Analysis of Traffic Safety in Mongolia

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Abstract: In this Article, the level of traffic safety in Mongolia was assessed during the period of 2005-2015 by analyzing the number of automobiles, growth in number of drivers, relationship between traffic accidents, methods to determine the level of traffic safety, growth in number of city and municipal roads or infrastructures. The purpose of this article is to determine the further actions needed for the issues of traffic safety in Mongolia.

Keywords: Traffic accident, The level of Traffic Safety, Driver assistance systems

1. INTRODUCTION

In 2010 a United Nations General Assembly resolution proclaimed a Decade of Action for Road Safety (2011–2020). This Decade was launched in May 2011 in over 110 countries, with the aim of saving millions of lives by improving the safety of roads and vehicles; enhancing the behaviour of road users; and improving emergency services.

In 2010, Bangkok Thailand, Asia Pacific Economy Commission’s regional traffic experts released “Recommendation for Traffic safety” to reduce number of deaths caused by road accidents. Mongolian Government supported the cause and decided to resolve some of the urgentproblems of traffic safety in the country. During 2011-2020, Mongolia is planning to decreasethe death on road rate by 50% and have already taken some actions (National Strategy of Traffic Safety, 2012).

The International Road Organization conducted a survey from 180 countries of theworld. According to the survey, Mongolia ranked 74thplace on a death on road per 100,000 people rank (Static Index of Roadside Accidents and Violations in Mongolia, 2015).

In order to determine the level of traffic safety in Mongolia, we studied various scholarly works on traffic safety previously done by other scientists as well as including available statistical data on traffic safety in our country.

To assess the level of traffic safety, three types of models are mainly used in other countries.

1) Statistical Models based on a comparison of actual data about the accident and the relative accident.
2) Practical Action Model, based on a comparison of the effectiveness of practical activities related to the improvement of the interactions in a complex system "Driver-Car-Road" (eg. use of seatbelts, helmets, improvement of highways and equipment .etc)

3) Models of strategic assessment, based on a comparison of federal programs to improve road safety management systems and organizational works to improve road safety. (Bayarsaikhan *et al.*, 2014).

The obstacle in the practical application of any method of assessing the level of road safety is the absence or lack of statistics on accident in different parts of the world, especially in developing countries. To develop an effective method, you must have an idea of having practical significance and the available data on accidents. There are several reasons for using a small number of variables at the beginning of the first models. This was done in order to simplify the model, reduce errors, and reducing time and cost of collecting and analyzing baseline data on accidents.

2. CURRENT SITUATION OF TRAFFIC SAFETY

2.1 Drivers, vehicles and road index

In 2015, the total number of drivers in Mongolia reached 1038624, out of which 61258 were registered in the same year. 65% percent of the total drivers are male and 35% are female (Static Index of Roadside Accidents and Violations in Mongolia, 2016). Number of female drivers increased 2% compare to the prior year.

In 2015, total of 789706 vehicles were registered in Mongolia. From which 64.5% were sedans, 21.4% were trucks, 4.9% were motorcycles, 0.8% were buses, 1.9% were special use, 2.7% were trailers, 1.3% were moving parts and 2.6 % were other. Compare to 2014 data, number of sedans increased 8.0%, number of trucks increased 4.7%, and number of moving parts increased 11.9% which indicated an increasing trend in trucks and heavy machinery (Static Index of Roadside Accidents and Violations in Mongolia, 2016).

The annual increase in number of automobiles in Mongolia results 1 car in every 3 adults in 2015. In 2015, the total length of roads n Mongolia was 49,200.4 km, out of which 18% were improved road and 82% were dirt road. Compare to the prior year, the length of the improved road increased by 1222.7 km (16%). There are 5.7 km road per thousand square kilometer in Mongolia. 5838.2 km (65.8%) of the total improved road is paved road , 1864.8 km (21%) is base course road, and 1172.6 km (13.2%) is gravel road.

2014-2015 Global Competitiveness Report of World Economic Forum gives Mongolia a rating of 3.1 and ranks 119th place out of 144 nations. Although Mongolia moved ahead of 14 nations in the ranking compared to prior years, the state of infrastructures in Mongolia especially the development and growth of roads are at inadequate stage.

58.5 % of all traffic accidents happen on the paved roads, 20.2% happens on base roads. Which leads to a conclusion that although improvement of roads improves the quality of travels it also fastens the speed of vehicles which results in increased number of car accidents.

2.2 Traffic accident index, cause

According to the official police report, there were 429 deaths and 1382 injuries in 2015. Compare to the 2000, number of deaths increased by 21.2% and injuries increased by 14.6%.

In 2015, 45161 roadside accidents recorded in Mongolia. 96.5% were due to drivers fault, 3.4% were due to pedestrian fault, and 0.1% was due to condition of the road. From 17848 car accidents caused by driver's faulty actions 8.3% were due to speeding.

According to 2015 study 55.8% of total injuries recorded were classified as slightly serious, 22.3 % were classified as serious, and 21.9% were classified light (Static Index of

Roadside Accidents and Violations in Mongolia, 2016).

The number of deaths due to car accident per 10000 was 28.5 in 2000 and 5.4 in 2013. Number of deaths due to car accident decreased 5 times and number of injuries due to car accident per 10000 decreased 7.8 times. However, these figures were only obtained from the police reports and have not been matched against hospital records.

In terms of number of years driven, 40.3% of total drivers who had traffic accidents had driven automobile for 0-5 years, 29.5% had driven for 11-15 years, 24.7% had driven 6-10 years, and 4.4% have driven for 16-20 years.

3. DETERMINING THE LEVEL OF TRAFFIC SAFETY IN MONGOLIA

3.1. The Methods to determine the level of traffic accidents based on population and automobile growth.

The first generation models represented a statistical model based on a comparison of the state of motion security using risk indicators and evidence but the accident rate and the level of motorization. These models are models analysis carried out in the same year in different countries at the same time.

The second generation model takes into account the time factor. These models allow you to perform a standard assessment of the accident in time row.Such models allow traffic in the country and suggest possible future development of the situation, monitoring changes in security trends.

In the third-generation model, developers take into account in the same model of the actual accident figures (the relative number of accidents) with other indicators (statistics and data on the effectiveness of the practical arrangements)

The fourth generation model focuses on all three of the above models with the use of indicators: Indicator, index action and indicator strategic situation. One approach is to develop indicators improve road safety, which brings together the majority of macro indicators in a single unit.

The first generation of models that take into account of motorization, traffic risk and personal risk. In 1949 prof. R.Smid based on analysis of accident data in European twenty countries, since 1938, has developed a regression model (log-linear model) and set back proportional relation between the risk of movement (with respect to the number of dead drivers vehicles) and motorized (total vehicle park on the number population). This regression equation is enough to give an accurate assessment of the risk level of traffic for any given level of motorization.

The equation shows that the annual increase in the number of traffic intensity per unit car decreases. Prof. R.Smid found that quantity in an accident (F) in any country during the year related to the number of registered vehicles (V) and population (P) in the country by the following equation:

$$\frac{F}{V} = \alpha\left(\frac{V}{P}\right)^{-\beta} \tag{1}$$

where,

F : the number of deaths in road accident
V : the number of registered vehicles
P : Population
a= 0.003, β= 2/3.

To this generation are many models developed to describe and forecasting security level in different countries and time series basic theories. They are related to non-belt functional time to determine the long-term changes in the level of security in the month, or year on the range. These models intended with respect to time series.

Koomstra (1992) showed that the motorization depends on the time between the number of victims and the public should also time. To measure the correlation between the input and output variables must be taken into account trends in the model. He got relationship to approximate the number of people killed in the country in a given year:

$$F_t = zV_t^x V_{t-k}^w \left(\left(\frac{V_{max}}{V_{t-k}}\right)^c - 1\right)^y \tag{2}$$

where,

F_t : the number of deaths in road accidents in the country for the year t,

V_{max} : maximum value of the car-miles,

κ : the time lag for years

X, W, Z, y, u, c : standing variables.

Third generation: The need for increased integration with a number of unused data. Most of the recent research has been directed at the accidents assessment using risk indicators (level), which few or limited. In models third into account the need to increase integration between h data (accident rate) and other indicators in the same one model. Page (2001) compared the situation with accident rate, and trends in Europe (OECD Test) from 1980 to 1994. He has developed a statistical model using a total cross-sectional analysis of time series. Model gives assessment of the state with the country's security to some positions, such as population density, car park, the number of cars on the per capita, the percentage of young people, and the level of alcohol consumption. Based on this model, the countries that were included Sweden, the Netherlands and Norway. Bester (2001) developed a model based on Stunenchatom regression analysis. The model allows to set variables which added or removed from the model.

Fourth generation: communication between all levels of performance Traffic safety. The latest generation realized the need to systematize the ways of uniting all potential indicators: human, vehicle, road, environment and management, combining them into a single weight index.This gives a broader picture of the possibilities of model, not focusing on one or more particular aspects.

RSDI, as an example, combines all three types of metrics together: indicators of actual statistics, the rate of practical strategic indicator. Thus, it is useful to show the difference between the progress of the shortcomings in the country. RSDI compares movement and progress compared with other countries and regions of the world. Each type of model is the sum of indicators and variables. Then it will be balanced as index for each value of statistical data, which can be obtained. Komnleksny RSDI rate is determined by the equation:

$$RSDI = \frac{\sum_{i=1}^{n} w_i x_i}{\sum_{i=1}^{n} w_i} \tag{3}$$

where,

x_i : normalized figure for the country

w_i : the weight x_i

n : the value

Weight changes from 0 to 1 and the sum of weights is equal to unity.

3.2. Analysis of the Traffic Accident Statistics

There are a number of factors that affected going up the number of traffic accidents, accidental deaths, casualties and damages (Table 1, 2).

Table 1. Population of Ulaanbaatar, Vehicles, Traffic Accident, Number of people involved in accident

Year	Population UB city (in thousands)	All vehicles (in thousands)	Traffic accident	Involved in an accident	Killed	Injured
2000	760.1	42.4	964	1132	145	987
2001	786.5	48.2	901	1226	105	1121
2002	812.5	59.5	838	999	130	869
2003	846.5	59.9	736	862	155	707
2004	893.4	69.6	721	794	143	651
2005	928.5	76.1	699	811	168	643
2006	965.3	82.1	856	895	152	743
2007	994.3	95.5	689	622	111	511
2008	1031.3	107.5	480	453	59	394
2009	1071.7	135.1	786	609	98	511
2010	1112.3	168.7	959	691	127	564
2011	1151.5	220.0	1013	725	103	622
2012	1287.1	321.3	1105	722	114	608
2013	1318.1	411.4	1211	843	117	726
2014	1372	443.3	1060	856	84	772
2015	1363	466.6	1068	861	112	749

Table 2. Population in Mongolia, Number of Drivers, Vehicles, Traffic Accident, People involved in accident

Year	Population in Mongolia (in thousands)	number of drivers (in thousands)	All vehicles (in thousands)	Traffic accident	Involved in an accident	Killed	Injured
2000	2403.1	181.5	118.4	1497	1957	338	1619
2001	2432.3	213.5	131.1	1474	2147	335	1812
2002	2465.6	238.1	142.4	1470	1963	327	1636
2003	2495.0	295.9	143.5	1235	1615	391	1224
2004	2521.7	352.3	154.5	1245	1504	385	1119
2005	2551.0	387.7	164.6	1190	1401	355	1046
2006	2583.2	425.5	177.3	1431	1648	378	1270
2007	2620.4	464.8	200.3	1343	1276	344	932
2008	2665.9	528.6	216.4	1202	1204	313	891
2009	2716.3	586.3	266.4	1390	1237	317	920
2010	2760.9	648.8	285.4	1632	1253	320	933

2011	2811.7	751.0	349.4	1862	1455	362	1093
2012	2867.7	805.3	554.6	1999	1447	369	1078
2013	2930.8	892.8	675.0	2143	1705	423	1282
2014	3002.5	977.4	739.6	1877	1796	492	1304
2015	3050.0	1038.6	789.7	2010	1811	429	1382

A. We created a time series model (Table 3), ARMA, to analyze the dynamic changes in population growth in the last 16 years, number of vehicles and traffic accidents by using ITSM program (Figure 1).

Table 3. Variables Dynamic Changes

Factors	Model	AR Coefficients	MA Coefficient
Population	ARMA(3,1)	1.000462, 0.671197, and -0.674310	0.380753
Number of vehicles	ARMA(2,1)	1.639810 and -0.654113	0.999778
Number of accidents	ARMA(1,0)	0.990482	-

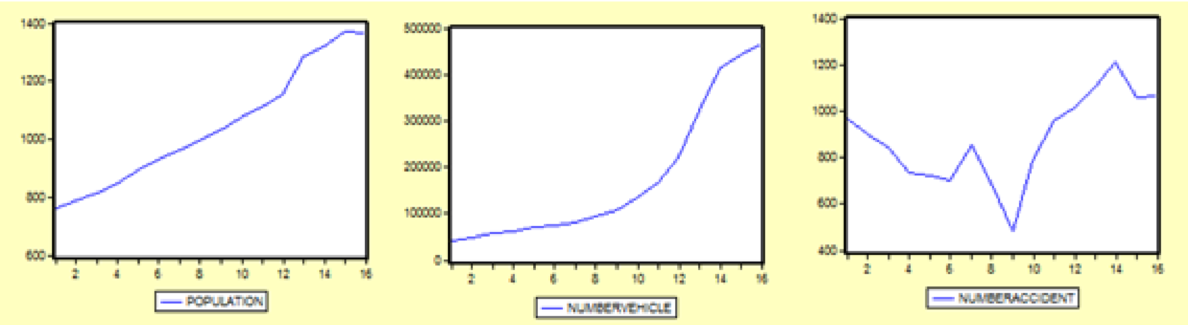

Figure 1. Variables Dynamic Changes

The model and the graphic result shows that population growth and number of vehicles are on continuously growing trend while the variable "traffic accident " shows unsteady pattern. In addition, according to the model and the graphic result, there are no significant relationship between number of traffic accidents and the years or time. This proves the fact that the variables have random relationship.

B. During 2000-2015 time period, there is a correlation between variables of population growth, number of vehicles, and traffic accidents (Figure 2). According to the Figure 2. there is a strong correlation between variables population growth and number of vehicles. however, the correlation between population growth and traffic accidents are relatively weak.

C. The number of vehicles and the traffic accidents are dependent from the population size of Ulaanbaatar. This relation was shown in the regression model created by using the least square method (Figure 3).

Based on the models mentioned above, creating a linear regression model depended from the variable "Population in Ulaanbaatar" is insufficient and fails to fully demonstrate the correlation between dependent and independent variables.

Therefore, An alternative regression equation was created by making population size x_1 and number of vehicles x_2 as independent variables and the variable traffic accident as dependent variable.

$$Y_1 = 1428.282 - 0.871267 \cdot x_1 + 0.002058 \cdot x_2 - 0.0001 \cdot x_1 x_2 \tag{4}$$

In this model, the last coefficient of non-linear relation is smaller. Figure 4 shows the model result.

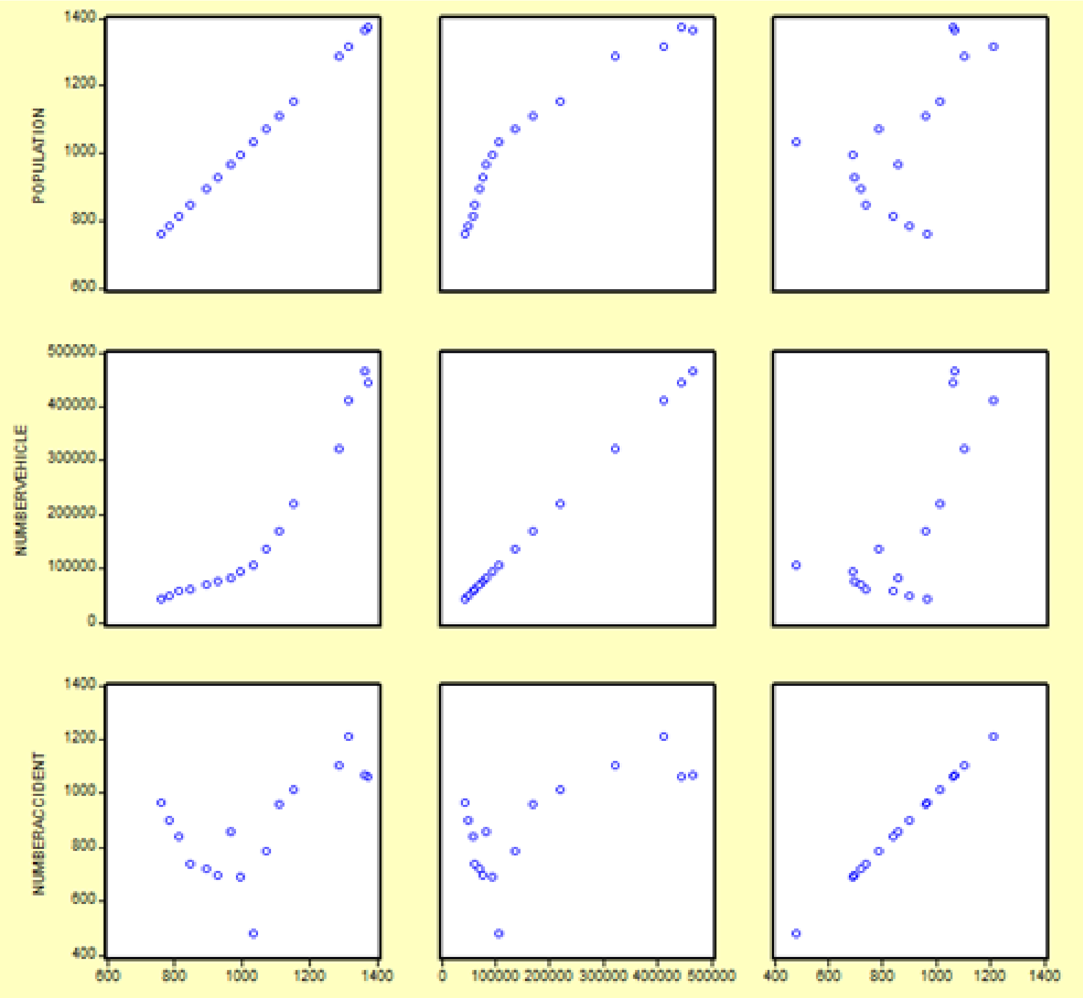

Figure 2. Correlation Between Variables

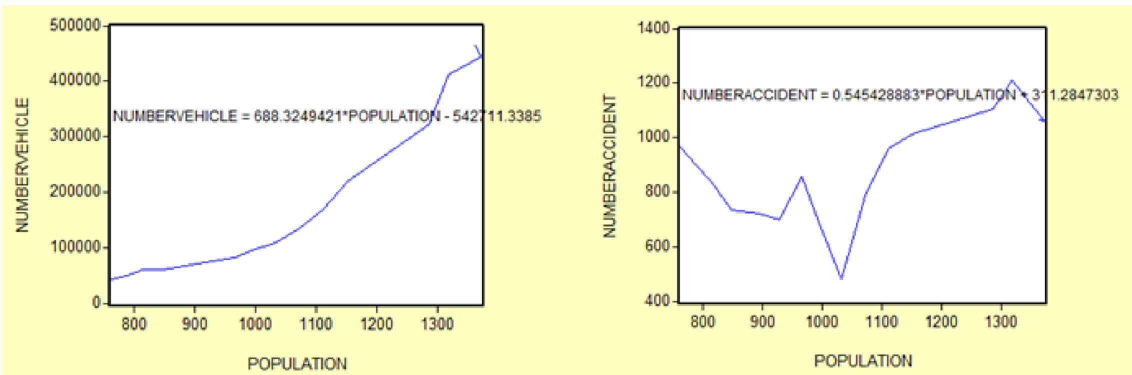

Figure 3. Models based on Population Growth

The model above displays perfect results by having Durban-Watson's statistics of $DW_{stat} = 1.87$, Fisher's Stats $F_{stat} = 10.09$ and 0.95% probability of normal distribution. In addition to that, the coefficient for general determination is $R^2 = 0.608$ thus, the number of traffic accident can be explained by population size and number of vehicles at 61%. Therefore, other additional variables can be used to further explain the relationship.

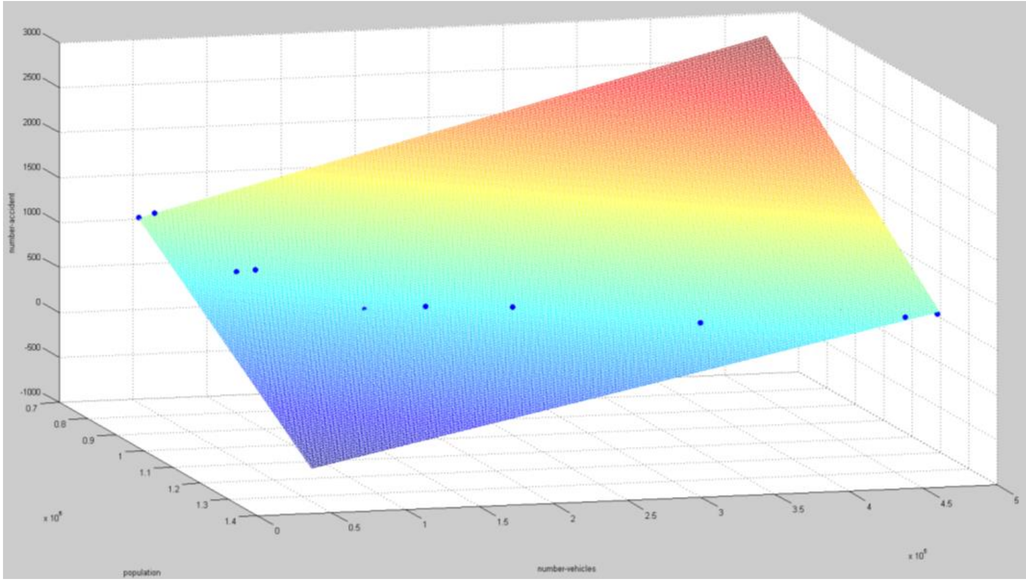

Figure 4. Multi-Variable Model Results

The model below shows the changes in number of people involved in traffic accidents Y_2– caused by the population x_1 and number of vehicles x_2

$$Y_2 = 2962.578838 - 2.595213411 \cdot x_1 + 0.003214326196 \cdot x_2 \tag{5}$$

For this model, DW statistical value is improved to $DW_{stat} = 1.89$ and the coefficient of determination is become $R^2 = 0.7797$. Therefore, the number of people involved in traffic accidents can be explained by the population size and the number of vehicles at probability rate of 78% .

4. CONCLUSION

In the frameworks of research, we need to study the relationship of other factors besides the factors of traffic accidents, number of vehicles, and the population size. The other factors includes following:

1) To make the research result more precise and detailed, we need to interrelate the micro and macro indicators such as population and vehicles density, maximum and minimum values of annual miles driven, and the risk degrees associated with the traffic accidents.
2) Enhancing drivers' accountability, discipline, skills, road condition, and building new roads or renovating the existing highways in both the capital and municipal areas.
3) Introducing modern technological advancement of driver-assistant- tools into traffic regulation and traffic safety.

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