TIME SERIES ANALYSIS FOR MODELING AND DETECTING SEASONALITY PATTERN OF AUTO-CRASH CASES RECORDED AT FEDERAL ROAD SAFETY COMMISSION, OSUN SECTOR COMMAND (RS 111), OSOGBO

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ABSTRACT: *Motor accident is a major cause of mortality and disability in Nigeria, which explains the reason for the establishment of Federal Road Safety Commission in 1988 to address the carnage and maiming on the highways and roads. This paper employed Time Series statistical tools to build model, and examine seasonality pattern of the number of cases of motor accident recorded at the Federal Road Safety Commission, Osun Sector command using secondary data collected from the record section of the command from 2006 to 2012. Autoregressive Integrated Moving Average (ARIMA) depicts reduction in the recorded number of cases recorded. This result was corroborated by Least Squares trend with quarterly decline of six (6) cases of motor accident. The seasonal pattern clearly portrayed quarter four (October, November, and December) as the season with high prevalence of motor accident. It was finally concluded that the Federal Road Safety Commission has been performing to expectation in the manner it discharges her duties by adjuring from the results of the analyses.*

KEYWORDS: accident, trend, model, seasonal, time series, road safety.

INTRODUCTION

The problem of transportation and its safety is of great importance. An analysis of the traffic crashes data recorded over a seven-year period of 2000 - 2006 shows that 98,494 cases of traffic crashes were recorded out of which 28,366 were fatal and resulted into 47,092 deaths (FRSC, 2009; Agbonkhese *et al.*, 2013). This revealing statistics show that Nigeria is placed among the fore front nations (especially the third world nations) experiencing the highest rate of road tragedies in the world. Many researches had been conducted on road accident in different states in Nigeria: Kogi State (), Katshina State (Suleiman, 2011), Ibadan (Charles *et al.*, 2007). Casualties in road accidents were studied by Aderamo (2012).

LITERATURE REVIEW

Road traffic accidents occur when a vehicle collides with another vehicle, pedestrian, animal, road debris, or other stationary obstruction, such as a tree or utility pole. Worldwide, road traffic accidents lead to death and disability as well as financial cost to both society and the individual involved (Eze, 2012).

Motor vehicle accidents are the leading cause of death in adolescents and young adults worldwide. Every year, according to statistics, about 1.2 million people are known to die in road accidents worldwide and others sustain severe injuries, while others suffer permanent disabilities due to number of fatal and serious cases of road accident (Olushina, 2012). Nearly three-quarters of road deaths occur in developing countries with 80% casualties (Odero *et al.*, 1997). In Nigeria, the increasing loss of lives on the road has become a worrisome experience. In 2006, about 4,944 deaths occurred in 9,114 road crashes with 17,390 persons injured. The situation in 2007 was 4,673 killed in 8,477 crashes leaving 17,794 injured. In Ekiti, Kogi and Kwara state, a total of 498 and 391 people died in the year 2006 and 2007 respectively which resulted from 402 and 413 crashes respectively (Omidiji and Ibitoye, 2010). Armed robbers attempts and attacks are discovered to be one of the major causes of auto-crash on Nigeria roads (Omidiji and Ibitoye, 2010). A conducted survey revealed that auto-crash is a function of traffic volume as shown by Atubi (2012). The research showed that peak rainy season (June, July and September) which may be due to slippery road and poor visibility of the drivers, and the September, October, November and December in Lagos state Nigeria.

The peak accident that occurs in the dry season is always due to impatience (Atubi, 2012). Ndefo reported that road failure is another cause of road accidents in Nigeria (Ndefo, 2012). According to (Eze, 2013), the causes of road traffic accidents are multi-factorial. These factors can be divided broadly into driver factors, vehicle factors and roadway factors. Accidents can be caused by a combination of these factors. Driver factors solely contributes to about 57 per cent of road traffic accidents and 93 per cent either alone or in combination with other factors. Driver's factors in road traffic accidents are all factors related to drivers and other road users. This may include driver's behaviour, visibility, auditory acuity, decision making ability and reaction speed. Drug and alcohol use while driving is an obvious predictor of road traffic accident, road traffic injury and death. Speeding, travelling too fast for prevailing conditions or above the speed limit, is also a driver factor that contributes to road traffic accidents. The risk of being injured increases exponentially with speed much faster than the average speed. The severity of injury depends on the vehicle speed change at impact and transfer of kinetic energy. Though vehicles travelling slower than average speed are also at increased risk of road traffic accidents, most involve speed too fast for the conditions. Many studies had been carried out on: causes and preventive measures of road accidents (Agbonkhese *et al.*, 2013), effect of visual ability of commercial drivers (Oladehinde *et al.*, 2007). Many agree that in the case of highways and road ways, crashes are not just a matter of luck or misfortune, but a combination of multiple conditions or actions. In this study the term "crash" or "collision" will be used in lieu of the term "accident".

RESEARCH METHODOLOGY

This section discusses various methods of data analysis and method of data collection. Furthermore, types of data and statistical packages used for data analysis are discussed.

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Material and Methods

Secondary data collected from record section of Federal Road Safety Commission of Nigeria (FRSCN) was used. Monthly data collected was converted to quarterly data which cover a period of seven years (2006-2012). The up-to-date data was not available as at the time of this study.

Estimation of Time Series Components

Time series components estimated in the study are Secular Movement or trend and Seasonal Variation.

Trend:

Least Squares method was used to estimate the trend. Least squares model minimizes the sum of squares for the error term.

$$T = a + \beta x + ei \qquad (1)$$

Equation (1) above gave birth to the two regression equations which can be used to estimate the regression coefficients:

$$\sum_{1}^{n} \mathrm{Y} = \mathrm{an} + \mathrm{b} \sum_{1}^{n} \mathrm{X} \qquad (2)$$

$$\sum_{1}^{n} \mathrm{XY} = \mathrm{a} \sum_{1}^{n} \mathrm{X} + \sum_{1}^{n} \mathrm{X}^2 \qquad (3)$$

From the above equations,

$$b = \frac{n \sum_1^n XY \ - (\sum_1^n X)(\sum_1^n Y)}{n \sum_1^n X^2 - (\sum_1^n X)^2} \qquad (4)$$

$$a = \bar{Y} - b\bar{X} \qquad (5)$$

Autoregressive model:

The general representation of an autoregressive model, well-known as AR (*p*), is:

$$Y_t = \ \alpha_0 + \alpha_1 Y_{t-1} + \ \alpha_2 Y_{t-2} + \ ... + \alpha_p Y_{t-p} + \varepsilon_t \qquad (6)$$

where the term ε_t is the source of randomness and is called white noise. It is assumed to have the following characteristics:

1. $£[\varepsilon_t] = 0,$
2. $£[\varepsilon_t^2] = \sigma^2,$
3. $£[\varepsilon_t \varepsilon_s] = 0 \; for \; all \; t \neq s.$

Stationary Time Series Models

White noise process, covariance stationary process, AR(p), MA(p) and ARIMA processes, stationarity conditions, diagnostic checks.

White noise process$x_t \sim i.i.d \quad N(0, \sigma^2)$

A sequence $\{x_t\}$ is a white noise process if each value in the sequence has:

1. Zero-mean: $E(x_t) = E(x_{t-1}) = .. = 0$
2. Constant conditional variance: $E({x_t}^2) = E({x_{t-1}}^2) = .\sigma^2 = Var(x_{t-1})$
3. uncorrelated properties with all other realizations:

$$E(x_t x_{t-s}) = E(x_{t-i} x_{t-i-s}) = . \ . \ . = 0 = Cov(x_{t-i} x_{t-i-s})$$

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Properties 1&2: Absence of serial correlation or predictability
Property 3 : Conditional homoscedasticity (constant conditional variance).

Covariance Stationarity (weakly stationarity)
A sequence $\{x_t\}$ is covariance stationary if the mean, variance and auto covariance do not grow over time, i.e. it has

1. finite mean: $E(x_t) = E(x_{t-1}) = . . . = \mu$
2. finite variance: $E[(x_t - \mu)^2] = E[(x_{t-1} - \mu)^2] = . . . = \sigma_x{}^2 = Var_x$
3. finite auto-covariance

$$E[(x_t - \mu)(x_{t-s} - \mu)] = E\left[\left(x_{t-j} - \mu\right)\left(x_{t-j-s} - \mu\right)\right] = . . . = \gamma_s = Cov\left(x_{t-j}x_{t-j-s}\right)$$

auto-covariance between $x_t, x_{t-s} = \sigma_s = \frac{\gamma_s}{\gamma_0}$

But white noise process does not explain macro variables characterized by persistence so we need AR and MA features.

AR (1): $x_t = \rho x_{t-1} + e_t$ $e_t \sim i.i.d(0, \sigma^2)$, (random walk: $\rho = 1$)
MA (1): $x_t = e_t + \theta e_{t-1}$
More generally:
AR(p): $x_t = \rho_1 x_{t-1} + \rho_2 x_{t-2} + . . . + \rho_p x_{t-p} + e_t$
MA(q): $x_t = e_t + \theta_1 e_{t-1} + \theta_2 e_{t-2} + . . . + \theta_q e_{t-q}$
ARMA (p,q):

$$x_t = \rho_1 x_{t-1} + \rho_2 x_{t-2} + . . . + \rho_p x_{t-p} + . . . + e_t + \theta_1 e_{t-1} + \theta_2 e_{t-2} + . . . + \theta_q e_{t-q} \quad (7)$$

Using the lag operator:
AR(1) : $(1 - \rho L)x_t = e_t$
MA(1) : $x_t = (1 + \theta L)e_t$
AR(p) : $\left(1 - \rho_1 L - \rho_2 L^2 - . . . - \rho_p L^p\right)x_t = \rho(L)x_t = e_t$
MA(q) : $x_t = \left(1 + \theta_1 L + \theta_2 L^2 + . . . + \theta_q L^Q\right)e_t = \theta(L)e_t$
ARMA (p,q): $a(L)x_t = b(L)e_t$

Statistical Package
The Statistical Package used are NCSS (Number Cruncher Statistical System) and E-view.

4. Data Presentation and Analysis

Table 1: Original data on Cases of Motor Accident Recorded between 2006 and 2012

YEAR	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4
2006:1	191	155	179	215
2007:1	129	202	198	172
2008:1	207	227	183	213
2009:1	162	197	205	171
2010:1	53	52	58	79
2011:1	61	57	52	100
2012:1	67	79	71	71

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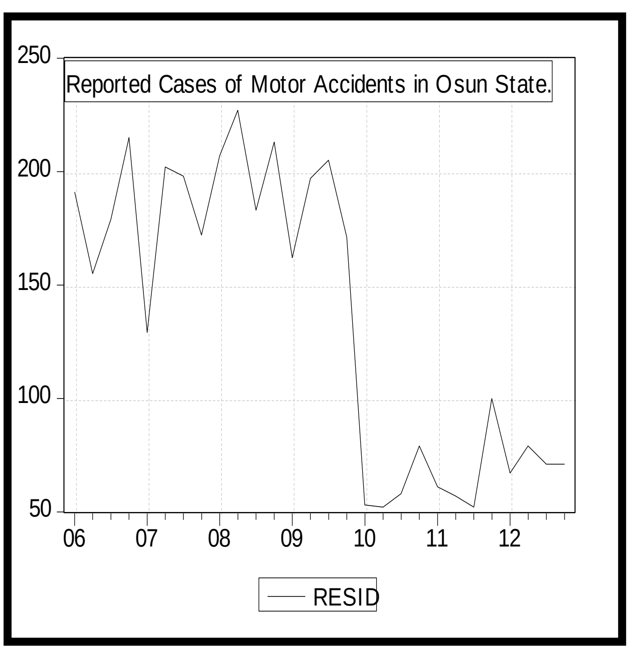
Source: Record Section of FRSCN, Osun sector command (RS 111), Osogbo

Descriptive Statistics.

Table 2: Descriptive Statistics

	MOTOR ACCIDENT
Mean	135.9286
Median	158.5000
Maximum	227.0000
Minimum	52.00000
Std. Dev.	64.64142
Skewness	-0.113328
Kurtosis	1.309191
Jarque-Bera	3.395242
Probability	0.183119
Observations	28

The distribution is negatively skewed with average of 136 reported cases of auto crash.
Figures 1 and 2 above show decrease in trend; indicating quarterly decrease in cases of accident reported.



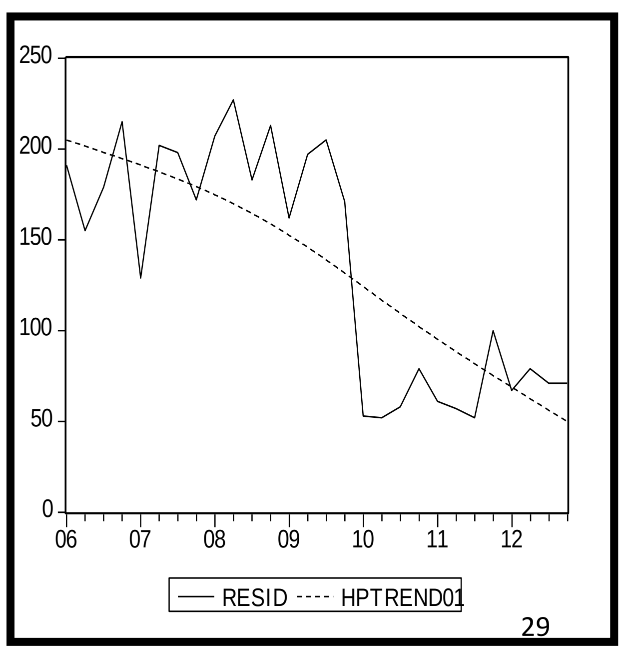


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Figure 1: Line graph of Motor Accident cases Figure 2: Scatter Plot of accident cases with trend

Least Squares Model:
The model for the relationship is: $X_t = 223.3016 - 6.025725t$ (8)
There is quarterly decrease of six reported cases of auto-crash.

Table 3: Autocorrelation and Partial autocorrelation Functions.

<table>
<tr><th>Autocorrelation</th><th>Partial Correlation</th><th></th><th>AC</th><th>PAC</th><th>Q-Stat</th><th>Prob</th></tr>
<tr><td>****| . |</td><td>****| . |</td><td>1</td><td>-0.578</td><td>-0.578</td><td>9.7362</td><td>0.002</td></tr>
<tr><td>. | . |</td><td>***| . |</td><td>2</td><td>0.043</td><td>-0.438</td><td>9.7924</td><td>0.007</td></tr>
<tr><td>. | . |</td><td>***| . |</td><td>3</td><td>0.033</td><td>-0.343</td><td>9.8260</td><td>0.020</td></tr>
<tr><td>. | . |</td><td>. *| . |</td><td>4</td><td>0.061</td><td>-0.157</td><td>9.9485</td><td>0.041</td></tr>
<tr><td>.**| . |</td><td>***| . |</td><td>5</td><td>-0.196</td><td>-0.379</td><td>11.286</td><td>0.046</td></tr>
<tr><td>. |*** |</td><td>. |**. |</td><td>6</td><td>0.425</td><td>0.261</td><td>17.872</td><td>0.007</td></tr>
<tr><td>****| . |</td><td>. *| . |</td><td>7</td><td>-0.496</td><td>-0.121</td><td>27.294</td><td>0.000</td></tr>
<tr><td>. |**. |</td><td>. | . |</td><td>8</td><td>0.275</td><td>0.011</td><td>30.354</td><td>0.000</td></tr>
<tr><td>. *| . |</td><td>. *| . |</td><td>9</td><td>-0.074</td><td>-0.093</td><td>30.586</td><td>0.000</td></tr>
<tr><td>. |* . |</td><td>. | . |</td><td>10</td><td>0.070</td><td>0.009</td><td>30.806</td><td>0.001</td></tr>
<tr><td>.**| . |</td><td>.**| . |</td><td>11</td><td>-0.211</td><td>-0.243</td><td>32.973</td><td>0.001</td></tr>
<tr><td>. |*** |</td><td>. | . |</td><td>12</td><td>0.331</td><td>-0.056</td><td>38.655</td><td>0.000</td></tr>
</table>

The correlogram plot shows a sharp decay to zero from lag 1. The data is non-stationary.

Autoregressive Integrated Moving Average (ARIMA (1,1,1))
The data is non-stationary hence, first order seasonal differencing to make the data stationary

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Table 4**: ARIMA Model Parameters**

				Estimate	SE	T	Sig.
Autocrash-Model_1	Auto-crash	Constant		-1.434	9.500	-.151	.881
		AR	Lag 1	.280	.450	.621	.541
		Difference		1			
		MA	Lag 1	.662	.368	1.798	.085
	Time	Numerator	Lag 0	-.211	.588	-.359	.723

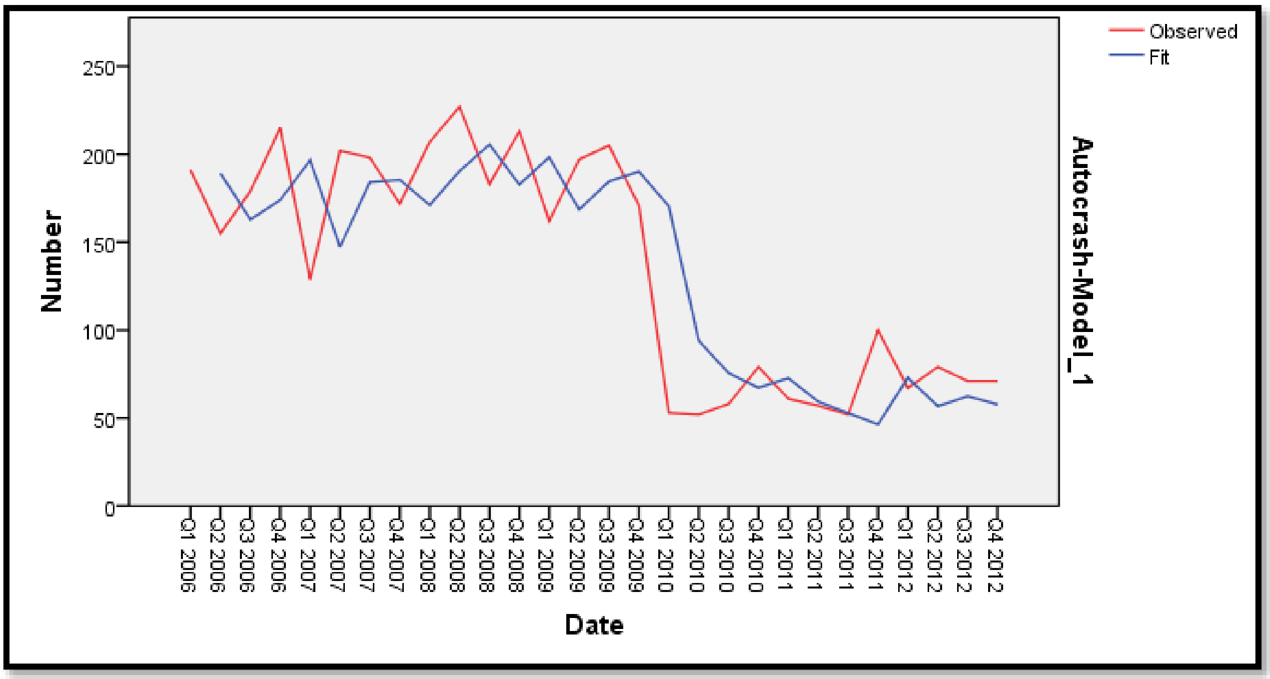

Figure 3: Model fitting using ARIMA and original data.

SEASONAL INDICES

Sample: 2006:1 2012:4
Included observations: 28
Ratio to Moving Average
Original Series: RESID
Adjusted Series: RESIDSA

Scaling Factors:	
1.	0.836378
2.	1.001986
3.	0.996717
4.	1.197192

5.

RESULTS/FINDINGS AND DISCUSSION

RESULTS

Least Squares model, $X_t = 223.3016 - 6.025725_t$ revealed a quarterly decrease of six (6) in the number of auto-crash cases reported, buttressed by Autoregressive Integrated Moving Average ARIMA (1,1,1) in table 4 and figure 3. This result suggests that FRSCN has been effective in its effort to reducing motor accident cases in the state of Osun; however, the corporation needs adequate supervision for better performance and effective public enlightenments for road users as posited by researches (Onuka and Akinyemi, 2012; Folorunso *et al.*, 2013).

It was also discovered from the seasonal indices that motor accident is prevalent during the fourth quarter (October, November, and December) typically referred to as "Ember Months". This can be attributed to impatient attitude of drivers especially; commercial drivers who are always in quest for passengers for the quick turn-over during the yuletide. This is in agreement with the submission of (Atubi, 2012) that attributed high rate of auto-crash to drivers' impatience. The correlogram demonstrated in stem-and-leave graph in table 4, and the ARIMA result shows that a is noticeable negative trend. The seasonal indices also isolated the first quarter of the year (January, February, and March) as the month when motor accident least occur.

IMPLICATION TO RESEARCH AND PRACTICE

Positive impact of FRSCN in its effort to reducing the frequency of auto-crash in the state of Osun has been revealed. It is recommended that adequate support be given to the commission in terms of procurement of modern equipments,, and adequate training for corps member for better service delivery.Drivers are advised to always drive with cautions especially during months towards year ending and during other festivals when there is possibility of increased demand for their services in other to reduce the frequency of auto-crash. Drivers should also endeavor to obey traffic rules.

CONCLUSION

Adducing from the foregoing, it is concluded that the effort of Road Safety Commission of Nigeria (FRSCN) in combating auto-crash on highways and roads in the state of Osun has been yielding positive results. It is also concluded that occurrence of Auto-crash is very prevalent in the "Ember Months" i.e. in the months of October, November, and December.

FUTURE RESEARCH

Since a similar research had been carried out in Osun State, Lagos State, other states in the South Western States of Nigeria. This will enable the Federal Road Safety Corporation in those states and other states with similar traffic volume to understand probable means/ways of reducing auto-crash and loss of lives on Nigeria roads.

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