting model, while a value near one indicates a well-fitting model, this value (19.90%) indicate that about 20% of the crime rate is determined by time. Residual Sum of Squares presents the sum of the squared residuals this is the value that is being minimized by the algorithm. Mean Square Error is the average squared residual (MSE), which is a measure of how closely the forecasts track the actual data. The statistic is popular because it shows up in analysis of variance tables. However, because of the squaring, it tends to exaggerate the influence of outliers (points that do not follow the regular pattern). Root Mean Square is the square root of MSE. This statistic is popular because it is in the same units as the time series.

Table 3.3 Model estimation section

Parameter Name	**Parameter Estimate**	**Standard Error**	**T-Value**	**Prob Level**
AR(1)	0.4117909	0.1477031	2.7880	0.005304
AR(2)	-0.4835263	0.3768807	-1.2830	0.199503
MA(1)	1.310181	0.4818036	2.7193	0.006542
MA(2)	-0.1966075	0.4494427	-0.4374	0.661787

It can be seen from Table 3.3 that the estimates of the ARIMA model parameters can be given as follows:

AR(1) The 1st-order autoregressive parameter is 0.4117909.
AR(2) The 2nd-order autoregressive parameter is -0.483562.
MA(1) The 1st-order moving average parameter is 1.310181.
MA(2) The 2nd-order moving average parameter is -0.1966075.

The ARIMA model is therefore given by the equation:

$$(1-L)y_t = 0.411y_{t-1} - 0.484y_{t-2} + 1.310\varepsilon_{t-1} - 0.196\varepsilon_{t-2}.$$

Parameter estimate is the estimated parameter value. The Standard Error is the estimate of the standard error of the parameter value. The T-value is the t-test value testing whether the parameter is statistically significant (different from zero). The Probability Level is the probability level for the corresponding t-test. The p-value would have to be less than 0.05 in order for the parameter to be considered statistically different from zero. The above analysis shows that the p-values of the AR(1) and MA(1) (0.005 and 0.006 respectively) are less than 0.05 indicating that the 1st-order autoregressive parameter and 1st-order moving average parameter are significant, but the p-values of the AR(2) and MA(2) (0.199 and 0.661 respectively) are greater than 0.05 indicating that the 2nd-order autoregressive parameter and 2nd-order moving average parameter is not significant.

Table 3.4 Asymptotic correlation matrix of parameters

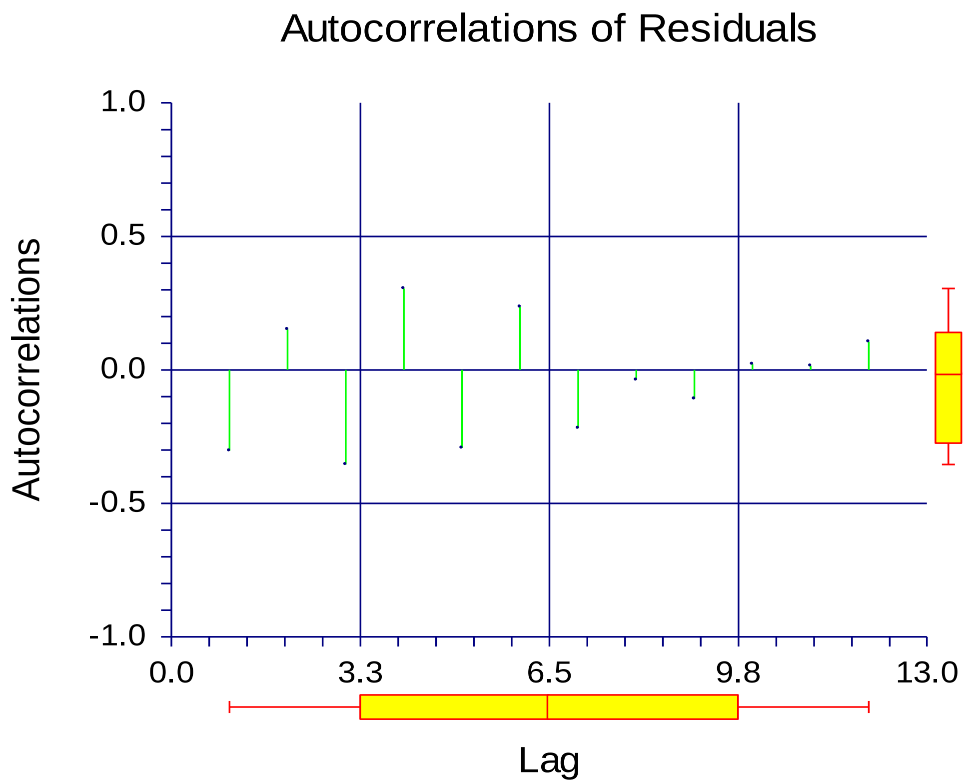
	AR(1)	**AR(2)**	**MA(1)**	**MA(2)**
AR(1)	1.000000	0.989966	0.587114	-0.399626
AR(2)	0.989966	1.000000	0.518744	-0.430849
MA(1)	0.587114	0.518744	1.000000	-0.685189
MA(2)	-0.399626	-0.430849	-0.685189	1.000000

Table 3.4 gives the asymptotic estimates of the correlation between the parameter estimates. If some of the correlations are greater than 0.9999, the appropriate parameters are removed, in this analysis, the highest correlation is 0.9899 indicating that none of the parameters shall be removed.

2	0.151336	5	-0.292838	8	-0.037631	11	0.014799
3	-0.354306	6	0.235722	9	-0.108505	12	0.105290

Significant if |Correlation| > 0.516398

The autocorrelations are all non-significant, implying that the residuals are white noise and therefore the model is fit for use.



Fiure. 3.1 Autocorrelation plot

Fig. 3.1 plot is the key diagnostic to determine if the model is adequate. Since no autocorrelations or a pattern of autocorrelations is found in the residuals, the model is assumed to be as good as possible and we proceed to use the forecasts.

Table 3.5 Forecast section of crime rate

Row	Date	Actual	Residual	Forecast	Lower 95% Limit	Upper 95% Limit
1	2002	444.0	27.8	416.2	207.7	624.8
2	2003	483.0	53.8	429.2	220.6	637.7
3	2004	405.0	4.8	400.2	191.7	608.7
4	2005	389.0	30.7	358.3	149.8	566.8
5	2006	333.0	-47.9	380.9	172.3	589.4
6	2007	357.0	-29.4	386.4	177.9	594.9
7	2008	368.0	-55.1	423.1	214.5	631.6
8	2009	462.0	34.7	427.3	218.8	635.9
9	2010	307.0	-132.1	439.1	230.6	647.7
10	2011	453.0	75.4	377.6	169.1	586.2
11	2012	262.0	-201.3	463.3	254.8	671.9
12	2013	361.0	-30.4	391.4	182.8	599.9
13	2014	532.0	37.7	494.3	285.8	702.9
14	2015	659.0	159.8	499.2	290.7	707.8

15	2016	332.0	-94.7	426.7	218.1	635.2
	Forecast					
16	2017			291.4	82.9	499.9
17	2018			414.2	175.9	652.4
18	2019			484.4	232.7	736.1
19	2020			453.9	202.2	705.6

Table 3.5 presents the forecasts and the 100(1-alpha)% prediction limits of the forecast, the analysis indicates that in the year 2017 the number of reported crime is expected to be 291 (the number can at least become 83 crimes and at most 500 crimes) while in 2018, 2019 and 2020 the reported crime is forecasted to rise to a high level of 414, 484 and 454 respectively all within prediction limits..

Table 3.6 Autocorrelations of residuals of crime rate-mean

Lag	Correlation	Lag	Correlation	Lag	Correlation	Lag	Correlation
1	-0.302900	4	0.304680	7	-0.218449	10	0.021190
2	0.151336	5	-0.292838	8	-0.037631	11	0.014799
3	-0.354306	6	0.235722	9	-0.108505	12	0.105290

Significant if |Correlation| > 0.516398

The autocorrelations are all non-significant, implying that the residuals are white noise and therefore the model is fit for use.

Regression Analysis
Multiple linear regression analysis is used to investigate the effect of drug abuse, unemployment and arrests on the crime rate

Table 3.7 Model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.918[a]	.843	.773	49.25537

a. Predictors: (Constant), Number of previous arrest, Number of arrests, unemployment rate, drug abuse cases recorded

The analysis in Table 3.7 shows that the multiple correlations between the independent variables (number of arrests, unemployment rate, drug abuse cases, and previous number of arrest) and the crime rate is 0.918, implying a strong linear relationship. The adjusted coefficient of determination R-Square is 0.773 indicating that 77.3% of the variation in the crime rates is explained by the number of arrests, unemployment rate, drug abuse cases, and previous number of arrest.

Table 3.8: ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	116800.390	4	29200.098	12.036	.001[b]
	Residual	21834.824	9	2426.092		
	Total	138635.214	13			

a. Dependent Variable: Crime Rate
b. Predictors: (Constant), Number of previous arrest, Number of arrests, unemployment rate, drug abuse cases recorded

Table 3.8 shows that the p-value of the ANOVA of this regression model (0.001) is less than 0.05 we therefore conclude that the model is significant and therefore fit for use

Table 3.9 Regression coefficient

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-148.500	694.715		-.214	.836
	Number of arrests	-.429	.224	-.448	-1.911	.088
	unemployment rate	7.535	3.899	.298	1.932	.085
	drug abuse cases recorded	2.808	.936	.651	2.999	.015
	Number of previous arrest	-.518	.167	-.456	-3.096	.013

a. Dependent Variable: Crime Rate

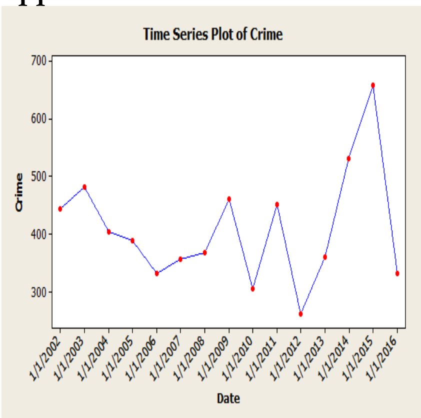
$$Crime = -148.5 - 0.429 * Arrest + 7.535 * Unemp + 2.808 * Drug - 0.518 * \Pr ev\_Arrest$$

$\boldsymbol{y = -148.5 - 0.429 * x_1 + 7.535 * x_2 + 2.808 * x_3 - 0.518 * x_4}$. where y is the total number of crime rate, x_1 is the Number of arrests, x_2 is the unemployment rate, x_3 is the drug abuse cases, and x_4 is the number of arrests in the previous year.

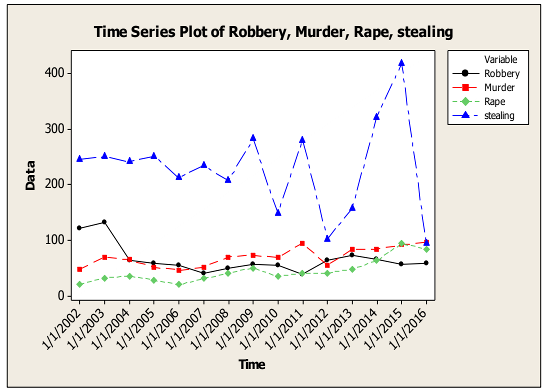
4 Discussion and conclusion

The p-value of the coefficients of x_3 and x_4 in the model (0.015, and 0.013 respectively) are less than 0.05. We therefore conclude that drug abuse, and arrests in the previous year have significant effect on crime. The signs of the coefficients indicate that drug abuse caused an increase in crime rate while previous arrests caused a decrease in crime rate.

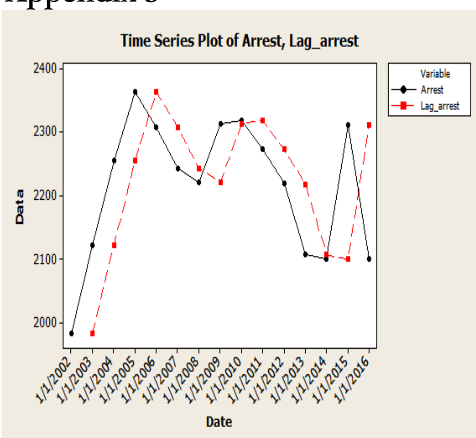
Appendix 1



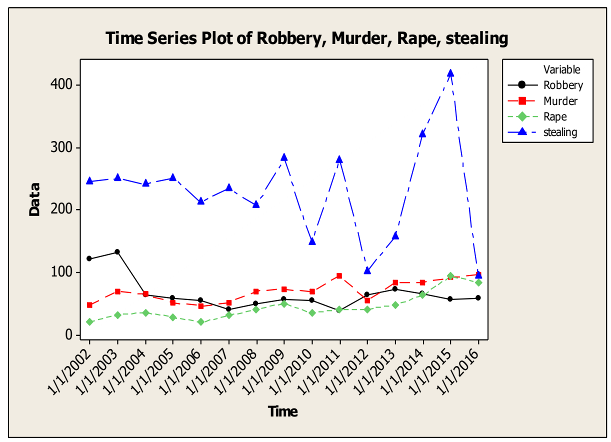
Appendix 2



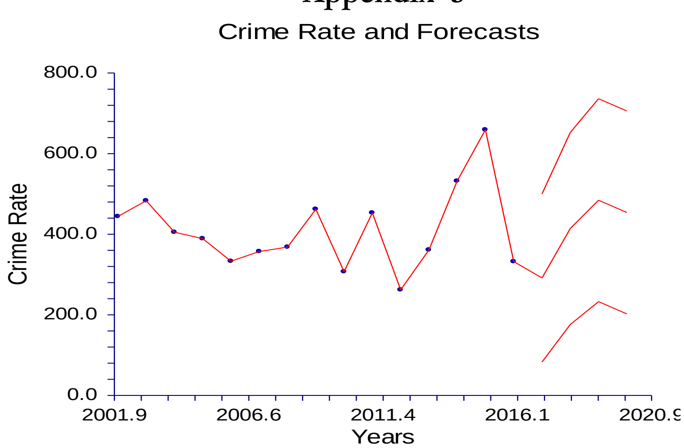
Appendix 3



Appendix 4



Appendix 5



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