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CONSEQUENCES OF ROAD TRAFFIC ACCIDENT IN NIGERIA: TIME SERIES APPROACH

F.B. Adebola
Department of Statistics
Federal University of Technology Akure.
Nigeria.

Ridwan A Sanusi
Department of Mathematics and Statistics
King Fahd University of Petroleum and Minerals,
Saudi Arabia.

N.A. Adegoke
Department of Statistics
Federal University of Technology Akure.
Nigeria.

Abstract: Road traffic accident in Nigeria is increasing at a worrying rate and has raised one of the country major concerns. We provided appropriate and suitable time series model for the consequences of road accident, the injured, killed and total casualty of the road accident in Nigeria. The most widely used conventional method, Autoregressive Integrated Moving Average (ARIMA) model of time series, also known as Box-Jenkins method is applied to yearly data on the consequences of road accident data in Nigeria from 1960-2013 to determine patterns of road traffic accident consequences; injured, killed and total casualty of the road accident along the Nigeria motorway. Appropriate models are developed for the accident consequences; injured, killed and total casualty. ARIMA (0; 2; 1) model is obtained for the injury and total casualty consequences, whilst ARIMA(1,2,2) model is obtained for the killed consequences, using the data from 1960-2011. The adequacy and the performance of the model are tested on the remaining data from 2012 to 2013. Seven years forecast are provided using the developed models and showed that road traffic accident consequences examined; injured, killed and total casualty would continue to increase on average.

Keywords: ARIMA; forecast; injured; killed; casualty

1. INTRODUCTION

Road Traffic Accident occurs when there is collision of vehicle with another vehicle, pedestrian and animals among other, which at times result in injury, loss of property and death. As mentioned in [11], road traffic accident leads to approximately two million killed and approximately ten million injuries annually. Also, an estimated value of 3000 people die in the world as a result of road traffic accidents daily. A prediction of global leading causes of killed from 2008 to 2030 by World Health Organization revealed that, if current trends and patterns continue, road traffic accidents will increase from ninth to fifth of world leading cause of killed 3.6% of global killed, up from 2.2% in 2004 [11]. While, disability-adjusted life years will rise from ninth with 2.7% of total disability-adjusted life in 2004 to third and 4.9% of total disability-adjusted life in 2030 [10].

Nigeria, the most populous black country, has the highest rate of mortality from road accidents in the world according to statistics compiled by the Federal Road Safety Commission **(FRSC)**. The country leads 43 other nations with killed in 10,000 vehicle crashes. Ethiopia ranked second with 219 killed per 10,000 vehicles while Malawi, took the third position and Ghana took the fourth position with 183 and 178 killed respectively [1].

Road traffic accidents is one of the leading causes of death among older children and economically active adults between the ages 30 and 49 years ([8];[9]; [6]). Considering the importance of the road and the increased level of road traffic accidents in recent years along the Nigeria roads, this study aimed at characterizing the road traffic accident in Nigeria by providing appropriate models that explain the consequences of killed, injured and the total casualty from road accident in the country so as to provide an enabling base for the development of countermeasures by the government and the traffic control agents to reduce incidences of road traffic accident on the road.

Time series analysis encompases methods for analyzing data ordered in time in order to develop appropriate model and other characteristics of the time ordered data. It is commonly used in the fields of business, economics, finance, agriculture among others, as appropriate tool for model building. It systematics examine the ordered data with the aim of studying dynamic regularities that may enable forecasting future or even controlling the variable, the forecast model will then be used to predict future values based on previously observed values. In theory, Auto-regressive Integrated Moving Averages ARIMA Models are the most universal class of models for forecasting a time series data. As proposed by Box and Jenkins, that in general, forecasting based on ARIMA models comprises of three different steps: Model Identification, Parameter estimation and Diagnostic checking. Until a desirable model for the data is identified, the three steps will be repeated [3]. The method of Box and Jenkins dictates an iterative process requiring a sound understanding of time series analysis technique, some degree of judgement and many rounds of trials [13].

Numerous works have been done on the analysis of Road accidents. [5] examined road accidents in Kuwait, he used an ARIMA model and compared it with ANN to predict killed in Kuwait, he concluded that ANN was better in case of long term series without seasonal fluctuations of accidents or autocorrelations' components. [4] used Bayesian Model for ranking hazardous road sites, their model made use of all relevant information per accident location, including the total number of accidents and the number of killed, as well as the number of slight and serious injuries. Moreover, the model included the use of a cost function to rank the sites with respect to their total expected cost to society.

A procedure of Road Traffic Injury (RTI) in China by using RTI data from 1951 to 2003 was established by [12]. A series of predictive equations on RTI were established based on ARIMA models. They concluded that time series models thus established proves to be of significant usefulness in RTI prediction. Two time series techniques; ARMA and Holt-Winters (HW) algorithm to predict annual motor vehicle crash killed were used by [7]. They concluded that the values predicted by ARMA models are a little bit higher than the ones obtained by HW algorithm. Intervention analysis with univariate Box-Jenkins method to identify whether a change in a particular policy had made an impact on the trends in killed and fatality rates in Illinois was used [2]. He developed ARIMA forecasting model for future trends in motorway killed in an effort to provide assistance to policy development in reducing fatality rates in Illinois.

Time series analysis have been used in many fields of research and road safety is no exception. The results of this research would also add to the many research works carried out in road safety.

2. MATERIALS AND METHODS

Data used for the study is a secondary data, it was collected on yearly basis from the office of the Federal Road Safety Corps of Nigeria for the period 1960 to 2013. The data represents the total number of registered consequences of injuries, killed and total casualty for the period under study. The **Box and Jenkins** approach for time series analysis was employed for data analysis. According to **Box and Jenkins**, as mentioned above, the steps include, the identification of appropriate model for the data under study, estimation of model parameters, model diagnostic and adequacy checking and lastly, the model, if found appropriate would be used for forecasting. Data from 1960 to 2011 are used for models building, while, data from 2012 to 2013 are used for models validation and forecast values of the best models for the variables under study are obtained from 2014 to 2020. Meanwhile, It is worth mentioning here that because of the volume of the work, the best models out of several competing models that explain the variables under study are only included in the work.

3. MODEL BUILDING

The first step in model building is to obtain the time plot of the data. This will give us an insight of the behaviour of the series. Figures (1a, 1b, and 1c) show the time series plot of injuries consequences, killed consequences and total casualty from the total number of road accident in Nigeria.

The plots exhibit upward and downward movement for all the three variables under study, with some significant upward and downward trends at some parts of the series. The mean and variance of the variables are not stable and varies with time.

The autocorrelation function of the studied variables has shown in Figure (2a), Figure (2b) and Figure (3) describe the correlation between values of the studied variables at different points in time, as a function of the time difference. The first several autocorrelations are persistently large and trailed off to zero rather slowly for all the three variables and their spikes also went of the autocorrelations limit at lag 13 the variables under study.

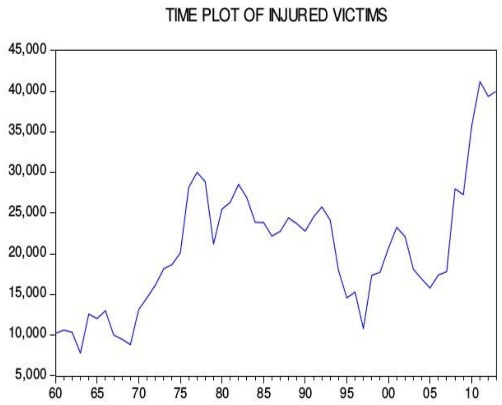


Figure 1a: Time Series Plot of Injured Victims from Road Accidents in Nigeria.

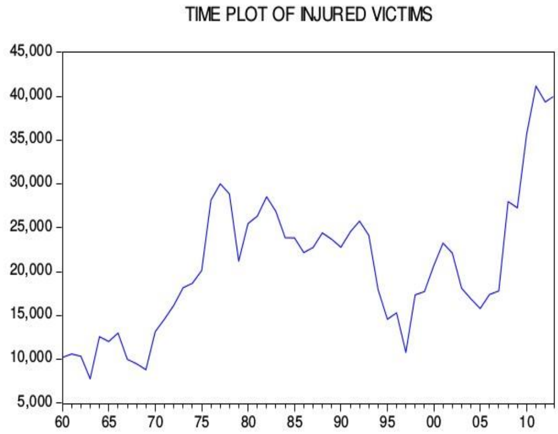
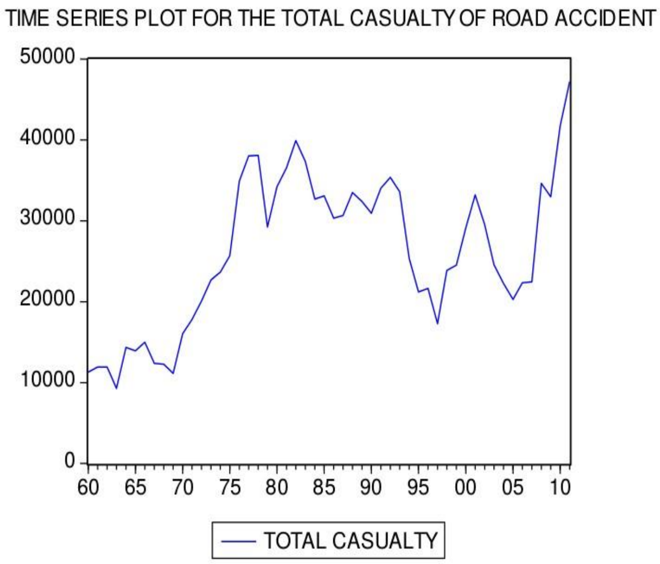
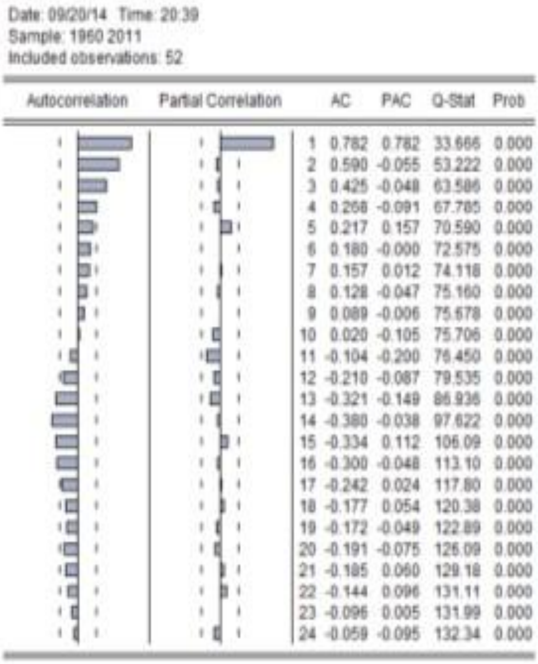


Figure 1b: Time Series Plots of killed from Road Accidents in Nigeria.



Figures 1c: Time Series Plot of Total Casualty from Road Accidents in Nigeria.

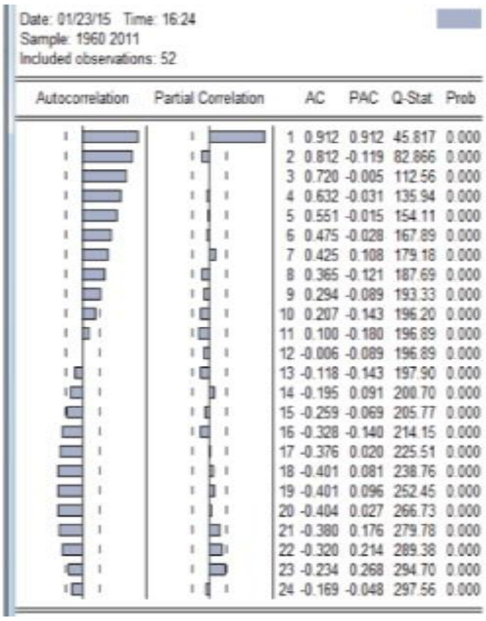
The Augmented Dickey Fuller test as given in Figures (4a and 4b) and Figure (5) give a p-value of 0.91 for the injured



Date: 09/20/14 Time: 20:39
Sample: 1960 2011
Included observations: 52

	AC	PAC	Q-Stat	Prob
1	0.782	0.782	33.666	0.000
2	0.590	-0.055	53.222	0.000
3	0.425	-0.048	63.586	0.000
4	0.268	-0.091	67.785	0.000
5	0.217	0.157	70.590	0.000
6	0.180	-0.000	72.575	0.000
7	0.157	0.012	74.118	0.000
8	0.128	-0.047	75.160	0.000
9	0.089	-0.006	75.678	0.000
10	0.020	-0.105	75.706	0.000
11	-0.104	-0.200	76.450	0.000
12	-0.210	-0.087	79.535	0.000
13	-0.321	-0.149	86.936	0.000
14	-0.380	-0.038	97.622	0.000
15	-0.334	0.112	106.09	0.000
16	-0.300	-0.048	113.10	0.000
17	-0.242	0.024	117.80	0.000
18	-0.177	0.054	120.38	0.000
19	-0.172	-0.049	122.89	0.000
20	-0.191	-0.075	126.09	0.000
21	-0.185	0.060	129.18	0.000
22	-0.144	0.096	131.11	0.000
23	-0.096	0.005	131.99	0.000
24	-0.059	-0.095	132.34	0.000

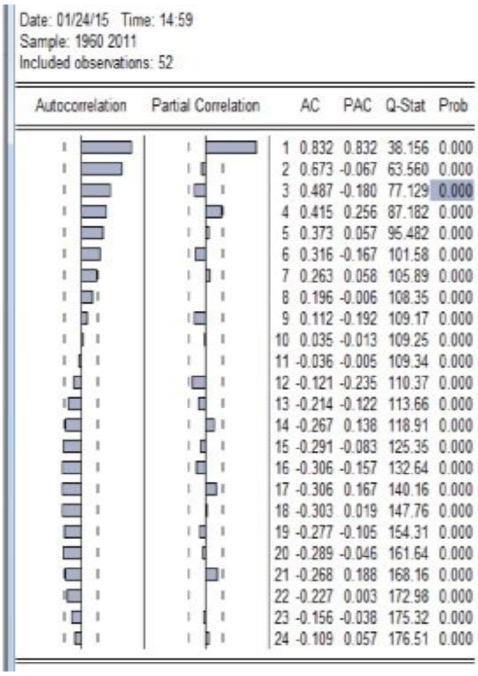
Figure 2a: Correlogram Plot of the Injured Victims Nigeria



Date: 01/23/15 Time: 16:24
Sample: 1960 2011
Included observations: 52

	AC	PAC	Q-Stat	Prob
1	0.912	0.912	45.817	0.000
2	0.812	-0.119	82.866	0.000
3	0.720	-0.005	112.56	0.000
4	0.632	-0.031	135.94	0.000
5	0.551	-0.015	154.11	0.000
6	0.475	-0.028	167.89	0.000
7	0.425	0.108	179.18	0.000
8	0.365	-0.121	187.69	0.000
9	0.294	-0.089	193.33	0.000
10	0.207	-0.143	196.20	0.000
11	0.100	-0.180	196.89	0.000
12	-0.006	-0.089	196.89	0.000
13	-0.118	-0.143	197.90	0.000
14	-0.195	0.091	200.70	0.000
15	-0.259	-0.069	205.77	0.000
16	-0.328	-0.140	214.15	0.000
17	-0.376	0.020	225.51	0.000
18	-0.401	0.081	238.76	0.000
19	-0.401	0.096	252.45	0.000
20	-0.404	0.027	266.73	0.000
21	-0.380	0.176	279.78	0.000
22	-0.320	0.214	289.38	0.000
23	-0.234	0.268	294.70	0.000
24	-0.169	-0.048	297.56	0.000

Figure 2b: Correlogram Plot of the killed from Road Accidents in Nigeria



Date: 01/24/15 Time: 14:59
Sample: 1960 2011
Included observations: 52

	AC	PAC	Q-Stat	Prob
1	0.832	0.832	38.156	0.000
2	0.673	-0.067	63.560	0.000
3	0.487	-0.180	77.129	0.000
4	0.415	0.256	87.182	0.000
5	0.373	0.057	95.482	0.000
6	0.316	-0.167	101.58	0.000
7	0.263	0.058	105.89	0.000
8	0.196	-0.006	108.35	0.000
9	0.112	-0.192	109.17	0.000
10	0.035	-0.013	109.25	0.000
11	-0.036	-0.005	109.34	0.000
12	-0.121	-0.235	110.37	0.000
13	-0.214	-0.122	113.66	0.000
14	-0.267	0.138	118.91	0.000
15	-0.291	-0.083	125.35	0.000
16	-0.306	-0.157	132.64	0.000
17	-0.306	0.167	140.16	0.000
18	-0.303	0.019	147.76	0.000
19	-0.277	-0.105	154.31	0.000
20	-0.289	-0.046	161.64	0.000
21	-0.268	0.188	168.16	0.000
22	-0.227	0.003	172.98	0.000
23	-0.156	-0.038	175.32	0.000
24	-0.109	0.057	176.51	0.000

Figure 3: Correlogram Plot of the Total Casualty from Road Accidents in Nigeria.

Null Hypothesis: IJ has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		0.970792	0.9100
Test critical values:	1% level	-2.611094	
	5% level	-1.947381	
	10% level	-1.612725	

*MacKinnon (1996) one-sided p-values.

Figure 4a: Unit Root Test of Injured consequences from Road Accidents in Nigeria.

Null Hypothesis: KL has a unit root
Exogenous: None
Lag Length: 0 (Automatic based on SIC, MAXLAG=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.109354	0.6412
Test critical values:	1% level	-2.611094	
	5% level	-1.947381	
	10% level	-1.612725	

*MacKinnon (1996) one-sided p-values.

Figure 4b: Unit Root Test of killed from Road Accidents in Nigeria.

victims, 0.6412 for the killed consequences and 0.8779 for the total casualty, these indicate the presence of unit roots for the series. All these aforementioned characteristics of the studied variables show that the series are not stationary, thus require differencing.

Null Hypothesis: TOTC has a unit root
Exogenous: None
Lag Length: 0 (Automatic based on SIC, MAXLAG=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		0.775684	0.8779
Test critical values:	1% level	-2.611094	
	5% level	-1.947381	
	10% level	-1.612725	

*MacKinnon (1996) one-sided p-values.

Figure (5): Unit Root Test of total casualty from Road Accidents in Nigeria.

Figures (6a, 6b, and 6c), show the second difference of the studied variables, the series look more stable around the mean, which shows that the variables are now stationary. All the three variables become stationary after taken second non-seasonal difference

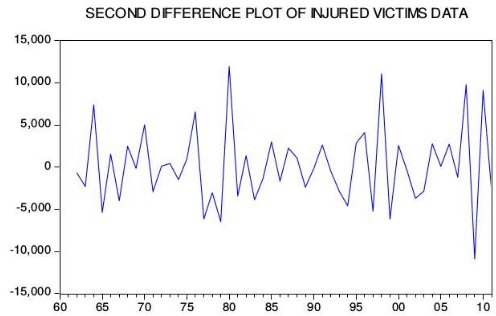


Figure 6a: Time Series Plot of the Second Difference for the Injured Victims consequences of Road Accidents.

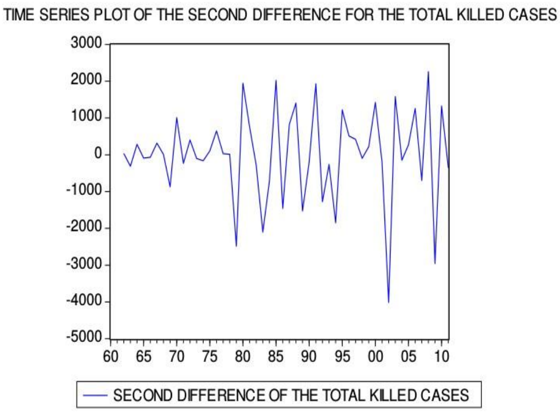


Figure 6b: Time Series Plot of the Second Difference for the killed consequences of Road Accidents.

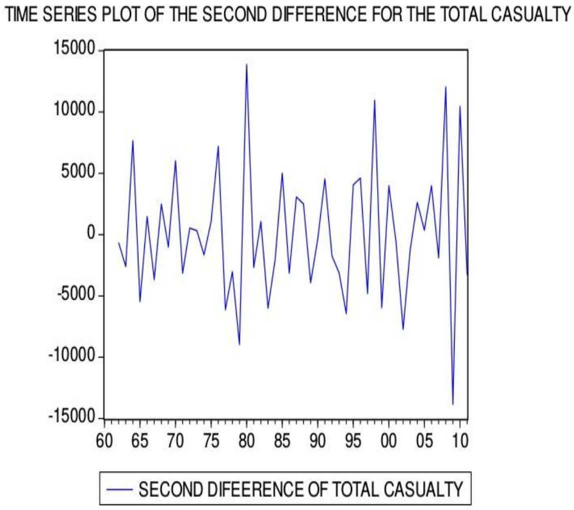
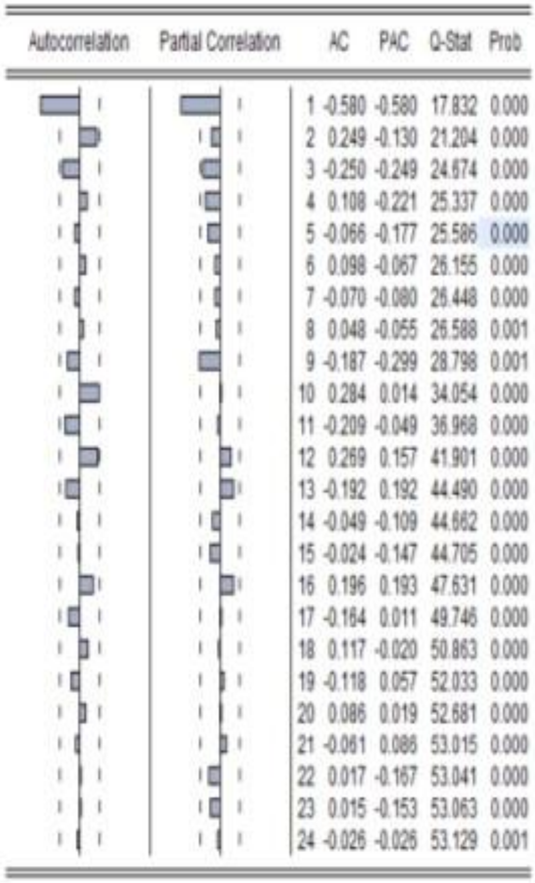


Figure 6c: Time Series Plot of the Second Difference for the Injured Victims, killed and Total Casualty consequences of Road Accidents.



Date: 09/20/14 Time: 21:51
Sample: 1960 2011
Included observations: 50

	AC	PAC	Q-Stat	Prob
1	-0.580	-0.580	17.832	0.000
2	0.249	-0.130	21.204	0.000
3	-0.250	-0.249	24.674	0.000
4	0.108	-0.221	25.337	0.000
5	-0.066	-0.177	25.586	0.000
6	0.098	-0.067	26.155	0.000
7	-0.070	-0.080	26.448	0.000
8	0.048	-0.055	26.588	0.001
9	-0.187	-0.299	28.798	0.001
10	0.284	0.014	34.054	0.000
11	-0.209	-0.049	36.968	0.000
12	0.269	0.157	41.901	0.000
13	-0.192	0.192	44.490	0.000
14	-0.049	-0.109	44.662	0.000
15	-0.024	-0.147	44.705	0.000
16	0.196	0.193	47.631	0.000
17	-0.164	0.011	49.746	0.000
18	0.117	-0.020	50.863	0.000
19	-0.118	0.057	52.033	0.000
20	0.086	0.019	52.681	0.000
21	-0.061	0.086	53.015	0.000
22	0.017	-0.167	53.041	0.000
23	0.015	-0.153	53.063	0.000
24	-0.026	-0.026	53.129	0.001

Figure 7a: Correlogram Plot of the Second Difference for the Injured Victims consequences of Road Accidents.

Date: 01/23/15 Time: 16:48
Sample: 1960 2011
Included observations: 50

Lag	AC	PAC	Q-Stat	Prob
1	-0.400	-0.400	8.5012	0.004
2	-0.088	-0.296	8.9241	0.012
3	-0.012	-0.230	8.9316	0.030
4	-0.029	-0.227	8.9803	0.062
5	0.098	-0.072	9.5396	0.089
6	-0.049	-0.084	9.6802	0.139
7	-0.066	-0.154	9.9431	0.192
8	0.111	-0.009	10.700	0.219
9	-0.112	-0.131	11.490	0.244
10	0.204	0.148	14.206	0.164
11	-0.056	0.156	14.416	0.211
12	-0.086	0.093	14.920	0.246
13	-0.011	0.022	14.929	0.312
14	-0.034	-0.056	15.014	0.377
15	0.140	0.076	16.461	0.352
16	-0.056	0.021	16.704	0.405
17	-0.016	0.061	16.725	0.473
18	0.005	-0.002	16.727	0.542
19	-0.038	-0.051	16.847	0.600
20	0.010	-0.133	16.857	0.662
21	0.046	-0.062	17.047	0.708
22	-0.043	-0.044	17.219	0.751
23	0.009	-0.035	17.226	0.798
24	0.003	0.014	17.227	0.839

Figure 7b: Correlogram Plots of the Second Difference for the killed consequences of Road Accidents.

Date: 01/24/15 Time: 15:04
Sample: 1960 2011
Included observations: 50

Lag	AC	PAC	Q-Stat	Prob
1	-0.545	-0.545	15.761	0.000
2	0.208	-0.127	18.102	0.000
3	-0.197	-0.200	20.252	0.000
4	0.017	-0.250	20.269	0.000
5	0.061	-0.079	20.487	0.001
6	0.013	0.012	20.498	0.002
7	-0.065	-0.107	20.754	0.004
8	0.038	-0.063	20.843	0.008
9	-0.096	-0.132	21.423	0.011
10	0.113	-0.050	22.246	0.014
11	0.018	0.076	22.268	0.022
12	0.045	0.152	22.409	0.033
13	-0.086	0.050	22.929	0.043
14	-0.051	-0.069	23.117	0.058
15	-0.013	-0.109	23.130	0.081
16	0.135	0.071	24.531	0.079
17	-0.052	0.064	24.747	0.101
18	-0.024	-0.048	24.796	0.131
19	-0.022	-0.019	24.836	0.166
20	-0.034	-0.068	24.939	0.204
21	0.056	-0.090	25.216	0.238
22	-0.027	-0.129	25.283	0.284
23	0.007	-0.120	25.287	0.336
24	0.023	-0.013	25.341	0.387

Figure 7c: Correlogram Plots of the Second Difference for the Total Casualty consequences of Road Accidents.

The autocorrelation functions of the second difference for the studied variables, has shown in Figures (7a, 7b, and 7c), also confirm that the second difference are now stationary. Also, the Augmented Dickey Fuller test as given in Figures (8a, 8b, and 8c) gave a p-value of 0.000 for the Injured victims, 0.0004 for the killed consequences and 0.000 for the total casualty, these also indicate the absence of unit roots in the series, which confirm that the second differenced series are stationary.

UNIT ROOT TEST AFTER SECOND DIFFERENCE.

Null Hypothesis: DIJN has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-13.42695	0.0000
Test critical values:	1% level	-2.613010	
	5% level	-1.947665	
	10% level	-1.612573	

*MacKinnon (1996) one-sided p-values.

Figure 8a: Unit Root Test for the Second Difference for the Injured Victims consequences of Road Accidents.

Null Hypothesis: DKL has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic based on SIC, MAXLAG=2)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.918669	0.0004
Test critical values:	1% level	-4.004425	
	5% level	-3.098896	
	10% level	-2.690439	

*MacKinnon (1996) one-sided p-values.
Warning: Probabilities and critical values calculated for 20 observations and may not be accurate for a sample size of 14

Figure 8b: Unit Root Tests for the Second Difference for the killed consequences of Road Accidents.

Null Hypothesis: DTOTC has a unit root
Exogenous: None
Lag Length: 0 (Automatic based on SIC, MAXLAG=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-12.76199	0.0000
Test critical values:	1% level	-2.613010	
	5% level	-1.947665	
	10% level	-1.612573	

*MacKinnon (1996) one-sided p-values.

Figure 8c: Unit Root Tests for the Second Difference for the Total Casualty consequences of Road Accidents.

By comparing the autocorrelations functions with their error limits, the only significant autocorrelations are at lag 1 for all the three variables, that is, the autocorrelations cut off after lag one which shows the existence of MA(1) behavior. Similarly, the partial autocorrelations also cut off after lag one for the injured consequences and total casualty, this indicates the existence of AR(1) for the two variables (that is, injured consequences and total casualty). Meanwhile, the partial autocorrelation cuts off after lag two for the killed consequences, which shows the existence of AR(1) and AR(2) for the variable. Based on the features of the correlogram plots of the stationary series, the following model in Figure (1), are suggested.

Injured Victims	killed	Total Casualty
ARIMA(0,2,1)	ARIMA(0,2,2)	ARIMA(0,2,1)
ARIMA(1,2,0)	ARIMA(1,2,2)	ARIMA(1,2,0)
ARIMA(1,2,1)	ARIMA(1,2,3)	ARIMA(1,2,1)

Table 1: Suggested Models Based on the Correlogram Plots

Each of the model is assessed based on its parameter estimates, the corresponding diagnostics of the residuals, the AIC and SIC in order to select the best model for forecasting into the future. Meanwhile, out of all the competing models that explain the variable of interest, the best models are; ARIMA(0,2,1) for the Injured Victims consequences, ARIMA(1,2,2) for killed consequences and ARIMA(0,2,1) for the total casualty. The models are given in Figures (9a, 9b, and 10).

Time Series Models for the Injured Victims, killed and Total Casualty consequences of Road Accidents are given in Figures (9a, 9b, and 10), the models coefficients are significant and all the inverted AR roots satisfy the minimum stationarity condition, the invertibility condition of MA is satisfied and also. Also, the Durbin-Watson statistics is not far from 2, which implies that there is no serial correlation in the model residual, that is the model residual is not forecastable.

MODEL OUTPUT OF INJURED CASES, ARIMA(0,2,1)

Dependent Variable: D(IJ,2)
Method: Least Squares
Date: 09/20/14 Time: 16:27
Sample (adjusted): 1962 2011
Included observations: 50 after adjustments
Convergence achieved after 8 iterations
MA Backcast: 1961

Variable	Coefficient	Std. Error	t-Statistic	Prob.
MA(1)	-0.954388	0.031563	-30.23748	0.0000

R-squared	0.438091	Mean dependent var	101.5200
Adjusted R-squared	0.438091	S.D. dependent var	4692.813
S.E. of regression	3517.759	Akaike info criterion	19.18883
Sum squared resid	6.06E+08	Schwarz criterion	19.22707
Log likelihood	-478.7208	Hannan-Quinn criter.	19.20340
Durbin-Watson stat	1.861128		

Inverted MA Roots	.95

Figure 9a: Time Series Models for the Injured Victims consequences of Road Accidents.

Dependent Variable: D(KL,2)
Method: Least Squares
Date: 01/23/15 Time: 16:50
Sample (adjusted): 1963 2011
Included observations: 49 after adjustments
Convergence achieved after 20 iterations
Backcast: 1961 1962

Variable	Coefficient	Std. Error	t-Statistic	Prob.
AR(1)	-0.832466	0.089079	-9.345282	0.0000
MA(2)	-0.968707	0.040191	-24.10259	0.0000

R-squared	0.459802	Mean dependent var	-5.367347
Adjusted R-squared	0.448308	S.D. dependent var	1281.902
S.E. of regression	952.1448	Akaike info criterion	16.59527
Sum squared resid	42609245	Schwarz criterion	16.67249
Log likelihood	-404.5841	Durbin-Watson stat	1.925381

Inverted AR Roots	-.83	
Inverted MA Roots	.98	-.98

Figure 9b: Time Series Models for the killed consequences of Road Accidents.

Date: 01/24/15 Time: 14:57
Sample (adjusted): 1962 2011
Included observations: 50 after adjustments
Convergence achieved after 9 iterations
Backcast: 1961

Variable	Coefficient	Std. Error	t-Statistic	Prob.
MA(1)	-0.959777	0.028209	-34.02330	0.0000

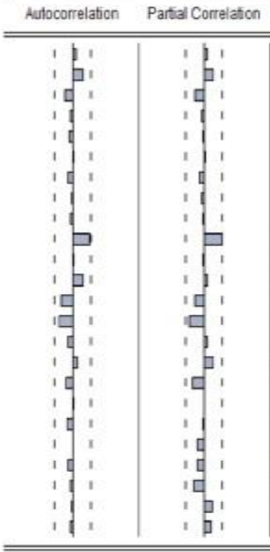
R-squared	0.427033	Mean dependent var	96.96000
Adjusted R-squared	0.427033	S.D. dependent var	5545.392
S.E. of regression	4197.560	Akaike info criterion	19.54219
Sum squared resid	8.63E+08	Schwarz criterion	19.58043
Log likelihood	-487.5548	Durbin-Watson stat	1.815913

Inverted MA Roots	.96

Figure 10: Time Series Models for the consequences of Road Accidents

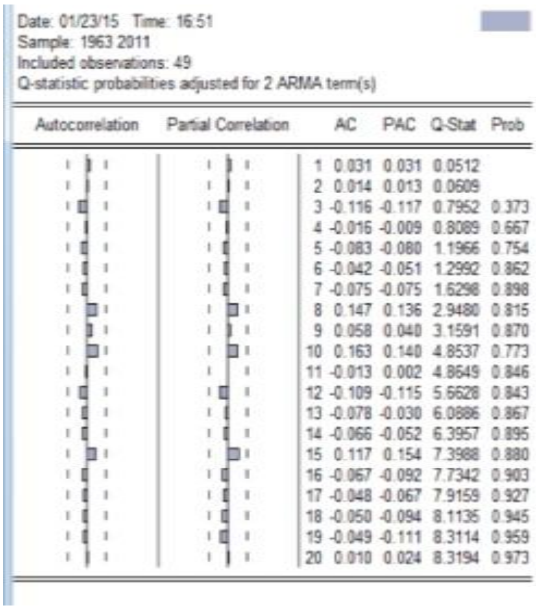
Also, all the Q-Stat of the correlogram plot of models residuals are greater than 0.05 for the lags as given in Figures (11a and 11b) and Figure (12), these imply that the model residuals are White-Noise, that is adjacent observations are not related (random) and which support the fact that the models may be the appropriate models for the observed time series.

Date: 09/20/14 Time: 17:56
Sample: 1960 2011
Included observations: 50
Q-statistic probabilities adjusted for 1 ARMA term



	AC	PAC	Q-Stat	Prob
1	0.051	0.051	0.1359	
2	0.157	0.154	1.4640	0.226
3	-0.127	-0.145	2.3497	0.309
4	-0.031	-0.043	2.4053	0.493
5	-0.063	-0.016	2.6353	0.621
6	0.014	0.014	2.6474	0.754
7	-0.069	-0.070	2.9318	0.817
8	-0.021	-0.032	2.9595	0.889
9	-0.036	-0.011	3.0434	0.932
10	0.273	0.282	7.8818	0.546
11	0.024	-0.013	7.9200	0.637
12	0.162	0.064	9.7194	0.556
13	-0.182	-0.155	12.051	0.442
14	-0.216	-0.243	15.412	0.282
15	-0.068	0.060	15.754	0.329
16	0.080	0.145	16.243	0.366
17	-0.108	-0.174	17.167	0.375
18	0.024	-0.006	17.216	0.440
19	-0.086	-0.009	17.834	0.467
20	-0.001	-0.103	17.834	0.534
21	-0.080	-0.100	18.406	0.561
22	-0.029	-0.156	18.485	0.618
23	-0.013	0.116	18.501	0.676
24	-0.041	0.113	18.671	0.720

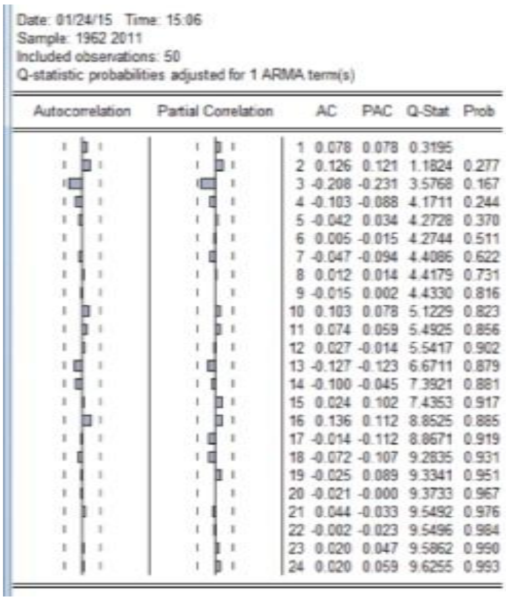
Figure 11a: Correlogram Plot of the Residuals for the Injured Victims killed of Road Accidents.



Date: 01/23/15 Time: 16:51
Sample: 1963 2011
Included observations: 49
Q-statistic probabilities adjusted for 2 ARMA term(s)

	AC	PAC	Q-Stat	Prob
1	0.031	0.031	0.0512	
2	0.014	0.013	0.0609	
3	-0.116	-0.117	0.7952	0.373
4	-0.016	-0.009	0.8089	0.667
5	-0.083	-0.080	1.1966	0.754
6	-0.042	-0.051	1.2992	0.862
7	-0.075	-0.075	1.6298	0.898
8	0.147	0.136	2.9480	0.815
9	0.058	0.040	3.1591	0.870
10	0.163	0.140	4.8537	0.773
11	-0.013	0.002	4.8649	0.846
12	-0.109	-0.115	5.6628	0.843
13	-0.078	-0.030	6.0886	0.867
14	-0.066	-0.052	6.3957	0.895
15	0.117	0.154	7.3988	0.880
16	-0.067	-0.092	7.7342	0.903
17	-0.048	-0.067	7.9159	0.927
18	-0.050	-0.094	8.1135	0.945
19	-0.049	-0.111	8.3114	0.959
20	0.010	0.024	8.3194	0.973

Figure 11b: Correlogram Plot of the Residuals for the killed of Road Accidents.

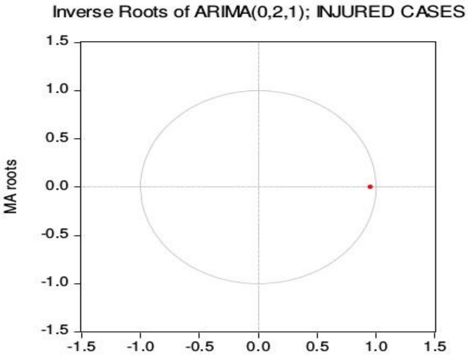


Date: 01/24/15 Time: 15:06
Sample: 1962 2011
Included observations: 50
Q-statistic probabilities adjusted for 1 ARMA term(s)

	AC	PAC	Q-Stat	Prob
1	0.078	0.078	0.3195	
2	0.126	0.121	1.1824	0.277
3	-0.208	-0.231	3.5768	0.167
4	-0.103	-0.088	4.1711	0.244
5	-0.042	0.034	4.2728	0.370
6	0.005	-0.015	4.2744	0.511
7	-0.047	-0.094	4.4086	0.622
8	0.012	0.014	4.4179	0.731
9	-0.015	0.002	4.4330	0.816
10	0.103	0.078	5.1229	0.823
11	0.074	0.059	5.4925	0.856
12	0.027	-0.014	5.5417	0.902
13	-0.127	-0.123	6.6711	0.879
14	-0.100	-0.045	7.3921	0.881
15	0.024	0.102	7.4353	0.917
16	0.136	0.112	8.8525	0.885
17	-0.014	-0.112	8.8671	0.919
18	-0.072	-0.107	9.2835	0.931
19	-0.025	0.089	9.3341	0.951
20	-0.021	-0.000	9.3733	0.967
21	0.044	-0.033	9.5492	0.976
22	-0.002	-0.023	9.5496	0.984
23	0.020	0.047	9.5862	0.990
24	0.020	0.059	9.6255	0.993

Figure 12: Correlogram Plot of the Total Casualty consequences of Road Accidents.

Figure 13a: Unit Root Test for the Injured Victims consequences of Road Accidents.



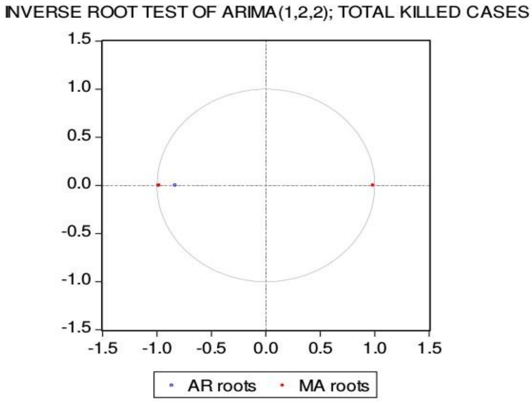


Figure 13b: Unit Root Test for the killed consequences of Road Accidents.

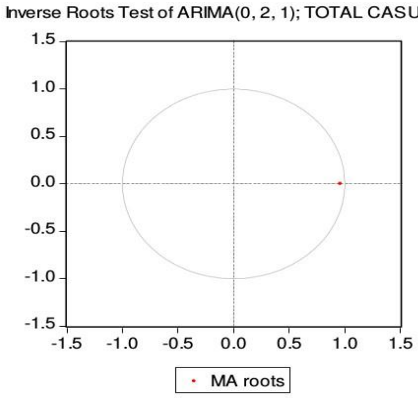


Figure 13c: Unit Root Test for the Total Casualty consequences of Road Accidents.

The unit roots tests of the models as given in Figures (13a, 13b, and 13c), show that the inverse roots of the models are within a unit circle, which confirmed that the models in Figures (9a, and 9b) and Figure (10) are stationary and invertible. Thus, the models can be written as general linear form

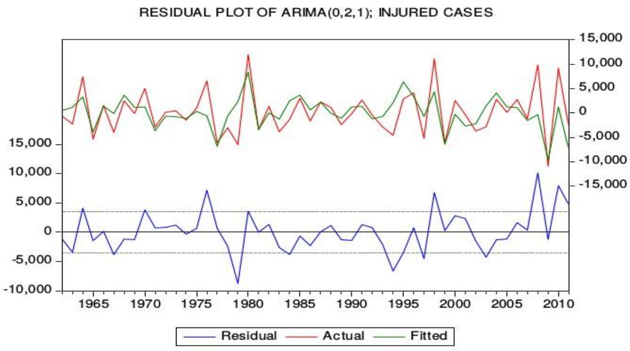


Figure 14a: Residual Plot for the Injured Victims consequences of Road Accidents.

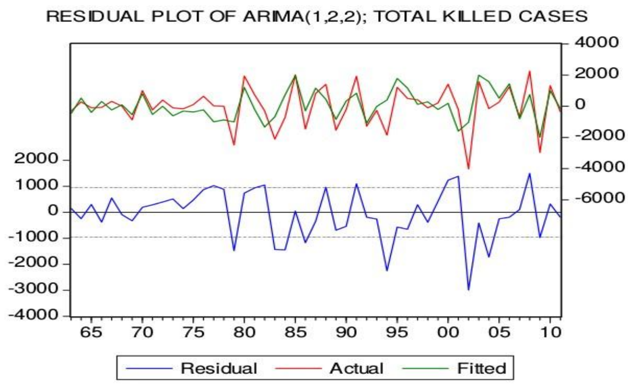


Figure 14b: Residual Plot for the killed consequences of Road Accidents.

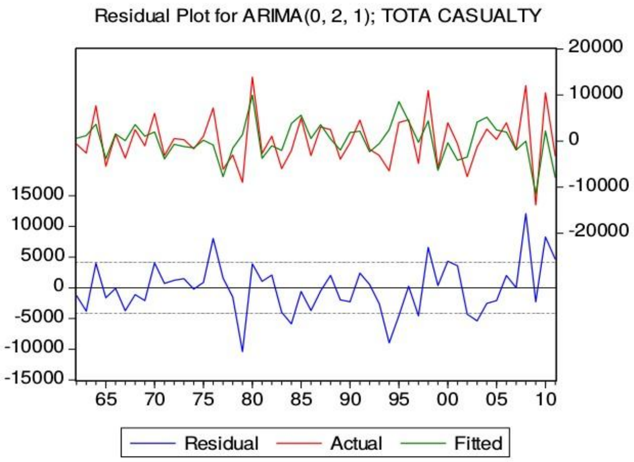
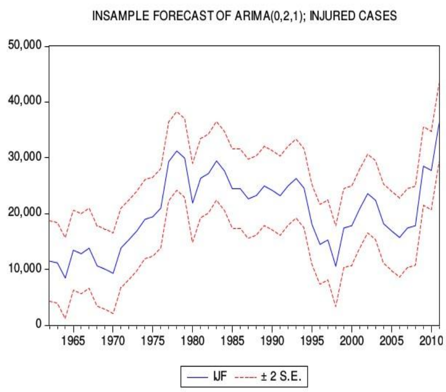


Figure 14c: Residual Plot for the Total Casualty consequences of Road Accidents.

The residual plots of the models as shown in Figures (14a, 14b, and 14c), also confirm that the models residuals are random and non-forecastable, which implies that the models are good.

Figures (15a, 15b, and 15c) gives the visual representation of the original Injured consequences, killed consequences and the Total casualty consequences, the data (blue line) and confidence interval (red

Figure 15a: In-sample Forecast Graph for the Injured cases.



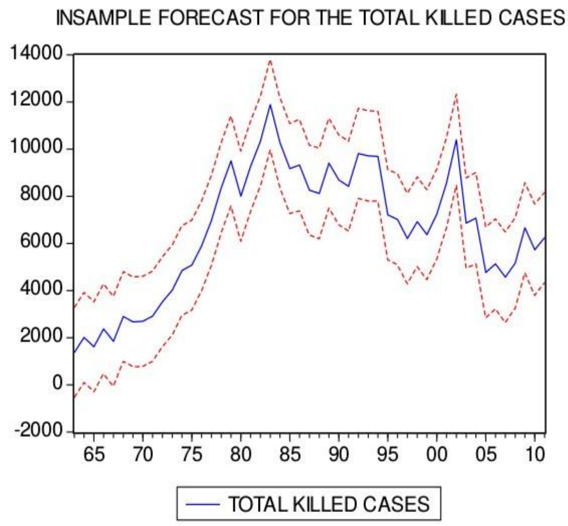


Figure 15b: In-sample Forecast Graph for the killed cases.

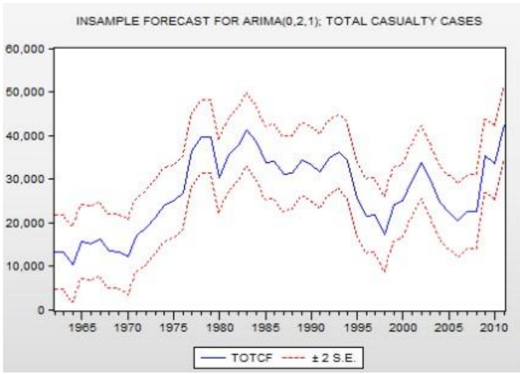


Figure 15c: In-sample Forecast Graph for the Total Casualties.

lines). The in-sample forecasts for the models fall within the 95% confidence Interval. Figures (16a, 16b, and 17) give the in-sample models evaluations, the bias proportion and variance proportion, which are used to check how far is the forecast mean from the mean of the actual series and how far is the forecast variance from the variance of the actual series respectively are very close to zero and comparatively much lower than the covariance proportion which measure the remaining systematic forecast error. Note, the sum of the bias proportion, variance proportion and the covariance proportion is 1.

Forecast: IJF
Actual: IJ
Forecast sample: 1960 2011
Adjusted sample: 1962 2011
Included observations: 50

Root Mean Squared Error	3482.404
Mean Absolute Error	2545.251
Mean Absolute Percentage Error	13.77604
Theil Inequality Coefficient	0.081381
Bias Proportion	0.000286
Variance Proportion	0.015474
Covariance Proportion	0.984240

Figure 16a: In-sample Forecast Evaluation for the Injured cases.

Forecast: KLF
Actual: KL
Forecast sample: 1960 2013
Adjusted sample: 1963 2013
Included observations: 51

Root Mean Squared Error	912.4187
Mean Absolute Error	682.1671
Mean Absolute Percentage Error	10.24490
Theil Inequality Coefficient	0.064911
Bias Proportion	0.009011
Variance Proportion	0.016297
Covariance Proportion	0.974692

Figure 16b: In-sample Forecast Evaluation for the killed cases.

Forecast: TOTCF
Actual: TOTC
Forecast sample: 1960 2011
Adjusted sample: 1962 2011
Included observations: 50

Root Mean Squared Error	4155.372
Mean Absolute Error	3159.498
Mean Absolute Percentage Error	12.78031
Theil Inequality Coefficient	0.073602
Bias Proportion	0.000689
Variance Proportion	0.001886
Covariance Proportion	0.997424

Figure 17: In-sample Forecast Evaluation for the Total Casualties

3.1 MODEL VALIDATION

Table 2: Validation Table for ARIMA(0,2,1) Model of Injured consequences.

Year	Injured consequences	Forecast	% Variation
2012	39348	42213.26	7.28%
2013	40057	43261.51	7.99%

After determining the best-fit model for the series and estimating related parameters, the third phase of Box-Jenkins fitting model was evaluated for series prediction. Using the ARIMA (0,2,1) model, the model predicted that in 2012 an approximately 42213.26 Injure consequences, this gives 7.28% percentage increase when compared with the real value of 39348 Injured consequences. Also, the model predicted that in 2013 an approximately 43261.51 Injure consequences, this gives 7.99% percentage increament when compared with the real value of 40057 Injured consequences as given in Table (2).

Table 3: Validation Table for ARIMA(1,2,2) Model of Killed consequences.

Year	killed consequences	Forecast	% Variation
2012	6092	6046.28	-0.75%
2013	6544	6236.27	-4.702%

Also, Table (3) gives the model validation for ARIMA (1,2,2) model. The model predicted that in 2012 an approximately 6046.28 killed consequences of accident, this gives 0.75% percentage decrease when compared with the real value of 6092 killed consequences. Also, the model predicted that in 2013 an approximately 6236.27 killed consequences, this gives 4.702% percentage decrease when compared with the real value of 6544 killed consequences.

Table 4: Validation Table for ARIMA(0,2,1) Model of Total Casualty.

Year	Total Casualy	Forecast	% Variation
2012	45440	46504.31	2.34%
2013	46601	46838.61	0.51%

Lastly, Table (4) gives the model validation for ARIMA (0,2,1) model. The model predicted that in 2012 an approximately 46504.31 Total casualty consequences of accident, this gives 2.34% percentage increase when compared with the real value of 4544 total casualty consequences. Also, the model predicted that in 2013 an approximately 46838.61 total casualty consequences, this gives 0.51% percentage increase when compared with the real value of 46601 killed consequences.

3.2 Models Forecasting

Table 5: Forecast Table for ARIMA(0,2,1) Model of Injured consequences.

Year	Lower Control Limit	Forecast	Upper Control Limit
2014	31660.6	44309.8	56959.2
2015	30375.7	45358.1	60340.4
2016	29235.8	46406.3	63576.8
2017	28186.1	47454.5	66722.9
2018	27195.4	48502.8	69810.2
2019	26243.8	49551.1	72858.3
2020	25318.2	50599.3	75880.4

Table 6: Forecast Table for ARIMA(1,2,2) Model of killed consequences.

Year	Lower Control Limit	Forecast	Upper Control Limit
2014	2775.5	6261.7	9747.9
2015	2299.2	6424.1	10549.0
2016	1853.8	6472.4	11091.0
2017	1481.3	6615.8	11750.2
2018	1107.5	6680.0	12252.5
2019	785.5	6810.1	12834.6
2020	455.6	6885.4	13315.2

Table 7: Forecast Table for ARIMA(0,2,1) Model of Total Casualty consequences.

Year	Lower Control Limit	Forecast	Upper Control Limit
2014	32833.4	47415.9	61998.3
2015	30053.2	47145.8	64238.5
2016	27649.7	46679.6	65709.6
2017	26135.3	46897.7	67660.1
2018	24745.0	47274.3	69803.6
2019	22911.4	47098.1	71284.9
2020	21177.0	46794.0	72410.9

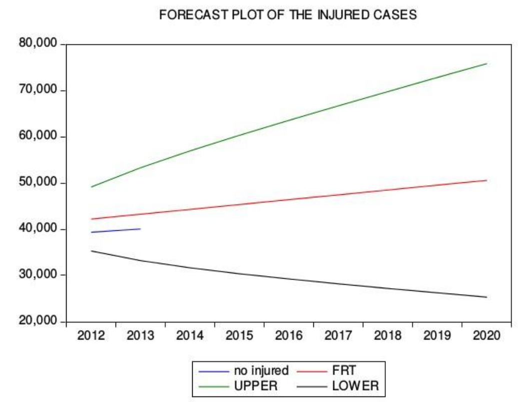


Figure 18a: Forecast Plot for the Injured cases.

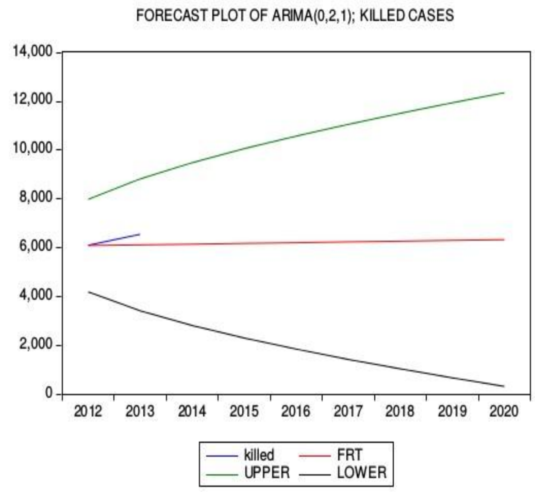


Figure 18b: Forecast Plot for the killed cases.

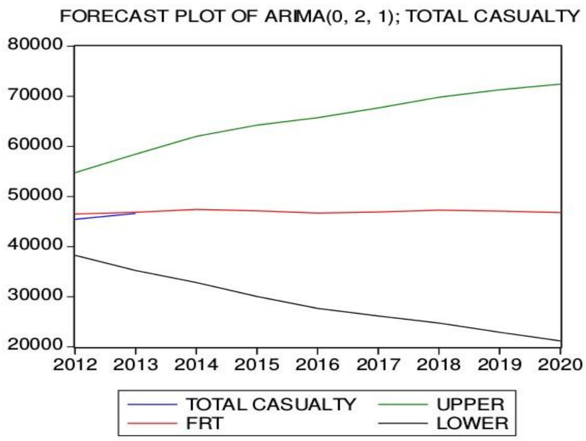


Figure 18c: Forecast Plot for the Total Casualties.

3.3 General Difference Form of the Models.

The general difference of ARIMA (0,2,1); Injured consequences is given as,

$Yt = 2Yt{-}1 - Yt{-}2 + et - \theta 1et{-}1,$

$Yt = 2Yt{-}1 - Yt{-}2 + et - \theta 1et{-}1.$

Substituting the value θ as given in Figure (9a), then the model for the Injured consequences becomes,

$Yt = 2Yt{-}1 - Yt{-}2 + et + 0.954388et{-}1.$

Also, the general difference of ARIMA (1,2,2); killed consequences is given as,

$Yt = 2Yt{-}1 - Yt{-}2 + \psi 1(Yt{-}1 - 2Yt{-}2 + Yt{-}3) + et - \theta 1et{-}1 - \theta 2et{-}2,$

but $\theta_1 = 0$,

$Yt = (2 + \psi 1)Yt{-}1 - (1 + 2\psi 1)Yt{-}2 + \psi 1Yt{-}3 + et - \theta 2et{-}2.$

Substituting the values of ψ and θ as given in Figure (9b), then the model for the killed consequences becomes,

$Y_t = 1.167534Y_{t-1} + 0.66492Y_{t-2} - 0.832466Y_{t-3} + e_t + 0.968707e_{t-2}.$

Lastly, the general difference of ARIMA (0,2,1); total casualty consequences is given as,

$$Yt = 2Yt{-}1 - Yt{-}2 + et - \theta 1et{-}1,$$

$$Yt = 2Yt{-}1 - Yt{-}2 + et - \theta 1et{-}1,$$

Substituting the value θ as given in Figure (10), then the model for the total casualty consequences becomes,

$$Yt = 2Yt{-}1 - Yt{-}2 + et + 0.959777et{-}1.$$

4. Discussion

Road traffic accident in Nigeria is increasing at a worrying and alarming rate and has raised one of the country major concerns. Federal Road Safety Corps of Nigeria recognizes the negative impacts of road safety accident and has commended the positive contribution of road safety researches as necessary tools to have significant accident initiatives. The paper was carried out in order to identify the patterns of road traffic accident consequences; injured, killed and total casualty by developing appropriate time series ARIMA models and predict 7 years consequences of road traffic accident; injured, killed and total casualty along the Nigeria motorway.

Time series analysis of the data from the years 1960-2013 showed that patterns of road traffic accident consequence; injured; killed and total casualty are increasing along the Nigeria motorway. The most widely used conventional method of time series known as Autoregressive Integrated Moving Average (ARIMA) model was applied to the annual-consequence of road accident data in Nigeria from 1960-2013 to determine patterns of road traffic accident consequences; injured, killed and total casualty of the road accident along the Nigeria motorway. After identifying various tentative models the appropriate models for the accident consequences; injured, killed and total casualty. ARIMA (0,2,1) model was found to be suitable model for the injury and total casualty consequences, whilst ARIMA(1,2,2) model was found to be suitable model for the killed consequences using the data from 1960-2011. The adequacy and performance of the model were tested on the remaining data from 2012 to 2013.

We provided 7 years forecasts of the consequences of road accident using the models developed and they showed that, road traffic accident consequences examined; injured, killed and total casualty will continue to increase. The study also revealed that road traffic accident cases; injured and killed along the motorway would continue to increase over the next 7 years. This study has provided reliable and genuine information that could be useful for determining road accident rate on Nigeria motorway and provide necessary prevention for the unwanted act. The study will also be used for providing important information in raising the level of awareness among stakeholders in road safety, since the problem has become a growing rife in Nigeria and also, be useful in setting priorities when planning road traffic accident interventions. Most Importantly, this study will provide expected benefit to the road users, Federal Road Safety Corps, researchers and other stakeholders in understanding the future rate of the consequences of road accident.

5. RECOMMENDATION

We have derived appropriate ARIMA Models that explain the behaviour and also the future patterns of the consequences of Road Accident along motor highway in Nigeria. Meanwhile, caution should be exercise in using the model, as it should not be used beyond the forecasted period, this is mainly because long time forecast may give arbitrary large forecast. Also, appropriate laws should be made to caution drivers that over-speed beyond the standard. Strict laws should be made to enforce the use of seat-belt among the driver and also, the passenger sitting in the front seat. This if enforced may reduce the critical state of the accident.

The Federal Road Safety Corp (FRSC) and all the stakeholders in charge of motorway in Nigeria should ensure proper maintenance of the motorway, it should be maintained in terms of the use of appropriate materials for patching pot holes, provision of street lights to aid visibility in the night, installation of traffic lights at new intersections created along the road. Also, proper education should be made known to the drivers on how to overtake on the motorway.

Appropriate training and retraining of drivers should be encourage towards reducing the carnage on over roads this will greatly reduce the rate of road traffic accident in the country. Road signals and signs that guide and instruct the drivers on what is happening in some kilometers ahead should always be made available on the motorway. Drivers should be discourage from receiving or making calls while driving.

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