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Using Single and Double Exponential Smoothing for Estimating The Number of Injuries and Fatalities Resulted From Traffic Accidents in Jordan (1981-2016)

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Abstract: This study aimed at estimating the number of injuries and fatalities resulted from traffic accidents in Jordan for the period of (1981-2016) by using the Single & Double Exponential Smoothing, This study specifies the best model which depends on the(MAPE, MAD, MSD) results , (Minitab) used to analyze the study data, The study approved that the Double Exponential Smoothing is an appropriate model to measure and analyze injuries and fatalities in Jordan.

Key words: Double Exponential Smoothing · Fatalities · Injuries · Jordan · Traffic Accidents · Single Exponential Smoothing

INTRODUCTION

Scientific research needs the time series for analysis, which represent the behavior and nature of the changes that occur to the phenomenon during certain periods of time. Time series can therefore be used for planning and forecasting and that the methodology of time series in general. It has become the most common and used instrument in a scientific community, that methodology proved to be highly efficient in data modeling of time and forecasting [1].

One of the common methods of forecasting and planning is the Exponential Smoothing methods. The methods is very important in the statistical methods and procedures addressing noise and random errors [2], Exponential Smoothing methods can be defined in general as that fine-tuning or smoothing data where interference, it is a kind of estimation process , it is proven through the study of cases that depend on time or change with time. Statisticians develop a group of methods and statistical methods for use in forecasting and these methods to boot exponential method [3]. Hyndman [4] extended the methods of the exponential smoothing and incorporated the Damped Holt method.

Previous Studies: Hamooodat, AllaAbdulsattar, [2]. In this article, the two methods of exponential smoothing were compared,And the impact of interference in the selection of the best model of the time series, Annual data International grain prices, As well as the use of the effect of interference on the chain data and determine the rank of the model by drawing functions As well as the use of the effect of interference on the chain data and determine the rank of the model by drawing functions autocorrelation function(ACF) and partial autocorrelation function(PACF)

Aldalkhi, Sarmad Alwan [5]. This paper addressed a number of statistical tools and how to use them to control inventories,The exponential smoothing method was used to forecast the amount of demand during the waiting period, The best method of forecasting was found to be the single exponential model.

Al Ajili , Saad Saber Mohammed, [2] This research aims to analyze seasonal time series using exponential smoothing models (Holt-Winter). in the case of multiplicative and the additive seasonal model .and the single and double exponential seasonalas well asthe linear trendmodel.

Musa, Fares Jalal Abdullah, [6]. In this study, an attempt was made wheat production modeling in Sudan in order to reach the model represents a pattern which indicates it can be used to forecast the future, The researcher applied the Arima models and the Exponential Smoothing models to wheat production data, The model that gave the best fit for the series according to the criteria used is the Holt model for the exponential smoothing.

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Munahil and Yunus [7] explained the trend seasonality of time series, indeed the triple exponential method (Winter's Method) model is better than additive model by using many criterions .MAD, MAPE, MSE Safawi and Ghanem, [8] explained the comparison between the Box-Jenkins method and Exponential Smoothing methods and compare the standard based on the (MSE) (MAE) and (MAPE) Al-Tai and Al-Kurani, [9] mentioned the reconciliation of one of the time series models, Prediction It is reached to the best Models in the proportional because it has the less value for statistical standard Akaike Information Criterion and Mean Square Error.

Initial Value: (Taylor, J.W. [10]) The smooth Exponential methods need an initial value to start to find a prediction algorithm, In most cases, the first real value is considered as the initial value of the smoothing when using the simple exponential.

Parameters Estimation: (Philipp K . Janert [11]) The estimation parameters which is called a constant smoothing of the most important steps in the forecasting process. The methods of the exponential smoothing depend on the value of the smoothing constant. The researchers disagreed on determining the value of this fixed value, which is sandwiched between zero and one.

Choose the Model: There are several criteria for selecting the best model among the estimated models and these criteria: (Sha'rawi, Samir Mustafa, [12, 13].

Akaike Information Criterion

$AIC(M) = nLn\sigma^2 + 2M$

Schwartz 's Bayesian Information Criterion

$SBIC(M) = nLn\sigma^2 + MLnn$

m: number of Parameters in the model

Test the Accuracy of the Predictive Results: The prediction of time series assumes that the time series is a set of patterns and some random errors , which aims to separate the pattern from the error by understanding the direction of the pattern of data in its long-term increase or decrease and seasonality, any changes caused by seasonal factors and that the goal of forecasting is to reduce the risk in the decision-making process and that the more low error rate was accurate prediction [14].

There are several criteria by which to compare the methods used to predict time series. The lower these values, the closer to the predicted values of the real values, Among the most important of these standards [15, 16].

- Mean Squared Error (MSE)

$$MSE = \frac{\sum_{t=1}^{n}(X_t - \hat{X}_t)^2}{n} \tag{3}$$

- Root Mean Squared Error (RMSE)

$$RMSE = \sqrt{\frac{1}{n}\sum_{t=1}^{n}(X_t - \hat{X}_t)^2} \tag{4}$$

- Mean Absolute Percent Error (MAP)

$$MAP = [\frac{1}{n}\sum_{t=1}^{n}\frac{|X_t - \hat{X}_t|}{X_t}]*100 \tag{5}$$

- Mean Absolute Error (MAE)

$$MAE = [\frac{1}{n}\sum_{t=1}^{n}|X_t - \hat{X}_t|] \tag{6}$$

where,

X_t: is the actual observation at time t
$\hat{X}_t$: is the forecast value of X_t
n: is the total number of observations

Single Exponential Smoothing: The smooth can be described by the following equation simple exponential equation, [17]:

$$F(t+1) = \alpha X(t) + (1-\alpha)F(t) \tag{7}$$

Such that
$X(t)$: Represents the real value at time(t):
$F(t)$: the forecast value at time(t)Represents:
$F(t+1)$: Represents the forecast value at time(t+1):

Represents a fixed Softening value limited and between $(0 \le \alpha \le 1)$

This method is called exponential smoothing to give the previous observations weights of unequal values and these weights are decreasing exponentially sequentially and can be illustrated by the following equations:

$$S_t = \alpha X_t + (1-\alpha)X_{t-1} \tag{8}$$

X_t: Represents the real value at time(t)
S_{t-1}: Represents the real value of prediction at time(t-1)

S_t: Represents the real value of prediction at time(t)
α: Represents a fixed Softening value limited and between (0 ≤ α ≤ 1)

When substation (S_t) in (S_{t-1}) we get:

$$S_t = \alpha X_t + (1-\alpha)[\alpha X_{t-1} + (1-\alpha)s_{t-2}] \quad (9)$$

When substation (S_t) in (S_{t-1}) we get:

$$S_t = \alpha X_t + (1-\alpha)[\alpha X_{t-1} + (1-\alpha)[\alpha X_{t-2} + (1-\alpha)s_{t-3}].] \quad (10)$$

And repeat the process of compensation we get

$$S_t = \alpha X_t + \alpha(1-\alpha)X_{t-1} + \alpha(1-\alpha)^2 X_{t-2} + \alpha(1-\alpha)^3 X_{t-3} + ... + (1-\alpha)^t S_t \quad (11)$$

$$S_t = \alpha \sum_{j=1}^{t} (1-\alpha)^j X_{t-j} + (1-\alpha)^t S_o \quad (12)$$

S_o: Represents the initial value of the smooth process

The Practical Side:

Table (1) shows the number of injuries and fatalities resulting from traffic accidents in Jordan for the period (2016-1981)

Year	Injuries	Fatalities
1981	8439	457
1982	8956	485
1983	8178	443
1984	8943	493
1985	9100	527
1986	8341	355
1987	8956	396
1988	9956	364
1989	9474	355
1990	10464	379
1991	10126	379
1992	10676	388
1993	11754	440
1994	12516	443
1995	13184	469
1996	15375	552
1997	16259	577
1998	17177	612
1999	19015	676
2000	18842	686
2001	18832	783
2002	17381	758
2003	18368	832
2004	16727	818
2005	17579	790
2006	18019	899
2007	17969	992
2008	13913	740
2009	15662	676
2010	17403	670
2011	18122	694
2012	17143	816
2013	15954	768
2014	14790	688
2015	16139	608
2016	17435	750

Source: The Hashemite Kingdome of Jordan , Ministry of Interior, Public Security Directorate, Jordan Traffic Institute, , , Jordan Traffic Institute. Annual Report of Traffic Accidents for the Period (2000-2016) [18]

Table 2: Shows the value (MAPE, MAD, MSD) according to different values (α) using the Single Exponential Smoothing for Injuries

α	0.1	0.2	0.3	0.4	0.5
MAPE	15	11	9	8	8
MAD	2284	1591	1298	1165	1080
MSD	9124021	4526732	3016241	2326838	1964778
α	0.6	0.7	0.8	0.9	
MAPE	7	7	7	7	
MAD	1027	1005	991	980	
MSD	1758661	1635296	1560502	1518475	

Double Exponential Smoothing (Philipp K . Janert [11]): The binary exponential smoothing method is one of the exponential longitudinal smoothing methods, which smooth's the time series twice. The statistical sooth from the first and second levels uses the prediction calculation. The smooth of the second grade series equation as in the following equation:

$$S_t^{"} = \alpha S'_t + (1-\alpha) S^{"}_{t-1} \tag{13}$$

The initial prediction (ℓ) for the steps The steps for the time series for period (t) are:

$$\hat{Y}_{t+\ell} = \hat{\mu} + \hat{b}_t \ell \tag{14}$$

Such that: ℓ = 1,2,.....

$$\hat{\mu} = 2S'_t - S^{"}_t \ell \tag{15}$$

$$\hat{b}_t = \frac{\alpha}{1-\alpha}(S'_t - S^{"}_t) \tag{16}$$

$S_t^{"}$: Smooth from the second grade series

In equations (15), (16) the ($\hat{\mu}$) represents the local smooth level at time (t), while ($\hat{b}_t$) represents the smooth level of the general trend of the time series(t), the prediction is horizontal to (ℓ) and replaced($\hat{\mu}$) and ($\hat{b}_t$) in (S'_t) and ($S^{"}_t$), we get:

$$\hat{Y}_{t+\ell} = (2 + \frac{\alpha}{1-\alpha}\ell)S'_t - (1 + \frac{\alpha}{1-\alpha}\ell)S_t^{"} \tag{17}$$

When $\ell = 1$

$$\hat{Y}_{t+1} = (\frac{2-\alpha}{1-\alpha})S'_t - (\frac{1}{1-\alpha})S_t^{"} \tag{18}$$

The results shown in the table above show, based on a criterion (Least MAPE, MAD, MSD) that the best forecast is when the value of (α) is equal to (0.9).

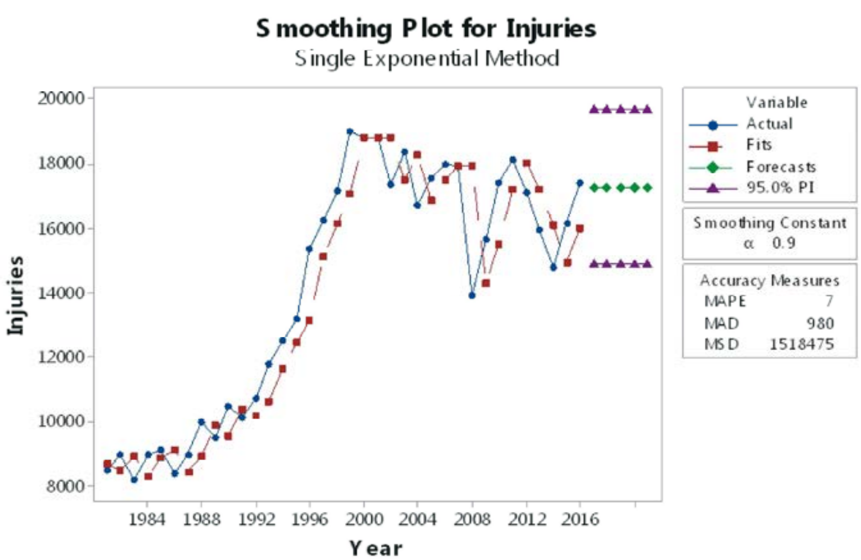

Fig. 1: Represents Single Exponential Smoothing Plot for Injuries

Table 3: Shows the number of injuries expected during the years (2017-2021) according to the use of the method Single Exponential Smoothing

Year	Forecast	Lower	Upper
2017	17293.2	14893.4	19693.0
2018	17293.2	14893.4	19693.0
2019	17293.2	14893.4	19693.0
2020	17293.2	14893.4	19693.0
2021	17293.2	14893.4	19693.0

Table 4: Shows the value (MAPE, MAD, MSD) according to different values (α) using the Single Exponential Smoothing for Fatalities

α	0.1	0.2	0.3	0.4	0.5
MAPE	16.3	14.5	12.86	11.57	10.74
MAD	105.1	90.2	79.17	70.8	65.47
MSD	19248.7	11810.7	8787.58	7303.22	6530.81
α	0.6	0.7	0.8	0.9	
MAPE	10.04	9.56	9.27	9.2	
MAD	61.10	58.33	56.57	56.02	
MSD	6121.10	5910.03	5817.80	5806.34	

The results shown in the Table(4) above show, based on a criterion (Least MAPE, MAD, MSD) that the best forecast is when the value of (α) is equal to (0.9)

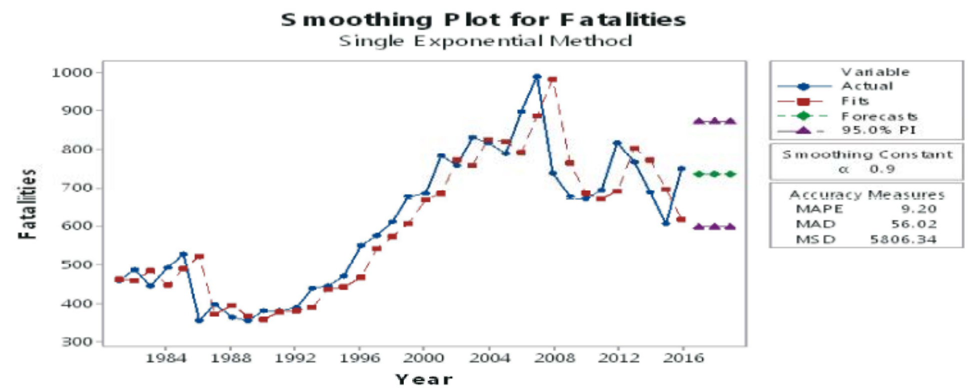

Fig. 2: Represents Single Exponential Smoothing Plot for Fatalities

Table 5: Shows the number of Fatalities expected during the years (2017-2021) according to the use of the method Single Exponential Smoothing

Year	Forecast	Lower	Upper
2017	736.684	599.447	873.920
2018	736.684	599.447	873.920
2019	736.684	599.447	873.920
2020	736.684	599.447	873.920
2021	736.684	599.447	873.920

Table 6: Shows the value (MAPE, MAD, MSD) according to different values (α) & (γ) using the Double Exponential Smoothing for Injuries

α				0.1				
α				0.1				
γ	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
MAPE	12	14	14	14	14	13	14	14	14
MAD	1846	2039	2119	2138	2087	1997	2046	2105	2129
MSD	5649675	6848578	7403546	7446776	7325475	7251403	7236398	7193473	7043974
α					0.2				
γ	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
MAPE	10	10	10	10	10	9	9	8	8
MAD	1516	1537	1513	1531	1494	1399	1320	1266	1259
MSD	3912901	4056920	3982931	3865784	3670047	3413682	3160934	2954541	2802144

Table 6: Continued

α					0.3				
γ	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
MAPE	9	9	8	8	8	7	7	7	7
MAD	1253	1263	1239	1165	1137	1121	1104	1101	1094
MSD	2748174	2720880	2613171	2469299	2331403	2230000	2166561	2131574	2117158
α					0.4				
γ	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
MAPE	8	7	7	7	7	7	7	7	7
MAD	1108	1095	1049	1054	1043	1048	1066	1077	1087
MSD	2163326	2124205	2049628	1982904	1947032	1943553	1966865	2012892	2080026
α					0.5				
γ	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
MAPE	7	7	7	7	7	7	7	8	8
MAD	1009	994	1003	1018	1039	1055	1081	1106	1129
MSD	1862946	1847720	1824087	1822889	1852391	1909735	1990786	2092362	2211389
α					0.6				
γ	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
MAPE	7	7	7	7	7	7	8	8	8
MAD	952	974	995	1020	1051	1081	1105	1132	1164
MSD	1702260	1716646	1735551	1779082	1849122	1941060	2049377	2168301	2291570
α					0.7				
γ	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
MAPE	7	7	7	7	7	8	8	8	8
MAD	938	968	994	1035	1065	1091	1123	1149	1166
MSD	1613783	1653659	1702677	1773334	1863741	1967587	2078068	2188894	2295001
α					0.8				
γ	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
MAPE	7	7	7	7	8	8	8	8	8
MAD	941	975	1008	1040	1074	1104	1125	1145	1168
MSD	1566161	1625773	1694972	1781123	1880464	1986737	2094592	2200725	2304333
α	0.9								
γ	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
MAPE	7	7	7	8	8	8	8	8	9
MAD	955	985	1016	1051	1080	1103	1134	1162	1187
MSD	1546484	1622268	1707087	1805548	1914182	2028942	2147915	2271867	2403968

The results shown in the Table (6) above show, based on a criterion (Least MAPE, MAD, MSD) that the best forecast is when the value of (α) is equal to (0.9) &(γ) is equal to (0.7)

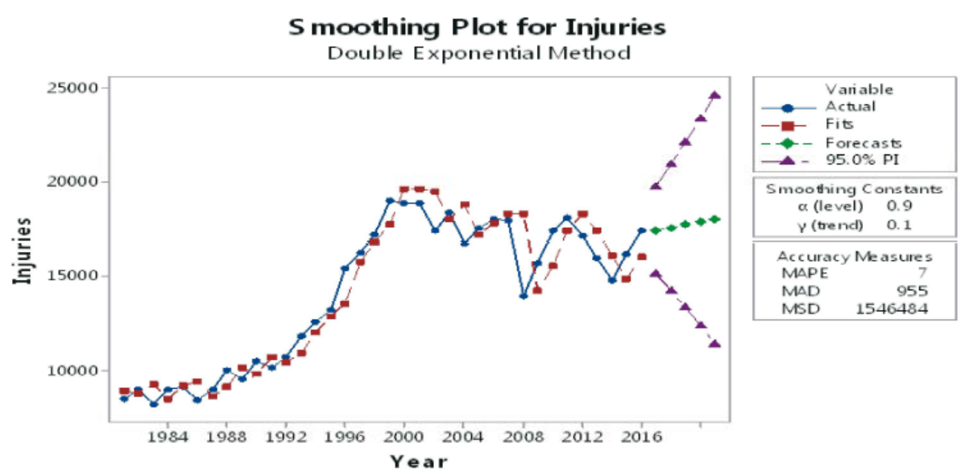

Fig. 3: Represents Double Exponential Smoothing Plot for Injuries

Table 7: Shows the number of Injuries expected during the years (2017-2021) according to the use of the method Double Exponential Smoothing

Year	Forecast	Lower	Upper
2017	17436.0	15097.2	19774.8
2018	17578.3	14233.6	20922.9
2019	17720.6	13307.4	22133.7
2020	17862.9	12354.9	23370.8
2021	18005.1	11389.1	24621.2

Table 8: Shows the value (MAPE, MAD, MSD) according to different values (α) & (γ) by using the Double Exponential Smoothing for Fatalities

α					0.1				
α					0.1				
.γ	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
MAPE	18.9	20.7	22.2	22.8	23.0	22.9	22.7	21.8	21.4
MAD	110.3	122.4	131.6	134.8	134.4	131.9	130.8	125.1	122.5
MSD	15106.2	18906.7	22687.0	25468.8	26770.2	26804.7	26143.3	25271.9	24380.5
α					0.2				
γ	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
MAPE	16.5	17.2	17	16.5	16.3	16.1	15.6	15.2	14.92
MAD	95.1	98.3	95.5	92.1	91.5	89.8	86.7	83.5	81.66
MSD	12665.4	14270.4	14452.6	13878.3	13065.9	12142.5	11214.6	10441.3	9927.76
α					0.3				
γ	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
MAPE	14.25	14.1	13.82	13.51	13.3	12.94	12.62	12.43	12.41
MAD	81.15	79.3	77.49	75.34	73.91	71.91	70.42	69.68	69.99
MSD	9749.13	10029.2	9688.88	9209.55	8779.55	8505.82	8414.84	8466.81	8607.65
α					0.4				
γ	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
MAPE	12.44	12.33	12.19	11.99	11.68	11.60	11.51	11.48	11.65
MAD	71.32	70.36	68.94	67.95	66.77	66.68	66.70	67.13	68.38
MSD	8040.16	8083.28	7900.57	7755.31	7734.21	7844.92	8060.81	8357.20	8720.64
α					0.5				
γ	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
MAPE	11.23	11.29	11.18	10.99	10.89	10.76	10.89	11.12	11.39
MAD	65.16	64.96	64.58	64.04	63.93	63.81	64.80	66.50	68.31
MSD	7151.25	7232.40	7246.42	7342.33	7550.19	7858.00	8246.07	8697.48	9197.58
α					0.6				
γ	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
MAPE	10.51	10.55	10.39	10.24	10.13	10.52	10.96	11.38	11.79
MAD	61.60	61.61	61.30	60.89	60.85	63.23	66.12	68.95	71.59
MSD	6701.38	6872.31	7040.61	7294.35	7641.46	8066.23	8549.67	9074.26	9624.25
α					0.7				
γ	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
MAPE	9.99	9.99	9.80	9.96	10.41	10.87	11.25	11.65	12.03
MAD	59.21	59.30	58.69	60.03	62.83	65.73	68.21	70.65	72.76
MSD	6487.50	6746.72	7028.28	7386.33	7818.33	8306.17	8829.57	9368.99	9906.05
α					0.8				
γ	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
MAPE	9.61	9.68	9.83	10.18	10.64	11.06	11.40	11.72	12.0
MAD	57.61	58.11	59.18	61.53	64.31	66.81	68.79	70.44	72.0
MSD	6410.03	6745.61	7110.93	7539.93	8024.44	8545.23	9082.49	9619.45	10144.8
α	0.9								
γ	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
MAPE	9.53	9.67	10.00	10.43	10.78	11.13	11.61	12.04	12.5
MAD	57.18	58.07	60.08	62.70	64.88	66.76	69.50	71.82	73.9
MSD	6422.59	6824.95	7257.80	7743.39	8272.31	8828.65	9399.74	9980.44	10575

The results shown in the Table (9) above show, based on a criterion (Least MAPE, MAD, MSD) that the best forecast is when the value of (α) is equal to (0.9) & (γ) is equal to (0.1)

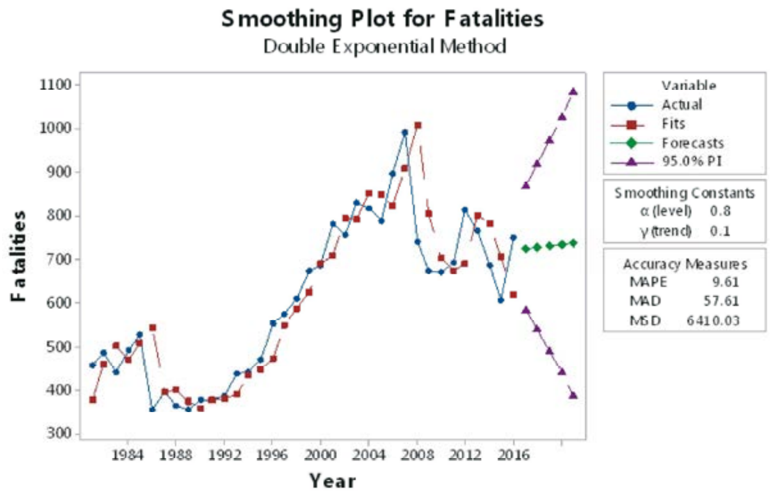

Fig. 4: Represents Double Exponential Smoothing Plot for Fatalities

Table 9: Shows the number of Fatalities expected during the years (2017-2021) according to the use of the method Double Exponential Smoothing

Year	Forecast	Lower	Upper
2017	726.732	585.587	867.88
2018	729.436	540.069	918.80
2019	732.139	490.950	973.33
2020	734.843	440.122	1029.56
2021	737.546	388.371	1086.72

Results:

- The study showed that the best forecast of injuries resulted from traffic accidents in Jordan when using the Single Exponential Smoothing) according to least criteria of (MAPE, MAD, MSD) is when the value of (α) is equal to (0.9).
- The study showed that the best forecast of fatalities resulted from traffic accidents in Jordan when using the Single Exponential Smoothing) according to least criteria of (MAPE, MAD, MSD) is when the value of (α) is equal to (0.9)
- The study showed that the best forecast of injuries resulted from traffic accidents in Jordan when using the Double Exponential Smoothing) according to least criteria of (MAPE, MAD, MSD) is when the value of (α) is equal to (0.9)& (γ) is equal to (0.1)
- The study showed that the best forecast of fatalities resulted from traffic accidents in Jordan when using the Double Exponential Smoothing) according to least criteria of (MAPE, MAD, MSD) is when the value of (α) is equal to (0.9)& (γ) is equal to (0.1)
- The study proved that the use of the double exponential smoothing technique for the future forecasting of injuries resulted from traffic accidents in Jordan is better than using the Single Exponential Smoothing technique,
- The study proved that the use of the double exponential smoothing technique for the future forecasting of fatalities resulted from traffic accidents in Jordan is better than using the Single Exponential Smoothing technique,

Recommendations:

- The researcher recommends the subject of injuries resulted from traffic accidents in Jordan is a great importance by researchers because the results have vital social and economic impacts.
- The researcher recommends the subject fatalitiesresulted from traffic accidents in Jordan the great importance by researchers because the results have vital social and economic impacts.
- The researcher recommends using the double exponential smoothing technique for the future forecasting of injuries resulted from traffic accidents in Jordan.
- The researcher recommends using the double exponential smoothing technique for the future forecasting of fatalities resulted from traffic accidents in Jordan

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