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Modeling and Statistical Analysis of Traffic Accidents in Saudi Arabia: Emphasis on Asir Region

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Abstract

This research aims at modeling and statistically analyzing traffic accidents in Saudi Arabi during the period 1433–1437 H. We collected data from the thirteen provinces and pooling them together in a Panel data. Fixed effects model was the main estimation instrument to estimate the model. Artificial Network Analysis (ANN) has supported estimation showing the significance impact of traffic accidents. Results reveal that inside and outside traffic accidents together cause injuries. While outside accidents lead to loss of lives. Vehicles and taxes cause accidents more than other cars. ANN displays that private cars and bus have a significant role in traffic accidents.

Keywords: traffic accidents, ANN, instrument, injuries, death.

1.Introduction

The problem of traffic injuries on the roads has social, economic and health aspects associated with development. Where traffic accidents lead to loss of more than 103 million people lives worldwide every year and at least infect 50 million. The problem is worse in developing countries than in developed countries due to lack of material resources to spend on road maintenance, and lack of traffic culture required when most people do not know the financial cost implications of traffic accidents. Consequently, developing countries bear the greater part of the burden of road traffic accidents represent one of the development issues, which negatively affect the poor in those countries Where SAP traffic accidents usually from 1% to 3% of GDP of any country. Traffic accidents are the major problems facing all countries in general and developing countries in particular. Saudi Arabia as a developing country has been experiencing rapid growth of traffic accidents. This problem influences negatively the human, economic resources and social life affecting the family, society and the State. Because of the significant adverse effects of traffic accidents, it is indispensable to study the problem in order to reduce these negative effects. An Artificial Neural Network (ANN) support the analysis by showing the significant role of various modes of transport in traffic accidents. ANN is an information-processing paradigm that is inspired by the way biological nervous systems, such as the brain, process information. The key element of this paradigm is the novel structure of the information processing system. It is composed of a large number of highly interconnected processing elements (neurons) working in unison to solve specific problems. The preliminary inspection of the available data identifies the significance of traffic accidents in Saudi Arabia, especially Asir province. There is an

obvious different impact of accidents inside and outside the cities in causing injuries and death in three regions of the Kingdom. The impact of traffic accidents in Asir mediates Mecca and Medina, Qassim and the Eastern region. The use of the advanced statistical analysis in scrutinizing and predicting traffic accidents displays the importance of the economic and social consequences in Saudi Arabia. The increasing numbers of modes of transport every year results in an increase in traffic accidents. Thus, the importance of this research stems from predicting the size of future traffic accidents based on the results of this study hoping that authorities take appropriate decisions to reduce accidents and in turn reduce their economic and social consequences. The research aims at using quantitative methods in general and advanced econometric tools in particular to assist in analyzing the traffic accident indicators, and forecast over the next few years. The research intends to provide decision makers with the research results to aid them in making the right decisions about the increasing traffic accidents to limits their implications on the society. The research seeks to achieve many important goals in the following aspects:

1) Learn about the essence of traffic accidents issues in Saudi Arabia, especially Asir province.

2) Using quantitative methods to analyze and extrapolate trends of traffic indicators.

3) Provide scientific recommendations and findings to decision makers to contribute in solving the problem of traffic accidents.

4) Employ advanced statistical model to estimate and predict the traffic accidents in the future.

The research depends on quantitative descriptive analysis and extrapolation of traffic indicators, using data officially published statistics by the Ministry of the Interior, and the General Authority for Statistics covering the 13 provinces for the period 1433 -1437. Panel data entails the use of Fixed and Random effects models. Another advanced econometric tool in use is the Neural Network Analysis. Traffic accidents are more prevalent in the world suffer from Saudi Arabia amid growing numbers of cars coming into service that entail an increase in the rates of traffic accidents in the absence of the expansion and maintenance of roads and lack of traffic awareness and speeding and congestion. Accordingly, the questions below will explored the traffic problem of the research.

What is the effect of the change in the number of modes of transport on traffic accidents?

What are the socio-economic effects of traffic accidents?

What future prospects to solve traffic problems and reduce accident rates?

Section one: introduction, research importance, research objectives, research methodology, research problem, and literature review. Section II: Theoretical Background. Section 3, Econometric Modeling 4: Artificial Neural Network and empirical results. Section 5: and the conclusions.

2. Literature Review

There are many previous studies on traffic accidents and economic and social consequences and psychological impact on families and society. Below we review the most important studies and their findings. Abdul Wahab (2014) run quantitative analysis of traffic accidents in Saudi Arabia "Analytical Study of Traffic Accidents in Riyadh" during the period from 1424-1433. This study aimed to identify the volume of traffic accidents in the Riyadh region, seriousness and level of traffic safety and traffic forecasting in Riyadh and to know the strength of the relationship between incidents with the type of accident, vehicles vehicle type, mortality by sex and age, patients' type, drivers' participants of the incident and citizenship.

Ghalib, et al (2009) used quantitative analysis models to predict traffic accidents indicators in Jordan so as to assist decision makers in their study "Quantitative Analysis of Indicators of Traffic Accidents in Jordan (Automobile Risk Management Study)" Their results showed that both the number of incidents and the severity rate are very high to global averages in some Arabic countries.

Habtoor (2011) conducted statistical analysis of traffic accidents in the Republic of Yemen in an Unpublished Master submitted to the School of Administrative Sciences-Aden University. The aim of this study is to analyze the actuality of traffic accidents in the Republic of Yemen and the material and human losses resulting from these incidents. Results indicated that the main causes of traffic accidents are speeding, bad roads, traffic unawareness, lack of proper screening of vehicles, as well as poor oversight in the licenses granted to drive cars. As the study showed that traffic accidents might cause social and economic disasters and waste of human and material losses and psychological pain to families and society.

Study of Ghneim (2010) "Social and physical cost of traffic accidents in Jordan" aimed to assess the growing social and physical cost of traffic accidents in Jordan. The study found a discrepancy in social and material cost of traffic accidents between the Hashemite Kingdom provinces due to the variance in population numbers and the number of vehicles registered and set up traffic accidents and their gravity. As the study shows that, there is a correlation between the numbers of traffic accidents and the awareness of the population, as well as the conditions of vehicles registered. Registration by hand varies from one governorate to another. The study recommends the need to create a database of traffic accidents at province level to include how much these incidents and the type, seriousness and social, physical and environmental costs resulting from each incident.

Hawalf (2012) studied economic and social costs of traffic accidents in Algeria aiming at analyzing the problematic traffic safety in numbers in terms of the number of deaths and casualties. The scary obsession for users of roads in Algeria caused high horror numbers where traffic accidents results in 13 dead and 175 injured every day on average, that is an average of 4500 deaths annually and 3500 people permanently and young people, especially males who constitute the largest proportion of victims of traffic accidents.

Maan (2005) intended in his study "Economic and Social Development and Their Impact on Traffic Accidents" to use traffic problems as an indicator of changes caused by economic and social development and awareness of instructions and traffic systems as a civilized

community need to reduce the rate of traffic problems. This study also led to the interpretation of traffic accidents from the angle of economic and social changes caused by the pending development programmes in the community because any change reflected directly or indirectly on the behavior of individuals. The study showed that traffic accidents are caused by not adopting motorists of traffic rules in order to achieve own behavior, bypassing the traffic laws and the public interest, which reflects negatively on inner-city traffic behaviors and problems traffic accidents thus reflects on The lives and property of the State.

3.Theoretical Background

The economic concept illustrates traffic accident as a loss of life, the bodies that can result from such injuries partial disability or total disability, and loss of funds. Where the loss of life and injury to two objects that is the important human resource, and loss of funds and other economic resources, which includes natural and financial resources in kind or cash. Since economic development is fundamental to the human and financial resources and natural without which society there can be no development and no economy. Data that includes cross section and time series are common in economics. Pooling of cross section and time series gives more information but can bear serious problems of autocorrelation and heteroscedasticity. Ordinary least squares does not deal well with these problems together. Fixed and random effects models deals and solves these problems. A fixed effects model is a statistical model in which the model parameters are fixed or non-random quantities. This is in contrast to random effects models and mixed models in which all or some of the model parameters are random variables. In many applications including econometrics (Greene 2011) a fixed effects model refers to a regression model in which the group means are fixed (non-random) as opposed to a random effects model in which the group means are a random sample from a population (Ramsey 2002).

Generally, data can be grouped according to several observed factors. The group means could be modeled as fixed or random effects for each grouping. In a fixed effects model each group mean is a group-specific fixed quantity. When using FE we assume that something within the individual may affect or bias the predictor or outcome variables and we need to control for this. The key insight is that if the unobserved variable does not change over time, then any changes in the dependent variable must be due to influences other than these fixed characteristics." (Stock and Watson, 2003, p.289-290). FE model is presents the model below by adding dummy variables to allow unequivocal change across cross section units and across time (Arabi 2008).

$Y_{it}= \beta_0 + \beta_1 X_{1,it} +\ldots+ \beta_k X_{k,it} + \gamma_2 E_2 +\ldots+ \gamma_n E_n + \delta_2 T_2 +\ldots+ \delta_t T_t + u_i$ **(1)**

*Y_{it} is the dependent variable (DV) where i = entity and t = time.

*X_k,it represents independent variables (IV),

*β_k is the coefficient for the IVs,

* u_{it} is the error term –En is the entity n. Since they are binary (dummies) you have n1 entities included in the model.

* γ_2 is the coefficient for the binary regressors (entities) .

*T_t is time as binary variable (dummy), so we have t-1 time periods.

* δ_t is the coefficient for the binary time regressors .

The rationale behind random effects model is that,the crucial distinction between fixed and random effects is whether the unobserved individual effect embodies elements that are correlated with the regressors in the model, not whether these effects are stochastic or not" [Green, 2008, p.183].

An Artificial Neural Network (ANN) is an information processing paradigm that is inspired by the way biological nervous systems, such as the brain, process information. The key element of this paradigm is the novel structure of the information processing system. It is composed of a large number of highly interconnected processing elements (neurons) working in unison to solve specific problems. ANNs, like people, learn by example. An ANN is configured for a specific application, such as pattern recognition or data classification, through a learning process. Learning in biological systems involves adjustments to the synaptic connections that exist between the neurones. This is true for ANNs as well (Minin 2006).

ANN dismantle the complex system networks to eventually combine simple elements made up a complex system. Networking is characterized as a set of neurons neurons communicate. Neurons can be seen as computational units that receive and process inputs to get the result. Specifies the communication between neurons flow of information which can be unidirectional or bilaterally. The interaction of communication between neurons to show the General behavior of the network can be seen in the network elements separately this behavior General reportedly originating (Everson 1994, Gonzalez, & Desjandins 2001, Principe, 2000, Smith 2004)).

Artificial neural networks Artificial Neural Network ANN is a very effective tool in many fields of scientific statistical modeling technique has emerged as an attractive alternatives for researchers and practitioners (Abdelkader 2004, tignvistki 2004). Artificial neural networks can detect basic functions within a set of data and perform tasks such as pattern recognition, classification, calendar, modeling, forecasting, and control. I prefer using nonparametric models when you don't meet the requirements.The following the procedure of calculation:

$$Y_j = f\left(\sum_i w_{ij} X_{ij}\right) \quad (2)$$

Where Y_j is the node j in the activation function; w_{ij} is the contact weight between node J and node I; X_{ij} signal.

Empirical Results

Table (1) Empirical Results Injuries

Dependent Variable: INJURED				
Method: Panel Least Squares				
Date: 10/15/18 Time: 09:52				
Sample: 1432 1437				
Periods included: 6				
Cross-sections included: 13				
Total panel (unbalanced) observations: 77				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
INSIDE	0.006159	0.002786	2.210736	0.03080
OUTSIDE	0.040943	0.012211	3.352968	0.00140
C	2429.346	147.1461	16.50976	0.00000
Effects Specification				
Cross-section fixed (dummy variables)				
R-squared	0.982516	Mean dependent var		2931.844
Adjusted R-squared	0.978567	S.D. dependent var		2981.075
S.E. of regression	436.4257	Akaike info criterion		15.16805
Sum squared resid	11808977	Schwarz criterion		15.62464
Log likelihood	-568.97	Hannan-Quinn criter.		15.35068
F-statistic	248.8572	Durbin-Watson stat		1.832955
Prob(F-statistic)	0.00000			

INJURED = 0.0061590877*INSIDE + 0.04094*OUTSIDE + 2429.346 + [CX=F,ESTSMPL="1432 1437"]

Table (2) Empirical Results Death

Dependent Variable: DEAD				
Method: Panel Least Squares				
Date: 10/15/18 Time: 09:54				
Sample: 1432 1437				
Periods included: 6				
Cross-sections included: 13				
Total panel (unbalanced) observations: 77				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
INSIDE	-0.00105	0.000558	-1.87835	0.0650
OUTSIDE	0.019914	0.002444	8.148664	0.0000
C	469.6817	29.44977	15.94857	0.0000
Effects Specification				
Cross-section fixed (dummy variables)				
R-squared	0.97607	Mean dependent var		597.9351
Adjusted R-squared	0.970666	S.D. dependent var		509.9878
S.E. of regression	87.34611	Akaike info criterion		11.95057
Sum squared resid	473019.3	Schwarz criterion		12.40716
Log likelihood	-445.097	Hannan-Quinn criter.		12.1332
F-statistic	180.6337	Durbin-Watson stat		1.328432
Prob(F-statistic)	0.00000			

DEAD = -0.001047*INSIDE + 0.0199144*OUTSIDE + 469.6817 + [CX=F,ESTSMPL="1432 1437"]

Table (3) Empirical Results Total Trafic Accedents

Dependent Variable: TOTAL				
Method: Panel EGLS (Cross-section weights)				
Date: 10/11/18 Time: 19:30				
Sample: 1432 1437				
Periods included: 6				
Cross-sections included: 13				
Total panel (unbalanced) observations: 77				
Linear estimation after one-step weighting matrix				
White cross-section standard errors & covariance (d.f. corrected)				
WARNING: estimated coefficient covariance matrix is of reduced rank				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	24684.22	1434.725	17.20485	0.0000
BUS	0.095601	0.011253	8.495236	0.0000
TAXI	0.492219	0.130924	3.759571	0.0004
TRUCKS	-0.07135	0.011849	-6.02104	0.0000
VEHICLES	2.328104	0.508919	4.574604	0.0000
CYCLE	0.265105	0.096063	2.759701	0.0077
PRIVATE	0.010221	0.000957	10.6788	0.0000
Effects Specification				
Cross-section fixed (dummy variables)				
Weighted Statistics				
R-squared	0.976713	Mean dependent var		39320.36
Adjusted R-squared	0.969486	S.D. dependent var		22508.3
S.E. of regression	5812.84	Sum squared resid		1.96E+09
F-statistic	135.1479	Durbin-Watson stat		2.457098
Prob(F-statistic)	0.0000			
Unweighted Statistics				
R-squared	0.979503	Mean dependent var		39234.88
Sum squared resid	3.36E+09	Durbin-Watson stat		2.490521

TOTAL = 24684.2184 + 0.0956*BUS + 0.492219*TAXI - 0.0713446*TRUCKS + 2.32810*VEHICLES + 0.2651*CYCLE + 0.010221*PRIVATE + [CX=F,ESTSMPL="1432 1437"]

Nueral Network

Multilayer Perceptron

Table (4) Case Processing Summary

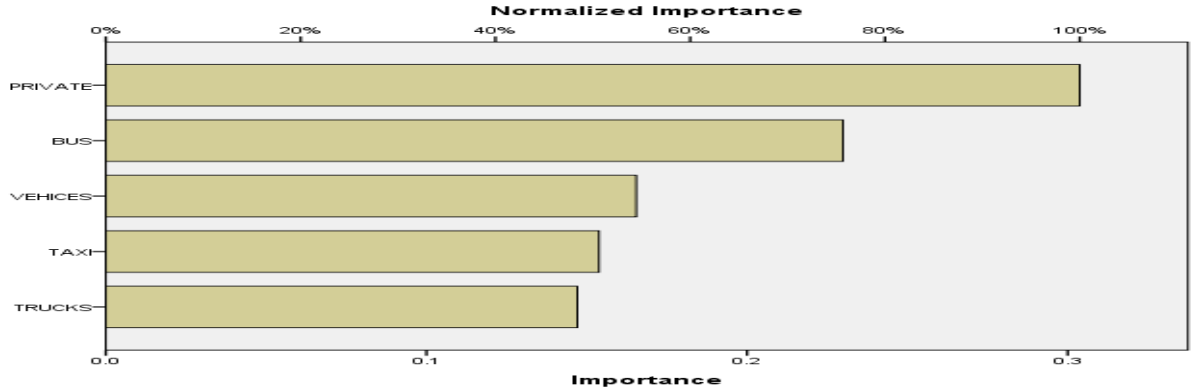
		N	Percent
Sample	Training	5	83.3%
	Testing	1	16.7%
Valid		6	100.0%
Excluded		2	
Total		8	

Table(5) Independent Variable Importance

	Importance	Normalized Importance
TAXI	.154	50.6%
BUS	.230	75.7%
TRUCKS	.147	48.4%
PRIVATE	.304	100.0%
VEHICES	.165	54.5%

The sample has been divided to 83% and 17% between training and testing according to relative importance. The above table contains quantitative measure of the relative efficiency of vehicles that caused traffic accidents.

Figure (1) Normalized Importance Modes of Transport



The figure above shows the clearly the relative importance of the effects of inputs on output (accidents). Private cars has the highest relative important, followed by bus, while trucks has the least importance.

Effects of Accidents In and Out of Cities

The sample division has been different from above; testing share has been reduced to 60% at the cost of training.

Table (6) Case Processing Summary

		N	Percent
Sample	Training	3	60.0%
	Testing	2	40.0%
Valid		5	100.0%
Excluded		3	
Total		8	

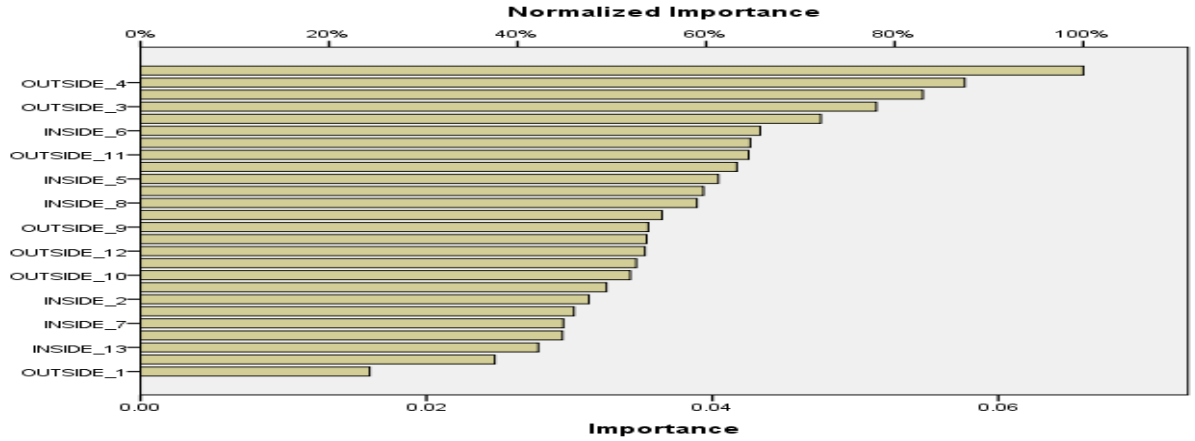
Input and output also differed from its predecessor so the relative importance of traffic outside and inside cities and its impact on injuries has been measured.

Table (7) Independent Variable Importance

	Importance	Normalized Importance
OUTSIDE_1	.016	24.3%
OUTSIDE_2	.036	55.3%
OUTSIDE_3	.051	78.1%
OUTSIDE_4	.058	87.4%
OUTSIDE_5	.043	64.7%
OUTSIDE_6	.048	72.2%
OUTSIDE_7	.066	100.0%
OUTSIDE_8	.033	49.4%
OUTSIDE_9	.036	53.9%
OUTSIDE_10	.034	52.0%
OUTSIDE_11	.043	64.5%
OUTSIDE_12	.035	53.5%
OUTSIDE_13	.035	53.7%
INSIDE_1	.055	83.0%
INSIDE_2	.031	47.6%
INSIDE_3	.025	37.6%
INSIDE_4	.039	59.7%
INSIDE_5	.040	61.3%
INSIDE_6	.043	65.7%
INSIDE_7	.030	44.8%
INSIDE_8	.039	59.0%
INSIDE_9	.035	52.6%
INSIDE_10	.042	63.3%
INSIDE_11	.030	44.8%
INSIDE_12	.030	46.0%
INSIDE_13	.028	42.2%

Relative importance was arranged for the influence of accidents inside and outside cities in injuries in the figure below. Accident outside Medina revealed highest importance followed by accidents outside the city of Mecca, which makes sense as many travel to these cities to perform religious ceremonies. Accidents outside Riyadh was least important followed by incidents within the city of Al-Jouf.

Figure (2) Normalize Importance of Inside and Outside Cities



Impact of Accidents Inside and Outside the Cities on Death

Table (8) Case Processing Summary

		N	Percent
Sample	Training	2	40.0%
	Testing	3	60.0%
Valid		5	100.0%
Excluded		3	
Total		8	

The sample has been divided 40% to 60% for the impact of accidents inside and outside the cities contrary to the injuries sample.

Table (9) Independent Variable Importance

	Importance	Normalized Importance
OUTSIDE_1	.028	50.5%
OUTSIDE_2	.046	82.5%
OUTSIDE_3	.043	76.2%
OUTSIDE_4	.049	87.5%
OUTSIDE_5	.040	72.0%
OUTSIDE_6	.040	70.9%
OUTSIDE_7	.045	80.7%
OUTSIDE_8	.047	84.4%
OUTSIDE_9	.033	59.5%
OUTSIDE_10	.025	44.6%
OUTSIDE_11	.033	58.7%
OUTSIDE_12	.048	84.7%
OUTSIDE_13	.027	48.4%
INSIDE_1	.039	69.7%
INSIDE_2	.028	49.6%
INSIDE_3	.027	48.8%

INSIDE_4	.020	35.9%
INSIDE_5	.047	83.0%
INSIDE_6	.038	67.1%
INSIDE_7	.048	85.2%
INSIDE_8	.041	73.6%
INSIDE_9	.035	61.8%
INSIDE_10	.056	100.0%
INSIDE_11	.040	71.7%
INSIDE_12	.031	54.7%
INSIDE_13	.043	76.3%

The figure below reflects the order of the relative importance of accidents inside and outside cities in causing death. The relative importance accidents causing death outside the cities of matches with injuries. Incidents within the eastern region occupied second place in relative importance whereas accidents inside Medina less relative importance followed by incidents outside the Al-Jouf. Thus the incidents inside and outside hollow of less importance in causing injury and death.

5. Conclusion

Through the data available through the book identified statistical reality of traffic accidents issues in Saudi Arabia, especially Asir. Where the differential effects of accidents inside and outside the cities the size of injuries and death in three regions of the Kingdom. Either Asir in particular the impact of the accident has mediated in and out of cities in injuries and death for a group of Mecca and Medina, Qassim and the eastern region as a group up and rest areas as a group. As to the estimated negative cutter Asir indicates that accidents inside and outside cities reduce their impact compared to areas with contrast cation cutouts categorical effect positive effect on death in Asir. Been using quantitative methods: descriptive statistics, random effects models and artificial networks analysis and extrapolation of trends in traffic indicators. With an average impact of traffic accidents outside the cities in injuries and deaths by 37% and 10%, respectively, compared with 8% and 2% of accidents within cities. Random effects models applied provided morale estimates for parameters types of vehicles and their effect on accidents and incidents parameters of inside and outside cities and their effect on injuries and death in addition to relative importance through artificial neural networks results. Providing scientific recommendations and findings to decision makers and relevant traffic accidents to contribute to solving the problem of traffic accidents.

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