Relationship Between Motorcycle Accidents and Economic Indicators: Empirical Evidence From Malaysia Via ARDL Approach

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Abstract: In Malaysia, motorcycle fatalities constituted about 60% of the total road fatalities yearly and have reached alarming state in Malaysia. Despites the high fatalities, the number of motorcycles is still on a steady rise. The reasons are mainly due to its ease maneuver in heavy traffic stream, cheap operation cost and time effective. This study is aimed to investigate the impact of economic indicators such as GDP, household income, unemployment rate, world oil price, motorcycle ownerships on the motorcycle accidents between 1991 to 2018. ARDL approach was used in this study with the assumption that the long-term relationships are linear and symmetric. The results showed that these economic indicators were cointegrated with motorcycle accidents and have significant impact on motorcycle accidents in long run and short run.

Keywords: Motorcycle Accident, ARDL Approach, Economic Indicators

1. INTRODUCTION

Road traffic injuries and fatalities are a major concern globally. According to WHO report, approximately 1.35 million people die in the road traffic crashes yearly (WHO, 2020). Of these, nearly 30% of the fatalities were motorcyclists or their pillions. In Malaysia, motorcycle fatalities constituted about 60% of the total road traffic fatalities (RPM, 2018). The significant number of deaths are attributed to its inherent vulnerability, risk taking behavior, travel speed and the high number of motorcycles on the roads (Yousif et al., 2020).

Though the motorcycle fatalities are over-represented and is alarming in the world, the number of motorcycles is still increasing. Empirical evidences prove that the uniqueness of motorcycle in terms of cost-effective, better fuel thrift, ease of maneuvering in congested traffic condition are the main contributors to the exponential growth of number of motorcycles particularly in low- and middle-income countries as compared to other modes of transportation. In Malaysia, motorcycle comprised of one-third of the total motor vehicle population (Manan and Varhelyi, 2012). Figure 1 presents the motorcycle accidents and total number of motorcycles registered between 1991 – 2008. The motorcycle ownerships are increasing over the years and similar trend is also observed for motorcycle accidents. Figure 2 displays the time series plots for other variables (GDP, household income, world oil price and unemployment rates).

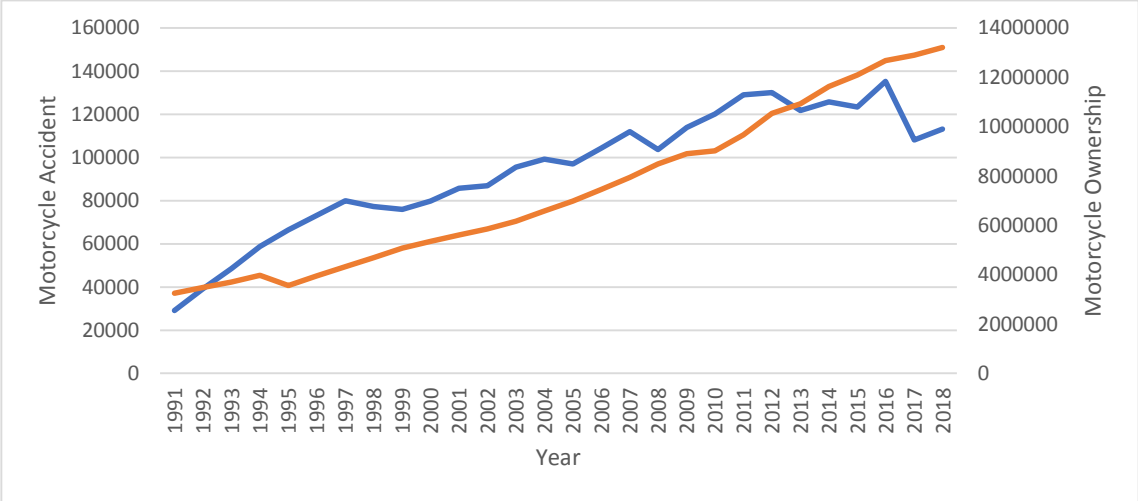

Figure 1 Motorcycle accident and ownership profiles between 1991 to 2018

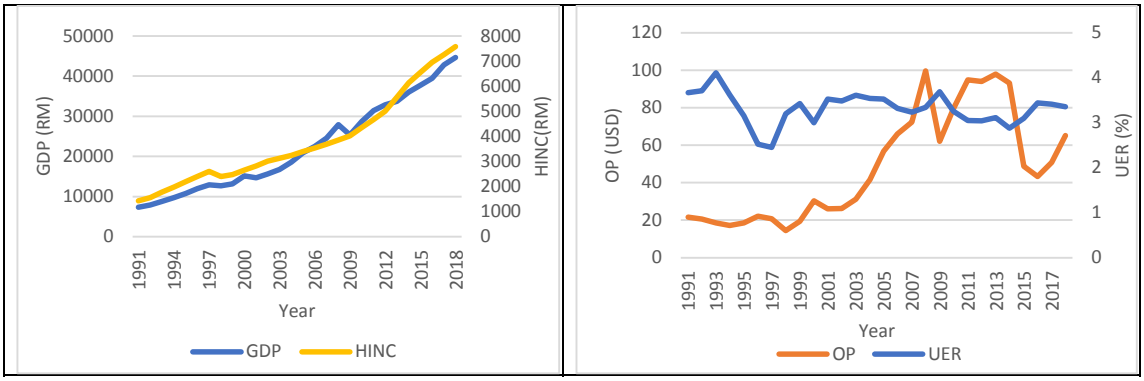

Figure 2 Plots of other economic variables (GDP, HINC, OP, UER) between 1991 to 2018

Over the years, many studies have established the relationship of vehicle ownership and traffic fatalities with nation economy growth. It has been proved that socio-economic indicators have significantly influenced the ownership of cars, motorcycles, or both (Dargay and Gately, 1999; Jou and Sun, 2007; Clark, 2007; Whelan 2007; Matas and Raymond, 2008; Van Acker and Witlox, 2010). Dargay and Gately (1999) in their studies show that mobility activities grow inline with the economic expansion. It is further proved that at the initial phases of economic expansion, there are excessive demand for motorcycle ownership. Then, as economic grows, there will be a transformation from motorcycles to passenger car which is from high risk and low cost to low risk and high cost comfortable transport mode (Pongthanaisawan and Sorapipatana, 2010; Law et al., 2015).

While the country economic growth takes a very long periods to be equally distributed to the nation, household income indicator is more often to be used in studies to evaluate the quality of life of the population. Studies by Jou et al. (2012), Guiliano and Dargay (2006), Clark (2007) and Whelan (2007) have indicated a long-term equilibrium relationship with income variable. Geographical factors, job accessibility, urbanization, efficiency of public transport system and infrastructure are also deeply related to vehicle ownership (Alvin et al., 2020; Rode et la., 2014; Lin and Truong, 2012).

On the other hand, economic development contributes to high demand of vehicle ownerships. When the number of vehicles increases, road traffic crashes would not be avoided.

There are numerous evidences on the linkages between the economic indicators and the traffic casualties. Bishai et al. (2006) used traffic fatalities, GDP per capita, number of vehicles oil consumption, population for 41 countries between 1992 and 1996 to study the contributory factors to traffic casualties. It was found that there was a positive relationship between traffic crashes with economic growth in low income countries but opposite relationship was observed in high income countries. Kopit and Cropper (2005) used panel data for 88 countries between 1963 to 1999 showed that traffic fatality rate increases with per capita income but the trend drops after hitting a peak of 8600 US dollars.

Akinyemi (2020) reviewed 49 studies and found that 69% of the studies had showed significant positive relationship between traffic casualties and GDP per capita as well as unemployment rates. On the other hand, in high income countries such as US, Germany, New Zealand and Japan, the traffic fatalities increase when unemployment rates decrease (Ruhm, 2000; Neumayer, 2004; Schuffham, 2003; Granados, 2008).

Bougueroua and Carnis (2016) in their study applied cointegration approach and vector error correction model to evaluate the short and long-term relationship between the number of traffic accidents, fuel consumption and GDP per capita from 1970 to 2013. It was found that in Algeria, the GDP per capita contributes positively to the number of traffic crashes in short run and long run. Antoniou et al. (2016) by using Common Correlation Effects Mean Group Estimator (Pesaran) had also found that a long-term elasticity value of 0.63 for the relationship between GDP and traffic fatalities in 10 European countries.

Besides, oil price has also proved to have effect on the traffic casualties. Wilson et al. (2015) by using random effect models showed that traffic fatalities increased in developed countries when oil price declined between 1996 – 2012. Grabowski and Morrisey (2004) based on panel data found that a 10% reduction in oil price would reduce the fatality rates by 2.3% over a two-year period between years 1983 – 2000.

The review of literature has provided concrete evidences on the long-term equilibrium relationships between the economic growth, vehicle ownerships and traffic crashes in developing countries. However, to the best knowledge of the authors, no study is yet taken to examine on the contribution of economic indicators such as GDP, unemployment rate, oil price, household income to the motorcycle ownerships and motorcycle accidents in Malaysia. This study is deemed to be very significant as about 12 motorcyclists died on the roads everyday in Malaysia and the number is believed to be continuously on the rise. Moreover, a unique situation was observed in Malaysia during the COVID-19 lock down periods (Marizwan, 2021). It was reported a tremendous hike in the motorcycle activities as many people have turned to join delivery services using motorcycles. All in all, it is the aim of this study to examine the short- and long-run relationship between the economic indicators and the motorcycle accidents which can shed some lights to the policy makers in devising proper policy to effectively reduce the number of motorcycle fatalities in the country.

2. DATA

This study uses the motorcycle accident data and economic indicators from 1991 to 2018. Motorcycle accident is the main subject of this study and other explanatory variables include Gross Domestic Product (GDP), average household income, world oil price, Malaysia total registered motorcycles and unemployment rates. The GDP is used instead of GDP per capita because result of GDP is found to be more pronounce in this study as compared to GDP per capita. These data were obtained from Royal Malaysia Police accident statistics reports and the database of Economic Planning Unit Malaysia. Table 1 lists the variables included in the study.

Table 1 Variables considered in this study

Variable	Description	Unit
MA	Motorcycle accident	Case
MO	Motorcycle ownership	Registered vehicle
GDP	Gross domestic product	RM (Million)
OP	World oil price	USD (Dollar)
HINC	Household income	RM
UER	Unemployment rate	%

3. METHODOLOGY

In this study, Autoregressive Distributed Lag (ARDL) Bound Testing approach introduced by Pesaran et al. (2001) is used to examine the short and long-run dynamics relationship of the motorcycle accidents and economic indicators. It is assumed that the relationship is linear and symmetry. The merits of ARDL are that it can be applied on a small sample sizes and different order of integration.

Prior to ARDL test, the order of integration and stationarity of the variables were evaluated by using Augmented Dicky-Fuller (ADF) and Phillips-Perron Unit Root Tests. The Augmented Dickey-Fuller (ADF) and Phillips-Perron unit root test is used to confirm the stationarity characteristics of variables. The ARDL test will not be valid if there is variable with I(2) because the inclusion of I(2) variable will produce spurious results (Pesaran et al., 2001). Then, before vector error correction model is performed to obtain the short-run dynamics and the long-run equilibrium relationships, it should ensure that the errors of the model are serially independent (Pesaran et al., 2001). The Schwarz Information Criterion (SBC) is the criteria suggested by Pesaran and Shin (1998) in determining the best model in ARDL as it can define more parsimonious specifications. Lastly, the diagnostic and stability tests for the estimated coefficients are conducted. The cumulative sum (CUSUM) test is applied to evaluate the structural stability of regression coefficients over time. Breusch-Godfrey Serial Correlation LM Test is used to check the serial correlation for the errors of the model.

The long run (cointegration form) of the model in the log form is expressed as below.

$$lnMA = \theta_0 + \theta_1 lnGDP_{t-1} + \theta_2 lnOP_{t-1} + \theta_3 lnHINC_{t-1} + \theta_4 lnMO_{t-1} + \theta_5\, lnUER_{t-1} + \varepsilon_t \quad (1)$$

where MA, GDP, OP, HINC, MO, UER represent motorcycle accidents, gross domestic product, oil price, household income and unemployment rate, respectively.

In a complete ARDL form, the equation is as follows:

$$\Delta lnMA_t = \beta_0 + \sum_{i=1}^{p} \beta_i\, \Delta lnGDP_{t-1} + \sum_{i=1}^{p} \beta_i\, \Delta lnMO_{t-1} + \sum_{i=1}^{p} \beta_i\, \Delta lnOP_{t-1} + \sum_{i=1}^{p} \beta_i \Delta lnHINC_{t-1} + \sum_{i=1}^{p} \beta_i\, \Delta lnUER_{t-1} + \theta_1 lnGDP_{t-1} + \theta_2 lnMO_{t-1} + \theta_3 \ln OP_{t-1} + \theta_4 \ln HINC_{t-1} + \theta_5 \ln UER_{t-1} + \varepsilon_t \quad (2)$$

where Δ is the difference operator, p is the maximum lag order, t is the period, the coefficient β is the lagged level term which represent the long-run relationships, the coefficients in the summation group represents the short-run relationship. The variables are cointegrated if all the lagged level variables are jointly significant by using F test in bound test.

4. RESULTS

Table 2 presents the descriptive statistics of the variables used in this study. An average of 94,074 motorcycle accidents were reported during the study periods between 1991 to 2008 and the highest number of accidents were 135,181 cases. The average household income for Malaysia in the past 28 years were RM 3,795 whereas the unemployment rates ranged between 2.45 % and 4.11%.

Table 2 Descriptive statistics of variables

	Motorcycle Accident (MA)	**GDP**	**Motorcycle Ownership (MO)**	**World Oil Price (OP)**	**Household income (HINC)**	**Unemployment Rate (UER)**
Mean	94,074	619,459	7,429,978	48.29	3,795	3.31
Median	98,150	508,813	76,774,918	42.40	3,322	3.30
Max	135,181	1,447,451	13,217,057	99.67	7,587	4.11
Min	29,237	1,351,244	3,251,289	14.42	1,429	2.45
Std Dev	28461	401,771	3,246447	29.28	1,793	0.35
Skewness	-0.56	0.58	0.39	0.51	0.75	-0.42
Kurtosis	2.51	2.10	1.84	1.83	2.45	3.68
Jarque-Bera	1.75	2.57	2.30	2.83	2.96	1.36

Before proceeding to ARDL test, Augmented Dickey-Fuller (ADF) and Phillips-Perron unit root test were performed to confirm the stationarity characteristics of variables. Table 3 illustrates the results of the unit root tests which indicates that all the variables are significant at 10% significance level for the first difference. In other words, the null hypothesis of unit root was rejected and conclude that all the variables are denoted at I(1).

Table 3 Unit Root Test

Variable	**ADF**		**PP**	
	Intercept without trend	Intercept with trend	Intercept without trend	Intercept with trend
		LEVEL		
LMA	-5.8041***	-3.9096*	-5.8041***	-4.0759**
LGDP	-1.2526	-2.9279	-2.4697	-2.8365
LMO	-0.6988	-2.7264	-0.9003	-2.8103
LOP	-1.0365	-1.7212	-1.0365	-1.7212
LHINC	0.7401	-2.0561	-0.8472	-2.2964
LUER	-2.6850	-2.5972	-2.7504*	-2.6704
		FIRST DIFFERENCE		
LMA	-4.4106***	-5.3852***	-4.4105***	-5.3852***
LGDP	-6.2111***	-6.3650***	-6.3187***	-6.6352***
LMO	-5.7119***	-5.6325***	-6.1085***	-6.0333***
LOP	-4.6026***	-4.5172***	-4.5757***	-4.4768***
LHINC	-3.2799**	-3.2302*	-3.2353*	-3.2320**
LUER	-4.4846**	-4.4227***	-4.6565***	-4.6984***

*Note: *** , ** and * denote significant at 1%, 5% and 10%, respectively*

The results in Table 4 exhibits the existence of cointegration among the impulses. Hence, it is ascertained that all these variables move together in the long-run.

Table 4 Cointegration Bound Test

Model	F-statistic
Model: MA=f(GDP, HINC, MO, OP, UER)	5.6788***

With the results show that the series are cointegrated, further analysis was conducted to obtain the long run coefficient for the five variables and presented in Table 5. Based on the Schwarz Information Criterion (SBC), the best lag structure for this series is ARDL (1,1,2,2,0,0). The findings indicated that all the five variables GDP, HINC, MO, OP, UER have significant relationships with the motorcycle accident occurrences. The GDP has a negative effect at 5% significant level while has a positive effect at 5% significant level with a one-year time lag. The world oil price with a two-year lag has a significant positive effect on motorcycle accidents. On the other hand, the unemployment rate reduced the motorcycle accidents at 5% significant level. By contrast, motorcycle ownership has important positive effect on the motorcycle accidents. Lastly, household income (HINC) was found negatively influenced the motorcycle accidents at 10% significant level.

Table 5 Estimated long-run coefficients ARDL (1,1,2,2,0,0)

Variable	Coefficient	t-statistic	p-value
Constant	-6.5064	-1.4950	0.1571
LMA(-1)	0.6784	4.7351	0.0003***
LGDP	-1.1148	-2.2248	0.0430**
LGDP(-1)	0.89099	2.3029	0.0371**
LOP	-0.0075	-0.0742	0.9419
LOP(-1)	-0.2322	-1.7532	0.1014
LOP(-2)	0.1742	2.4000	0.0309**
LUER	-0.65410	-2.6126	0.0205**
LUER(-1)	-0.03800	-0.1623	0.8734
LUER(-2)	0.7365	2.7561	0.0155**
LHINC	-0.6897	-1.8151	0.0910*
LMO	1.2105	2.3034	0.0371**

*Note: ***, ** and * denote significant at 1%, 5% and 10%, respectively*

In short run (as shown in Table 6), the coefficient of EC is -0.43 indicating there is cointegration relationship among the variables in the model and the speed of adjustment to long-run equilibrium after a shock on motorcycle accident is relatively fast. In other words, any short-run deviation will take 2.3 years to adjust to long-run equilibrium. It is interesting to note that oil price is negatively significant in contributing to the motorcycle accidents in short run with a two-year time lag which is in contrast to the long run effect. This implies that the negative effect of oil price on motorcycle accidents would only materialized with a time lag of two years. It was also found that GDP and unemployment rate with time lag have pronounce effects on the motorcycle accident in the short run. Apart from this, motorcycle ownership did not seem to have influence on the motorcycle accidents in short run model.

Table 6 Results of estimated short-run coefficients: ARDL (1,1,2,2,0,0)

Variable	Coefficient	t-Statistic	P value
D(LGDP)	0.6746	1.7473	0.1025
D(LGDP(-1))	-1.3337	-2.3611	0.0332**
D(LOP)	-0.1028	-1.2580	0.2290
D(LOP(-1))	0.07172	0.7016	0.4944
D(LOP(-2))	-0.2329	-2.4704	0.0270**
D(LUER)	0.0504	0.2176	0.8309
D(LUER(-1))	-1.0222	-3.1170	0.0076***
D(LUER(-2))	-0.8772	-3.2815	0.0055***
D(LHINC)	-0.8408	-1.7980	0.0938*
D(LMO)	0.2309	0.4690	0.6463
EC(-1)	-0.4387	-3.557	0.0032***

*Note: *** , ** and * denote significant at 1%, 5% and 10%, respectively*

Diagnostic check such as Breusch-Godfrey Serial Correlation LM Test and CUSUM test were also performed on the models. F-statistic and the respective critical values are involved in ascertain the model. The results of LM test are listed in Table 7 and it can be concluded that the model has no serial correlation problem.

Table 7 Diagnostic check

Diagnostic Check	F-statistic	Prob. Chi-Square (4)
Breusch-Godfrey Serial Correlation LM Test	1.3591	0.0673

Figure 3 illustrates the plot of CUSUM for motorcycle accidents. The CUSUM statistics are within the critical bounds of 5% significance level which implies that the estimated long-run coefficients are stable over the study period between 1991 to 2018.

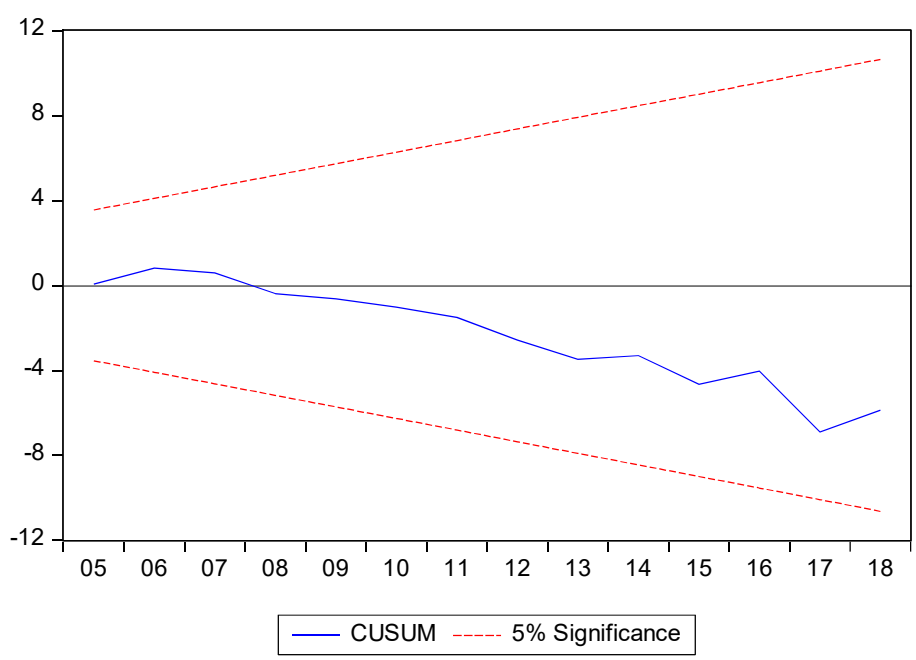

Figure 3 Plots of CUSUM for Motorcycle accidents

5. CONCLUSION AND POLICY IMPLICATIONS

This study employed ARDL approach to evaluate the short and long-run relationships between motorcycle accidents and economic indicators such as GDP, motorcycle ownership, world oil price, household income and unemployment rate over the period of 1991 to 2018. The empirical results show that in short run, the GDP, oil price, household income and unemployment rates have significant impacts on the motorcycle accidents which are consistent with the results in other countries. The household incomes indicate that negative relationship with the motorcycle accidents. This is also consistent with other studies where proved that people would shift to more comfortable and less risk of mode of transport when the income improves (Yousif et al.; 2020; Poi et al., 2021). Oil price with lag year has statistical influence on motorcycle accidents with opposite coefficient signs in both short-run and long-run models. Based on the results, any short-run deviation would take 2.3 years to adjust to long-run equilibrium.

This study is important in shedding some light on the impact of the economic variables on the motorcycle accidents in Malaysia. While achieving Vision Zero has been the main task for every country, it is acknowledged that combating traffic accident is a big challenge to every government. Despite various policies and incentives implemented by the government, the number of traffic casualties are continuously on the rise.

Based on the findings, the policy makers may make the right policy at different levels in response to the short term and long term national or global economic changes. Provision of infrastructure for motorcyclists, for instance exclusive motorcycle lane and periodic pavement maintenance are important to reduce the motorcycle accidents. However, upgrading infrastructure usually involves long term planning and huge investment and would bring negative impacts to the environmental. In another aspect or in short term, enforcement and education on proper usage of motorcycle are more fruitful in reducing motorcycle accidents and the risk of motorcyclists. Stringent laws on running red, not wearing helmet and riding without license should be enforced. Besides, proper training course to the riders should be emphasized as part of the licensing program and elderly retraining program as per implemented in other countries can be considered in Malaysia. The finding of oil price affected the motorcycle accidents with a time lag of two year may suggest that the government should always provide a more comprehensive public transport plan. Besides, working from home culture may also be adopted in the future to reduce the travel on roads.

On the other hand, inequality in income distribution exists in developing countries as GDP grows. Motorcycle is usually the main mode of transport for lower household income groups where the motorcycle is used for all the trip purposes such as work, school and other essential trips. Consequently, with the high exposure rates on the road, the vicious cycle of the high accident risk for motorcyclists would remain unchanged unless other mitigation measures are proposed. In this regard, incentives to use public transport, proper town planning that can reduce the commuting time in daily essential trips, minimizing job dispersion are recommended to target at the lower income groups.

This study is not without limitations. Firstly, only five economic variables, GDP, household income, world oil price, motorcycle ownership and unemployment rate are examined for their relationships with the motorcycle accidents. More economic variables such as infrastructure growth, vehicle kilometer travelled, modal split can be considered for more comprehensive understanding of the traffic crashes in Malaysia. Besides, other dependent variables such as traffic casualties, passenger car accidents, commercial vehicle accidents and transport demand could also be explored. On the other hand, this study presumed a linear and symmetric relationship between the variables. In reality, the asymmetry relationships may exist. Lastly, as suggested by Jou et a., (2012) that geographic factor influenced the vehicle ownership,

it is worth to include this factor in the next study as in Malaysia, the motorized activities are highly concentrated in 3 main states, Klang Valley, Penang and Johor. The understanding of contributory factors can help the government in prioritizing the allocation of budget for infrastructure development among the states in Malaysia.

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