THE EFFECT OF ECONOMIC CRISIS AND TARGETED MOTORCYCLE SAFETY PROGRAM ON TRAFFIC DEATHS IN MALAYSIA

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ABSTRACT

This paper presents the effects of the recent economic crisis and the motorcycle safety program (MSP) on traffic deaths in Malaysia. The transfer function Autoregressive Integrated Moving Average (ARIMA) technique was used to evaluate the overall effects of the interventions. The variables used in developing the model were the population, registered vehicle, Gross Domestic Product (GDP) and traffic safety programs. Traffic death data from 1971 to 1998 were taken from the Traffic Police headquarters computer system while the GDP quarterly data were obtained from the Central Bank of Malaysia. The GDP data were used in this analysis since they reflect reasonably well to the effects of the recent economic down turn in the country. In addition, traffic exposure data particularly the number of population and registered vehicles were obtained from Statistical Department, Malaysia for the same years. The final model indicates that changes of population, registered vehicles and economy performance are positively correlated with the traffic deaths. In contrast, the safety intervention (MSP) was found to be significant (p<0.05) in reducing traffic deaths in Malaysia.

Keywords : *Traffic deaths, motorcycle safety program, economic performance, traffic exposures, transfer function, ARIMA.*

INTRODUCTION

Motor-vehicle accidents (MVA) are one of the leading causes of injury-related deaths in Malaysia. In the last decade, approximately 51 thousands deaths were reported in Malaysia and this rate is increasing in line with the growth of traffic exposures. Within this number, motorcyclist deaths constitute about 60 percent of total traffic deaths in Malaysia.

Since then, a number of efforts have been made to reduce these MVA problems. Among the efforts carried out were (i) improvements to road conditions, (ii) emphasis on behavior modifications and (iii) intensive traffic enforcement. Among the strategic approaches taken, in line with the above efforts was the implementation of the motorcycle safety program (MSP). The program is specifically targeted to motorcyclists and was launched by the Prime Minister in 1997. Apart from introduction of more exclusive motorcycle lanes, road safety auditing and selective enforcement, the long term program was aimed to modify road user attitudes and behavior on identified motorcycle safety issues [1] such as proper use of helmet, lack of conspicuity and excessive speeding.

Since 1997, traffic safety in Malaysia has improved considerably. In 1997, the death figures declined marginally for the first time in almost ten years despite the increasing rate of motorization. By 1998, this number has fallen to 5,477 cases. This suggests that the 30% reduction targets formulated by the Malaysia Government [2] in the Long Term Policy for Traffic Safety could have been achieved partially.

Apart from the MSP, the recent economy recession could also have some effects in reducing the traffic deaths. This could due to less trips resulting from less economic activities which in turn reduce the traffic exposures. This phenomenon is supported by Walker [3], Broadbent [4] and Hoxie et al. [5] who pointed that economic recession has an impact on death rates due to changes in travel patterns. As such, the effects of these factors in explaining the deaths trends worth further investigation.

This paper therefore examines the effects of both the motorcycle safety intervention (MSP) as well as the economic crisis on the traffic deaths in Malaysia. The transfer function Autoregressive Integrated Moving Average technique was used to model the proportion of death due the traffic crashes. Time series technique is applied chronologically. The information pertaining to the proportion of traffic death in each year is treated as the prior for the information in subsequent year. This is repeated until all the data are combined and the estimated overall proportion of traffic death from the year 1971 to 1998 is found.

PREVIOUS TRAFFIC DEATH MODELS

Although traffic deaths are influenced by a large number of factors related to traffic environment, vehicles and road user behavior, most death models compounded the 'unexplained variables' into the 'error component' of the models. This could due to the unavailability of long series data or due to variables unique to the country. As such, the most commonly independent variables used are the population, road length and registered vehicles [6, 7, 8, 9].

One of the limitations of previous models is that none of the previous model seems to be completely satisfactory in predicting high accuracy estimation especially when applied to developing countries. Jadaan [10] explained that this may be attributed to the facts that the models built were based on developed countries situation and did not include factors that may significantly affect traffic deaths in developing countries. Kim [9] pointed that this limitation is due to different type of social life style between the developed and developing countries.

The capability and accuracy of traffic death model depends generally on the details and reliability of the data on which the models are built. Apart from quality data, the accuracy of a model can be significantly improved by means of suitable method and incorporating more explanatory factors into the model. In view of this, Radin [2] further improves the accuracy of Rehan's [11] model by considering more exposure variables and data structure to better suit developing country environment. Apart from that, the time series log-linear model with Poisson errors was established to explain the relationship between traffic deaths and traffic exposures. The interaction between population, vehicles and road length was used as proxy to explain traffic exposures and to overcome the unavailability of real exposure data such as vehicle-kilometer traveled in Malaysia.

METHODOLOGY

Comparative studies of statistical methods have found that in most cases ARIMA (Autoregressive Integrated Moving Average Model) more accurately accounts for regularity in time series data than alternative strategies of analysis, such as before and after comparison and regression [12, 13, 14].

The goal of the ARIMA method is to describe the stochastic autocorrelation structure of the data series and, in effect, filter out any variance in a dependent variable that is predictable on the basis of the past history of that variable [14]. Transfer function based on ARIMA modeling can explain if there is a certain event that occurs that changes a time series. In addition, this technique allows the modeling of seasonal cycles, trends and pattern in the time series that results a greater accuracy in estimating the intervention effects.

The general form of the transfer function ARIMA model comprises a part relating to the transfer function and another part relating to the error terms, is defined as

$$Y_t = \sum_{i=1}^{n} V_i \ (B)x_{it} + N_t \tag{6}$$

Where Y_t is the road accident death rate, x_{it} is the explanatory variables and N is the noise term assumed to follow a general ARIMA structure.

Fitting an ARIMA model to time series data was done in three steps, which are identification, parameter estimation, and diagnostic checking. The probability theory of the time series often requires one to transform a non-stationary series into a stationary series. Generally, a time series is said to be stationary if there is no systematic change in mean or no trend, if there is no systematic change in variance. Sample Autocorrelation Function (ACF) is normally used to identify the non-stationary series. In general, if the ACF of the time series die down slowly, then the time series values are considered as non-stationary. Most of the time a non-stationary series can be transformed to stationary series by taking the log-transformation of the non-stationary time series data.

The second step of model building is to select the appropriate Autoregression (AR) and Moving Average (MA) parameters of the model. The estimation of the AR and MA parameters are achieved using the autocorrelation function (ACF) and the partial autocorrelation function (PACF) of the time series. The selection of the model is based on the criteria defined by Box and Tiao [15].

Diagnostic check is needed to determine the best model among the tentative 'adequate' model. A number of criteria for model comparisons have been proposed. The diagnostic tools used included statistical significance of the parameters, the Box-Ljung (Q) statistic and the Akaike information criterion (AIC). The best model should have lowest AIC value, a statistically insignificant Q statistic at a lag of about one-quarter of the sample size. After carrying out the complete identification, estimation and diagnosis iterative scheme of Box Jenkins, the final ARIMA model was obtained for each leading indicator series.

For this study, transfer function ARIMA analysis was applied to evaluate the impact of the MSP, economy recession that changed the trend of the traffic deaths in Malaysia. The MSP intervention was used as step function while GDP was introduced as transfer function in the model.

DATA AND MODEL STRUCTURE

The validity of any evaluation depends on the quantity and, more importantly, the quality of data available. In this study, traffic death data compiled by the traffic police from 1971 through 1998 were used. This provides a 2-year intervention period and a 26-year base period. Exposure data namely population and registered were obtained from the Statistical Department, Malaysia for the same year.

In addition, the Gross Domestic Product (GDP) index during study period was collected from the Central Bank of Malaysia. This parameter is used as an explanatory variable in explaining the effects of the economic down turn currently faced by the country. A summary of the coding used in this modeling is shown in table I.

The evaluation method used in this analysis is the quasi-experimentally interrupted time series design. The main

Table 1: Data structure and coding

Variable	Description	Coding
Traffic Deaths	Deaths within 30 days following an accident for the year	Casualties
Registered Vehicle	Total number of registered vehicle in Malaysia for the year	In million
Population	Total number of population in Malaysia for the year	In million
MSP	Motorcycle Safety Program (Dummy Variable)	0 before MSP 1 after MSP
GDP	Gross Domestic Product (Total income earned domestically)	In million

advantage of this method is that the model is dynamic in the sense that changes in the levels of trends or seasonality in data can often be automatically adjusted for by the model. In addition, transfer function time series analysis [15] could be used to examine the results of unusual conditions, such as economy recession and changes of government policy as well as changes in traffic exposure such as the increased in vehicle and population.

To model the traffic deaths and the effect of Motorcycle Safety Program, registered vehicle, population growth and economic crisis, the Zero-order transfer function was considered in the multivariate models. The general Model is in the form of:

$$Y_t = v_1(B)X_{1t} + v_2(B)X_{2t} + v_3(B)X_{3t} + v_4(B)X_{4t} + w_0 I_t + N_t \quad (1)$$

Where

Y_t = Traffic deaths at each year during study period;
X_{1t} = Annual Gross Domestic Product;
X_{2t} = Annual population number;
X_{3t} = Annual registered vehicle;
X_{4t} = Adjustment after year 1981;
$v_1(B)$ = Function that relates the X_{1t} and Y_t;
$v_2(B)$ = Function that relates the X_{2t} and Y_t;
$v_3(B)$ = Function that relates the X_{3t} and Y_t;
$v_4(B)$ = Function that relates the X_{4t} and Y_t;
w_o = Impact of Motorcycle Safety Program, average yearly change in Y_t;
I_t = Dummy variable of presence of Motorcycle Safety Program (when $t \leq 26$, $I_t = 0$; otherwise $I_t = 1$);
N_t = Unmodel error;

The t-test was used to determine parameter significance with p value of 0.05 or better.

RESULT

Time Series Stationarity

The Autocorrelation Function (Figure 1) of traffic deaths dies down slowly, therefore it can be concluded that these time series values are non-stationary. This suggests that it may be good idea to transform non-stationary series to stationary by taking logarithms transformation. The autocorrelations of the transformed data (figure 2) clearly decay for larger lags, indicating that the transformed series is stationary.

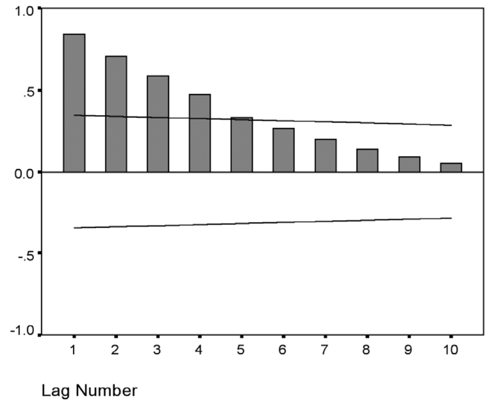

Figure 2: Autocorrelation Function for traffic deaths after logarithm transformation

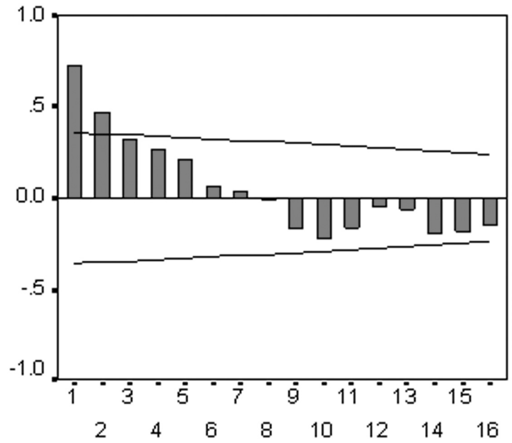

Figure 3: Partial Autocorrelation Function for traffic deaths after logarithm transformation

ARIMA and Transfer Function Analysis

ARIMA models were run on a yearly time series of deaths. From the plots in Figure 2 and 3, the autocorrelation function of the deaths appears to be dying down exponentially, while the partial autocorrelation function cuts off to zero at lag 1 and 2, thus suggesting a Autoregressive AR(1,2) model.

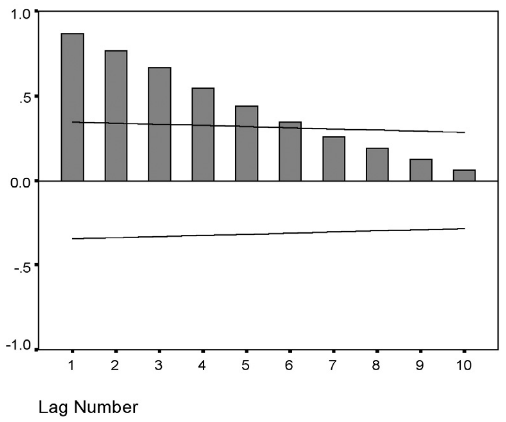

Figure 1: Autocorrelation Function for traffic deaths before ogarithm transformation

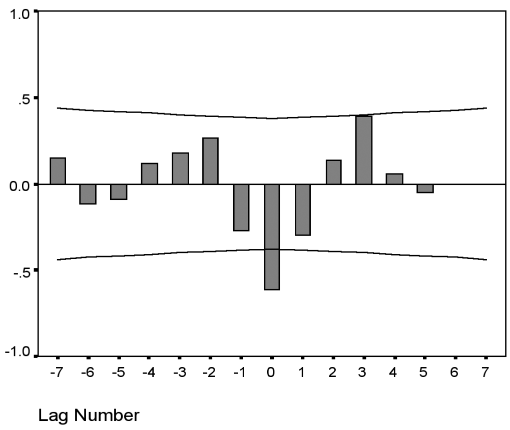

Figure 4: Cross-correlation functions of the pre-whitening time series between Motorcycle Safety Program (MSP) and death series

Transfer function analysis is used to generate the impulse response of GDP, MSP, population and registered vehicle to unit changes in the death series. Using the autoregressive and moving average factors calculated in the previous section, GDP, MSP, population and registered vehicle are pre-whitened with the death series. The cross-correlation functions of the pre-whitened time series are shown in Figures 4, 5, 6 and 7. It can be observed that death time series was significantly negatively correlated with MSP only at lag 0. In contrast, the death series was significantly positively correlated with GDP, population and registered vehicle time series at lag 0.

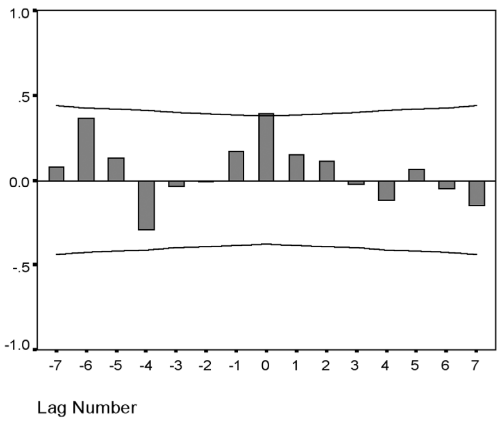

Figure 5: Cross-correlation functions of the pre-whitening time series between Gross Domestic Product (GDP) and death series

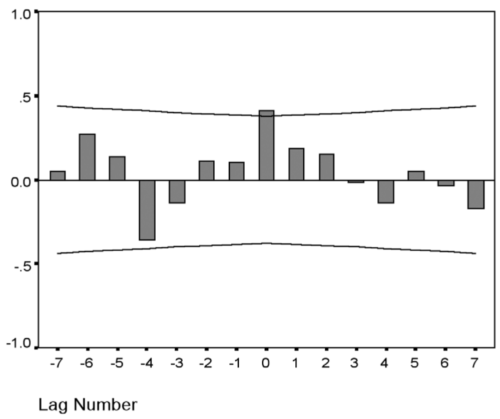

Figure 6: Cross-correlation functions of the pre-whitening time series between population and death series

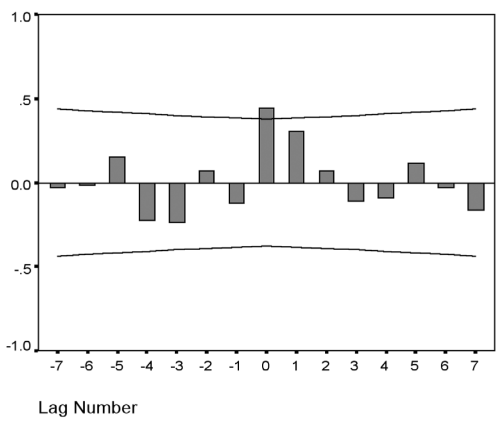

Figure 7: Cross-correlation functions of the pre-whitening time series between registered vehicle and death series

Table 2 shows the parameter estimates for the model. The t-ratio for all the component and independent variables are significant at the 5 percent level. Adequacy of the model is further supported by lowest AIC and insignificant of Box-Ljung statistic.

Table 2: Estimation for the model of yearly Traffic Deaths

Parameter	Estimate	Std Error	t-value	Lag	p-value
Constant	7.334	0.05256	139.54	0	$p<0.05$
Autoregressive (1,1)	-0.439	0.19173	-2.29	2	$p<0.05$
Autoregressive (1,2)	-0.677	0.18687	-3.62	4	$p<0.05$
Adjustment after year 1981	0.0727	0.03207	2.27	0	$p<0.05$
Motorcycle Safety Program	-0.104	0.05374	-1.94	0	$p<0.05$
Gross Domestic Product	$3.84x10^{-6}$	$1.02x10^{-8}$	3.77	0	$p<0.05$
Population	$2.74x10^{-8}$	$6.72x10^{-9}$	4.08	0	$p<0.05$
Registered Vehicle	$9.39x10^{-8}$	$1.57x10^{-8}$	5.96	0	$p<0.05$

AIC = 23.321* (Note : * - lowest AIC value)

The final time series model obtained from the above analysis can be mathematically summarized as follow:

$$L_n(Y_t) = 7.33+3.84x10^{-6} X_{1t}+2.74x10^{-8}X_{2t} ++9.39x10^{-8}X_{3t} ++ 0.07X_{4t} - 0.104I_t+ \frac{N_t}{(1+0.43B)(1+0.65B^2)} \qquad (2)$$

Graphically, this can be demonstrated by the plot of the actual traffic deaths and estimated traffic deaths (Figure 8). As can be seen, there is reasonably good match between the observed and expected deaths and this suggests that the above model explain well the traffic deaths in Malaysia.

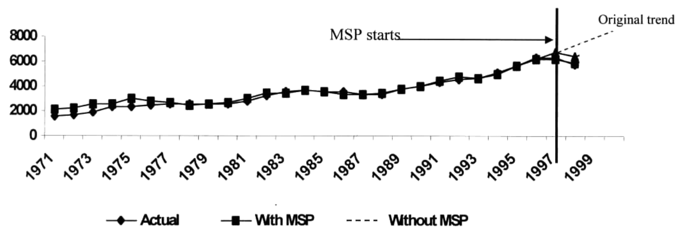

Figure 8: Predictive Model of yearly Traffic Deaths

DISCUSSION AND CONCLUSION

The coefficient of Motorcycle Safety Program is negative, indicating that the presence of Motorcycle Safety Program has significantly reduced the road deaths by about 11 percent ($e^{-0.104}$) following its implementation in 1997. This finding supports Radin and Law's [16] earlier analysis, that the MSP was effective in improving traffic deaths and casualties in Malaysia.

In a separate study, Ahmad et al. [17] found that the campaign has significantly improve riders' perception and understanding on safety issues highlighted in the campaign. Further, Radin [18] observed that the proper strapping of helmet compliance increased significantly from about 41% in the before period to 66% in the after period.

Apart from motorcycle casualties, the safety program is expected to reduce other accidents and casualties such as pedestrian and bicyclist who involved in motorcycle crashes. This is because they are equally vulnerable with the motorcyclists. In addition, the multimedia campaign is also expected to affect other motorists as the campaign crosses to the general public and sizeable number of motorists own both car and motorcycles. Therefore, the improvement in traffic safety consciousness is expected in all road users but higher results are expected to motorcyclists as they represent 60% of death toll in Malaysia.

Implementation of safety program, however, is not the sole factor behind the decline in traffic death number. Economic slow down seem significantly ($p<0.05$) plays a role. In present study, the economic performance indicator, (GDP), was found significant in reducing the number of traffic deaths. This is indicated by the diversion of the death trends as shown in Figure 8. This result implies that the relationship between GDP and road deaths are closely associated with the economic activities and hence the traffic exposures.

In the present study, the population and registered vehicle are found to be significant in explaining traffic deaths. This is in line with Smeed [6], Andreasson [7], Rehan [11] and Radin [2], who showed that death number increases as these two factors increase. Compared to Radin [2] earlier model, the current model is able to refine the accuracy of prediction. The deviation between the present model (5,858 deaths) and the actual deaths (5,744 deaths) in 1998 is only 2 percent compared with 6,606 deaths predicted earlier. This higher accuracy could due to the inclusion of economic indicator and MSP which was not included in the earlier model.

Based on the above analysis, it can be concluded that targeted Motorcycle Safety Program was effective in reducing traffic deaths in Malaysia. Apart from that, changes of population and registered vehicles are found to be positively correlated to traffic deaths. The economic performance indicator (GDP) was also found to be significantly in explaining traffic deaths in Malaysia.

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