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A Perspective Analysis of Road Accident Using Data Envelopment Analysis

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Abstract – *The rapid growth of the economy has led to the increased in road traffic networks and had indirectly led to the rapid cases of road accidents in Malaysia. Road accidents are one of the main contributors to human deaths in Malaysia. This paper attempts to measure road accidents in Malaysia by looking at the road accidents of 13 states and a federal territory. The aim is to measure the numbers and causes of road accidents by using Data Envelopment Analysis (DEA). Due to that, the input and output are identified to compute the efficiency level of road accidents. Apart of that, the trends in the number of road accidents in Malaysia is also depicted. For this study, the data from 2008 to 2011 for each Decision Making Unit (DMU) is analyzed. The result shows that the efficiency level did not determined by the number of vehicles on the road and the size of the state but it is determined by the utilization of resources by the authorities. It shows that managing input is important when the level of efficiency for the Decision-Making Unit (DMU) for the output is concerned. The outcome of this study supports the government measures to level up road maintenance in order to improve the efficiency level and curb the numbers of road accidents in Malaysia.*

Keywords: Road accident, Data Envelopment Analysis (DEA), states, Decision Making Unit (DMU)

1.0 INTRODUCTION

After the Asian financial crisis in 1997, the economy is growing rapidly nowadays. The rapid growth of the economy has resulted in the development of road traffic networks in Malaysia. Road traffic networks are transportation systems that quick, flexible, and reliable for passengers, goods, and services. However, the increase in road traffic networks has been a problem as it increases the number of road accidents. Road accidents are one of the major issues in the country. However, unluckily, road accidents happen every day in every country. Road injuries are the eighth leading cause of death in the world in 2013, according to the (World Health Organization, 2013).

Road accidents are one of the main contributors to human deaths in Malaysia. In a developing country such as Malaysia, there was a tremendous increase in the number of vehicles on the roads years by years. This has led to a significant increase in the number of road accidents on the streets of Malaysia. Based on statistical data, the number of accidents for the year 2003 was 298,651 accidents. While in 2012, the data shows that the number of road accidents rises about 163,772 accidents to 462,423 accidents. This indicates that the number of road accidents increased by 54.84% over the previous 10 years.

Road accidents will cause death, severe injuries, and minor injuries. Death is an accident causing a victim to stop all biological functions that maintain the living organism. Severe injuries are the accident causing the victim nearest to fatal but did not cause death whereas minor injuries are the accident caused the victim to face slight injury. Malaysia's current scenario about road fatalities is more than 6,000 per year, or about 18-20 people were killed every day (Figure 1). Therefore, a study is needed to measure the level of accident rate in Malaysia to solve this particular issue.

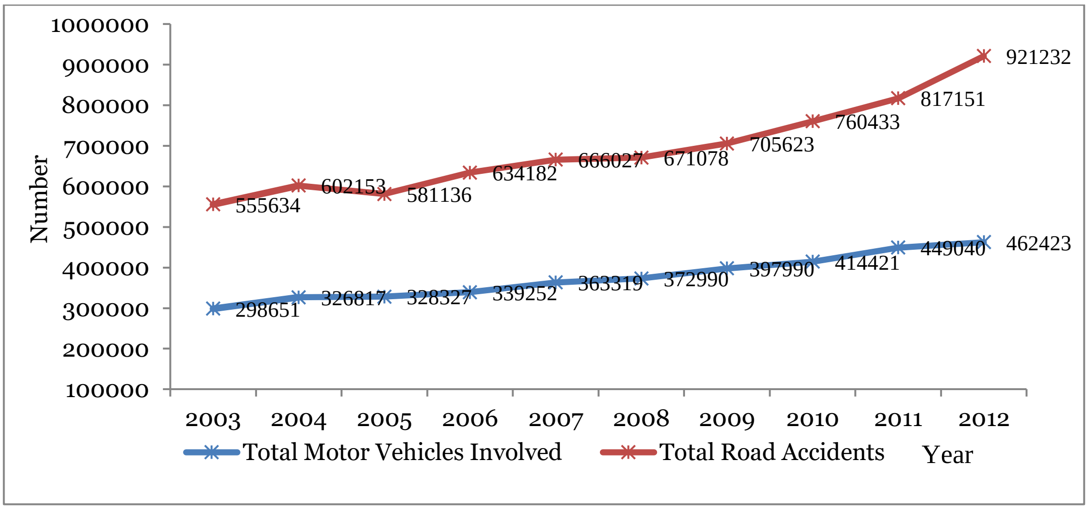

Figure 1: Total road accidents and motor vehicles involved (MOT, 2013)

2.0 PREVIOUS STUDY

Silva (1978) states weather condition is one of the causes of road accidents. There were 10,538 cases of accidents during clear weather conditions in 1970 and rose to 40,925 cases in 1975. However, during other weather conditions such as wet conditions were 1,432 cases, misty was 2,968 cases, poor light 2,677 cases, and heavy rain was 1,093 cases. The second cause is the road surface. For the year 1975, there were 952 cases (1.97%) on laterite roads, increased to

10,402 cases (21.57%) on gravel roads, and 36,879 accidents on metaled roads (76.46%). The study shows that the better the road conditions, the higher number of the road accident. This proves that town areas are more congested with vehicular traffic and the faster the speeds whereas in rural areas are less crowded and the lower the speeds. The third cause is locality. In I970, there were 6,926 cases of road accidents in towns and built-up areas but there were only 695 cases in rural areas. In I973, the number of road accidents rose to 14,207 cases in towns and built-up areas, and for the urban areas, still stays constant and lower than the previous years.

Mohamed et al. (2012), driving under the influence of drugs and alcohol are causes of road traffic deaths in Malaysia. The study indicated that 23.3% of the drivers whose death were positive for alcohol, for drugs 11% positive, and both drugs and alcohol were 2.3% positive. When the crash happened, there are 36.6% of drivers who fatal were under the influence of substance use. Driving under the influence of medicinal drugs particularly the benzodiazepines group will cause the driver to face a high risk of involvement in a road accident as Benzodiazepines relieve anxiety, help sleep which causes a person to easily depression and memory impairment. The negative effect of benzodiazepines is to raise inhibitory neurotransmitters that will slow down central nervous system electrical signals in the brain which affect the central nervous system producing mental confusion, drowsiness, lack of concentration, and coordination which can jeopardize a driver to drive safely.

Jawi et al. (2009) explained that weather can cause road accidents. In 2000, there are 250,417 cases of an investigated road accidents, total investigated road accidents with recorded weather conditions are 13,811 cases (5.52 %). This number rose to 315,973 cases of an investigated road accident and 27,593 cases (8.73%) of investigated road accidents with the recorded weather condition in the year 2007. Besides that, the study also found that the highest number of road accidents happened in fine weather and followed by rain, foggy, and windy condition. This is proved by the number of road accidents according to weather conditions. From the total of 97,856 cases of road accidents, fine weather happened 88,875 cases (90.82%) of road accidents, windy weather happened 306 cases (0.31%) of road accidents, foggy weather happened 1,705 cases (1.74%) of road accidents, and rain weather happened 6,970 cases (7.12%) of road accidents.

3.0 RESULTS AND DISCUSSION

3.1 Data Envelopment Analysis

Efficiency is derived and part of productivity, where it is a ratio of actual output attained to standard output expected (Sumanth, 1984). Mali (1978) express together the terms productivity, effectiveness, and efficiency as follows:

$$\text{Productivity index} = \frac{\text{output obtained}}{\text{input expected}} = \frac{\text{performance achieved}}{\text{resources consumed}} = \frac{\text{effectiveness}}{\text{efficiency}} \tag{1}$$

Therefore, Sumanth (1984) expresses efficiency as follow:

$$Efficiency = \frac{Output}{Input} \tag{2}$$

The (2-0) equation applies to the evaluation of simple data. The entity of output and input are diverse significantly. Therefore, equation (2-0) is not suitable for the complex relationship between outputs and inputs. The weight cost approach is the solution for the complexities of outputs and inputs as follows:

$$Efficiency = \frac{\sum weighted\ of\ outputs}{\sum weighted\ of\ inputs} \tag{3}$$

By assuming all weights are uniform, the mathematical equation is expressed as follows:

$$Efficiency = \frac{\sum_{r=1}^{n} u_r y_r}{\sum_{s=1}^{n} v_s x_s} \tag{4}$$

Where;

yr = quantity of output r
ur = weight attached to output r
xs = quantity of input s
vs = weight attached to input s

An efficient is denote = 1, therefore, to classify unit of efficiency is set as 0 < Efficiency ≤ 1.

Table 1: Input and Output of the Decision Making Unit

No	Input	Output
1	Active Vehicle	Maintenance
2	Non-Active Vehicle	
3	No of Accident	
4	No of Death Accident	

The number of vehicles on the road is defined as the total number of vehicles designed to legally carry people or cargo on public roads and highways such as busses, cars, trucks, vans, motor homes, and motorcycles. This would not include motor-driven vehicles not approved for use of the road, such as forklifts or marine vehicles.

The number of vehicles non-active on the road is defined as the total number of invalid vehicles that not scrapped or vehicles that have road tax, driving license, and insurance that already expired but not renews and still using the vehicles on the road.

Total road accidents are defined as the total number of an accident involving at least one road vehicle, pedestrians or cyclists occurring on a road open to public circulation, and in which at least one person is injured or killed and occurs when a vehicle that is moving along a roadway collides with another vehicle or object.

Total deaths caused by road accidents are defined as the total number of a person killed immediately or dying within 30 days as a result of a road accident.

Road maintenance is defined as costs related to keeping the road in its originally constructed condition to provide convenient and safe travel along the route. Road maintenance includes patching potholes, cleaning drainage, maintaining bridges, and solving other roadway problems.

3.2 Model Development

The model is developed from the extension of the ratio technique used in traditional efficiency approaches. The measurement is obtained from DMU as the maximum of a ratio weighted output to weighted input. The numbers of DMUs are not determined as outputs and inputs, however, larger DMUs can capture higher performance. This would determine the efficiency frontier (Golany & Roll, 1989). Besides, the number of DMUs should be at least twice the number of inputs and outputs (Golany & Roll, 1989).

The parameters and variables are needed in developing the model. Therefore, the model is based on the following parameters and variables:

N = number of DMU	$\{j = 1,2,...n\}$
y = number of outputs	$\{y = 1,2,...R\}$
x = number of inputs	$\{x = 1,2,...S\}$
y_i = Quantity of output r^{th} of output of j^{th} DMU	
x_i = Quantity of input s^{th} of input of j^{th} DMU	
u_r = weight of r^{th} output	
v_s = weight of s^{th} input	

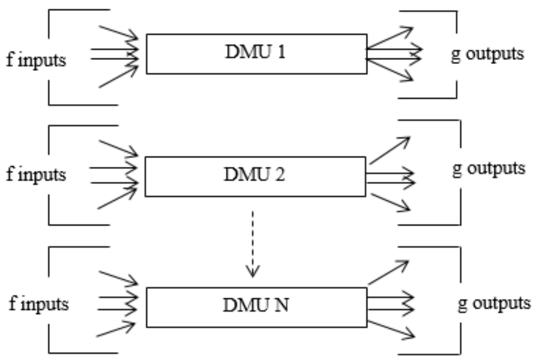

Figure 2: DMU and homogeneous units

Golany and Roll (1989) describe that a homogenous unit is important in choosing DMUs to be compared and identifying the factors affecting DMUs (Figure 2). Therefore, a homogenous group of units needs to perform similar tasks and objectives, under the same set of market conditions and the factors (inputs and outputs). Figure 5 depicts the DMU and homogeneous units.

This concept is using linear programming (LP) formulation to compare the relative efficiency of a set of decision-making units (DMUs). Farrell (1957) has developed a similar approach to compare the relative efficiency of a cross-section sample of agricultural farms.

The efficiency measures under constant returns to scale (CRS) is obtained by N linear programming problems under Charnes et al. (1978) as below:

$$\begin{aligned} & Min_{\psi,\lambda}\ \psi_j \\ & \sum_{i=1}^{N} \lambda_i y_{ri} \geq y_j; \quad r = 1,\dots,R \\ & \sum_{i=1}^{N} \lambda_i x_{si} \leq \psi_j x_j; \quad s = 1,\dots,S \\ & \lambda_i \geq 0; \quad \forall i \end{aligned} \tag{5}$$

Where $y_i = (y_{1i}, y_{2i}, \dots, y_{Ri})$ is the output vector, $x_i = (x_{1i}, x_{2i}, \dots, x_{si})$ is the input vector. Solving the above equation for each one of the *N* container terminals of the sample, *N* weights, and *N* optimum solution found. Each optimum solution ψ_j^* is the efficiency indicator of the container terminal j and, by construction satisfies $\psi_j^* \leq 1$. Those container terminals with ψ_j^* < 1 are considered inefficient and $\psi_j^* = 1$ are efficient. Charnes et al. (1978) model constant returns to scale (CRS) was modified by Banker et al. (1984) by adding the restriction $\sum_{i=1}^{N} \lambda_i = 1$ this has the generalizing model to variable returns to scale (VRS) as below:

$$\begin{aligned} & Min_{\vartheta,\lambda}\ \vartheta_j \\ & \sum_{i=1}^{N} \lambda_i y_{ri} \geq y_j; \quad r = 1,\dots,R \\ & \sum_{i=1}^{N} \lambda_i x_{si} \leq \vartheta_j x_j; \quad s = 1,\dots,S \\ & \sum_{i=1}^{N} \lambda_i = 1; \lambda_i \geq 0; \quad \forall i \end{aligned} \tag{6}$$

Charnes et al. (1978) from DEA-CCR discover the objective evaluation of overall efficiency and identify the resources and estimates the amounts of the identified inefficiencies. Thus it is called the constant return to scale (CRS). Albeit, Banker et al. (1984), DEA-BCC remove the constraint from the CCR model by adding, thus, BCC can distinguish between technical and scale inefficiencies by (i) estimating pure technical efficiency at the given scale of operation and (ii) identifying whether increasing, decreasing or constant return to scale possibilities are present for further exploitation. It is called the variable return to scale. Therefore, for CCR efficient is required both scale and technical efficiency, BCC efficient is only required technically efficient.

4.0 RESULTS AND DISCUSSION

The level of road accidents in Malaysia can be analyzed base on the percentage of road accidents and causes of road accidents through the Statistical data and reports. The previous data from Royal Malaysian Police showed that road accidents increased year by year. The number of road accidents for eight states consists of Johor (JHR), Kedah (KDH), Melaka (MLA), Negeri Sembilan (NS), Pahang (PHG), Sabah (SBH), Sarawak (SWK), Selangor (SLR), and a federal territory which is Wilayah Persekutuan (WP) illustrated that there is an increased number of road accidents in Malaysia year by year from the year 2008 until the year 2011. Selangor states have the highest number of road accidents for each year in Malaysia compared to the other states in Malaysia. The number of road accidents for SLR2008 is 100,380 cases increased by 7.02% which is 7,049 cases to 107,429 cases in SLR2009. This figure increased again around 7.57% which is 8,136 cases to 115,565 cases in SLR2010. Next, this number climbed again around 11.52% which is 13,311 cases to 128,876 cases in SLR2011.

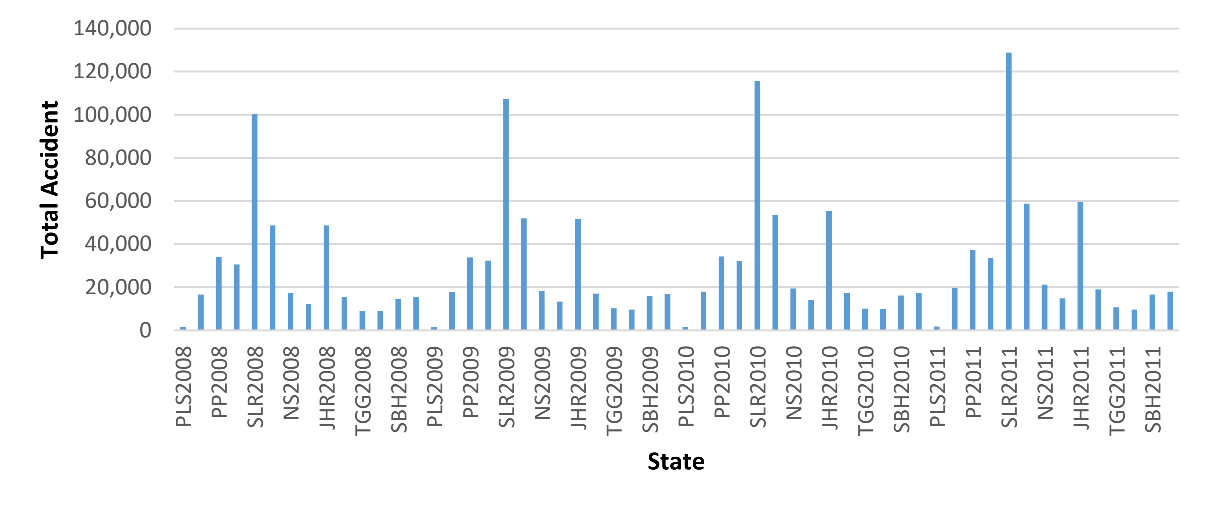

Figure 3: Total road accidents by states, 2008-2011

The number of road accidents for five states which involved Kelantan (KTN), Perak (PRK), Perlis (PLS), Pulau Pinang (PP), and Terengganu (TGG) demonstrated that there is a fluctuation in the number of road accidents in Malaysia for the four years 2008 until 2010. The number of road accidents for TGG2008 is 8,814 cases rose about 14.79% which is 1,304 cases to 10,118 cases in TGG2009. This amount is slightly reduced by around 0.12% which is 12 cases to become 10,106 cases in TGG2010. Afterward, this number of cases increased back around 5.72% which is 578 cases to 10,684 cases in TGG2011.

The total number of road accidents by all of the states in Malaysia reflects that the road accidents cases increased yearly. The total number of road accidents in Malaysia for the year 2008 in 372,990 cases. This number increased by 6.53% which is 24,340 cases to 397,330 cases in the year 2009. This figure increased again around 4.30% which is 17,091 cases to 414,421 cases in 2010. Next, this number climbed again around 8.35% which is 34,619 cases to 449,040 cases for the year 2011.

Data from Royal Malaysian Police proved that road accident deaths for every state in Malaysia fluctuated from year to year. The number of deaths caused by road accidents for 13 states and a federal territory illustrated that is inconsistent from the year 2008 until the year 2011. The number of road accidents for SLR2008 caused road accident death 1,083 cases decreased by 9.88% which is 107 cases to 976 cases in SLR2009. This figure increased around 8.71% which is 85 cases to 1,061 cases in SLR2010. Next, this number rose to 0.85% which is 9 cases to 1,070 cases in SLR2011.

The number of deaths caused by road accidents for TGG2008 is 293 cases climbed about 18.77% which is 55 cases to 348 cases in TGG2009. This amount reduced around 9.77% which is 34 cases to become 314 cases in TGG2010. Afterward, this number of cases declined again around 7.01% which is 22 cases to 292 cases in TGG2011.

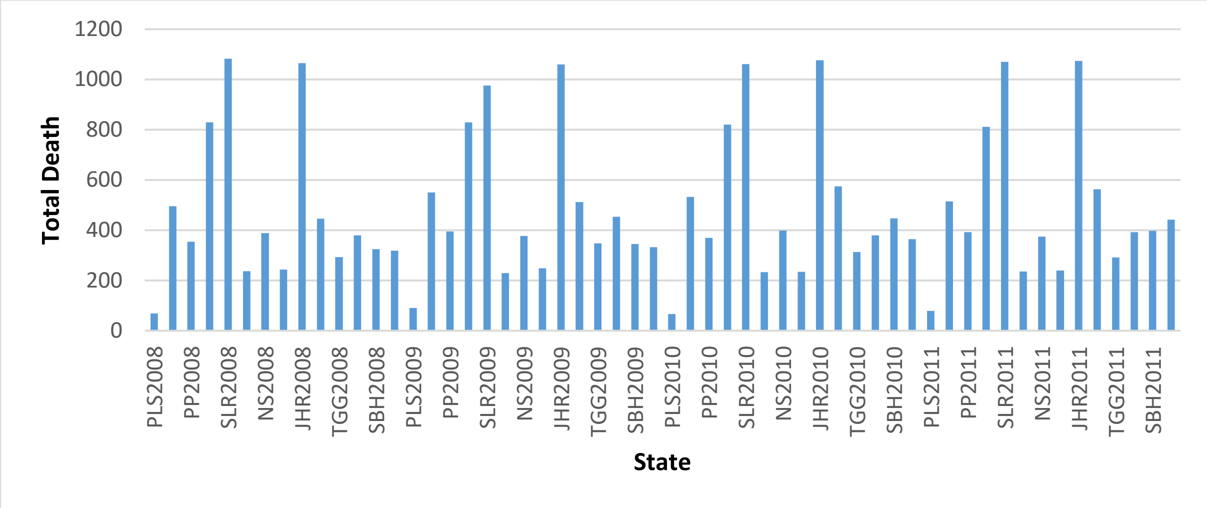

Figure 4: Total deaths caused by road accidents by year and states, Malaysia, 2008-2011

The total number of deaths caused by road accidents by all of the states in Malaysia shown that the fatalities of road users due to road accidents cases are increased every year. The total number of deaths caused by road accidents in Malaysia for the year 2008 was 6,527 cases. This amount increased by 3.34% which is 218 cases to 6,745 cases in the year 2009. This figure rises around 1.88% which is 127 cases to 6,872 cases in 2010. Next, this number slightly climbed again around 0.07% which is 5 cases to 6,877 cases for the year 2011.

4.1 Assessed Number of Road Accident Deaths by Category of Road User Based on Types of Driving Licenses in Malaysia

Malaysian Road Safety Plan 2014-2020 report showed that the number of road accident deaths by category of road users in the year 2013 for the motorcyclist and car driver/passenger which under Competent Driving License (CDL) is 4,294 cases and 1,399 cases respectively. The pedestrian and cyclist represent 455 cases and 159 cases respectively. The number of road accident deaths for van driver/passenger, bus driver/passenger, and 4-wheel drive vehicle driver/passenger under Public Service Vehicle Driving License (PSV) is 80 cases, 60 cases, and 158 cases respectively. For truck driver/attendant under Goods Vehicle Driving License (GDL), the number of road accident deaths is 210 cases. Lastly, the number of road accident deaths for other vehicle drivers/passengers is 100 cases. Therefore, the total number of deaths caused by road accidents in the year 2013 is 6,915 cases.

Based on an in-depth study conducted by MIROS, there are three main causes of road accidents: dangerous driving, speeding, and fatigue. These factors will be addressed based on internal factors and external factors to reduce the number of deaths caused by road accidents in Malaysia. The internal factors are the human factor that causes an accident to happen consist of dangerous driving, speeding, fatigue, safety, health, and environment, driving under the influence of alcohol/drugs, and driving with overloaded are 6 internal factors that cause road accidents. The external factors are the outside influences that cause an accident to happen included road damage, brake damage, visibility, and damage to tires.

The factors of dangerous driving, speeding, and fatigue are the top three internal factors contributed to 121, 93 and 70 cases in the year 2013. While other internal factors including safety, health and environment, driving under the influence of alcohol/drugs, and driving with overloaded limit were recorded with 38, 24, and 11 cases respectively. As for external factors, the road damage led to 36 cases, brake damage (20 cases), visibility (18 cases), and tire damage (14 cases).

Overall, from the total number of road accidents in 2013, more than half were from external factors, which shows that most road users in Malaysia have taken concerned about internal factors as measures to prevent from road accident. Table 2 describes descriptive statistics analysis which indicates the maximum, minimum, average, and standard deviation of inputs and outputs.

Table 2: Descriptive statistics on input/output data

	Active Vehicles	Non-Active Vehicles	No of Accident	No of Death Accident	Maintenance
Max	4041587	922059	128876	1083	502312210
Min	56557	15171	1417	66	18495850
Average	1050187	352942.2	29174.66	482.5179	183594408
SD	904751.9	237048.4	27880.62	287.7059	137856420

The descriptive statistics illustrate the difference in result since the vehicles and road users involved in road accidents in Malaysia are different in type and state. The correlation between variables is shown in Table 3. As seen, there is a weak correlation (0.086) for Active Vehicles and Maintenance. The highest correlations are 0.91784 between Vehicles Active and New Vehicles which indicates that the pair of variables are linearly related.

Table 3: Correlation between variables

	Active Vehicles	Non-Active Vehicles	No of Accident	No of Death Accident	Maintenance
Active Vehicles	1	0.91784	0.618465	0.269236	0.08558266
Non-Active Vehicles	0.91784	1	0.799062	0.605231	0.22437463
No of Accident	0.618465	0.799062	1	0.705719	0.31790321
No of Accident	0.269236	0.605231	0.705719	1	0.45828034
Maintenance	0.085583	0.224375	0.317903	0.45828	1

4.2 Discussion of Result

Tables 4 and 5 show the ranking score for efficient and inefficient DMUs. There are seven 7 DMU that represents the efficiency of 1, the other 49 DMUs are inefficient for DEA-CCR. The most inefficient DMU is WP2011, in which represent inefficient of 0.360. In general, the bottom three of inefficient DMUs are WP2008 (0.387) and WP2009 (0.378). Rank 8 (PHG2011), 9 (SLR2010) and SBH2009 (0.968) represents closely efficient for DMUs. The efficient DMUs are i.e., SLR2011, PHG2010, and PLS2009. On the other hand, efficient DMUs for DEA-BCC are 13 and 43 are inefficient i.e., SWK2011 (1) and WP2011 (0.364). The inefficient DMUs indicates that between inputs and output, the utilization of resources is not as maximum as possible, where some improvement could be done by government, traffic police, and road users in achieving efficiency in Malaysia.

Table 4: DEA-CCR ranking score (input-oriented)

Rank	DMU	Score	Rank	DMU	Score
1	SLR2011	1	29	KTN009	0.709815
1	PLS2011	1	30	KDH2009	0.690478
1	PHG2010	1	31	KDH2008	0.666936
1	SLR2009	1	32	KDH2010	0.660051
1	PLS2009	1	33	KTN008	0.657396
1	SLR2008	1	34	PRK2009	0.632613
1	SBH2008	1	35	KDH2011	0.6311
8	PHG2011	0.979311	36	KTN010	0.591549
9	SLR2010	0.975443	37	KTN011	0.581437
10	SBH2009	0.968468	38	PRK2010	0.580455
11	PLS2008	0.967392	39	PRK2008	0.5647
12	SWK2009	0.948886	40	PRK2011	0.560567
13	SBH2010	0.939707	41	JHR2009	0.529088
14	PHG2008	0.884176	42	MLA2009	0.528118
15	TGG2009	0.878365	43	JHR2008	0.521832
16	SWK2010	0.868744	44	JHR2010	0.521693
17	SBH2011	0.859712	45	JHR2011	0.514411
18	PLS2010	0.844565	46	MLA2008	0.508791
19	SWK2011	0.830205	47	MLA2011	0.495744
20	NS2009	0.827052	48	MLA2010	0.491341
21	TGG2008	0.819236	49	PP2008	0.469831
22	NS2011	0.813077	50	PP2009	0.437785
23	SWK2008	0.804148	51	WP2010	0.41147
24	PHG2009	0.79911	52	PP2011	0.407994
25	TGG2010	0.798688	53	PP2010	0.403953
26	NS2010	0.787103	54	WP2008	0.387009
27	NS2008	0.754496	55	WP2009	0.378292
28	TGG2011	0.747948	56	WP2011	0.359862

Table 6 and 7 show the efficiency and projection score of input and output for DEA-CCR and DEA-BCC. The analysis for DEA-CCR for SLR2008 is efficient, led by a maximum utilization of all inputs and outputs. The projection score is also efficient when technical efficient is at 1. This means that all resources assigned for that time are at maximum level with the output that is produced. Nevertheless, when a technical efficient score is inefficient and the projection score is more than 1, it shows that some of the inputs are not fully utilized.

Table 8 describes technical efficiency and projection score DEA-BCC. From here, it can be seen that the technical efficiency was efficient for PLS2008 and inefficient for KDH2008 (0.82).

Table 5: DEA-BCC ranking score (input-oriented)

Rank	DMU	Score	Rank	DMU	Score
1	SWK2011	1	29	KTN008	0.882915
1	PLS2008	1	30	PRK2010	0.872497
1	SLR2011	1	31	JHR2008	0.871473
1	PLS2011	1	32	NS2011	0.870287
1	SBH2010	1	33	TGG2011	0.840606
1	SLR2008	1	34	NS2008	0.835234
1	PHG2010	1	35	PRK2011	0.820722
1	SWK2009	1	36	KDH2008	0.819127
1	KTN009	1	37	JHR2009	0.814545
1	TGG2009	1	38	SWK2008	0.813785
1	SLR2009	1	39	KDH2010	0.79783
1	PLS2009	1	40	JHR2010	0.769333
1	SBH2008	1	41	KTN010	0.763268
14	SLR2010	0.997911	42	JHR2011	0.74746
15	PHG2011	0.990461	43	KTN011	0.7402
16	SWK2010	0.985544	44	KDH2011	0.738968
17	SBH2009	0.9689	45	MLA2009	0.604921
18	SBH2011	0.964186	46	MLA2008	0.562325
19	PHG2009	0.963419	47	MLA2011	0.540688
20	PRK2009	0.95416	48	MLA2010	0.540072
21	NS2009	0.945711	49	PP2008	0.473902
22	PLS2010	0.937996	50	PP2009	0.439125
23	PRK2008	0.934372	51	WP2010	0.412017
24	TGG2008	0.917148	52	PP2011	0.41106
25	NS2010	0.910612	53	PP2010	0.407339
26	PHG2008	0.897404	54	WP2008	0.39337
27	TGG2010	0.89125	55	WP2009	0.38388
28	KDH2009	0.887814	56	WP2011	0.36414

Table 6: Efficiency and projection score of inputs and output (Input-oriented DEA-CCR)

No.	DMU	Score	Rank	No.	DMU	Score	Rank
1	PLS2008	0.967392	11	29	PLS2010	0.844565	18
2	KDH2008	0.666936	31	30	KDH2010	0.660051	32
3	PP2008	0.469831	49	31	PP2010	0.403953	53
4	PRK2008	0.5647	39	32	PRK2010	0.580455	38
5	SLR2008	1	1	33	SLR2010	0.975443	9

6	WP2008	0.387009	54	34	WP2010	0.41147	51
7	NS2008	0.754496	27	35	NS2010	0.787103	26
8	MLA2008	0.508791	46	36	MLA2010	0.491341	48
9	JHR2008	0.521832	43	37	JHR2010	0.521693	44
10	PHG2008	0.884176	14	38	PHG2010	1	1
11	TGG2008	0.819236	21	39	TGG2010	0.798688	25
12	KTN2008	0.657396	33	40	KTN010	0.591549	36
13	SBH2008	1	1	41	SBH2010	0.939707	13
14	SWK2008	0.804148	23	42	SWK2010	0.868744	16
15	PLS2009	1	1	43	PLS2011	1	1
16	KDH2009	0.690478	30	44	KDH2011	0.6311	35
17	PP2009	0.437785	50	45	PP2011	0.407994	52
18	PRK2009	0.632613	34	46	PRK2011	0.560567	40
19	SLR2009	1	1	47	SLR2011	1	1
20	WP2009	0.378292	55	48	WP2011	0.359862	56
21	NS2009	0.827052	20	49	NS2011	0.813077	22
22	MLA2009	0.528118	42	50	MLA2011	0.495744	47
23	JHR2009	0.529088	41	51	JHR2011	0.514411	45
24	PHG2009	0.79911	24	52	PHG2011	0.979311	8
25	TGG2009	0.878365	15	53	TGG2011	0.747948	28
26	KTN009	0.709815	29	54	KTN011	0.581437	37
27	SBH2009	0.968468	10	55	SBH2011	0.859712	17
28	SWK2009	0.948886	12	56	SWK2011	0.830205	19

Table 7: Efficiency and projection score of inputs and output (Input-oriented DEA-BCC)

No.	DMU	Score	Rank	No.	DMU	Score	Rank
1	PLS2008	1	1	29	PLS2010	0.937996	22
2	KDH2008	0.819127	36	30	KDH2010	0.79783	39
3	PP2008	0.473902	49	31	PP2010	0.407339	53
4	PRK2008	0.934372	23	32	PRK2010	0.872497	30
5	SLR2008	1	1	33	SLR2010	0.997911	14
6	WP2008	0.39337	54	34	WP2010	0.412017	51
7	NS2008	0.835234	34	35	NS2010	0.910612	25
8	MLA2008	0.562325	46	36	MLA2010	0.540072	48
9	JHR2008	0.871473	31	37	JHR2010	0.769333	40
10	PHG2008	0.897404	26	38	PHG2010	1	1
11	TGG2008	0.917148	24	39	TGG2010	0.89125	27
12	KTN008	0.882915	29	40	KTN010	0.763268	41
13	SBH2008	1	1	41	SBH2010	1	1
14	SWK2008	0.813785	38	42	SWK2010	0.985544	16
15	PLS2009	1	1	43	PLS2011	1	1
16	KDH2009	0.887814	28	44	KDH2011	0.738968	44

17	PP2009	0.439125	50	45	PP2011	0.41106	52
18	PRK2009	0.95416	20	46	PRK2011	0.820722	35
19	SLR2009	1	1	47	SLR2011	1	1
20	WP2009	0.38388	55	48	WP2011	0.36414	56
21	NS2009	0.945711	21	49	NS2011	0.870287	32
22	MLA2009	0.604921	45	50	MLA2011	0.540688	47
23	JHR2009	0.814545	37	51	JHR2011	0.74746	42
24	PHG2009	0.963419	19	52	PHG2011	0.990461	15
25	TGG2009	1	1	53	TGG2011	0.840606	33
26	KTN009	1	1	54	KTN011	0.7402	43
27	SBH2009	0.9689	17	55	SBH2011	0.964186	18
28	SWK2009	1	1	56	SWK2011	1	1

Table 8 shows the efficiency return to scale for DEA-BCC, where 1 efficient DMU is in increasing return to scale, 7 efficient DMUs with constant return to scale and 4 efficient DMUs with decreasing in return to scale. From the findings, it shows that 7 DMUs are efficient in the returns to scale compared to the previous year i.e., SLR2008, SBH2008, PLS2009, SLR2009, PHG2010, PLS2011, and SLR2011 and 4 constants DMUs for PP2009, SBH2009, PP2010, and PP2011 (0.439, 0.969, 0.407, and 0.411) respectively. Besides, there is 1 efficient DMU in the increase return to scale i.e., PLS2008.

The score of PLS2010 is 0.938, meaning that the RTS of projected DMU is increasing, indicating a potential towards an efficient score for the next year. The score of PLS2011 is 1 which showed that the DMU is efficient and RTS is constant. The score of TGG2009 is 1 which means is efficient, but since the RTS is decreasing, it implies that this efficiency has a potential to deteriorate for the next year. This is shown by the score of TGG2010 (0.891) which is inefficient. Nonetheless, the RTS of DMU is projected as decreasing. In the year 2011, the score of TGG2011 is decreased to become 0.841 and the RTS is also decreasing. The score of SLR for the years 2008 and 2009 are efficient. Nevertheless, the score of SLR for 2010 is decreased to 0.998 and the DMU is projected to decrease in the following year. However, this has been proved otherwise then the score of SLR for the year 2011 is 1 and the RTS is constant which means that the efficiency score will continue to be the same in 2012.

Table 8: Technical efficiency return to scale DEA-BCC score (Input-oriented Rating)

No.	DMU	Score	RTS	RTS of Projected DMU	No.	DMU	Score	RTS	RTS of Projected DMU
1	PLS 2008	1	Increasing		29	PLS 2010	0.937996		Increasing
2	KDH 2008	0.819127		Decreasing	30	KDH2 010	0.79783		Decreasing
3	PP 2008	0.473902		Increasing	31	PP 2010	0.407339		Constant
4	PRK 2008	0.934372		Decreasing	32	PRK 2010	0.872497		Decreasing
5	SLR 2008	1	Constant		33	SLR 2010	0.997911		Decreasing
6	WP 2008	0.39337		Increasing	34	WP 2010	0.412017		Increasing
7	NS 2008	0.835234		Decreasing	35	NS 2010	0.910612		Decreasing

8	MLA 2008	0.562325		Decreasing	36	MLA2010	0.540072		Decreasing
9	JHR 2008	0.871473		Decreasing	37	JHR 2010	0.769333		Decreasing
10	PHG 2008	0.897404		Decreasing	38	PHG 2010	1	Constant	
11	TGG 2008	0.917148		Decreasing	39	TGG2010	0.89125		Decreasing
12	KTN 2008	0.882915		Decreasing	40	KTN2010	0.763268		Decreasing
13	SBH 2008	1	Constant		41	SBH 2010	1	Decreasing	
14	SWK 2008	0.813785		Decreasing	42	SWK2010	0.985544		Decreasing
15	PLS 2009	1	Constant		43	PLS 2011	1	Constant	
16	KDH 2009	0.887814		Decreasing	44	KDH2011	0.738968		Decreasing
17	PP 2009	0.439125		Constant	45	PP 2011	0.41106		Constant
18	PRK 2009	0.95416		Decreasing	46	PRK 2011	0.820722		Decreasing
19	SLR 2009	1	Constant		47	SLR 2011	1	Constant	
20	WP 2009	0.38388		Increasing	48	WP 2011	0.36414		Increasing
21	NS 2009	0.945711		Decreasing	49	NS 2011	0.870287		Decreasing
22	MLA 2009	0.604921		Decreasing	50	MLA2011	0.540688		Decreasing
23	JHR 2009	0.814545		Decreasing	51	JHR 2011	0.74746		Decreasing
24	PHG 2009	0.963419		Decreasing	52	PHG 2011	0.990461		Decreasing
25	TGG 2009	1	Decreasing		53	TGG2011	0.840606		Decreasing
26	KTN 2009	1		Decreasing	54	KTN2011	0.7402		Decreasing
27	SBH 2009	0.9689		Constant	55	SBH 2011	0.964186		Decreasing
28	SWK 2009	1	Decreasing		56	SWK2011	1	Decreasing	

5.0 CONCLUSION

This paper analyzed the level of road accidents in Malaysia by using Data Envelopment Analysis. From the findings, Selangor has the highest number of road accidents compared to other states in Malaysia. The number of fatalities, on the other hand, is inconsistent from the 2008 until 2011. Three main causes of road accidents in Malaysia is summarized and this includes dangerous driving, speeding, and fatigue.

DEA-CCR and DEA-BCC models are incorporated to measure the technical efficiency of the DMUs. DEA-BCC focuses on technical efficiency whereas DEA-CCR covers both scale and technical efficiency. This paper recognized technical efficiency to study the level of road accidents in Malaysia and indicates the efficiency for each state.

This paper analyses all 13 states and a federal territory to measure the cases of road accidents in Malaysia. The input-oriented ranking indicates 7 and 13 efficient DMUs for DEA-CCR and DEA-BCC. Due to the constraint in DEA-CCR, CCR- efficiency does not go beyond

BCC- efficiency. Hence, the different results shown between DEA-CCR and DEA-BCC, with more inefficient DMU for DEA-CCR is seen, compared to DEA-BCC.

The study reflects that all inputs must be assigned efficiently to ensure full utilization of resources. In sum, it shows that everybody should play their role; with the government, traffic polices, and road users work *hand in hand* in curbing the road accidents cases in Malaysia.

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