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Speed Cameras

Improving Safety or Raising Revenue?

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Abstract

Despite numerous studies showing the effectiveness of speed enforcement, especially automated speed enforcement, in reducing crashes, public debate still continues in regard to the revenue-raising aspect of speed enforcement. Using speed camera enforcement data from the City of Edmonton, this study found that catching offenders had a significant effect in reducing injury crashes that was beyond the deterrent effect provided by the presence of police on the roads alone. The apprehension of offenders is therefore a key component needed to maximise the effectiveness of the speed camera programme and not solely as a means to raise revenue.

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1.0 Introduction

Road crashes are a major cause of deaths and serious injuries in many countries and inflict enormous economic and social costs on society. In Canada, for example, there were 2,778 fatalities and 224,000 injuries resulting from road crashes in 2001, and the annual social cost was estimated at $25 billion (Transport Canada, 2004). Although the factors contributing to crashes are numerous and diverse, speeding is widely considered to be a major determinant (Tay, 2004, 2005a, 2009; Evans, 2004; Dee and Sela, 2003; McCarthy, 2001; TRB, 1998; Lave and Elias, 1997; Jorgensen and Polak, 1993; Lave, 1985). The common response by many governments to the speeding problem is to impose a legal speed limit on the roads and the effects of such legislation and enforcement have been well researched and documented (Tay, 2004, 2005a; Hess, 2004; Mountain *et al*., 2005; Elvik, 1997; Graves *et al*., 1989, 1993; McCarthy, 1991, 1994; Levy and Asch, 1989; Snyder, 1989; Fowles and Loeb, 1989). Despite numerous studies showing the effectiveness of speed enforcement, especially automated speed enforcement, in reducing crashes, public debate still continues in regard to the revenue-raising aspect of speed enforcement (Buckingham, 2003a, b; Cameron, 2003; Platt, 2008; MacPherson, 2008).

Although many issues are raised in the numerous and constant debates on the revenue-raising aspect of speed enforcement, one key area of knowledge that can shed some light on it has yet to be highlighted, especially in the research literature. Do we really need to catch offenders to be effective? Can crashes be reduced simply by the presence of enforcement without the need to issue tickets? Previous research has shown that even plywood replicas of police cars had an effect on driver behaviour (Baker and Lawder, 1968) and simply giving a warning also had an effect on driver speed (Ennis, 1967). If the mere presence of police is sufficient to deter speeding, then there is no escape from the revenue-raising allegations.

However, the above study also showed that those who were issued a ticket were less likely to reoffend later on the same trip than those who were simply given a warning (Ennis, 1967). The more important question is whether issuing tickets to offenders has a significant effect in reducing crashes beyond the deterrent effects provided by the presence of police. If the number of tickets issued has a significant effect independent from that of police presence, then it is not solely a revenue-raising instrument but has a direct impact on saving lives and preventing injuries.

The purpose of this study is to examine the effects of police presence on the roads and the number of tickets issued on road safety using speed camera enforcement and injury crash data from the City of Edmonton.

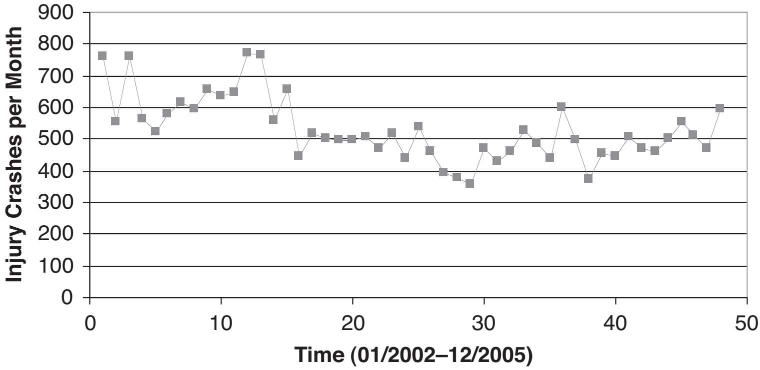
This programme is chosen because it is one of the very few programmes from which data are routinely collected in recent years to support an evidence-based approach to traffic enforcement. The speed camera or photo radar programme in the City of Edmonton was introduced in 1993 and was considered by the police service as an extremely accurate and effective means of traffic enforcement. Currently, the Edmonton Police Service employs twenty Special Constables from the Corps of Commissionaires with five photo radar vehicles rotated throughout the city. The weekly list of sites is posted on the website of the Edmonton Police Services with a note stating that the sites are not the only sites that the police may operate the cameras and not all sites listed will be enforced for that particular week.

2.0 Methodology

Two primary sources of data were used for this study. The first source was the Edmonton Police Services which provided monthly data on crashes and speed enforcement from January 2002 to December 2005. The speed enforcement data provided include the number of hours of operation of the speed cameras and the number of tickets issued. The second source comprised the economic data, such as the employment rate, extracted from information compiled by Statistics Canada. The short period of time used in this study is constrained by the availability of traffic enforcement data but it provides an added advantage, which is to exclude other confounding effects from other policies that may have an impact on crashes.

The main performance indicator in this study is the total number of injury crashes (crashes involving at least one injury or fatality) per month which has a mean of 529.62 and standard deviation of 101.4 (see Figure 1). Over the period under analysis, there is a slight downward trend ($\widehat{\beta} = -4.05$) in the number of injury crashes per month and the relationship appears to be highly significant (p-value < 0.0001). Note that the total number of injury crashes is selected over the number of speed-related crashes per month because the definition and classification of speed-related crashes is very imprecise and subjective, and the Province of Alberta does not compile data on speed-related crashes. More importantly, the presence of police on the roads is expected to have a significant spillover effect on other types of crash as well, especially crashes due to illegal and risky behaviour such as following too closely, failure to give way, joyriding, and aggressive driving.

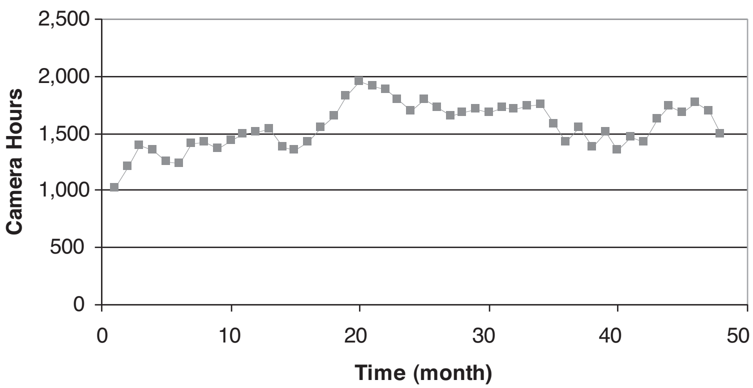
Figure 1
Number of Injury Crashes per Month: January 2002–December 2005



It should also be noted that although not all crashes are reported to the police, the reporting rate of injury crashes is expected to be quite high. More importantly, using only fatal crashes is expected greatly to underestimate the social cost of road crashes and may lead to non-optimal allocation of scarce road safety resources (Tay, 2002). Also, the extremely low number of fatal crashes per month (often zero) may pose some estimation problems. On the other hand, the reliability of the data on property-damage-only crashes is not expected to be very high and thus, they are excluded from the analysis. Non-injury crashes exceeding a cost of $1,000 are supposed to be reported but many are not reported in practice.

There are two main enforcement variables (independent variables) that are of interest in the data analyses. The first variable is the number of hours of operation per month and is shown in Figure 2. The mean of the series is

Figure 2
Speed Camera Operating Hours per Month



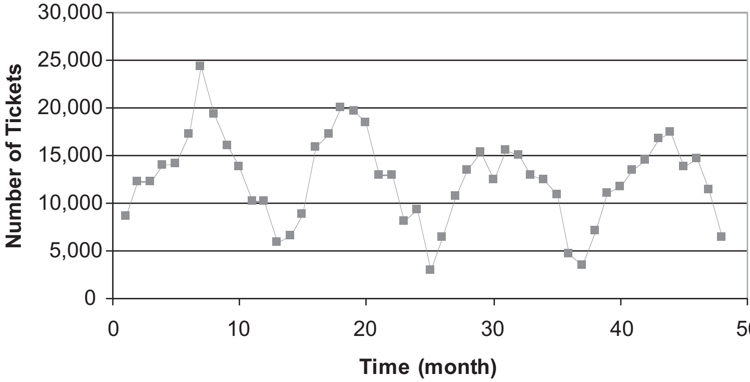
1,560.3 hours per month and the standard deviation is 202.3 hours per month. The number of hours of operation is used in this study to capture the presence of police on the roads. It should be noted that most police vehicles operating speed cameras, even if they are unmarked, are clearly noticeable by the driving public due to the type of vehicle used, their locations and effects on traffic flow in the vicinity of the police vehicle. A photograph of a typical photo radar vehicle is also posted on the police's website.

The second enforcement variable of interest is the number of violations or tickets issued under the speed camera programme (see Figure 3). It is clear from the figure that the number of speeding violations issued is very seasonal, with the highest rates occurring in summer when the roads are fairly clear and dry, and the incidences of speeding tend to be higher. The mean of number of violations issued per month is 12,533.6 and the standard deviation 4,576.3. It should be noted that although the number of citations is expected to be somewhat correlated with the number of hours of operation, they can be fairly independent owing to the different enforcement styles including where and when to enforce. The correlation coefficient between the number of hours of operations and number of tickets issued is estimated at only 0.172 for the data used.

The main performance indicator (dependent variable) in this study, y, is the total number of injury crashes, which is assumed to be dependent on the number of operating hours for the speed cameras and the number of violations issued. In addition to these two independent variables, a trend term is included in the model to account for the influence of gradual and longer term improvements in the road environment and vehicle safety (Joksch, 1984; Tay, 2005c, 2006) and an economic indicator, the employment rate, is also included to capture fluctuations due to changes in the level of economic and traffic activities (Tay, 2003a, b, 2005a). Note that a change in the employment rate has two opposing effects. An increase in the employment rate is expected to increase traffic and hence the number of crashes. On the other hand, it also increases income and the demand for safety as well as increasing the revenue available for road maintenance, traffic enforcement, and public education campaigns. Finally, since monthly data are used and Figure 3 shows a strong seasonal effect, monthly dichotomous variables are included to capture any seasonal effects and to minimize potential serial correlation. For convenience, the month of December was set to zero because a reference case has to be chosen to avoid perfect multicollinearity.

Since the number of serious crashes, y, is a count data and likely to have a Poisson distribution (Michener and Tighe, 1992; Nicholson and Wong,

Figure 3
Speeding Tickets per Month



1993; Tay, 2001, 2005b, d), a Poisson regression model is then estimated using the maximum likelihood method

$$P(Y = y) = \frac{e^{-\lambda}\lambda^{y}}{y!} \quad y = 0, 1, 2, 3, \ldots, \tag{1}$$

$$\begin{aligned}\ln(\lambda) = {} & \beta_0 + \beta_1 \text{ OpHrs} + \beta_2 \text{ Tickets} + \beta_3 \text{ Employment} \\ & + \beta_4 \text{ Trend} + \beta_{5-12} \text{ MonthlyDummies},\end{aligned} \tag{2}$$

where λ is the mean of the distribution.

Note that the Poisson regression model is a non-linear model and care should be exercised in interpreting the results, especially the estimates of the coefficients. It can be easily shown that the expected number of injury crashes per month and the marginal effect of any independent variable are given by

$$E(y|x_i) = e^{x\beta}, \tag{3}$$

$$\frac{\partial E(y|x_i)}{\partial x_i} = \lambda\beta_i. \tag{4}$$

3.0 Estimation Results

The estimation results are shown in Table 1. In general, the model fitted the data quite well, with a highly significant chi-square statistic, a high pseudo R-squares, all independent variables except some monthly dummy variables were statistically significant, and the estimated coefficients had the expected signs. There was a negative and significant downward trend as

Table 1
Estimation Results

Number of observations	48	
Log-likelihood	−283.2	
Chi-square	702.56	
Pseudo R-square	0.8062	
Significance level	<0.0001	
Dependent variable	Number of injury	Crashes per month
Independent variables	Coefficients	Std Errors
Constant**	11.8612	0.5336
January*	−0.1239	0.0328
February**	−0.3718	0.0317
March**	−0.1820	0.0313
April**	−0.3546	0.0373
May**	−0.2460	0.0399
June**	−0.1091	0.0439
July	0.0162	0.0560
August	0.0571	0.0518
September*	0.0838	0.0401
October	−0.0027	0.0387
November*	−0.1021	0.0318
Trend**	−0.0072	0.0006
Employment rate**	−0.0730	0.0082
Number of operating hours (1,000 hrs)**	−0.1329	0.0478
Number of violations issued (1,000 tickets)**	−0.0108	0.0038

Note: Statistically significant at: * $\alpha = 0.05$ and ** $\alpha = 0.01$.

well as a negative and significant effect of employment rate on the number of injury crashes per month.[1]

With respect to the policy variables, both the number of operating hours per month and the number of tickets issued were found to have a statistically significant effect in reducing the number of injury crashes per month. However, unlike the OLS regression model, the Poisson regression model is a non-linear model and the coefficient estimates of the enforcement variables are not the marginal effects. The marginal effects of traffic enforcement on the number of injury crashes estimated using equations (3) and (4) were −70.41 crashes per 1,000 hours and −5.73 crashes per 1,000 tickets issued.[2]

To explicitly test the hypothesis that the number of tickets issued has an additional effect on safety over and above the effect of police presence, a

[1] Note that the estimates of the reduced model with only statistically significant variables retained were qualitatively very similar to the full model.

[2] The corresponding estimates for the reduced model were −83.27 crashes per 1,000 hours and −4.13 crashes per 1,000 tickets issued.

restricted model with all the variables except the number of tickets is fitted. The log-likelihood of the restricted model is -287.02. The corresponding chi-square statistic obtained for the change is 7.72, which is significantly greater than the critical value for one degree of freedom, indicating that the number of tickets issued has a significant safety effect above the effect of police presence.

One concern some researchers have about using the Poisson regression model is the possibility of an over-dispersion in the data. Preliminary analysis using the model reported found the over-dispersion coefficient to be very small ($\alpha = 0.005$). Moreover, the estimation results from both models are very similar. For example, the estimated coefficients for number of hours and number of tickets issued are -0.1329 and -0.0108, respectively, for the Poisson model and -0.1442 and -0.0110 for the negative binomial model.

4.0 Discussion and Policy Implications

Road crashes are a major cause of death and serious injuries in many countries including Canada, and speed-related crashes comprise a significant portion of these fatal and serious injury crashes. To reduce the prevalence of speeding on the roads and the resultant road trauma, many jurisdictions in Canada and around the world have implemented some form of speed camera programme. Given that a significant amount of scarce road safety resources is invested annually in these programmes, economic principles require that the effectiveness of the programmes be evaluated to ensure that these resources are used efficiently.

Adding to the existing research, this study found both the number of speed camera operating hours per month and the number of drivers apprehended per month had statistically significant effects in reducing the number of injury crashes per month. These results have several implications for the optimal deployment of traffic enforcement and allocation of scarce resources. First, holding the apprehension rate and other factors constant, an increase in the number of operating hours will result in a significant decrease in the number of injury crashes. Injury crashes can be further reduced by devoting more resources to the current speed camera programme. Second, holding the total number of operating hours and other factors constant, increasing the number of violations issued will also result in a significant decrease in the number of injury crashes. This result suggests that the efficiency of the current programme could be improved by increasing the apprehension rate by better targeting the time and location of the speed camera programme to catch more offenders.

In addition to providing some recommendations to increase the effectiveness and efficiency of the speed camera programme, this study also showed that the number of tickets issued has a significant independent effect in reducing the number of injury crashes above the deterrent effect provided by police presence alone. The speed camera programme is therefore not operated solely to raise revenue as suggested by some advocates. Our study showed that without issuing the citations, the safety effect of the speed camera programme was not maximized. The penalties and fines serve as a very critical component to improve the efficiency of the speed camera programme. It should be noted that the need to issue tickets to maximize safety benefits does not completely nullify the possibility that the cameras may still be operated partly to raise revenue.

In this case study, the speed camera enforcement used is a vehicle-based programme which provides a measure of police presence on the roads. While applicable to most enforcement methods with a police presence, the same methodology cannot be used for other enforcement programmes which do not have a police presence on the roads, such as a fixed camera speed enforcement system or a red light camera programme. The effect of not issuing a ticket in a red light camera system has been examined elsewhere (Tay and de Barros, 2008, 2009).

It should also be noted that the effect of punishment in our model is measured only by the number of tickets issued. In reality, there may be some supplementary effects that are not considered, such as an increase in insurance premium as a result of receiving a speeding ticket. For example, one driver in the United States received a speeding ticket, with a fine of about \$100, but this cost was dwarfed by the effect the citation had on the driver's automobile insurance which increased by about \$200 per year for five years. Given that a large fraction of the cost of getting a ticket is the increased insurance premium, it may be possible that if the police issued tickets with no monetary fine, there may still be a deterrent effect, thus the 'fine' may still mostly be for raising revenue. However, such supplementary effects could not be captured in our model owing to the lack of data.

Nevertheless, if we assume that drivers are sensitive to changes in cost, including both the monetary fines from the tickets and the associated supplementary costs, any increase in total cost is likely to increase the deterrent effect on drivers. Therefore, adding a real monetary fine is likely to increase the deterrent effect and reduce the likelihood of speeding by drivers. If this additional deterrence is significant, then the issuing of a speeding ticket with a monetary fine is not solely for the purpose of raising revenue but serves an important safety function as well. In practice, the significance of the monetary fine is likely to be dependent on the size of the fine relative to the increase in other supplementary costs.

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