International Journal of Engineering & Technology, 7 (4.19) (2018) 496-501

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Forecasting Traffic Accidents According to (Types of Roads and their Causatives) in Iraq using ARMA of Low Ordered Combinations Models

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Abstract

Objective: This research aimed to forecasting of an expected outcomes based on the numbers of traffic accidents concerning (Types of Roads, and Their Causatives), in Iraq through applying ARMA of low ordered combinations models.
Methodology: Data are selected from annuls statistical reports traffic accidents registered and published by ministry of planning for the time periods (2002-2015). Two statistical criteria had been applied, such that (MSE, and MPE), first statistic measuring the magnitude of the errors, a better model will give a smaller value. The second statistic measuring the bias, a better model will give a value close to zero. As well as 95% confidence interval limits of predicating long term trend are estimated.
Results and Findings: The best reference of predicating traffic accidents according to types of roads, and having significant parameters estimates in at least at P<0.05, and as follows: For high ways, results shows that ARMA(0,1) is the best model, and the projection are stationary according to general mean line, then followed with main roads, which proved that ARMA(1,2) is the best model, and projection are decreased, then followed with subsidiary roads, which proved that ARMA(1,0) is the best model, and projection are increased, then finally Arcadian roads, proved that ARMA(1,0) is the best model, and projection are increased.
As well as, best reference of predicating traffic accidents according to Causative sand having significant parameters estimates in at least at P<0.05, and as follows: For road, results shows that ARMA(0,1) is the best model, and future projection are increased, then followed with cars, which proved that ARMA(0,2) is the best model, and the projection are stationary at the general mean line, then followed with drivers, which proved that ARMA(0,2) is the best model, and the projection are stationary according to general mean line, then followed with infantry, which proved that ARMA(0,2) is the best model, and the projection are stationary according to general mean line, then followed with cars, which proved that ARMA(0,2) is the best model, passengers, proved that ARMA(2,1) is the best model, and the projection are non stationary, then finally other causatives, proved that ARMA(1,0) is the best model and projection are decreased.
Conclusions: Among several forecasted low ordered ARMA models, unique combination are nominated for each status of studied traffic accidents, either for types of roads, or for their causatives, and that were accordance of studied statistical indicators, which assigned a significant level for estimated parameter's models, and make high reliability for predicates of accidents numbers in the future projections.

Keywords: *Traffic Accidents, Forecasting Methods, ARMA (p, q) Time Series Models, Goodness of Fit, Future Projection.*

1. Introduction

World Health Organization "WHO" recently are publishing that about 1.25 million of people die every year as a results of road accidents, and 9 % occurs in low and moderate income countries, and that according to socio-economic status [1].
Road traffic accidents cause significant economic losses to individuals, their families and to entire States. These losses arise from the cost of treatment and the loss of productivity of persons who die or become disabled due to injuries, and family members who are forced to absent from work or school to care for injured. Traffic accidents in most countries cost 3% of gross domestic product GDP [2].
Rather than many researches dealt with the analysis of time series of traffic accidents, but most of them are focused on the issue of the number of wounded and the number of deaths without searching into causes of these accidents. With extreme increase of registered vehicle numbers beside population with each passing year causing an increase in fatalities in road traffic accident[3].
In this research, two main factors were addressed: traffic accidents according to type of roads, which are classified in to (High way, Main roads, Subsidiary roads, and Ar1cadian roads), as well as the causes of accidents according to different causatives, such that (Roads, Car, Driver, Infantry, Passenger, and Others), which lead to traffic accidents. In addition, mixed ARMA(p,q) of low ordered models are proposed, since most of time series data phenomena are to be realized. As well as the period of time assigned to future projection was during the years of time series (2002-2015) to draw the future projections concerning the traffic accidents, and that were either for long term trend or for their 95% confidence intervals according to the preceding of the two main factors, and that was for the first time as for (as we know).

2. Objectives

1. Forecast are based on traffic accidents in light of type of roads, such that (High ways, Main roads, Subsidiary roads, and Arcadian roads) in Iraq by applied of ARMA(p,q) for the possible combinations of low ordered models.

2. Forecast are based on traffic accidents in light of Causatives, such that (Roads, Car, Driver, Infantry, Passenger, and Others), in Iraq by applied ARMA(p,q) for all probable combinations of low ordered models.

3.Theoretical Aspects of ARMA Combinations Models [4]

A time series is a set of data points, which are indexed sequentially through time. The series may be indicated by Y1, Y2, ….., Yt, where t represents to the interval of time and Y represents the value. Theseries is called deterministic if the mathematical formula for Y's are specified accurately. On the other side, if future values can be assigned only by their probability distribution, the series is said to be a statistical or stochastic process. A special class of stochastic processes is a stationary stochastic process. A statistical process is stationary if the probability distribution is the same for all starting values of t. This implies that the mean and variance are constant for all values of t. A stationary stochastic process is completely defined by its mean, variance, and autocorrelation function. One of the steps in the Box – Jenkins method is to transform a non – stationary series into stationary one. The stationary assumption allows to make simple statements about correlation between two successive values, Yt, Yt+k. This correlation called autocorrelation of lag k of the series. The autocorrelation function displays autocorrelation on the vertical axis for successive values of k on the horizontal axis. The ARMA (autoregressive, moving average) model is defined as follows:

$$Y_t = Ø_1 Y_{t-1} + \;\; + Ø_p Y_{t-p} + a_t + \theta a_{t-1} - - \theta_q a_{t-q} \qquad (1)$$

Where the Ø's (Phis) are the autoregressive parameters to be estimated, the θ's (thetas) are the moving average parameters to be estimated, the Y's are the original series, and the a's are the series of unknown random errors (or residuals) which are assumed to follow the normal probability distribution. As well as autocorrelations contains fluctuations, for moderate sample sizes they are fairly accurate in signaling the order of ARMA model.
Box – Jenkins use the backshift operator to make writing these models easier. The backshift operator, B, has the effect of changing time period t to time period t-1.
Thus;

$$BY_t = Y_{t-2} \qquad (2)$$

Using this backshift notation, the above model may be rewritten as:

$$(1 - Ø\boldsymbol{B} - \cdots - Ø_P \boldsymbol{B^P})\boldsymbol{Y_t} \; = \; (1 - \theta_{\boldsymbol{1}} \boldsymbol{B} - \cdots - \theta_q \boldsymbol{B^q})\boldsymbol{a_t}$$

This may be abbreviated even further by writing:

$$Ø_{\boldsymbol{p}}(\boldsymbol{B})\boldsymbol{Y_t} = \; \theta_{\boldsymbol{q}}(\boldsymbol{B})\boldsymbol{a_t} \qquad (3)$$

These formula show that the operators $Ø_p(B)$ and $\theta_q(B)$ are polynomials in B of orders p and q respectively. One of the benefits of writing models in this fashion is that we can see why several models may be equivalent.

4. Results and Findings

First Application: (Types of Roads)
This procedure will forecast future outcomes for studied parameters, such that (Types of Roads) along (2015-2025) periods of years. The studied of parameter's series covering 14 yrs. of time periods (2002-2015) [5].
Currently, ARMA(p, q) of low ordered models, has been selected, since are accounted significant autoregressive and moving average, as well as goodness of fit in at least at $P<0.05$. These models assumes that the best forecast for future outcomes for types of roads, such that (High ways, Main roads, Subsidiary roads, and Arcadian roads) accidents.
Table (1) summarizes the performance of the currently selected models in fitting the previous data. It displays:
(1) The mean squared error (MSE).
(2) The mean percentage error (MPE), and that are accounted by application of statistical package named "STATGRAPHICS ver. 4" [6].

Table 1: Parameter's Estimates with Significant levels for ARMA Forecasting Models concerning Traffic Accident's percentages according to (Types of Roads)

Types of Roads	ARMA (p, q)	β's estimates & Sig. Levels								Indicators(*)	
		AR1		AR2		MA1		MA2		MSE	MPE
		β	P.V.	β	P.V.	β	P.V.	β	P.V.		
High Ways	1, 0	-.565	0.044							6.10441	-1.2556
	0, 1					1.284	0.000			2.96455	-.42834
	1, 1	-.261	0.553			0.574	0.144			5.68458	-.69779
	2, 0	-.833	0.015	-.461	0.134					5.31653	-.84467
	0, 2					0.844	0.026	-.457	0.232	5.55037	-1.0789
	2, 1	-.896	0.186	-.498	0.271	-.077	0.916			5.90248	-.83660
	1, 2	0.004	0.997			0.850	0.450	-.464	0.567	6.16620	-1.0800
	2, 2	-.408	0.245	-.565	0.122	0.453	0.001	-1.01	0.000	4.59674	-1.3396
Main Roads	1, 0	0.731	0.018							32.2637	-1.4529
	0, 1					-.389	0.200			41.6635	-1.2975
	1, 1	1.154	0.000			0.672	0.062			20.7308	-.56046
	2, 0	0.460	0.106	0.533	0.123					24.3169	-2.3046
	0, 2					-.012	0.960	-.774	0.001	36.5583	-1.2212
	2, 1	0.651	0.107	0.710	0.097	0.562	0.207			19.1070	-1.4373
	1, 2	1.079	0.000			1.095	0.000	-.801	0.000	11.9586	-.43096
	2, 2	0.847	0.037	0.282	0.519	1.080	0.000	-.782	0.000	12.6617	-.45438
Subsidiary Roads	1, 0	0.995	0.000							3.81043	0.35504
	0, 1					-.911	0.000			12.5177	-5.9419
	1, 1	0.998	0.000			-.004	0.988			4.11591	-.36215
	2, 0	1.071	0.013	-.077	0.859					4.29421	1.49336
	0, 2					-1.32	0.001	-.488	0.188	9.53845	-3.6981

	2, 1	0.811	0.187	0.186	0.742	-.168	0.777			4.68743	1.01433
	1, 2	1.114	0.000			0.095	0.824	0.114	0.742	4.34985	0.99123
	2, 2	0.683	0.649	0.311	0.841	-.336	0.797	-.014	0.970	5.31351	1.37910
Arcadian Roads	1, 0	0.862	0.002							0.42522	-.06278
	0, 1					0.580	0.036			0.61889	-2.0396
	1, 1	0.937	0.001			0.241	0.488			0.44045	1.83705
	2, 0	0.632	0.063	0.365	0.294					0.43425	1.08555
	0, 2					0.541	0.074	-.450	0.129	0.57620	-1.3508
	2, 1	0.531	0.492	0.462	0.440	0.028	0.971			0.46021	0.84491
	1, 2	0.977	0.000			0.398	0.144	-.178	0.546	0.44112	-.12254
	2, 2	0.500	0.511	0.488	0.423	-.044	0.954	-.003	0.988	0.52555	1.33853

(*)Mean Squared Error (MSE); Mean Percentage Error (MPE); (P<0.05: Significant).

High ways, Subsidiary roads and Arcadian roads shows that ARMA(0, 1) which are the best statistical predicted model either for measuring the magnitude of the errors, or measuring bias, since it will gave a values close to zero.

Main roads shows that ARMA(1, 2) is the best statistical predicted model either for measuring magnitude of errors, or measuring bias, (i.e. it will gave a value close to zero).

Figures (1) shows projection of long term trend concerning traffic accidents due to (Types of Roads) through applying an adequate of ARMA(p, q) of low ordered applying an optimal fitted model of the studied time series.

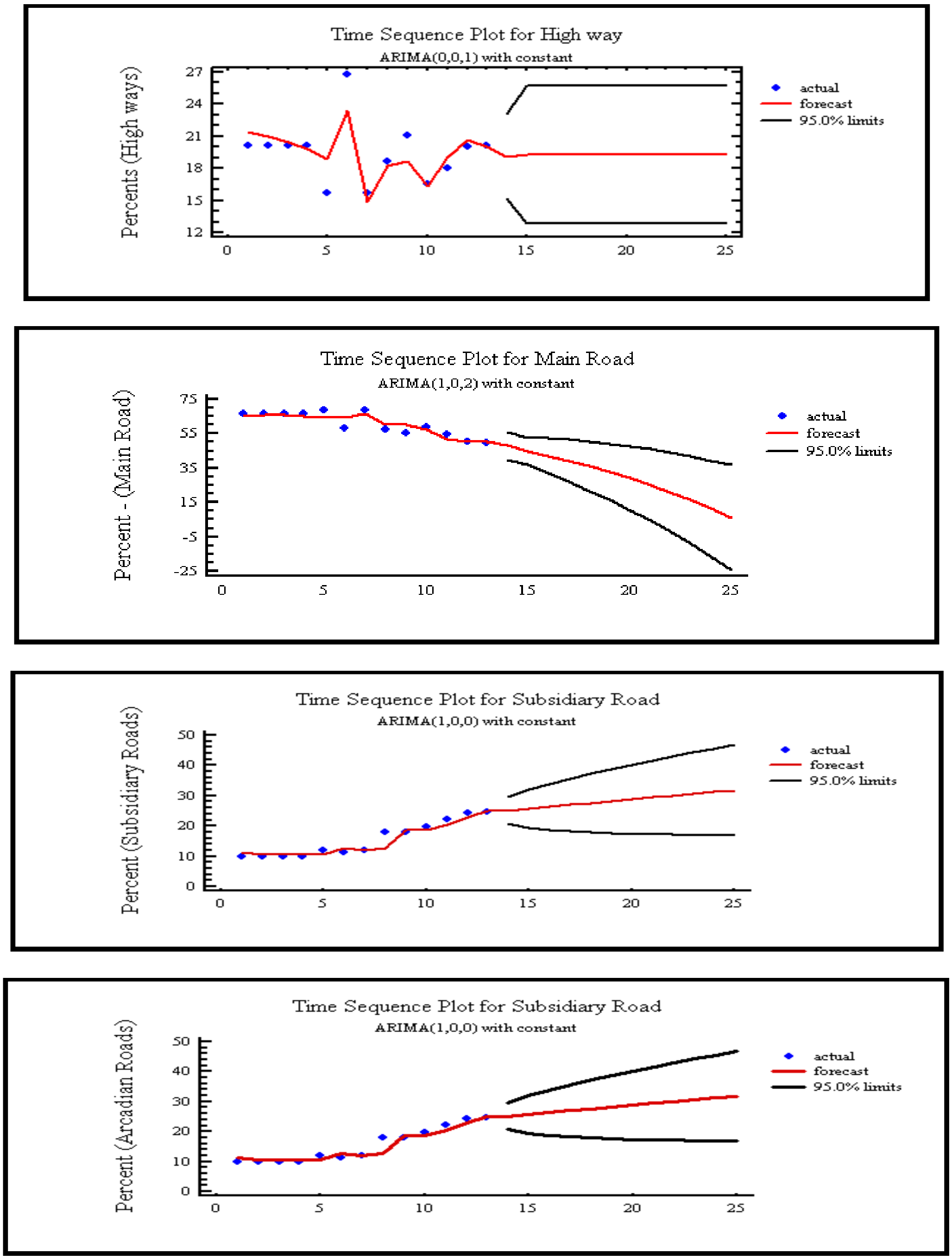

Fig. 1: Long term trend Plots of traffic accidents due to types of roads, (High ways, Main roads, Subsidiary roads, and Arcadian roads) in Iraq

Second Application: (Accident's Causatives)

This procedure will forecast future outcomes for studied parameters, such that (Causatives of accidents) along (2015-2025) periods of years [ ]. The studied of parameter's series cover 14 time periods (2002-2015).Currently, ARMA(p, q) of low ordered models, has been selected, since are accounted significant autoregressive and moving average, as well as goodness of fit in at least at $P<0.05$.

These models assumes that the best forecast for future outcomes for Causatives of accidents, such that (Roads, Car, Driver, Infantry, Passenger, and Others).

Table (2) summarizes the performance of currently selected models in fitting the previous data. It displays:

(1) The mean squared error (MSE).

(2) The mean percentage error (MPE), and that are accounted by application of statistical package named "STATGRAPHICS ver. 4" [6].

Table 2: Parameter's Estimates with Significant levels for ARMA Forecasting Models concerning Traffic Accident's percentages according to (Causatives of Accident)

Accidents Causatives	ARMA (p, q)	β's & Sig. Levels								Indicators(*)	
		AR1		AR2		MA1		MA2		MSE	MPE
		β	P.V.	β	P.V.	β	P.V.	β	P.V.		
Road	1, 0	0.984	0.000							1.42187	-2.1915
	0, 1					-.689	0.007			2.53792	-9.4025
	1, 1	0.975	0.000			0.086	0.736			1.58081	1.06414
	2, 0	0.790	0.029	0.201	0.598					1.47844	-.81078
	0, 2					-.873	0.012	-.408	0.181	2.34161	-8.0091
	2, 1	0.640	0.510	0.357	0.661	-.015	0.988			1.64836	-.38621
	1, 2	0.984	0.000			0.325	0.233	-.136	0.603	1.53823	-4.5063
	2, 2	0.405	0.918	0.574	0.879	-.398	0.921	0.068	0.930	1.89732	0.36905
Car	1, 0	0.732	0.004							9.01044	-3.5671
	0, 1					-.424	0.157			12.4779	-10.867
	1, 1	0.841	0.013			0.219	0.643			9.57560	-2.2600
	2, 0	0.537	0.108	0.320	0.338					9.21064	-1.0096
	0, 2					-1.05	0.000	-.922	0.000	6.82714	-.52262
	2, 1	0.067	0.903	0.683	0.079	-.517	0.459			9.45174	-.90716
	1, 2	0.272	0.559			-.437	0.222	-.608	0.044	9.35275	-4.4678
	2, 2	-.151	0.632	0.567	0.057	-1.26	0.000	-.963	0.000	7.08343	1.47631
Driver	1, 0	0.841	0.000							7.46961	-0.4906
	0, 1					-.591	0.035			12.6031	-.39628
	1, 1	0.849	0.003			0.032	0.942			8.20199	-.50798
	2, 0	0.787	0.053	0.089	0.825					8.24998	-.61169
	0, 2					-1.13	0.000	-.872	0.000	7.01144	-.65157
	2, 1	0.182	0.871	0.630	0.467	-.554	0.680			8.83544	-.59766
	1, 2	0.665	0.058			-.187	0.633	-.446	0.190	8.40742	-.38794
	2, 2	-.036	0.942	0.543	0.267	-1.07	0.043	-.590	0.136	8.62790	-.64352
Infantry	1, 0	0.124	0.696							1.52958	-3.1296
	0, 1					-.324	0.331			1.47875	-2.9265
	1, 1	-.231	0.845			-.507	0.645			1.59838	-2.9213
	2, 0	0.217	0.493	-.445	0.187					1.40435	-2.5026
	0, 2					0.721	0.009	0.735	0.095	0.68952	-1.0345
	2, 1	0.204	0.797	-.441	0.232	-.010	0.990			1.56079	-2.5211
	1, 2	0.338	0.500			0.711	0.260	0.659	0.292	1.96642	-.17540
	2, 2	0.530	0.480	-.287	0.657	0.561	0.448	0.370	0.627	1.39780	-4.1137
Passenger	1, 0	0.615	0.025							0.30249	-21.415
	0, 1					-.952	0.000			0.27945	-19.475
	1, 1	0.465	0.314			-.274	0.576			0.31514	-20.333
	2, 0	0.815	0.021	-.358	0.261					0.29244	-19.109
	0, 2					-.570	0.013	-.86	0.000	0.24059	-13.273
	2, 1	1.406	0.000	-.833	0.001	0.865	0.000			0.17433	-14.722
	1, 2	0.335	0.378			-.310	0.231	-.781	0.001	0.28860	-10.668
	2, 2	1.331	0.000	-.917	0.002	0.556	0.002	-.825	0.000	0.18326	-4.5847
Others	1, 0	0.966	0.000							0.47235	-11.280
	0, 1					-.746	0.002			0.86064	-28.221
	1, 1	0.936	0.001			-.109	0.755			0.51291	-9.3216
	2, 0	1.059	0.007	-.125	0.734					0.51463	-12.207
	0, 2					-1.02	0.002	-.89	0.009	0.55687	-12.679
	2, 1	0.610	0.933	0.329	0.962	-.288	0.956			0.57922	-12.832
	1, 2	0.844	0.030			-.241	0.581	-.18	0.659	0.56374	-11.904
	2, 2	0.525	0.750	0.281	0.856	-.547	0.731	-.25	0.569	0.62859	-12.193

(*) Mean Squared Error (MSE); Mean Percentage Error (MPE); ($P<0.05$: Significant).

Figures (2) shows the projection of long term trend graphically concerning traffic accidents due to Causatives of accidents, such that (Road, Car, Driver, Infantry, Passenger, and Other)by applying ARMA(p,q) of low ordered by fitted model of studied time series.

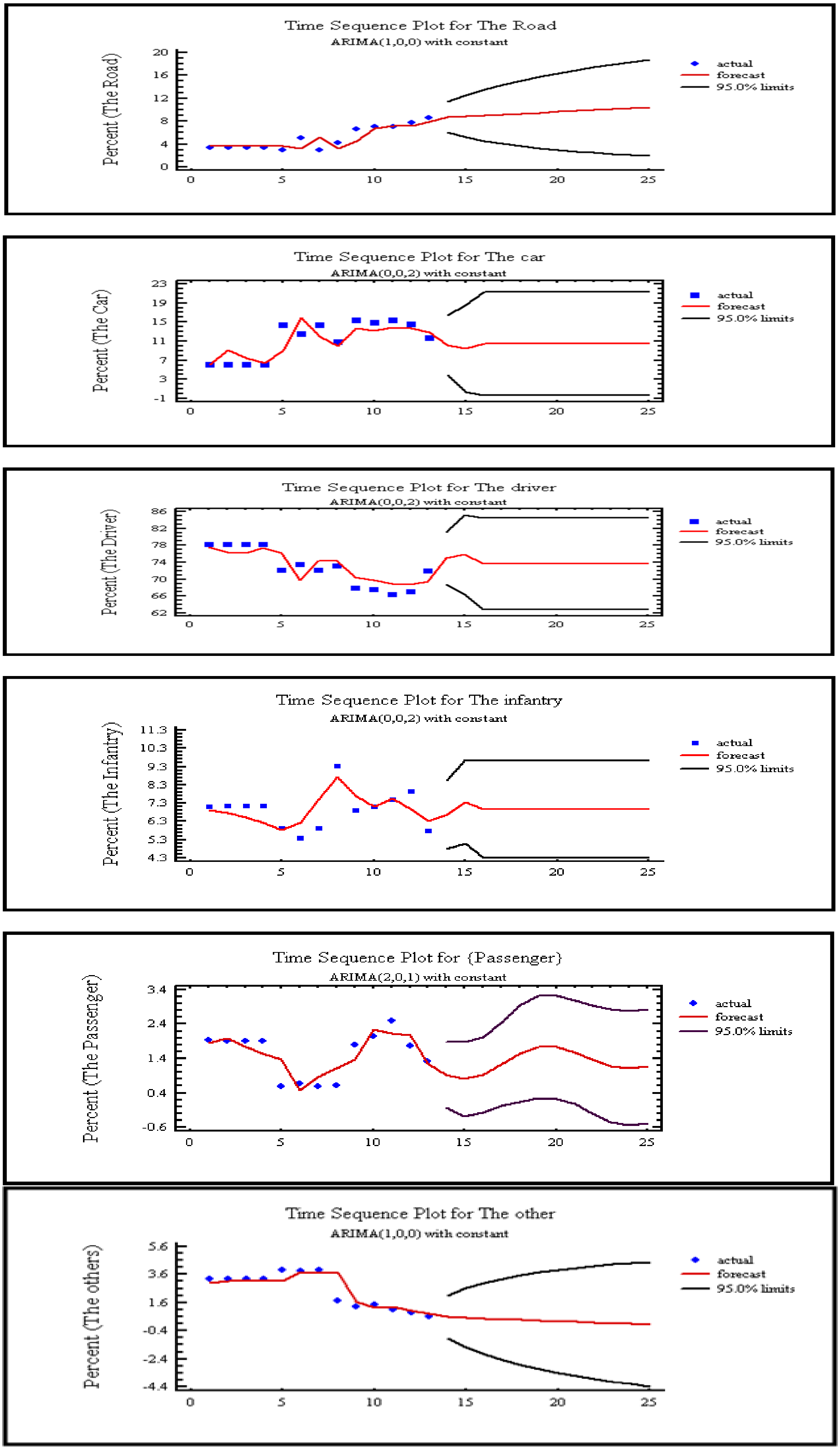

Fig. 2: Long term trend Plots of traffic accidents due to Causatives of accidents, (Roads, Cars, Drivers, Infantry, Passengers, and Others) in Iraq

5. Conclusions

Among several forecasted of low ordered ARMA models, unique combination are nominated for each status of studied traffic accidents for the types of roads, and that were accordance of studied statistical indicators, which assigned a significant level for estimated parameter's models, and make high reliability for predicates of an accidents numbers in the future projections.
Among several forecasted of low ordered ARMA models, unique combination are nominated for each status of studied traffic accidents for the different causatives, and that were accordance of studied statistical indicators, which assigned a significant level for estimated parameter's models, and make high reliability for predicates of an accidents numbers in the future projections.

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