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# Cost-Effectiveness of Road Safety Policy for Preventing and Reducing Road Traffic Fatalities in Thailand

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## Abstract

This paper aimed to analyze the effectiveness of road safety policy in Thailand. The cost-effectiveness analysis (CEA) was the method used to evaluate the policy involved in road safety; Drunk-Driving Law, Helmet Use Law, and Seat Belt Use Law. The data contained costs and the amount of road traffic deaths between 2012 and 2017 were collected. The evaluating results of the road safety policy were as follows: (1) the drunk-driving law was effective in reducing fatalities caused by all types of motor vehicles accidents including motorcycles and bicycles; (2) the seat-belt use law was also effective in reducing the number of motor vehicle traffic fatalities; and (3) the helmet use law was considered ineffective, which was insignificant in terms of effort. The policy recommendation was a reduction in the number of deaths leading to the realization that the behavior of riders needed to be focused on safety education for motorcyclists and law enforcement.

**Keywords:** Cost-effectiveness, Public Policy in Thailand, Traffic Fatalities
**JEL Classifications:** R41

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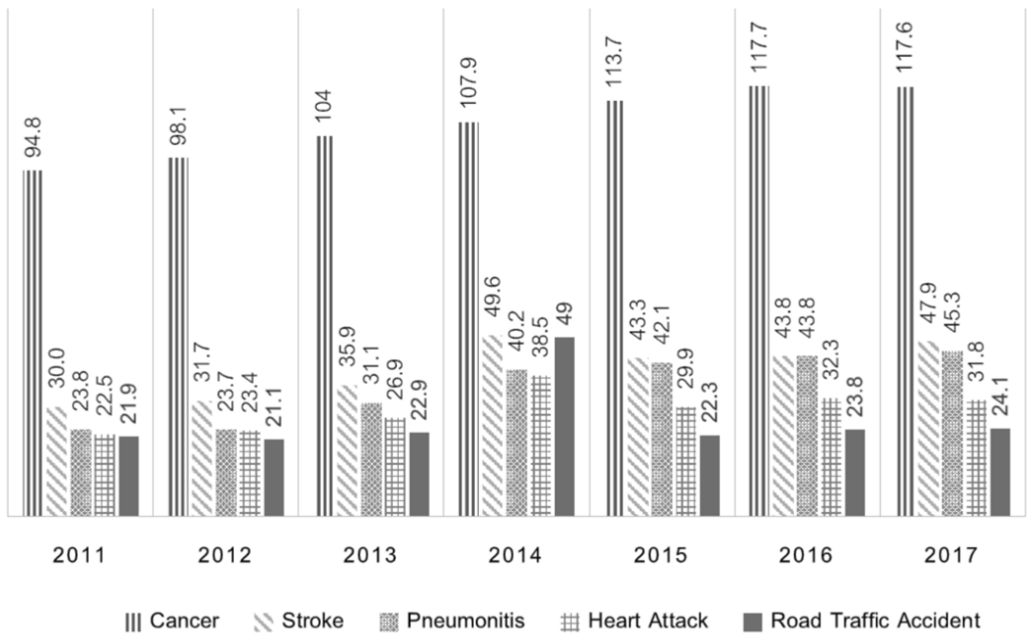
## 1. Introduction

Since 2011, Thailand has established the "Prevention and Reduction of Road Accidents" as a national agenda and has set goals to reduce the number of road traffic deaths to less than 10 deaths per 100,000 of the population (Road Accident Victim Prevention mentioned in Thai RSC, 2018), but based on the Global Status Report on Road Safety of WHO (2018), which showed that the number of deaths was not in decline but responsible for 33 deaths per 100,000 of the population. It indicated that so far Thailand has been unsuccessful in reducing the number of road traffic accidents. It is still a challenge for all relevant agencies to prevent road traffic accidents and to reduce the severity of accidents through public policies. Many studies have suggested that effective decision-making regarding road safety policy can only be made with adequate knowledge regarding its effectiveness. Therefore, an economic assessment of road safety policy can stimulate more efficient priorities for road traffic safety policy, and it can also provide alternative strategies for preventing or reducing losses from road traffic accidents as well (World Road Association, 2019; Gitelman and Hakkert, 2006; Baltussen, 2003).

From Figure 1, the office of Bureau of Non-Communicable Diseases (Strategy and Planning Division, 2018) reported that Thailand's road traffic death toll in 2017 was 24 deaths per 100,000 inhabitants (with cancer as number one, followed by stroke, pneumonitis, heart attack, and road traffic accidents, respectively). Based on these statistics, road traffic accidents were becoming one of the top five leading causes of death among Thai people. The Thai government has realized that road traffic accidents are serious problems. They not only cause the losses of human lives, but also massive damage to the economy, which is an obstacle to economic development.

Figure 1: Mortality Rates by Leading Cause of Death per 100,000 Population, 2011-2017

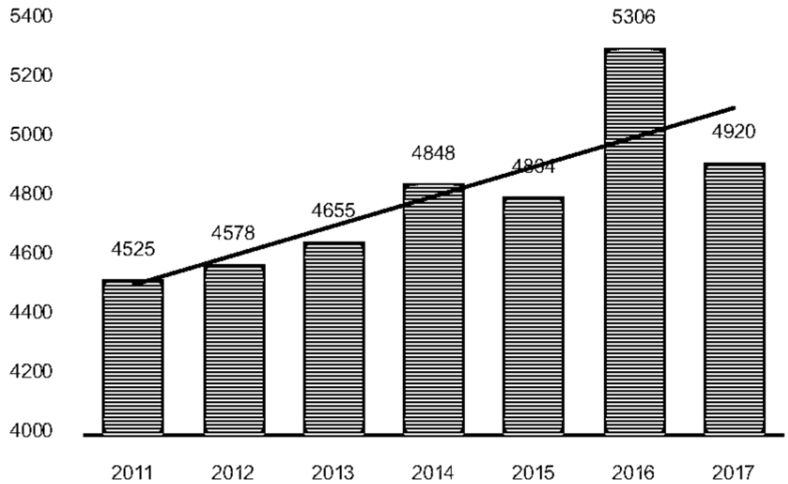



Source: revised from Strategy and Planning Division (2015), Strategy and Planning Division (2018).

The government has been concerned about this issue and has made an effort to solve the problem by continuing an increased budget for annual road traffic safety. In 2017, the road safety budget was almost doubled when compared with the road safety budget of 2011; from 6,442 million Baht in 2011, to around 12,584 million Baht in 2017

(Budget Bureau, 2019). The government budgets were used for the construction of roadways, the maintenance of road and bridges, and the correction of sections of hazardous roads, prevention and reduction of road traffic accidents during festivals and normal periods, disaster prevention and mitigation, and etc. Moreover, Thailand has implemented public policies following WHO recommendations, including a Speed Limit Law, a Helmet Use Law, a Seat Belt Use Law, and a Drunk Driving Law. Each policy has the following details (mentioned in WHO, 2016): *1) Drunk-Driving Law*: no drivers shall drive the vehicle while being drunk from alcohol or other intoxicants. Consistent with international standards, the legal limit for "Blood Alcohol Concentration: BAC" in Thailand is 0.05 g/dl, for both the general population and young/novice drivers. *2) Helmet Use Law*: the driver and passenger must wear helmets while driving and traveling at all times. *3) Seat Belt Use Law*: the driver and passenger must wear seat belts while driving and traveling at all times. The law only requires the front passenger to wear a seat belt, but not in the rear. *4) Speed Limit Law*: a driver must drive not exceed the speed prescribed in the Ministerial Regulation[1] or traffic signs installed on the road.

Figure 2: the number of deaths due to road traffic accident report from 2011 – 2017




Source: computed from ISIS (2011-2017).

However, Thailand road safety budget and significant traffic laws could not create a substantial change in the number of road traffic deaths as expected. Evidently, from the amounts of road traffic fatality data from the Injury Surveillance Information System reports, showed that between 2011 – 2017, the trend of road traffic deaths did not decline (as shown in Figure 2). Also, the road traffic deaths data based on ISIS report in 2017 revealed that there were 790 deaths caused by driving under the influence of alcohol, 431 deaths from not wearing a seat belt, 2,504 deaths from not wearing a helmet, and 1,195 deaths with no apparent cause (ISIS, 2017). These numbers were in contrast with the Global Status Report on Road Safety, which said that the estimation of Thailand road traffic fatalities was down from 37 deaths in 2015 to 33 deaths per 100,000 of population in 2018 (WHO, 2018).

The economic method as a road safety policy assessment might establish adequate knowledge of effectiveness of the policy and could help to improve road safety policy as well (Hoekstra & Wegman, 2011; Elvik & Amundsen, 2000). The evaluation begins with collecting evidence such as the costs and the benefits (or consequences) of policies, then comparing them to selected policies which gives the highest expected

[1] See WHO (2016) for detail

value (the Centre for Epidemiology and Evidence, 2017). The two most common methods used for economic evaluation in public policy include Cost-Benefit Analysis (CBA) and Cost-Effectiveness Analysis (CEA). The characteristics of these two methods can be summarized as followed: the *CBA* aims to inform decision-makers about the economic feasibility of policy or project (OECD, 2016), attempts to measure all of the costs and consequences associated with a given policy in terms of money. The variation in the different policies can be compared by using CBA because all costs and benefits are measured in money values, then computed by a benefit/cost ratio (RESTRAIL, 2014; Gitelman & Hakkert, 2006; Wesemann, 2000). However, in road safety issues, benefits are usually measured by changes in the number of deaths. For the ***CEA***, it is an efficient way to identify the most cost-effective option based on based on the concept of certain goals, such as reducing road traffic deaths. It minimizes the actual value of costs in order to maximize the output (Fryd et al., 2017; European Commission, 2015; Davalos, French, Burdick, & Simmons, 2009; Muennig, 2008; Reardon, 2005). CEA is most useful, owing to well-provided measuring in terms of a "natural unit," e.g., the number of road traffic accident fatalities prevented (Elvik & Veisten, 2005). The focus of the policy is on real outcomes and can be used as a natural unit because it is very difficult to place a cost on a human life. In terms of the cost, CEA seeks to identify and place a monetary value on policy. Thereby, the efficiency of measures can be evaluated by a dividing unit of effectiveness that refers to a death or an injury resulting from road traffic accidents in terms of the budget spent on road safety policy (Fryd et al., 2017; Newcomer, Hatry, & Wholey, 2015; RESTRAIL, 2014; Elvik & Veisten, 2005).

It can be seen that the CBA is an analytical economic feasibility method. The main objective is to compare the costs associated with administration or investment by the benefits of implementation in a monetary unit, while the CEA aims at determining the least cost option of attaining a target without a monetary measurement of benefits. In the context of road safety policy- making the given goals are generally set so as to minimize road traffic risk and the danger to human life. That means the CEA comes in after the road safety impact of the policy has been determined.

In order to support policies reducing the number of road traffic fatalities, the CEA was selected. The CEA is very useful since it allows comparisons among options with the same indicators of effectiveness in terms of natural units, e.g. the number of road traffic fatalities reduced (Fryd et al., 2017; Newcomer, Hatry, & Wholey, 2015; RESTRAIL, 2014; Elvik and Veisten (2005), compliant with the book “Making Choices in Health: WHO Guide to Use Cost-Effectiveness Analysis” (Adam & Murray, 2003) that suggested the exploration of the most cost-effective choice, based on policy targets.

This study aimed to evaluate an effectiveness of Thailand public policy on road safety. The CEA method was chosen and the efficiency of road safety measures can be evaluated as a Cost-Effectiveness Ratio (CER) by dividing the change in government budgets for road safety with the difference in the number of road traffic fatalities, then ranking each intervention from least to most effective. Furthermore, intervention with a lower CER is deemed preferable to one with a higher CER (Baltussen (2003). The expected results could give a suggestion for resource allocation for policy preventing or reducing life losses from road traffic accidents and could stimulate more efficient priorities for road traffic safety policy.

## 2. Methods

This study analyzed the effectiveness of road safety policy in Thailand, including Drunk-Driving Law, Helmet Use Law, and Seat Belt Use Law, policies involved the causes of traffic death from the ISIS database by comparing costs and effectiveness from

2012 to 2017. The ISIS database is the only source that provided and completed both numbers and causes of road traffic deaths requires for analysis. However, noted that the ISIS database did not have a report on the number of deaths causing by speeding. This study, therefore, is unable to analyze the effectiveness of the Speed Limited Law. The year 2012 was selected as it was the first year that it was implemented under the national agenda; "Prevention and Reduction of Road Accidents". 2017 was the most recent year that contained data on the unit of the effectiveness of the road safety policy.

This section presented methods for assessing policy effectiveness as well as the sources of the data used in the analysis. The research methods were sorted as follows: 1) model of traffic fatalities, 2) correlation analysis, and 3) cost-effectiveness analysis

### *2.1 Model of Traffic Fatalities*

The study started with developed an econometric model believed to be beneficial to confirm the statistical significance of road safety policies and the reduction of traffic deaths. The pooled time series data of 608 observations crossed 76 provinces and was applied to evaluate the effectiveness of the road safety policies. The study used panel data from 2012 to 2017 for estimating the traffic fatalities model by using the Pooled ordinary least squares (OLS) regression technique. The pooled OLS regression methods may have limitations that do not consider the fluctuations in road safety policy management in different provinces. However, the road safety policy for preventing and reducing road traffic fatality is the same law enforced throughout the country, and it may not be affected by different external factors in each province.

The general form[2]:

$$RTF = \beta_0 + \beta_1(Socio - Economic) + \beta_2(Geographic) + \beta_3(Demographic) + \beta_4(policy) + \varepsilon_t$$

### *2.2 Correlation analysis*

The Pearson’s correlation analysis was applied to evaluate the strength and direction of the relationship between a dependent variable, BUD, and explanatory variables; ACL, HEL, and SBL. A high correlation means that the budget for road safety and the policy variables have a strong relationship with each other, while a weak correlation means that the variables are hardly related.

### *2.3 Cost-effectiveness analysis*

The study analyzed the effectiveness of road safety policy by policy characteristics and type of vehicles as follows: 1) Motorcycles & Bicycles, the policies involved were the Drunk-Driving Law and the Helmet Use Law; 2) Automobiles, the policies involved were the Drunk-Driving Law and the Seat Belt Use Law. The study then evaluated road safety policies by using the Incremental Cost Effectiveness Ratio method (ICER).

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[2] The analysis used herein are following the study done by Sarawasee, Permpoonwiwat, and Fowles (2015).

Table 1 variables, definition road traffic fatalities model in 2012 – 2017

| Variable | Definition | Sources | Expected Sign |
|---|---|---|---|
| **Dependent Variable** | | | |
| RTF | Number of road traffic fatalities (person) | ISIS (2012 - 2017) | |
| **Independent Variables** | | | |
| **Socioeconomic Variables** | | | |
| GPP | Gross provincial product per capita (Baht/person) | Office of the National Economic and Social Development Council (2018) | + |
| EDU | Average year of schooling, age 15 – 39 (year) | Office of the Education Council (2018) | - |
| **Geographic Variable** | | | |
| DEN | Population density (people per square kilometer) | National Statistical Office (2019) | + |
| **Demographic Variables** | | | |
| NAB | Number of Automobiles (unit) | Department of Land Transport (2019) | + |
| NMC | Number of motorcycles (unit) | Department of Land Transport (2019) | + |
| **Policy-related Variables** | | | |
| BUD | The budget for road safety included direct budget and indirect budget (Baht) | Budget Bureau (2019 Thailand Health Promotion Foundation (2019) Road Safety Thailand (2019) | - |
| ACL | The proportion of those who do not drink alcohol before driving in each province (%) | Author's calculation | - |
| HML | Helmet use rate by province (%) | Thai Road Foundation (2019) | - |
| SBL | Seat belt use rate (%) | WHO (2013, 2015, and 2018) | - |

Source: collected from ISIS (2012 - 2017), Office of the National Economic and Social Development Council (2018), Office of the Education Council (2018), National Statistical Office (2019), Department of Land Transport (2019), Budget Bureau (2019), Thailand Health Promotion Foundation (2019), Road Safety Thailand (2019), Thai Road Foundation (2019), WHO (2013, 2015, and 2018)

ICER is an effective measure to diagnose the best and most effective policy. The ICER is used to rank each road safety policy in terms of the results achieved (Adam & Murray, 2003). This measure is achieved by taking the costs of the road safety policy and dividing them by the unit of effectiveness of the policy. The costs were the government budget on preventing and reducing road traffic accidents, while the natural unit of effectiveness was the number of deaths that could be reduced by each policy. The ICER can draw as:

$$\text{ICER} = \frac{\text{Average Different of Cost (ADC)}}{\text{Average Different of unit of Effectiveness (ADE)}}$$

ADC represents the average change of budget from 2012 to 2017, while ADE is the average change of number of deaths caused by road traffic accidents the number between the number in 2012 to 2017.

The ICER of each policy calculated from the above was taken into account with the cost-effective plane with four quadrants by plotting the graph according to the following concepts:

Figure 3: an analysis of cost-effective plane with four quadrants

| | | **Number of Deaths** | |
|---|---|---|---|
| | | **Decrease** | **Increase** |
| **Budget for Road Safety Policy** | **Increase** | **Quadrant II**<br>ADC > 0, while ADE < 0 | **Quadrant I**<br>ADC > 0, and ADE < 0 |
| | **Decrease** | **Quadrant III**<br>ADC < 0, and ADE < 0 | **Quadrant IV**<br>ADC < 0, while ADE > 0 |

Source: revised from Meerat & Lounkeaw (2016).

The meaning of each quadrant was explained as shown in Figure 4:

Figure 4: the meaning of each quadrant by the concepts of ICER

| | |
|---|---|
| **Quadrant II**<br>The road safety measure was effective, but still could not reduce the budget. | **Quadrant I**<br>Road safety policy was not effective at all; resulting in an increase in both the cost and the deaths. |
| **Quadrant III**<br>The expected goal. The policy was effective, the number of deaths and the budget decreased. | **Quadrant IV**<br>The number of deaths increased, while the budget reduced. So, the policy was ineffective. |

Source: revised from Meerat & Lounkeaw (2016).

The data used for evaluating the CEA of road safety policies in this study was as followings:

***2.3.1 Costs of Road Safety Policy***

This study is based on the complied budget for the prevention and reduction of road traffic accidents from government sectors and foundations from 2012 to 2017 only. The list of budgets for road safety policy can be characterized into two groups; direct budget and indirect budget for road safety policy following the studies of Sarawasee et al. (2015) and Kosalakorn (2001). The data collected for the road safety budget in 2012 to 2017 was from the Budget Bureau (2019), Thai Health Promotion Foundation (2019a) and Road Safety Thailand (2019).

***a. Direct Budgets*** (reported in the Budget Bureau (2019), were comprised of (1) the budget for the highway network safety from the Department of Highways, the Ministry of Transport, (2) the budget for the rural road network safety from the Department of Rural Roads, the Ministry of Transport, (3) the budget for the road safety prevention and reduction from the Department of Land Transport, the Ministry of Transport, (4) budget for road safety administration from the Office of Transport and Traffic Policy and Planning, the Ministry of Transport, (5) the budget for road accidents prevention and reduction during festivals and regular periods from the Department of Disaster Prevention and Mitigation, the Ministry of Interior, (6) the budget for training for disaster prevention and mitigation plan at the district/province level from the Department of Disaster Prevention and Mitigation, the Ministry of Interior, and (7) the budget for traffic and road safety administration, Royal Thai Police.

***b. Indirect Budgets,*** consisting of (1) the budget for road safety and disaster administration plans, the Thai Health Promotion Foundation (Thai Health Promotion Foundation, 2019), and (2) the budget for road safety, the Road Safety Thailand Foundation (Road Safety Thailand Foundation, 2019).

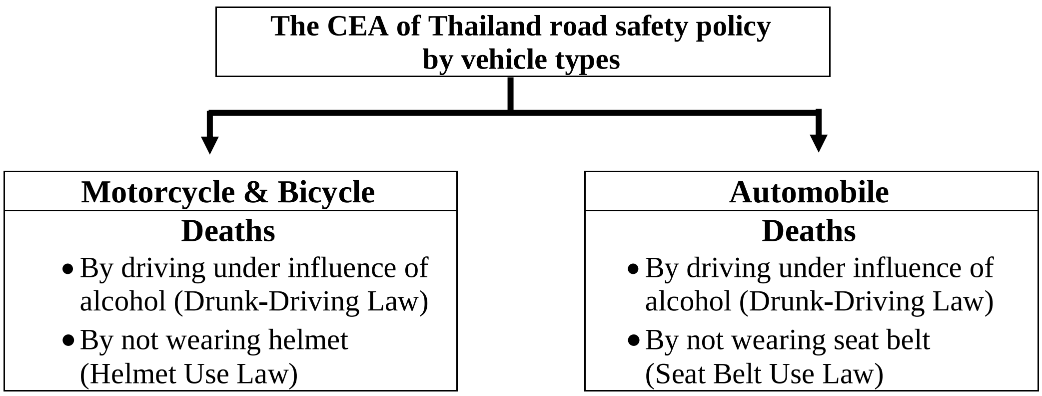
In addition, the total value of road safety budgets had been adjusted by the Consumer Price Indexes (CPI) of the year 2019 (Bank of Thailand, 2019).

***2.3.2 Unit of Effectiveness of Road Safety Policy***

The units of the effectiveness of road safety policy in this study were the annual number of deaths caused by driving under the influence of alcohol, not wearing a helmet, and not wearing a seat belt, in 2012 to 2017. These data were collected from the ISIS database (ISIS, 2012 - 2017).

The conceptual framework of Thailand road safety policy by vehicle types summarized as Figure 5:

Figure 5: conceptual framework of the CEA of Thailand Road Safety Policy




Source: Authors' discretions.

***2.3.3 Unit of Effectiveness of Road Safety Policy***

The units of the effectiveness of road safety policy in this study were the annual number of deaths caused by driving under the influence of alcohol, not wearing a helmet, and not wearing a seat belt, in 2012 and 2017. These data were collected from the ISIS database (ISIS, 2012 - 2017).

## 3. Results

### *3.1 Regression results on road traffic fatalities model*

Pooled time series analysis was used to evaluate the effectiveness of the road safety policies. The data description of the relevant statistics was defined as in Table 2.

Table 2: descriptive statistics of the model variables

| Variable | Mean | Median | S.D. | Min |
|---|---|---|---|---|
| RTF | 125.2 | 111 | 76.63 | 14 |
| GPP | 1.18E+05 | 62816 | 1.57E+05 | 8361 |
| EDU | 10.61 | 10.65 | 0.127 | 10.4 |
| DEN | 191.3 | 121.9 | 265.7 | 19.14 |
| NMV | 1.14E+05 | 90766 | 92988 | 4148 |
| NMC | 2.16E+05 | 1.89E+05 | 1.49E+05 | 6751 |
| BUD | 1.17E+10 | 1.25E+10 | 2.36E+09 | 6.44E+09 |
| ACL | 0.9622 | 0.9755 | 0.05031 | 0.4536 |
| HEL | 0.3615 | 0.35 | 0.1059 | 0.13 |
| SBL | 54.12 | 54 | 0.331 | 54 |

Source: Authors' estimations.

The Pooled OLS regression results on the model of road traffic fatalities after fixing various problems such as autoregressive, heteroskedasticity, and multicollinearity was presented in Table 3.

Table 3: pooled OLS model of the number of road traffic fatalities 2012 to 2017, using 608 observations

| Variable | coefficient | std. error | t-ratio | p-value |
|---|---|---|---|---|
| const | 1557.61 | 406.635 | 3.83 | 0.0001*** |
| GPP | 0.000108823 | 1.08E-05 | 10.1 | 3.07E-22*** |
| EDU | 6.28488 | 10.2858 | 0.6110 | 0.5414 |
| DEN | 0.0428048 | 0.00634854 | 6.742 | 3.68E-11*** |
| NAB | 0.000151978 | 4.23E-05 | 3.591 | 0.0004*** |
| NMC | 0.000314138 | 2.69E-05 | 11.69 | 1.38E-28*** |
| BUD | −4.37095e-09 | 1.10E-09 | −3.989 | 7.45E-05*** |
| ACL | −34.7795 | 26.3721 | −1.319 | 0.1877 |
| HEL | −19.8224 | 13.4605 | −1.473 | 0.1414 |
| SBL | −27.9618 | 7.40386 | −3.777 | 0.0002*** |
| **R-squared** | **0.837291** | | **Adjusted $R^2$** | **0.834843** |
| **F** | **341.92** | | **Durbin-Watson** | **1.980435** |

Note: *** is significant at the level of .001
Source: Authors' estimations.

From Table 3, the direction of relations of almost all independent variables is according to the hypothesis. For Thailand, when the GPP increases, the number of road traffic deaths increases with a mechanism that depends on increasing the number of road users. The same result in population density (DEN), the number of automobiles (NAB), and the number of motor vehicles (NMV) with statistically significant increases at the level of .001. For the relationship between road safety policies and the number of deaths, it is found that increases in the budget (BUD) and seat belt use rate (SBL) result in reducing the number of road traffic fatalities with statistical significance at the level of .001.

For the remaining policy, the Drunk-driving law which is the proportion of those who do not drink alcohol before driving: ACL and the increase in helmet use rate (HML), there is a statistically significant level lower than the 0.05. Still, when considering the direction of the relationship, it is found that there is an inverse relationship with the number of road traffic deaths. In other words, when the level of road safety policies increases, the number of deaths from accidents will decrease. The rise in the average year of schooling (EDU) in the population in the age group 15 - 39 years results does not follow the hypothesis; however, there is not statistically significant.

### *3.2 The correlation analysis results*

Table 4: the correlation analysis results between budget for road safety and interventions

| | BUD | ACL | HML | SBL |
|---|---|---|---|---|
| BUD | 1.00 | 0.082* | .143** | .144** |
| | | (.044) | (.000) | (.000) |
| ACL | | 1.00 | -0.002 | 0.011 |
| | | | (.956) | (.781) |
| HML | | | 1.00 | .261** |
| | | | | (.000) |
| SBL | | | | 1.00 |

Note:* is significant at the level of .05, ** is significant at the level of .01
Source: Authors' estimations.

For Pearson's correlation analysis results, the study found that the proportion of those who do not drink alcohol before driving in each province significantly correlated with the accident prevention budget at 0.05 level with the same direction. Simultaneously, the seatbelt and helmet wearing rates were positive at a statistically significant level of 0.01. Therefore, the study confirmed that policy mechanism like ACL, HML, and SBL has played a crucial role in road safety assessment via government budget.

### *3.3 The Unit of Effectiveness of Road Safety Policy*

The annual number of road traffic deaths/injuries from 2012 to 2017, caused by driving under influence of alcohol, not fastening a seat belt, and not wearing a helmet were used as the unit of effectiveness of the road safety policy, as shown in Table 5.

Table 5: annual number of traffic deaths from 2012 to 2017 (unit: person)

| **Cause of Road Traffic Fatalities** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** |
|---|---|---|---|---|---|---|
| **Motorcycle & Bicycle** | | | | | | |
| - Driving under influence of alcohol | 648 | 116 | 724 | 657 | 633 | 646 |
| - Not wearing helmet | 2,110 | 563 | 2,463 | 2,319 | 3,689 | 2,504 |
| **Automobiles** | | | | | | |
| - Driving under influence of alcohol | 119 | 20 | 128 | 116 | 112 | 114 |
| - Not wearing seat belt | 528 | 202 | 504 | 454 | 1,257 | 431 |

Source: computed from ISIS (2012 - 2017)

### *3.4 Budgets of Road Safety Policy*

The annual budgets for road safety policy from 2012 to 2017 from the related organizations as mentioned previously were computed and adjusted to 2017 value by using the consumer price index (Bank of Thailand, 2019) as shown in Table 6.

Table 6: the annual costs for road safety policy from 2012 - 2017 (Unit: Million Baht)

| List of Budgets for Road Safety Policy | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|
| **Direct Budgets** | 9.849 | 10.796 | 11.473 | 11.812 | 13.392 | 11.257 |
| 1) budget for the highway network safety[1] | 3.706 | 4.285 | 4.739 | 4.458 | 5.246 | 4.264 |
| 2) budget for the rural road network safety[1] | 1.548 | 1.565 | 2.209 | 2.442 | 2.961 | 2.344 |
| 3) budget for the road safety prevention and reduction[1] | 0.547 | 0.596 | 0.591 | 0.601 | 0.753 | 0.247 |
| 4) budget for road safety administration[1] | 0.004 | 0.004 | 0.004 | - | - | - |
| 5) budget for road accidents prevention and reduction[1] | 0.085 | 0.077 | 0.068 | 0.069 | 0.075 | 0.074 |
| 6) budget for training for disaster prevention[1] | 0.022 | 0.045 | 0.033 | 0.027 | 0.036 | 0.036 |
| 7) budget for traffic and road safety administration[1] | 3.937 | 4.222 | 3.828 | 4.213 | 4.321 | 4.292 |
| **Indirect Budgets** | 1.170 | 1.520 | 1.458 | 1.079 | 1.125 | 1.212 |
| 1) budget for road safety and disaster administration[2] | 0.196 | 0.186 | 0.217 | 0.260 | 0.260 | 0.260 |
| 2) budget for road safety Thailand foundation[3] | 0.974 | 1.334 | 1.241 | 0.819 | 0.865 | 0.952 |
| **Total** | 11.019 | 12.315 | 12.930 | 12.891 | 14.517 | 12.468 |
| **Present Value (based 2017)** | 3.465 | 4.540 | 5.462 | 4.240 | 5.489 | 2.468 |

Source: collected from [1]Budget Bureau (2019), [2] Thai Health Promotion Foundation (2019), and [3]Road Safety Thailand (2019).

### *3.5 An effectiveness of the policy.*

The ICER is an efficient method to analyze the cost-effective option based on the reduction of road traffic fatalities. The ICER method is using the changes in budget (average difference of cost: ADC) divided by changes in the number of fatalities of road traffic policies (average difference of unit of effectiveness: ADE) based on vehicle types, (1) motorcycles and bicycles, and (2) automobiles. The ICER was using to interpret the results with a cost-effective plane in the four quadrants, as previously shown in figure 4. The results were as follows (table 7).

Table 7: the effectiveness of policy involved motor vehicles

| Lists | **Average Different** from 2012 to 2017 | **ICER** (ADC/ADE) |
|---|---|---|
| Budget for Road Safety Policy | - 199,325,888.63 (ADC) | - |
| No. of Motorcycle & Bicycle Deaths | | |
| - Drunk-Driving Law | - 0.40 ($ADE_{MAL}$) | 498,314,721.58 ($ICER_{MAL}$) |
| - Helmet Use Law | 78.80 ($ADE_{MHL}$) | - 2,529,516.35 ($ICER_{MHL}$) |
| No. of Automobile Deaths | | |
| - Drunk-Driving Law | - 1.00 ($ADE_{AAL}$) | 199,325,888.63 ($ICER_{AAL}$) |
| - Seat Belt Use Law | - 19.40 ($ADE_{ASL}$) | 10,274,530.34 ($ICER_{ASL}$) |

Source: Authors' calculations.

From Table 7, the ICER of the Drunk-Driving Law to reduce deaths ($ICER_{MAL}$) from motorcycle and bicycle accidents was in the third quadrant. This represented that the policy was effective and efficient because the number of road traffic deaths was reduced; moreover, costs for road safety policy decreased as well. With regard to the

Helmet Use Law, the results of $ICER_{MHL}$ indicated that it was in the fourth quadrant, which means that the number of road traffic fatalities were not reduced while the cost was lower. This policy was not able to achieve its goals. Moreover, for the automobile accidents, the ICER of the Drunk-Driving Law ($ICER_{AAL}$) and the Seat Belt Use Law ($ICER_{ASL}$) were in the third quadrant. This means that the policies were effective and efficient, because not only was the number of motor vehicle deaths and injuries reduced, but the budgets for road safety policy also decreased. An analysis of cost-effective plane with four quadrants from motor vehicle accidents as shown in Figure 6.

Figure 6: an analysis of cost-effective plane with four quadrants from motor vehicle accidents

| | | **Number of Fatalities** | |
|---|---|---|---|
| | | **Decrease** | **Increase** |
| **Budget for Road Safety Policy** | **Increase** | **Quadrant II** | **Quadrant I** |
| | **Decrease** | **Quadrant III**<br>$ICER_{MAL}$, $ICER_{AAL}$, and $ICER_{ASL}$ | **Quadrant IV**<br>$ICER_{MHL}$ |

Source: Authors' discretions.

## 4. Discussions

From the results which showed that the Helmet Use Law in Thailand is ineffective and inefficient policy, according to the WHO (2018) report, the helmet-wearing rate in Thailand was about 51% for riders and 20% for passengers while the enforcement level was at level 6 (The level of law enforcement refers to the perception of the public regarding the severity of enforcement of the law. The score is measuring score from 1–10 with 1 being not enforced at all, and 10 being effective enforcement). When comparing helmet laws with Vietnam, countries in the same region, and middle-income countries, it is found that helmet laws in Vietnam are effective and they are successful policies to reduce motorcycle deaths (the helmet-wearing rate in Thailand was about 81% for drivers and 60% for passengers while the enforcement level was at level 8 mentioned in WHO, 2018). A significant accomplishment of the helmet use law in Vietnam is using strict and consistent enforcement, which requires every driver and passenger to wear a helmet on every road at all times. Moreover, there is also an increased fines rate that applies to offenders (Passmore, Nguyen, Nguyen & Olivé, 2010). Evidently, higher law enforcement is a key success factor that could help reduce the number of motorcycle deaths in Thailand.

Even though the Seat Belt Use Law was found to be an effective policy, seat belt-wearing rates in Thailand are quite low. WHO (2018) reported that under the Thai law, only drivers and front-seat passengers were mandated to wear seat belts. The enforcement level is at level 6, meaning the driver's seat belt wearing rate is about 58 percent and 40 percent for front seat passengers. If the rate of seat belt wearing were to go up, it would represent an efficient result for the road safety policies. Richard, Magee, Bacon-Abdelmoteleb, & Brown (2018) suggested that by doing short-term and high-visibility enforcement, such as a mass media campaign, it could prove useful for reaching people known to have lower rates of seat belt use, such as men, teens, and young adults.

The nighttime enforcement program is another evident short-term enforcement strategy because since crashes are most common at night when seat belt use is at its lowest. These policies should be combined with other enforcement laws, such as higher fines on drivers or vehicle owners. Moreover, they also recommended that Seat Belt Laws are most effective when they cover occupants in all seats.

For more than ten years, the Drink Don't Drive campaign and the danger of "drunk driving" has been introduced and encouraged widespread social awareness. It has influenced more severe penalties for drunk driving in Thailand, namely higher fines when the driver’s blood alcohol level exceeds 50 milligrams. This is in line with international guidelines from the Centers for Disease Control and Prevention or CDC (2020), Richard, Magee, Bacon-Abdelmoteleb, & Brown (2018), and WHO (2007). However, awareness has not stopped drunk driving behavior of some groups of people. The National Academies of Sciences, Engineering, and Medicine (2018) suggested raising alcohol taxes and regulating hours of alcohol sale to reduce impaired driving and related consequences.

Evidently, a significant accomplishment of road safety policies is using strict and consistent enforcements and increased fines rates. Combining these policies can help law enforcement use limited budgeting and resources for the most significant public safety impact.

## 5. Conclusions

The ISIS data pointed out that the annual number of road traffic deaths/injuries in Thailand between 2012 and 2017 followed the same pattern. The causes of deaths were the result of not wearing a helmet at the highest rate, followed by fatalities from driving under the influence of alcohol and not wearing seat belts, respectively. For the budgets of road safety policy in Thailand, the highest portion of the main budgets went to the traffic and road safety administration budget of Royal Thai Police, followed by highway network safety budget and rural road network safety. The budget for road safety prevention and reduction in nominal term in 2017 was increased, compared with the road safety budgets of 2012. However, the amount of the budgets in 2017 was considered to be lower than the amount in 2012 due to the present value adjustment.

The involved road safety policy, including the Drunk-Driving Law, the Helmet Use Law, and the Seat Belt Use Law, were analyzed using the CEA method and characterized into two groups based on types of vehicle: motorcycles and bicycles, and automobiles. The results were interpreted by using cost- effectiveness plane with four quadrants. It revealed that in terms of the road traffic policies related to motorcycles and bicycles, the ICER of the Drunk-Driving Law was in the third quadrant, which demonstrated on effective policy in reducing road traffic deaths and injuries. However, the ICER of the Helmet Use Law was in the fourth quadrant, which means the Helmet Use Law was not successful in reducing the number of motorcycle and bicycle deaths. For the policies relating to motor vehicles, the Drunk-Driving Law and the Seat Belt Use Law, the ICER of both policies were in the third quadrant, which means they were effective in reducing road traffic deaths while being able to utilize less of their budget.

The largest number of deaths from road traffic accidents, were those involving motorcycles. This was consistent with a recent data from the Injury Surveillance System, Bureau of Epidemiology, Department of Disease Control, Ministry of Public Health (mentioned in WHO, 2018). Moreover, from the above results, it can be inferred that the Helmet Use Law has not been successful. Note that the Drunk-Driving Law reduced the number of road traffic deaths, but only slightly.

It can be seen that the budget for prevention and reduction of accidents in Thailand is not classified according to the types and causes of road accidents. Therefore, promoting specific policies and budgets for each road safety policy is necessary. Moreover, increasing the rate of wearing helmets for both riders and passengers through higher law enforcement, the quality of helmets, and the education of the general public, especially young riders about the importance of helmet use will lead to reduced road traffic fatality rates. The study also found that there were many road traffic deaths for which a cause was unable to be determined were due in large part, to the fact that the data concerning road traffic fatalities caused by speeding were not available at the time of writing. There was a problem in the analysis of the data and finding a solution. Therefore, using technology to collect data may help improve the integrity of the data and lead to correct and sustainable road safety policies.

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