An Analysis of the Enduring Factors of Road Traffic Accidents in Sri Lanka

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Abstract

The number of road accidents in Sri Lanka drastically increased over the last few decades, with high numbers of fatalities, grievous injuries, and property damage. It is important to analyse the most influential factors and root causes of the trends in road accidents. The main objective of this study is to investigate the effective and enduring factors that influence Grievous road traffic accidents in Sri Lanka from 1997 to 2017. According to the preliminary test results, the study analyses three main variables; Grievous Accidents, Operated Vehicles, and Road Length for model formulation. The study employs the Johansen Cointegration Test and Vector Error Correction Model to examine long-run relationships and short-run dynamics between the variables. The results show a positive relationship between the number of Operated Vehicles and Grievous Road Accidents in the long-run. The estimated coefficient is significant and consistent. Grievous Road Accidents are also positively related to Road Length, and the coefficient is significant and consistent. The elasticity of Road Length is very influential in the model. The study provides guidance to the relevant authorities in taking the necessary precautions by increasing awareness and concern for road safety measures to minimise the tragic consequences of road accidents in Sri Lanka.

Keywords*: Road Traffic, Vector Error Correction Model, Cointegration Test, Accident Trends, Error Correction Term*

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INTRODUCTION

Road accidents are now a disturbing phenomenon in the world, leading to the loss of thousands of lives and considerable damage to property. Therefore, many countries are keen to analyse the trends in their road accidents and to investigate the root causes of such occurrences in order to minimise these unexpected and tragic events and their consequences. According to the World Health Organization (WHO) estimates, 1.25 million people die every year due to road traffic accidents while 20 to 50 million persons suffer non-fatal injuries. Many sustain disabilities as a result of such injury.

The statistics reveal that in many countries the cost of road accidents accounts for up to 3 percent of their Gross Domestic Product (GDP). More than 90 percent of road accidents occur in low and middle-income countries with lower socioeconomic status. Road injuries are now the tenth leading cause of death globally and are predicted to become the seventh leading cause by 2030 unless remedial actions are taken to halt this disastrous trend (WHO, 2015). These figures emphasize the need for serious measures to be taken in order to reduce the recurrence of road accidents. Human error is the leading cause of road accidents and it is important to act responsibly in maintaining a reliable and safe transport system. The construction of safe roads and pavements, the enforcing of safe speed limits and road rules, and the use of safe vehicles are all key elements in the quest to eliminate fatal crashes and reduce serious injuries (WHO, 2015). Road accidents are now a major concern across the world, as they directly affect economic growth and development.

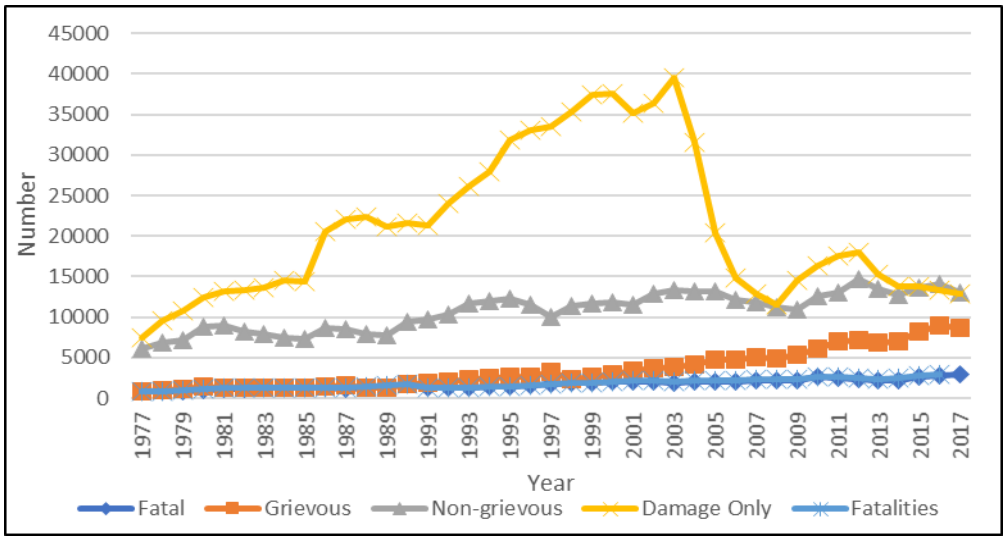
In Sri Lanka as elsewhere, road accidents are a serious issue, directly influencing public health and wellbeing by causing many disabilities as well as a great loss of life every year. Road accidents have thus become a significant social problem which should be highly alarming for every citizen and all concerned parties. Road accidents in Sri Lanka have also become a major problem from the perspective of the transportation sector, negatively affecting the sustainable development of the nation and causing massive losses to the economy. The economic cost of road accidents has been estimated at over Rs 10,000 million annually which is around 1 percent of Sri Lanka's GDP (Kumarage, 2003). Traffic police records (2017) in Sri Lanka revealed that on average six people die in road accidents every day while thousands of road accidents occur each week. As per the statistics, 1 in 45 deaths is caused by a road accident and the past trend in accidents reveals that the risk will be doubled for the next generation. Thus, it is vital to address the prevailing situation by taking corrective action immediately.

According to the road accident database maintained by the Traffic Police Headquarters, road accidents are categorised into four groups, i.e., fatal, grievous, non-grievous and damage only. Of these accidents, around 7 percent of total accidents are fatal while 23

percent are grievously injured. Non-grievous and damage only accidents are around 35 percent each during the last five decades (Traffic Police Records, 2017).

According to police statistics, there were 37,596 road accidents in Sri Lanka in 2017. Of these 2,962 were fatal while 8,666, 13,102, and 12,866 were reported as grievous, non-grievous and damage only accidents respectively. The number of road accidents has drastically increased over the last few decades, with high numbers of fatalities, grievous injuries, and property damage. Road fatalities have trebled during the last four decades and the age group between 21 and 30 years has become the most vulnerable category for fatalities in road accidents. In the road user categories, the drivers and riders are recorded as the highest number of those who are exposed to fatal accidents, accounting for 51.6 percent of the total fatalities (National Transport Statistics, 2017).

Figure 1: Road Accidents Trends in Sri Lanka



Source: Traffic Police Headquarters.

It is a significant fact that the number of grievous accidents including both fatal accidents and grievous injuries have trebled from 1977 to 2017, even though the number of non-grievous accidents does not show a significant increase during those four decades (Figure 1). "Damage only" accidents decreased remarkably during this period, from 33,481 in 1977 to 12,866 in 2017. As per previous studies, statistics pertaining to "damage only" accidents are unreliable because of their low reporting rate and those being subject to extraneous factors such as insurance requirements, the availability of police personnel for reporting, etc. (Kumarage et al., 2002).

As per the statistics of the Traffic Police database, the most important factor for road accidents in Sri Lanka is speedy, aggressive and negligent driving. Driving under the influence of alcohol and making errors of judgment are secondary reasons.

These factors only reflect the most significant causes of road accidents at a given specific time and do not reflect the long-term trend. In order to make long-term policy decisions relating to the prevention of road accidents, it is crucial to analyse the most influential factors and root causes of the trends in road accidents. For ascertaining the possible underlying causes for the trends in road accidents in Sri Lanka, it is important to study the relative trends under different socio-economic conditions, such as growth of population, degree of motorisation, improvement of roads and degree of urbanisation. The analysis by Kumarage et al., (2002) on trends in the growth rate of road accidents since 1980 revealed that all types of accidents reported in each have increased at a greater rate than the increase of population, but have remained lower than the growth in the fleet of vehicles.

Even though past research have focused on analysing the trend in comparison with the growth of accident-related variables, there is scant literature on Sri Lanka, and particularly on statistical and econometric analyses on trends in road traffic accidents and their long-term relationship. Hence, this study opted to focus on investigating the enduring factors that influence trends in road traffic accidents, using advanced statistical analysis. Since past researchers concluded that statistics on non-grievous accidents are unreliable due to the low rate of reporting to the police with insurance claims, whereas grievous accidents are almost always reported and are considered reliable for analysing road accidents, this study focused only on grievous road accidents in Sri Lanka.

Accordingly, the main objective of this study was to investigate the effective and enduring factors that influence grievous road traffic accidents in Sri Lanka. The study firstly identified the main factors of trends in road accidents using the knowledge acquired through the literature survey and brainstorming. Secondly, the study analysed these enduring factors and ascertained their significance in determining future trends in grievous road accidents in Sri Lanka. Thirdly, the study enabled offering guidelines for the necessary interventions and precautions to be taken by the relevant authorities to minimise the tragic consequences of road accidents in Sri Lanka.

LITERATURE REVIEW

Many researchers have investigated the trends of road accidents over the years, revealing the risk factors affecting the fluctuations of these dangerous events. Research conducted by Mouyid and Kunnawee (2008) to identify the factors in road accidents through in-depth accident analysis observed that in Thailand, road safety was directly influenced by the rising trend of motorisation driven by the improvement of socio-economic status of the Thai people. Through investigation of cases, they outlined the major risk factors of road accidents, namely, inaccurate risk assessment and late evasive action, the absence of street-light facilities, inadequate lane marking and visibility, which influence the increase in the severity of crashes and the injuries.

Atubi (2012) showed that road accidents are significantly associated with road length increases, presence of Road Safety Corps and population growth in Lagos State, Nigeria. According to Onakomaiya (1988), and Filani and Gbadamosi (2007), better quality highways would result in more accidents because drivers would be speeding more on good quality roads, leading to more frequent and fatal accidents. Adhikari (2016) conducted a research study to look at the trends in road traffic accidents on the Kathmandu-Bhaktapur road after the addition of lanes, and concluded that there was an increase in accidents immediately after the completion of road widening due to the drivers' unfamiliarity with the increased design speed and also due to unchanged behavior of pedestrians.

Abdul (2014), having conducted a study to identify factors causing severity of road accidents in Ghana, identified overloading of vehicles and disregarding road safety regulations being the most significantly associated variables with accident severity in the Northern Region. Research on suburban roads in Iran has found that insufficient road width and the level difference between roads and road shoulders cause frequency and severity of accidents (Khalili & Pakgohar, 2013). Banik et al. (2011) conducted a study on road accidents and safety in Sylhet Region of Bangladesh, and showed that rapid growth of road vehicles and growth of tourism caused severe road traffic accidents. The study conducted by Grimm & Treibich (2012) on determinants of road traffic crash fatalities across Indian states revealed that the rising motorisation, urbanisation and accompanying increase in the share of vulnerable road users act as major drivers of road traffic crash fatalities.

Dharmaratne and Jayatilleke (2015) conducted a study on road traffic accidents, injury and fatality trends in Sri Lanka from 1938 to 2013. They found that the fluctuations of accidents during this period were parallel to the country's political and economic development and that the number of crashes and injuries would increase when the number of vehicles grow, while it would decrease with better law enforcement, and greater penetration of the public transport system. Somasundaraswaran (2006), having conducted a study using statistics of road accidents during 1989-2005, revealed that the alarming rate of vehicle ownership combined with inadequacies in road network development to support the demand for transportation were the most significant reasons for the increased number of road accidents in Sri Lanka.

Kumarage et al., (2009) revealed that, over time, the vehicle fleet numbers and the number of accidents have steadily increased on Sri Lankan roads. The most likely reasons for the increasing trend in road accidents, according to that study, are the rapid increase in the amount of travel undertaken by the population, the shift from public transport to private vehicles (which are known to be unsafe modes for travel when compared to public transportation), weaknesses in traffic rules enforcement, poor road design and the lack of safety intervention and awareness programs.

It is frequently found in literature therefore that rapid motorisation, together with the expansion of the road network around the world, would create a high risk for all road users resulting in an increase in road accidents and injuries.

RESEARCH PROBLEM

In Sri Lanka, road accidents are a serious issue, directly influencing public health, wellbeing and the economy, causing many disabilities as well as loss of life every year. This problem has drastically increased over the last few decades, with increases in fatalities, grievous injuries and damage to property (Figure 1).

It is an important fact that grievous accidents (including both fatal accidents and grievous injuries) have trebled from 1977 to 2017, even though no significant increase in the number of non-grievous accidents could be observed during that period. Even though speeding and aggressive and careless driving, on the one hand, and driving under the influence of liquor and making errors of judgment, on the other, have been identified as primary and secondary causes as per the Traffic Police database, those factors merely indicate causes of road accidents at a given specific time. They do not reflect long-term trends. If frequency of grievous accidents are to be reduced in a sustainable manner, it is important to analyse the most influential factors and root causes behind trends in road accidents in the long run, and implement necessary preventive policies. It is this knowledge gap that was addressed through the present research.

OBJECTIVES

The main objective of this study was to investigate the important and enduring factors that influence the trends in grievous road traffic accidents in Sri Lanka.

Accordingly, the study was conducted with the objectives of (a) identifying the main factors influencing the trends in road accidents, using the knowledge gained from the literature survey and by brainstorming, (b) analysing these enduring factors to ascertain their significance, in order to determine the future trends of grievous road accidents in Sri Lanka, and (c) deriving guidelines that could be used by the relevant authorities in view of taking necessary action in relation to road safety, so that road accidents and their grievous consequences in Sri Lanka could minimised in the long run.

METHODOLOGY

The study considered the fluctuations and trends in road accidents within a 20-year period from 1997 to 2017. The selected key influential factors relating to trends in road accidents were based on the literature survey and an in-depth analysis of the economic

variables and fluctuations in road accident numbers during this period. The dependent variable of the preliminary model was grievous accidents (including pedestrian accidents) (GA). Eight independent variables; population, operated vehicles, road investments, employments, GDP (constant), railway investments, per capita GDP and the road length were considered. According to the preliminary test results, the study analysed three main variables; Grievous Accidents (GA), Operated Vehicles (OV) and Road Length (RL) for model formulation. This study used secondary data acquired from the Traffic Police Headquarters, the National Budget Department and the Central Bank of Sri Lanka.

The level variables were found non-stationary and all the variables were cointegrated in the first difference [I(1) variables], thus, the Vector Error Correction Modelling (VECM) with the Cointegration test was used to find the long-term relationship and short-term dynamics among the variables. Original data (level data) of variables; GA, OV and RL were transformed into log form as LGA, LOV and LRL to linearise the data since Vector Auto Regression models (VAR Models) do not capture nonlinear elements.

Among several unit root tests found in the econometric literature, the most commonly used are the Dickey-Fuller (DF) test and the Augmented Dickey-Fuller (ADF) test. The ADF test, an extension of the DF test, was used to remove any structural effects (autocorrelation) in the time-series. The ADF Unit-root testing, was deployed to determine whether the data series were stationary or non-stationary (Annexure A). To examine the long-run relationship between the three variables, the Johansen Cointegration test was employed while running a VECM to find short-run dynamics among variables.

Hypothesis 1: There is a positive relationship between the number of operated vehicles and the number of road accidents

$H_0: \varphi_1 = 0$

$H_1: \varphi_1 > 0$

φ_1= Operated vehicles coefficient of road accidents model (Should be positive)

Hypothesis 2: There is a positive relationship between RL and the number of road accidents

$H_0: \varphi_2 = 0$

$H_1: \varphi_2 > 0$

φ_2= Road length coefficient of road accidents model (Should be positive)

The proposed model is expressed in the equation (1).

$$LGA_t = \varphi_0 + \varphi_1 LOV_t + \varphi_2 LRL_t + \varepsilon_t \quad \text{.....(1)}$$

where,

LGA = Log of Grievous Accidents including pedestrians' accidents
LOV = Log of number of Operated Vehicles
LRL = Log of Road Length
φ_0 = Autonomous Grievous Accidents
φ_1 = Operated Vehicles coefficient of accidents model
φ_2 = Road Length coefficient of road accidents model
ε = Error term

RESULTS AND DISCUSSION

ADF Test Results

The stationarity of each series was examined using the ADF unit root test including a constant. Unit root tests were conducted for each variable, LGA, LOV and LR, and no evidence was found to reject the null hypotheses. It means that all variables, at level, were non-stationary. The first differences were then considered, and the null hypothesis (that there would be a unit root for the first difference of all variables) was rejected at 1% and 5% significant levels, portraying that differenced variables were stationary. Therefore, ADF unit root test indicated that these variables would be integrated in the order of 1, [I (1)] and those would be suitable for a VECM through cointegration test to examine both long-run cointegration relationship and short-run dynamics. Table 1 reports the results of the unit root test performed on level variables and their first differences.

Table 1: ADF Test Results

Variable	LGA	LOV	LRL
ADF test statistics (in levels)	-1.44	-1.21	-1.01
Critical values 5%	-3.05	-3.02	-3.02
ADF test statistics for 1st differenced data	-4.09***	-5.00***	-7.99***
Critical values 1%	-3.89	-3.83	-3.83

*Note: *** Significant at 0.01 level.*
Source: Authors' compilation.

Cointegration Test Results

VAR Lag Order Selection criteria indicated that variables with lag 1 could be used to perform regression (Annexure B). The Johansen test was performed using log likelihood ratios. A number of cointegrating relations were calculated assuming that there was no linear time trend. To determine the number of cointegrating vectors, both the Trace Test and the Maximum Eigenvalue Test were deployed.

Table 2 below reports the Maximum Eigenvalue results of the Cointegration test, using which, the null hypothesis of not having any cointegrating vectors (r=0) was tested against the alternative hypotheses of having one (r=1) or two (r=2) cointegrating vectors. According to the results of the Maximum Eigenvalue test, the null hypothesis of r=1 could not be rejected at 5% level of significance, thus suggesting that the variables were cointegrated, and that there would be one cointegrating relationship.

Table 2: Maximum Eigenvalue Test

Hypothesized No. of CEs	Maximum Eigenvalue statistics	0.05 Critical value	Prob
None**	23.9	21.13	0.02
At most 1	10.23	14.26	0.20
At most 2**	5.78	3.84	0.02

*Note: ** Significant at 0.05 level.*

Source: Authors' compilation.

Estimated Long-Run Model for Road Accidents

As per the results of VECM test, the estimated long-run model for road accidents is:

$$LGA_t = -8.88 + 0.40LOV_t + 1.13LRL_t + \varepsilon_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

As per the proposed model, in the long-run, OV and RL showed a positive relationship with grievous road accidents. The estimated coefficients of both OV and RL emerged significant and consistent. Besides, "road length" elasticity of road accidents appeared very influential in the model. The results thus revealed that increases in the number of operated vehicles would increase road accidents in Sri Lanka. This finding is consistent with the outcomes of the previous study by Grimm & Treibich (2012), which also has concluded that rising motorisation was a major driver of road traffic accidents in India. The results also indicated that road accidents in Sri Lanka could be caused by increasing length of the road network (km). While there may be other factors (such as technical and safety standards) that cause accidents more than the road length itself, this result conforms to the outcomes of the research by Atubi (2012), which had found that road traffic accidents in Lagos State, Nigeria, increased with increases in road length.

Short-run Dynamics

According to the estimated VEC model, 0.66 percent of the disequilibrium (ε_{t-1}) in road accidents could be corrected towards equilibrium within a one-year period, which is a good rate of adjustment. Final VECM results are summarised in Table 3.

Table 3: Vector Error Correction Estimates

Error Correction	D(LGA)	D(LOV)	D(LRL)
CointEq1	-0.665628*** [-3.12389]	0.100624 [0.35771]	0.063665 [0.74276]
D(LGA(-1))	0.218003 [1.54157]	-0.346043 [-1.85352]	-0.098214 [-1.72647]
D(LOV(-1))	-0.160406 [-0.86350]	0.086510 [0.35276]	-0.033845 [-0.45292]
D(LRL(-1))	-0.754216 [-1.37992]	-1.015515 [-1.40738]	-0.444732 [-2.02275]
C	0.084636*** [3.89460]	0.130825 [4.55999]	0.030433 [3.48122]
Adj. R-squared	0.254315	0.149749	0.337943

*Note: *** Significant at 0.01 level.*

Within parentheses are t-values.

CONCLUSION

The model results indicated that fatal and sever accidents could continue to increase when the number of operated vehicles and the road lengths increase. Accident reduction through a reduction of the number of operated vehicles could be achieved through promotion of public transportation and also through strategic introduction of transport demand management measures, as also suggested in literature. This would not only reduce road accidents, but also will help mitigate negative externalities such as pollution while saving foreign exchange through reduced fossil fuel imports.

The finding to effect that increasing road lengths could increase road accidents, however, is curious, which indicates that investing on road network expansion alone is unlikely to be a viable solution for the problem of increasing road accidents. Such could even be treated counter-productive when perceiving the results of this study, because increasing road lengths could attract more vehicles on to roads, and expanded or widened roads could induce speed driving; both effects leading to grievous accidents. Therefore, care has to be taken to ensure technical standards of roads, maintenance programmes, provision of facilities for vulnerable road users and safety imperatives, when extending length of national road network. Moreover, policy makers may have to consider introducing awareness campaigns to enhance road safety, while imposing and enforcing rules and regulations in order to discourage and minimise unsafe driving practices and prevent use of technically unsound vehicles, in view of minimising road accidents in the long run.

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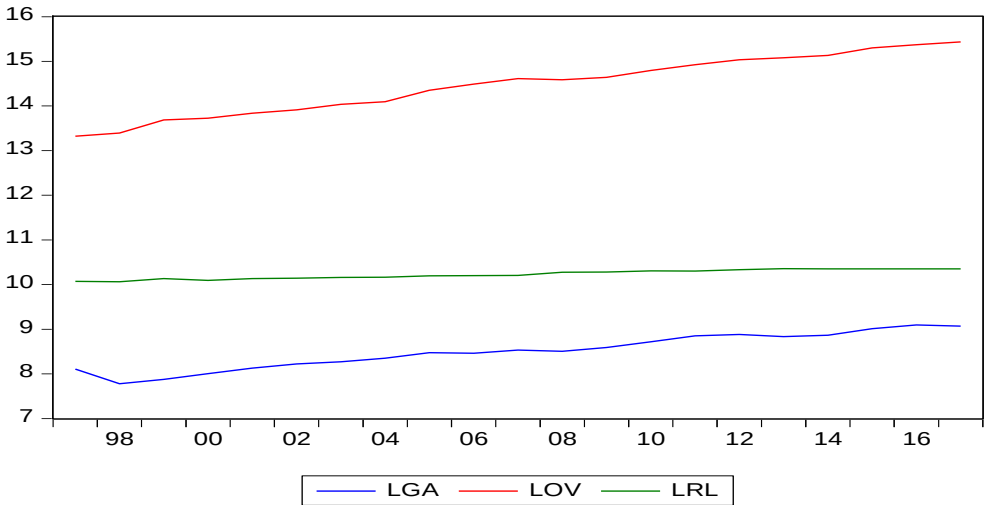
Annexure A

Unit Root Test



Annexure B

Lag Length Criteria

VAR Lag Order Selection Criteria

Endogenous variables: LGA, LOV, LRL

Exogenous variables: C

Date: 09/07/18 Time: 22:16

Sample: 1997- 2017 Included observations: 20

Lag	LogL	LR	FPE	AIC	SC	HQ
0	59.56240	NA	7.02e-07	-5.656	-5.5069	-5.62708
1	105.1232	72.897*	1.84e-08*	-9.312*	-8.7149*	-9.19569*

* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion