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## An Intervention Model of Road Accidents: The Case of OPS Sikap Intervention

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**Abstract:** The introduction of the integrated road safety operations commonly referred to as OPS Sikap on December 2001 was continuously implemented nationwide in Malaysia during every major festive season. The intervention carried out is aimed to reduce the number of road accidents and casualties. Though preliminary analysis based on before and after intervention implementation had concluded that the number of accident had decreased, our objective was to examine the effect in more detail. In this study, intervention analysis was conducted to investigate the effects of OPS Sikap on road accidents in Malaysia. The aim was to assess the intervention effect in comparison with the standard ARIMA model and hence to obtain the best model for forecasting purposes. Our results suggested that there was a drop in the number of road accidents during OPS Sikap II, VI, VIII, XII and XIV. However, the significant reduction could only be seen after the implementation of OPS Sikap VII and XIV with an expected number of reductions by about 1,227 and 1,484 accidents associated with respective intervention. This has suggested the intervention model with ARMA (1,12) is the best model to predict the number of road accidents.

**Key words:** Intervention model, pulse function, differencing, road accidents, ops sikap, stationarity

### INTRODUCTION

Road accident is one of the major causes of death. This phenomenon is quite alarming especially to developing countries like Malaysia. The number of accidents in Malaysia has recorded an increasing trend year by year. In 2007 alone, the total number of 363, 319 cases was reported compared to only 215, 632 cases in 1997 (Royal Malaysian Police, 2007). This increment has become a critical issue that needs to be tackled by all parties involved as it has created an adverse impact to the economy, society and the country as a whole. To address this alarming problem, various intervention programs and enforcement actions had been carried out to offset the road accident figure. Among which was the nationwide implementation of an integrated road safety operation commonly referred to as OPS Bersepadu or OPS Sikap.

In December 2001, the integrated road safety operation commonly known as OPS Sikap was introduced and continuously implemented nationwide during every festive seasons in Malaysia. The implementation of this intervention program was significantly important in examining the influence of the unique multi-cultural and religious activities of traffic exposure in Malaysia. It is common for Malaysians to take advantage of having a

long holiday during festive seasons to go back to their respective hometowns. This tradition has generated high volume of traffic on all highways and major roads nationwide and resulted in the increased number of accidents. However, after eight years, the extent of OPS Sikap's effectiveness is still under discussion (Sunday Star, 2009). Preliminary analysis of the short term impact of OPS Sikap XII based on telemetric data plot, cumulative fatality plot and speed change analysis revealed commendable results of fewer deaths compared to normal days (MIROS, 2007a). Findings from the chi square analysis on the impact of before and after OPS Sikap XIII intervention also indicated a decrease in the number of fatalities and total accidents (MIROS, 2007b). While MIROS conducted a simple before and after comparison to conclude that casualties had decreased, our objective is to examine the effects in more detail. This is due to analysis based on standard t-test may not be appropriate to examine changes in the mean level of a time series with intervention. This test is only valid if the mean observations before and after intervention vary normally and independently with constant variance (Box and Tiao, 1975). Unlike the time series data set of traffic accident and casualties, the observation may be serially correlated and formed a non-stationary in series due to seasonality,

randomness and trend component in the time series. For this reason, this study adopted the Box-Tiao time series modeling technique that extended the ARIMA model to evaluate the impact of intervention on the mean level of time series using intervention analysis. This modeling technique has been widely used in various applications (Sharma and Khare, 1999; Chang and Lin, 1997) including the most relevant to this work which is in the road safety modelling (Noland *et al.*, 2008). The primary objective of this study is to investigate whether the OPS Sikap intervention program implemented by the Malaysian government is effective in reducing the number of road accidents and road accident deaths. Monthly time series data from January 1996 to December 2007 on road accidents were analyzed.

### THE INTERVENTIONS

Road safety intervention program is an initiative to reduce road accidents. To address the issue concerned, several interventions such as daytime Running Head Light (RHL) for motorcyclist (Radin Umar *et al.*, 1996), new law regarding rear seat belt wearing among car occupants, including taxi and rented vehicles has been implemented in Malaysia. One of the major and continuous programs comprehensively prepared by the Ministry of Transport (MOT) is the introduction of OPS Sikap integrated road safety intervention. This comprehensive plan involves inter-departmental and organizational co-operation that needs to be carried out by several agencies during the OPS Sikap. Among the agencies involved are the government agencies of Polis DiRaja Malaysia (RMP), Jabatan Keselamatan Jalan Raya (JKJR), Jabatan Kerja Raya (JKR), Lembaga Lebuhraya (HPU), Kementerian Kesihatan Malaysia (KKM), Lembaga Perlesenan Kenderaan Perdagangan (LPKP), PUSPAKOM, PETRONAS, Non Governmental Organisations (NGOs) and others (MIROS, 2007a, b).

This intervention plan involves four major strategies. The strategies adopted in reducing the number of accident include the exposure control, crash prevention, injury control and post injury control. For exposure control, the strategies implemented are by promoting the use of public transport especially to motorcyclist, banning lorries and trucks on festive days. While for the crash prevention, the strategies involved are the enforcement by Police and JPJ such as undercover enforcement, campaign through mass media and reduction of speed limit. For injury control, the advocacy on the use of safety helmets, belts and rear seat belts, paramedics and injury management strategy are implemented. Finally, for post injury control trauma management at hospital

and after care strategies are adopted to ensure victims are treated within hours interval and ensure the victim fully recovered after the treatment. As the aim of OPS Sikap intervention is to reduce the number of accidents, investigation on the extent of the effectiveness of the intervention is needed to reveal the full benefit from this road safety intervention implementation in terms of the number of accident reduction in Malaysia.

**Related work:** The influential of seminal work by Box and Tiao (1975) model had resulted in applications of intervention analysis in various fields. Box and Tiao had developed the intervention model with the application to economic and environmental problems. Specifically, this intervention analysis with ARIMA models was used when exceptional external event, called intervention, affected the variable to be forecasted (Bowerman and O'Connel, 1987).

Sharma and Khare (1999) had developed an intervention analysis model to study the impact of the intervention brought in by Government of India, to control the CO pollution caused by the vehicular exhaust emissions by the enforcement of the emission standards for the vehicle. Application of the model suggested that the intervention had not been effective in bringing down the desired change. In another study, time series intervention modeling technique had been used to analyze the recycling impact on solid waste generation (Chang and Lin, 1997). In this study, they considered a local recycling program as the intervention event to solid waste generation. Special kinds of dummy variables that were pulse and step functions were applied in building time series intervention models. The result of their study unambiguously had shown that recycling impacts were of importance in the prediction of solid waste generation. In another study, Abraham (1980) had discussed a model that introduced to encapsulate interventions in a multiple time series. The approach adopted in his study was the Box and Tiao intervention analysis where interventions were considered in a univariate time series but he modestly extended the results to the multiple time series.

In road accident modeling application, there were many traffic safety studies that had successfully applied the Box and Tiao intervention analysis methodology. Among the application was in modeling the impact of changes in environment variable on traffic data. One of the models was introduced by Bhattacharyya and Layton (1979). They used the intervention analysis to study the effect of seat belt legislation introduced in the state of Queensland on road death and concluded that the intervention had significant effect on the volume of deaths. Hilton (1984) also used the intervention analysis

to investigate the impact of recent changes in California drinking-driving laws on fatal accident levels during the first post intervention year. However, he found that the change in that law, did not indicate a different impact occurred in reductions of fatal accident levels.

Noland *et al.* (2008) had investigated the effect of the congestion charge on traffic casualties for motorist, pedestrians, cyclist and motorcyclist, both within the charging zone and in areas of London outside the zone using intervention analysis. They adopted the Box-Tiao intervention analysis in study. The result showed that there was no significant effect for the total causalities, but within the charging zones the motorist causalities and cyclist causalities had been a statistical significant effect. The same intervention analysis methodology was used to study the impact of an anti-drinking and driving advertising campaign on highway accident data (Murry *et al.*, 1993). The result suggested that four models demonstrated a decreased proportion of fatal and incapacitating accidents during the campaign intervention period.

## MATERIALS AND METHODS

To examine the effect of intervention and develop the road accident model, the modeling process was divided into two phases. First is the identification of the preintervention univariate model describing the 84 observations before the interventions is done using Box-Jenkins methodology. The Box-Jenkins model used in the first phase consisted of the autoregressive model, moving average model and Autoregressive-moving Average (ARMA) models.

The Autoregressive (AR) is defined by:

$$Y_t = \phi_0 + \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \dots + \phi_p Y_{t-p} + \varepsilon_t \quad (1)$$

where,  $Y_t$  is the actual value of the series at time  $t$ ,  $Y_{t-i}$  is the actual value of the series at the time  $t-i$ ,  $\phi$  is the autoregressive parameter for  $Y_{t-i}$  and  $\varepsilon_t$  is the irregular fluctuation at time  $t$ , not correlated with past values of the  $Y$ 's (Makridakis and Hibon, 1997).

The Moving Average (MA) model is expressed by:

$$Y_t = \theta_0 + \varepsilon_t - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \dots - \theta_q \varepsilon_{t-p} \quad (2)$$

where,  $Y_t$  is the actual value of the series at time  $t$ ,  $\theta_q$  is the moving average parameter for  $\varepsilon_{t-i}$ ,  $\varepsilon_t$  is the error term at time  $t$ ,  $\varepsilon_{t-i}$  is the error term at time  $t-i$  (Makridakis and Hibon, 1997).

In 1938, World had combined both AR and MA schemes and showed that ARMA process could be used to model a large number of stationary time series as long as the appropriate order of  $p$ , the number of AR term and  $q$  the number of MA term, were appropriately specified (Makridakis and Hibon, 1997). This means that a general series  $Y_t$  can be modeled as a combination of past  $Y_t$  and/or past  $\varepsilon_t$  error which is:

$$Y_t = \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \dots + \phi_p Y_{t-p} + \varepsilon_t + \theta_0 + \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \dots - \theta_q \varepsilon_{t-p} \quad (3)$$

If differencing is required to achieve stationary, then the series will eventually have to be undifferentiated or integrated before forecasting. In this case, the Integrated ARMA (ARIMA) model is also considered. This model has combined the Autoregressive (AR) and Moving Average (MA) model with a differencing factor that removed trend or seasonal in the data. The letter  $I$ , between AR and MA, stood for Integrated and reflected the need for differencing to make the series stationary. The ARIMA model equations are the same as ARMA equations except  $Y_t$  is replaced by the different series  $Z_t$  and it can be defined as:

$$Z_t = \phi_1 Z_{t-1} + \phi_2 Z_{t-2} + \dots + \phi_p Z_{t-p} + \varepsilon_t + \theta_0 + \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \dots - \theta_q \varepsilon_{t-p} \quad (4)$$

where,  $Z_t = \Delta^d Y_t = (1-\beta)^d Y_t$  with  $\beta$  as the backward shift operator and  $d$  is the number of differencing being performed. The model in (4) is an ARMA ( $p, q$ ) process for  $Z_t$  in the form  $\phi(\beta)(1-\beta)^d Y_t = \theta(\beta)\varepsilon_t$ , the model is an ARIMA of order ( $p, d, q$ ) for  $Y_t$ .

While the first phase is to identify the best Box-Jenkins model, the second phase is to incorporate the intervention analysis. The hypothesis of this study is that the introduction of OPS Sikap does not have any effect on road accidents and casualties. If this hypothesis is to be rejected, the nature and the magnitude of such effect can be estimated. The intervention Box-Tiao model used in this study takes the following form:

$$Y_t = f(I, X) + N_t \quad (5)$$

where,  $t$  is the discrete time (in this case month),  $Y_t$  is the dependent variable for a particular time (the number of accidents),  $f(I, X)$  is the dynamic part of the model that contains the intervention component ( $I$ ) and deterministic effects of independent variables ( $X$ ) and  $N_t$  is the noise component (Box and Tiao 1975; Bowerman and O'Connell 1987). In order to model the effect of OPS Sikap I until OPS

Sikap XV, the Box-Jenkins models found in the first section were used to hypothesized the effect of the intervention using special kind of dummy variables called pulse function. The general type of intervention analysis can be described as:

$$z_t = v_t + N_t + \frac{\theta_q(B)\theta_Q(B^L)\alpha_t}{\phi_p(B)\phi_P(B^L)} \quad (6)$$

in which,  $v_t$  is one of the pulse functions as described by the pattern of OPS Sikap,  $N_t$  is the error term and

$$\frac{\theta_q(B)\theta_Q(B^L)\alpha_t}{\phi_p(B)\phi_P(B^L)}$$

is univariate model that is obtained by Box-Jenkins methodology (Chang and Lin, 1997). The following intervention model was considered,

$$z_t = C_{1t}P_{1t} + C_{2t}P_{2t} + \dots + C_{15t}P_{15t} + \frac{\theta_q(B)\theta_Q(B^L)\alpha_t}{\phi_p(B)\phi_P(B^L)} \quad (7)$$

where,  $P_{1t}$ ,  $P_{2t}$ , ...,  $P_{15t}$  are called pulse variables that representing all OPS Sikap implemented since December 2001. These pulse variables are defined as follows:

$$P_{1t} = \begin{cases} 1 & \text{if } t = 72(\text{December 2001}) \\ 0 & \text{otherwise} \end{cases}$$

$$P_{2t} = \begin{cases} 1 & \text{if } t = 74(\text{February 2002}) \\ 0 & \text{otherwise} \end{cases}$$

$$P_{3t} = \begin{cases} 1 & \text{if } t = 83 \text{ and } 84(\text{November and December 2002}) \\ 0 & \text{otherwise} \end{cases}$$

$$P_{4t} = \begin{cases} 1 & \text{if } t = 85 \text{ and } 86(\text{January and February 2003}) \\ 0 & \text{otherwise} \end{cases}$$

$$P_{5t} = \begin{cases} 1 & \text{if } t = 95 \text{ and } 96(\text{November and December 2003}) \\ 0 & \text{otherwise} \end{cases}$$

$$P_{6t} = \begin{cases} 1 & \text{if } t = 97(\text{January 2004}) \\ 0 & \text{otherwise} \end{cases}$$

$$P_{7t} = \begin{cases} 1 & \text{if } t = 107(\text{November 2004}) \\ 0 & \text{otherwise} \end{cases}$$

$$P_{8t} = \begin{cases} 1 & \text{if } t = 110(\text{February 2005}) \\ 0 & \text{otherwise} \end{cases}$$

$$P_{9t} = \begin{cases} 1 & \text{if } t = 118 \text{ and } 119(\text{October and November 2005}) \\ 0 & \text{otherwise} \end{cases}$$

$$P_{10t} = \begin{cases} 1 & \text{if } t = 121 \text{ and } 122(\text{January and February 2006}) \\ 0 & \text{otherwise} \end{cases}$$

$$P_{11t} = \begin{cases} 1 & \text{if } t = 122(\text{February 2006}) \\ 0 & \text{otherwise} \end{cases}$$

$$P_{12t} = \begin{cases} 1 & \text{if } t = 130(\text{October 2006}) \\ 0 & \text{otherwise} \end{cases}$$

$$P_{13t} = \begin{cases} 1 & \text{if } t = 134(\text{February 2007}) \\ 0 & \text{otherwise} \end{cases}$$

$$P_{14t} = \begin{cases} 1 & \text{if } t = 142 \text{ and } 143(\text{October and November 2007}) \\ 0 & \text{otherwise} \end{cases}$$

$$P_{15t} = \begin{cases} 1 & \text{if } t = 145(\text{December 2007}) \\ 0 & \text{otherwise} \end{cases}$$

The autocorrelation plots of either original or transformed series suggested various types of AR, MA and mixed ARMA or ARIMA models. The method of conditional least square (CLS) was used to do the estimation. The CLS method was being run using Statistical Analysis System (SAS). At diagnostic checking stage, the model would be checked for adequacy by using some simple diagnostic tests that checked whether the residual of each model of the observed values were independent and identically distributed (iid) random variable.

The sample autocorrelation of an iid sequence with finite variance was approximately iid with distribution  $N(0, 1/n)$ . Therefore if the sequence was iid, then about 95% of the sample, autocorrelations was expected to fall between the bound of  $\pm 1.96/\sqrt{n}$ . If the computation of sample autocorrelations up to lag 40 and more than 2 or 3 values fall outside the bound or 1 value falls far outside the bounds, the iid hypothesis has to be rejected.

The Akaike Information Criterion (AIC) and Schwarz's Bayesian Criterion (SBC) information criteria were used to evaluate the model. The model with the smaller information criteria was said to fit the data better. The AIC was computed as:

$$AIC = -2\ln(L) + 2k \quad (8)$$

where,  $L$  is the likelihood function and  $k$  is the number of free parameters. The SBC was computed as:

$$SBC = -2\ln(L) + \ln(n)k \quad (9)$$

where,  $n$  is the number of residuals that can be computed for the time series. Sometimes Schwarz Bayesian criterion is called the Bayesian Information Criterion (BIC). The estimation and diagnostic checking had been done for all possible ARMA models for both the transformed series.

A total of 144 monthly data points of road accident collected from January 1996 to December 2007 were used in this study. The monthly total road accidents or road crash used in this study referred to the total figure of their occurrences on public or private roads due to the negligence or omission by any party concerned (on the aspect of road users conduct, maintenance of vehicle and road condition), environmental factor (excluding natural disaster) resulting in a collision (including out of control cases and collision of victims in a vehicle against object inside or outside the vehicle e.g. bus passenger) which involved at least one moving vehicle whereby damage or injury was caused to any person, property, vehicle, structure, or animal was the other. These data series were obtained from Royal Malaysian Police Headquarters at Bukit Aman, Kuala Lumpur (Royal Malaysian Police, 2007).

## RESULTS AND DISCUSSION

The plot in Fig. 1 suggested the existence of an upward trend but did not clearly express the existence of seasonal component. Further inspection on the existence of seasonal component was done by examining the relationship between autocorrelation function (ACF) and the seasonality of time series.

For the series that exhibited seasonality pattern, the current data points would show some degree of correlation with data points which lead or lag by 12 months and the ACF exhibits peaks at lag 12, 24, 36, and so forth.

Figure 2a and b showed the ACF and PACF of original Malaysian road accidents. The ACF declined very slowly indicating that the series were not stationary (Murry *et al.*, 1993). This was also in agreement with inspection on the original values in Fig. 1 that did not seem to fluctuate around a constant mean suggesting a non-stationary series. In order to apply the Box-Jenkins method, we required the accident series to be stationary and this was done by differencing the original series,  $Y_t$  to obtain  $Z_t^* = (1-B)^1 Y_t$ .

Figure 3 showed the series in first difference fluctuates around constant mean and thus could be considered stationary. The ACF and PACF of the first difference (Fig. 4a, b) also suggested that the series are

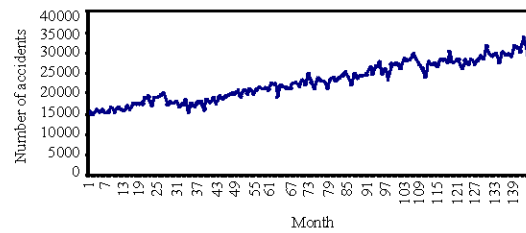


Fig. 1: Plot of Malaysian road accidents (January 1996 to December 2007)

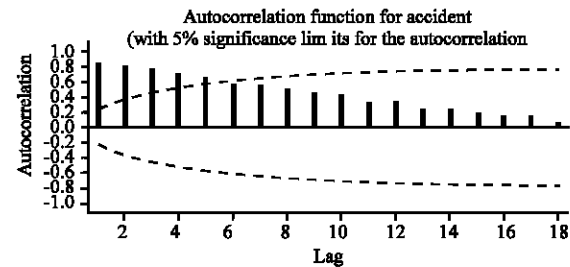


Fig. 2a: ACF plot for Malaysian road accidents (January 1996 to November 2001)

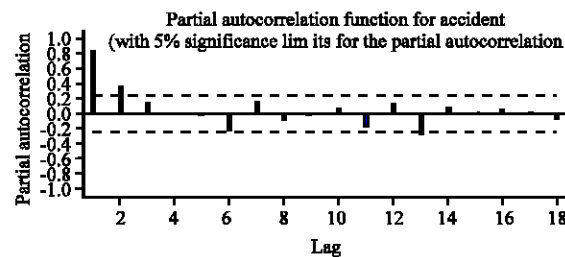


Fig. 2b: PACF plot for Malaysian road accidents (January 1996 to November 2001)

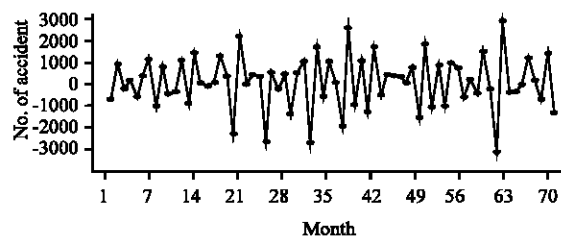


Fig. 3: Plot of Malaysian road accidents after first difference at lag 1 (January 1996 to December 2007)

now stationary implying that higher differencing or transformation is not necessary.

The ACF values indicated that the autocorrelation coefficients were significant at 5% level for lags 1 and 12 while PACF values on the other hand showed the

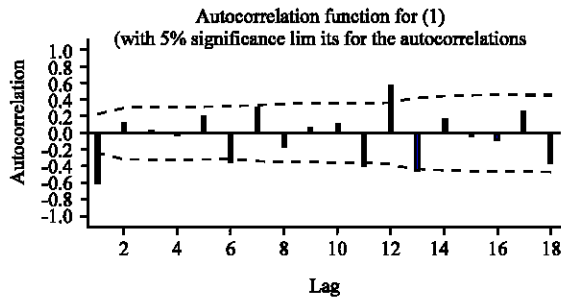


Fig. 4a: ACF plot for Malaysian road accidents after first difference at lag 1 (January 1996 to November 2001)

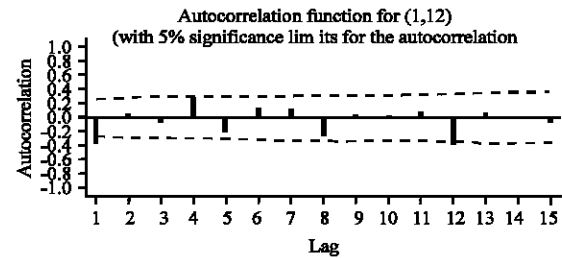


Fig. 5a: ACF plot for Malaysian road accidents after first difference at lag 1 then lag 12 (January 1996 to November 2001)

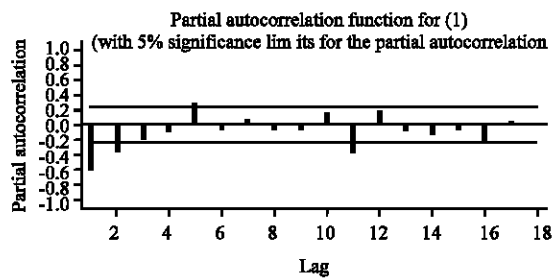


Fig. 4b: PACF plot for Malaysian road accidents after first difference at lag 1 (January 1996 to November 2001)

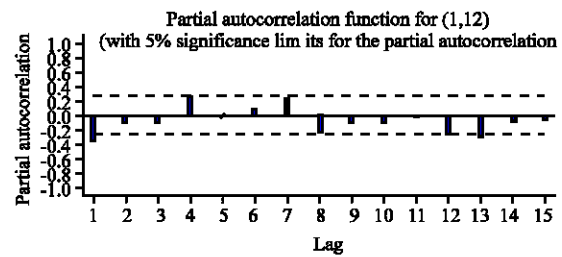


Fig. 5b: PACF plot for Malaysian road accidents after first difference at lag 1 then lag 12 (January 1996 to November 2001)

autocorrelation coefficients that were significant at 5% levels for lag 1, 2 and 11. Thus, it is suggested that the Moving Average (MA) model of order 1 and 12 and autoregressive model (AR) of order 1, 2 and 11 should be considered. Looking at the significant spike at lag 12 in ACF plot of the first difference, a second transformation was carried out to remove seasonality effect on the original series by first differencing the series at lag 1 then at lag 12 to yield a new series of  $Z_t = (1-B)(1-B^{12})Y_t$ .

Inspection on the ACF and PACF plot of the first differencing at lag 1 then at lag 12 series (Fig. 5a, b) suggested that the MA models of order 1 and 12 and AR model of order 1 should be considered.

Based on Table 1, we can see that all models of the second transformation have smaller AIC and SBC values compared to those of the first transformation. This implies that models of the second transformation with difference at lag 1 then lag 12 fit the road accidents data better than the first transformation with difference at lag 1.

Hence, the second analysis that incorporates the intervention analysis will concentrate on the models of second transformation. As for the model estimation, the possible combination AR, MA and ARMA model suggested from both transformed series were estimated

using the method of Conditional Least Square (CLS) and the selection of the best model was carried out using the AIC and SBC goodness of fit statistics.

Hence, the second analysis that incorporates the intervention analysis will concentrate on the models of second transformation. As for the model estimation, the possible combination AR, MA and ARMA model suggested from both transformed series were estimated using the method of Conditional Least Square (CLS) and the selection of the best model was carried out using the AIC and SBC goodness of fit statistics. The combination of Box-Jenkins intervention models were estimated by incorporating the intervention effect using pulse function.

Based on the perspective of Box-Jenkins models in Table 1, the resulting estimated intervention model was shown in Table 2. It is obvious that Model 3 with intervention of ARMA (1,12) using transformed series of difference at lag 1 then lag 12 is the best model to examine the effect of OPS Sikap intervention in reducing the number of road accidents. The model gives the smallest AIC. The least squares point estimates of C1 and C2 are negative representing the decrease in the expected number of road accidents per month by about 1,227 and 1,484 accidents during the implementation of OPS Sikap VIII and XIV, respectively.

Table 1: AIC and SBC Values for estimated ARMA models in first difference and models for first differenced at lag 1 then at lag 12 series

Models in first difference				Models in first difference at lag 1 then lag 12		
No	Model	AIC	SBC	Model	AIC	SBC
1	ARMA (1,0)	1165.25	1167.50	ARMA (1,0)	958.64	960.70
2	ARMA (1,1)	1159.69	1164.18	ARMA (1,1)	960.04	964.16
3	ARMA (1,12)	1155.96	1185.19	ARMA (1,12)	952.12	978.91
4	ARMA (0,1)	1162.62	1164.87	ARMA (0,1)	958.29	960.35
5	ARMA (0,12)	1158.71	1185.69	ARMA (0,12)	954.08	978.81

Table 2: Estimated model with and without intervention for first differenced at lag 1 then at lag 12 series

Parameter	With intervention			
	Without ARMA	ARMA (1,12) model 1	ARMA (1,12) model 2	ARMA (1,12) model 3
AR 1,1	-0.28539	-0.27365	-0.45701	-0.24556
MA 1,1	0.34540	0.32000		0.40607
MA 1,12	0.58919	0.57592	0.58709	0.56611
C1 (P8)				-1227.1
C2 (P14)		-1577.4	-1925.1	-1483.5
AIC	2141.89	2139.97	2146.31	2138.69

## CONCLUSIONS

This study attempts to evaluate the effect of OPS Sikap intervention implemented nationwide. Covering OPS Sikap I until OPS Sikap XIII, the intervention model with impulse function was adopted to model the interrupted effect on the number of road accidents in Malaysia. The results show that out of 15 OPS Sikap implemented, only OPS Sikap II, IV, VI, XII and XIV show a reduction in the number of road accidents occurrence though the reduction is not statistically significant. Nevertheless, OPS Sikap VII and XIV are found to be statistically significant in reducing the number of road accident. This is consistent with findings from a study done by MIROS in evaluating the effectiveness of OPS SIKAP XIV using before and after intervention data (MIROS, 2007b).

The model without intervention on the other hand, results in poor AIC to suggest that model with intervention is better though the significant effect of reduction can only be seen during implementation of OPS Sikap VI and XIV. In this study, the emphasis is not on whether the intervention programs reduce accidents per say, but whether more intervention strategies would have greater effect and if so by how much. This information is important to the policy makers in order to decide the level of intervention necessary to generate the desired positive effect.

Finally, it can be concluded that the implementation nationwide of OPS Sikap intervention plan has reduced the number of road accidents, especially during OPS Sikap VIII and XIV. Though, the implementation of OPS Sikap II, VI, and XII also shows some degree of reduction the amount is, however, not statistically significant. Thus, it is suggested that, in order to be more effective, additional

OPS Sikap strategies should be further implemented such as the increase in the number of police enforcement and longer period of intervention be carried out. The result of this study also provides not only clear evidence of the positive impact of intervention but also can be used to measure the effect of other road safety intervention plan in future.

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## REFERENCES

- Abraham, B., 1980. Intervention analysis and multiple time series. *Biometrika*, 67: 73-78.
- Bhattacharyya, M.N. and A.P. Layton, 1979. Effectiveness of seat belt legislation on the queensland road toll: An Australia case study in intervention analysis. *J. Am. Statist. Assoc.*, 74: 596-603.
- Bowerman, B.L. and R.T. O'Connell, 1987. *Time Series Forecasting: Unified Concepts and Computer Implementation*. Duxbury Press, USA.
- Box, G.E.P. and G.C. Tiao, 1975. Intervention analysis with applications to economic and environmental problems. *J. Am. Statist. Assoc.*, 70: 70-79.
- Chang, N.B. and Y.T. Lin, 1997. An analysis of recycling impacts on solid waste generation by time series intervention modeling. *Resour. Conservation Recycling*, 19: 165-186.
- Hilton, M.E., 1984. The impact of recent changes in california drinking-driving laws on fatal accident levels during the first post intervention year: An interrupted time series analysis. *J. Law Soc. Assoc.*, 18: 605-627.
- Makridakis, S. and M. Hibon, 1997. ARMA models and the Box-Jenkins methodology. *J. Forecasting*, 16: 147-163.
- MIROS, 2007a. OPS Bersepadu Conducted Over the Chinese New Year Period from 11–25 February 2007. MIROS, Kuala Lumpur.



- MIROS, 2007b. The Effectiveness of OPS Bersepadu Conducted Over the Hari Raya Period from 7-21 October 2007. MIROS, Kuala Lumpur.
- Murry, J.P., A. Stam and J.L. Lastovicka, 1993. Evaluating an anti-drinking and driving advertising campaign with a sample survey and time series intervention analysis. *J. Am. Statist. Assoc.*, 88: 50-56.
- Noland, R.B., M.A. Quddus and W.Y. Ochieng, 2008. The effect of the london congestion charge on road casualties: An intervention analysis. *Transportation*, 35: 73-91.
- Radin Umar R.S., M.G. Mackay and B.L. Hills, 1996. Modelling of conspicuity-related motorcycle accidents in Seremban and Shah Alam, Malaysia. *Accident Anal. Prevention*, 28: 325-332.
- Royal Malaysian Police, 2007. Statistical report road accident, Malaysia. Kuala Lumpur.
- Sharma, P. and M. Khare, 1999. Application of intervention analysis for assessing the effectiveness of CO pollution control legislation in India. *Transformation Res. Part, 4*: 427-432.
- Sunday Star, 2009. How effective is ops sikap. 1 February, pp: F24.