



MONASH University
Accident Research Centre

**INDEX TO MEASURE TRAFFIC
ENFORCEMENT EFFECTIVENESS
IN EACH POLICE REGION
OF VICTORIA**

by

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INDEX TO MEASURE TRAFFIC ENFORCEMENT EFFECTIVENESS IN EACH POLICE REGION OF VICTORIA

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Abstract:

The Victoria Police requested MUARC to develop a procedure that would measure traffic enforcement outcome levels against expected levels for each Victoria Police Region. To achieve this objective, relationships were developed that connected monthly casualty crashes in each of the five Police Regions with monthly variations in variables representing exposure, enforcement activity and other factors measured in each Region for the period 1989-1997. These relationships were achieved using structural ('state-space') time-series regression modelling techniques.

The models developed revealed the relative contribution of an increase in each enforcement operation to reducing the risk of casualty crashes in each Region after the effects of exposure changes and other factors had been taken into account. The coefficients (obtained from the regression models in most cases) measured the relative contribution of each enforcement operation, specific to each Region, and formed the basis of an index which allowed the overall contribution to traffic safety produced by the mix of enforcement activities in each Region to be assessed and compared between Regions.

An index for each Region was developed for the months January-December 1998 using the monthly average during 1997 as the base period. There was some variation found in the monthly indices both between and within Regions. When considering the overall index (i.e. for all regions combined – based on the five regions' average), the estimated index has shown that relative to the previous year (1997), the Police performed better than average during the first quarter of 1998, but decreased their performance for the rest of the year.

Although the Police performance, as reflected by the index, was below average for most of 1998, the index should still be considered as a valuable tool for Police. This is because the index specifies which enforcement operations Police should increase their resources in per Region, to reduce the risk of casualty crash in that Region.

The indices developed for each Region during January-December 1998 were tested against actual road safety performance by comparing the observed crash frequencies per month with the expected levels (projected from the estimated models). This testing procedure appeared to work best when Police were performing better than average (as measured by the index), with reductions in casualty crash risk occurring in most cases. This was even more evident when the current month's index was compared with the next month's crash risk outcomes.

Key Words: (IRRD except when marked*)

Enforcement, Police region, casualty crash, structural (state-space) time series model, crash risk

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EXECUTIVE SUMMARY

The Victoria Police requested the Monash University Accident Research Centre (MUARC) to develop a procedure that would measure traffic enforcement outcome levels against expected levels for each Victoria Police Region. This followed a MUARC review of a Police internally developed index that had been established to measure the effectiveness of Police Districts in meeting their road safety objectives.

The purpose of this study was to develop relationships connecting monthly casualty crashes in each of the five Police Regions with monthly variations in variables representing exposure, enforcement activity and other factors measured in each Region.

These relationships were achieved using ‘state-space’ or structural time-series regression modelling techniques. These models are a more flexible family of models than econometric or traditional ‘fixed-effects’ models in that they allow certain parameters to have stochastic (random) variation from one period of observation to the next.

The models developed revealed the relative contribution of an increase in each enforcement operation to reducing the risk of casualty crashes in each Region after the effects of exposure changes and other factors had been taken into account. The coefficients (obtained from the regression models in most cases) measured the relative contribution of each enforcement operation, specific to each Region, and formed the basis of an index which allowed the overall contribution to traffic safety produced by the mix of enforcement activities in each Region to be assessed and compared between Regions.

FORM OF INDEX

The relationship between casualty crashes and explanatory factors during time t was assumed to have the following form:

$$\text{Crashes}_t = a * (\text{exposure factor}_t)^b * (\text{enforcement factors}_t)^c * (\text{other factors affecting risk}_t)^d.$$

However, the only terms in this equation that were relevant to the calculation of the index were the enforcement factors. This is because the other variables or factors represent either the total potential for crashes (i.e. exposure such as population or vehicle travel) or represent the effects of other, non-enforcement factors on risk (i.e. unemployment rate, road safety advertising, alcohol sales) that are beyond the control of traffic police management.

Pragmatically, therefore, the index was expressed as:

$$\text{Index}_t = (\text{random breath tests}_t)^a * (\text{speed camera traffic infringement notices}_t)^b * (\text{penalty notice offences}_t)^c * (\text{mobile radar hours}_t)^d * (\text{laser hours}_t)^e.$$

The parameters relating to random breath tests (RBTs), speed camera traffic infringement notices (TINs) and Penalty Notice offences were found by regression methods (i.e. using 'state-space' modelling techniques) because there was sufficient historical data to allow for this type of estimation. However, the parameters relating to mobile radar and laser hours of operation were estimated from independent evaluation studies since the data for these types of operations covered a period of one year (for laser operations) and under three years (for mobile radar operations).

There was also a need to make the index independent of scale so that Regions could be compared. This involved re-expressing the index in terms of *ratios* of Police activity. The enforcement activity (hours or offences) achieved during a particular month was divided by the monthly average of a base period (e.g. the previous year) so that the indices developed for each Region would be on the same scale and therefore be comparable.

INDEX FOR JANUARY-DECEMBER 1998

An index for each Region was developed for the months January-December 1998 using the monthly average during 1997 as the base period. There was some variation found in the monthly indices both between and within Regions. For example, during January 1998 each Region performed better than what would have been expected on average during 1997, with Region 2 and Region 5 performing best amongst all Regions. However, during April, June, October and December each Region performed below what was expected on average for 1997. For the other months, some regions performed above average in a particular month whilst others performed below average.

When considering the overall index (i.e. for all regions combined – based on the five regions' average), the estimated index has shown that relative to the previous year (1997), the Police performed better than average during the first quarter of 1998, but decreased their performance for the rest of the year.

Although the Police performance, as reflected by the index, was below average for most of 1998, the index should still be considered as a valuable tool for Police. This is because each Region's developed index consists of *negative* parameters relating to all or some of the following enforcement operations – the number of random breath tests, the number of speed camera TINs issued, the number of penalty notice offences issued, the hours of mobile radar operations and the hours of laser operations.

The parameters or coefficients of these operations measured the relative contribution of an increase in each enforcement operation, specific to each Region, to reducing the casualty crash risk per Region. Because the parameters were, in most circumstances, negative, then this suggests that Police should *increase* their operations of that type of enforcement in a particular Region to reduce the risk of casualty crashes. Thus, the value of the index to the Police is that it indicates which enforcement operations Police should increase their resources in per Region to reduce the risk of casualty crash in that Region.

TESTING THE INDEX AGAINST CRASH OUTCOMES

Even though the indices developed for each Region had face value in that they could be assessed and compared, they needed to be tested against actual road safety performance. This was achieved by comparing the observed crash frequencies per month during January-December 1998 with the expected levels (projected from the estimated models).

This testing procedure appeared to work best when Police were performing better than average (as measured by the index), with reductions in casualty crash risk occurring in most cases. This was even more evident when the current month's index was compared with the next month's crash risk outcomes. However, when Police were performing below average, the index did not reflect casualty crash outcomes as well as it did when the performance was above average – both increases and decreases in casualty crash risk occurred.

1. INTRODUCTION

The Victoria Police requested the Monash University Accident Research Centre (MUARC) to carry out a review of an internally developed index which had been established by the Traffic and Operations Support Department to measure the effectiveness of Police Districts in meeting their road safety objectives. The first stage of the project recommended that the objectives of the index should be redefined by senior traffic police and new data used to develop a more suitable procedure. Details of the review and its recommendations can be found in Cameron (1997).

These recommendations led to the second stage of the project aiming to develop an index based on a comparison between actual reported crashes per month and expected trend levels. Such a comparison would be a definitive measure of police traffic enforcement effectiveness.

The objectives of the second stage were:

1. To develop statistical models which will project expected serious casualty crash trends for each Police District using Police crash data for 1990 to 1996.
2. To compare actual reported crashes each month during 1997 with the expected trend levels for one of the Police Districts to demonstrate the procedure. Reductions in crashes below trend would then be considered to be a measure of District traffic enforcement performance.

1.1 ACHIEVEMENTS OF STAGE 2

Two multivariate statistical models, one for the Melbourne Police Districts and one for the rural Victoria Police Districts were developed for the period 1990-1996. These models took into consideration a range of factors that affect trends in serious casualty crashes, such as road safety activities (i.e. enforcement and mass media publicity), unemployment rates, alcohol sales, vehicle kilometres travelled, new probationary car licences issued, and average rainfall and sunshine hours.

Traditional multivariate time series techniques that assumed ‘fixed-effects’¹ were used to estimate these models using the method given in Bowerman & O’Connell (1993).

When the data was available, some of these factors were considered at the District level (e.g. random breath test (RBT) and speed camera operations, and unemployment rates), whereas others were considered at the Victoria-wide or regional level (i.e. Melbourne versus rural Victoria). While the enforcement-related factors were candidates for explaining trends and variations in the number of serious casualty crashes in each District, only in some Districts were these factors statistically significant and hence included in the final models.

¹ ‘Fixed-effects’ modelling techniques assume that the effects of explanatory variables have fixed relations over the time period modelled.

Data on other indicators of traffic enforcement operations apart from RBT and speed cameras (such as mobile radar and laser speed detectors) were either not available or were only available for a short period during 1990-1996, so could not be considered as potential explanatory factors for District crash trends.

The model for Melbourne Police Districts was used to estimate the expected serious casualty crashes in 'E' District (incorporating the Dandenong area) for each month during January-July 1997, as a basis for illustrating a comparison with actual crashes during the same months. Regular crash data had been obtained for 'E' District periodically throughout 1997 for this purpose. The periodic receipt of the data also allowed investigation of the current time delays in the availability of complete crash data in the Police accident report system.

Greater detail of the modelling results and achievements can be found in Diamantopoulou et al (1998a).

1.2 OBJECTIVES

The use of the models to provide a basis for measuring District traffic enforcement performance, as illustrated by the comparison of actual and expected crashes in 'E' District, was considered valuable for police management purposes. However, there was concern regarding the absence of RBT and speed camera activity in terms of representing the monthly variations in crashes in most Districts, and the absence of measures of other traffic enforcement activities from all Districts because of data limitations. Desirably the models of monthly variations in crashes at the District level should include all of the key traffic enforcement activities, as well as other major influential factors.

These reactions and considerations have led to the following proposed revised objectives for the project:

- i. To link road crash trends and variations with traffic enforcement operations and other influential factors for each police District.
- ii. To develop a procedure to measure District traffic enforcement outcome levels against expected levels.

To better facilitate the revised objectives, the following variations to the data and analysis procedures used in Diamantopoulou et al (1998a) were considered.

a) Pooling the Police Districts into 5 regions

The use of 17 Districts resulted in relatively small monthly frequencies of serious casualty crashes in each District and hence a relatively high proportion of unexplainable (chance) variation in their number. The Victoria Police replaced their District structure with five Regions during the first half of 1999. Separate models of monthly crashes were developed for each region. The regions were comprised of the

pooled Police Districts. Greater detail on the composition and definition of the new Regions is given in the next chapter.

b) Considering all reported casualty crashes

While the majority of MUARC modelling in recent years has focused on serious casualty crashes (Newstead et al, 1995 & 1998), earlier research was able to develop successful models of monthly variations in all casualty crashes (Cameron et al, 1992b). Use of this larger set of crashes was expected to reduce the proportion of unexplainable variation in the number of crashes and to increase the power of statistical testing. It would also be preferable to consider a joint estimation of the effects for all Police Regions to increase the power of the statistical testing.

c) Considering RBT and speed camera activity at the regional level

Previous research (Newstead et al, 1995 & 1998), in which crashes have been divided into only two regions of Victoria (i.e. Melbourne and rural Victoria), has found statistically significant links between crashes and the measures of RBT operations (specifically, bus-based tests) and speed camera activity (specifically, speed camera traffic infringement notices (TINs) issued). Models were developed in which the coefficients of these enforcement activities were estimated from data at the regional level (refer Chapter 4).

d) Dividing the crashes into High and Low Alcohol Hours of the week

Previous research also divided the crashes into two periods of the week in which earlier research (Harrison, 1990) had shown to be more or less associated with the involvement of drink-driving in serious crashes². It is likely that the links between RBT operations and speed camera activity will be stronger with the HAH and LAH crashes, respectively. Dividing the crashes into High and Low Alcohol Hours of the week was feasible because a smaller number of Police regions and a larger set of crashes were analysed.

e) Considering additional Police operations and traffic offence data

The analysis in Diamantopoulou et al (1998a) only considered bus-based random breath tests and speed camera TINs as enforcement-related factors that could be potentially linked to crashes in each Police District. The monthly numbers of car-based random breath tests is also likely to be linked to crashes, especially in the rural Districts, however this data had not been made available by the Police since the beginning of 1996 because of doubts about its accuracy. Previous research (Cameron et al, 1993) has suggested that this data could still have explanatory value, even if it is

² High alcohol hours (HAH) of the week are those periods when illegal drink-driving is more likely to occur, and have been based on the definitions of Harrison (1990). The remaining hours of the week are described as low alcohol hours (LAH).

somewhat inaccurate. Other sources of traffic enforcement data that were considered (in addition to car-based RBTs) included:

- (i) **TOG Individual and Group Effectiveness Analysis forms**, which record the number of offences detected (by type) and hours spent on different traffic enforcement activities by the Traffic Operation Group of Victoria Police. MUARC has been provided with this information monthly since May 1995 when mobile radar activity was added to the form. The form also covers laser speed detector activity since January 1997.
- (ii) **Penalty Notice Offence data.** It is understood that this data covers all traffic offences, apart from serious and repeat drink-driving offences. Penalty Notices are prepared by Operations Department Police, who represent about 70% of the Force, whereas the forms described in (i) above are used only by the TOG (7% of the Force, but focused on traffic offences). Thus a more complete coverage of traffic offences detected at the District level may be available.

f) Considering more powerful statistical tools

The analysis in Diamantopoulou et al (1998a) used somewhat traditional multiple regression methods to fit time series models to crash data at the individual District level, or global models at the regional level for a group of Districts. Experience in other countries has suggested that structural time series models could be a powerful approach to this issue (Harvey & Durbin, 1986). Structural time series models (also known as ‘state-space’ models) offer increased power and flexibility in accident modelling so would offer valuable input to the project. The statistical methods that were used in this study are described in greater detail in Chapter 3.

1.3 GENERAL FRAMEWORK FOR THE INDEX

Traffic law enforcement has various ‘inputs’, perhaps best measured in terms of hours spent on various operations, but also measured in terms of numbers of random breath tests achieved because these are not necessarily directly related to hours. ‘Outputs’ can be measured in terms of numbers of offenders detected, which in turn relates to the amount of specific deterrence achieved. The number of potential offenders deterred, which is most strongly related to general deterrence, cannot be measured but perhaps can be represented by qualitative dimensions (e.g. visibility and threat) of operations such as random breath testing.

However, the bottom-line criterion for measuring the effectiveness of traffic law enforcement is the potential savings in road crashes and injuries due to the magnitude and mixture of the various inputs and outputs achieved by the enforcement operations. In this study it is proposed to measure the road safety ‘outcomes’ by the number of reported casualty crashes.

The number of casualty crashes in a month in a given Police Region is a function of a range of different types of factors, as follows:

1. **Exposure:** Factors representing the ‘size’ of the Region in terms of its potential for casualty crash occurrence (e.g. human population, vehicles registered, size of workforce, total distance travelled).
2. **Enforcement activity:** Measures of inputs and outputs for traffic enforcement operations aimed at offences associated with increased crash risk or increased injury severity.
3. **Other factors affecting casualty crash risk:** Variables representing other road safety programs (e.g. intensity of road safety advertising), socio-economic factors (e.g. unemployment rates and alcohol sales per head), weather patterns, other seasonal influences, and a general downward trend due to on-going but gradual improvements in vehicle safety and the road system.

The general aim is to develop relationships connecting monthly casualty crashes in each Region with monthly variations in variables representing the exposure, enforcement activity and other factors measured in each Region. It is expected that the analysis will reveal the relative contribution of an increase in each enforcement operation to reducing the risk of casualty crashes in each Region, after the effects of exposure changes and other factors have been taken into account.

The coefficients measuring the relative contribution of each enforcement operation, specific to each Region, will form the basis of an index which allow the overall contribution to traffic safety produced by the mix of enforcement activities in each Region to be assessed and compared between Regions.

Structural form of relationship

The relationship between casualty crashes and explanatory factors during time t is assumed to have the following form in which exposure can be the region’s population, the amount of vehicle travel or the number of registered vehicles.

$$Crashes_t = a * (exposure\ factor_t)^b * (enforcement\ factors_t)^c * (other\ factors\ affecting\ risk_t)^d$$

For example:

$$Crashes_t = a * (exposure\ factor_t)^b * (RBTs_t)^c * (speed\ camera\ TINS_t)^d * (Penalty\ notice\ offences_t)^e * (mobile\ radar\ hours_t)^f * (laser\ hours_t)^g * (other\ factor_t)^h * \dots * (other\ factor_t)^z$$

The only terms in this equation that are relevant to the calculation of the index are the enforcement factors. This is because the other variables or factors represent either the total potential for crashes (i.e. exposure) or represent the effects of other, non-

enforcement factors on risk (i.e. unemployment rate, road safety advertising, alcohol sales) that are beyond the control of traffic police management.

Pragmatically, therefore, the index can be expressed as:

$$Index_t = (RBTs_t)^a * (speed\ camera\ TINS_t)^b * (Penalty\ notice\ offences_t)^c \\ *(mobile\ radar\ hours_t)^d * (laser\ hours_t)^e.$$

The parameters relating to RBTs, speed camera TINs and Penalty Notice offences will be found by regression methods because there is sufficient historical data to allow for this type of estimation. However, the parameters relating to mobile radar and laser hours of operation will be estimated from independent evaluation studies since the data for these types of operations cover a period of one year (for laser operations) and under three years (for mobile radar operations).

2. DATA DESCRIPTION

2.1 CRASH DATA

Traffic Accident Information System (TAIS) crash data was provided to MUARC by the Traffic and Operations Support Department of the Victoria Police. The TAIS data was derived from Police accident report form 510. The data consisted of Police-reported crashes for 1989 to 1997, and contained the following crash information:

- Accident number of crash
- Police sub-district (This field was used to create a variable denoting the Police region where each crash occurred)
- Date of crash
- Time of day of crash
- Type of crash (e.g. collision with vehicle, struck pedestrian, collision with fixed object, no collision and no object struck, etc.).

In addition, for each person involved in a recorded crash the following information was given:

- Injury level of person [i.e. killed or died within 30 days, injured and admitted to hospital (major injury), other injury requiring medical treatment (serious injury), other injury not requiring medical treatment (minor injury), not injured, etc.]
- Hospital admittance status (i.e. admitted, not admitted, unknown)
- Road user type (e.g. driver, passenger, pedestrian, bicyclist, etc.).

Using the person injury level and their hospital admittance status, a new injury variable was created for each person, in order to be comparable with the corresponding injury level variable (i.e. INJNEW) given in the VicRoads database of Police-reported crashes. The levels of this new variable are fatality, serious injury, other injury or non-injury. Hence, the severity of each crash was re-defined based on the person in that crash with the most severe injury, as given by the new injury level variable.

The focus of the previous analysis was on serious casualty crashes, defined as those resulting in death or serious injury. However, to increase crash numbers and hence statistical power, this study used all reported casualty crashes (i.e. those involving any injury) to model the monthly number of crashes in each region.

Previous studies (Cameron et al, 1992b & 1993) have found an understanding of influential factors affecting all reported casualty crashes during low alcohol hours of the week.

2.2 DEFINITION OF POLICE REGIONS

To proceed with the analysis described in the next chapter it was necessary to pool the 17 existing Police Districts of Victoria into larger regions. The Victoria Police replaced their District structure with five regions in 1999 that were formally defined in March-April. These five regions consist of an inner Melbourne region and four other regions made up of a mix of former metropolitan and rural Districts based on Police resources, population and geographical boundaries.

The current database of crashes defines the crashes at both the District level and the sub-District level. A sub-district is a smaller area of a District named after the Police station located in that sub-district. For example, Police District B is made up of six Police sub-districts (i.e. BEL (Elwood), BPM (Port Melbourne), BPR (Pahran), BSK (St Kilda), BSM (South Melbourne), BSR (St Kilda Road)).

It was found that aggregation of the Police Districts was not sufficient to define the new regions, hence the sub-districts were used because they give finer areas of coverage than the districts. Tables A1 to A5 in Appendix A give the composition of each new region in terms of Police sub-Districts and Districts.

Table 2.1 gives the average number of crashes occurring per month in each new Police region for the period January 1989-December 1997 during high and low alcohol hours of the week.

Table 2.1: Monthly Average Number of Casualty Crashes during HAH and LAH of the week for each Police Region, January 1989 to December 1997

Region	HAH of the week	LAH of the week
Region 1	115	168
Region 2	117	165
Region 3	123	179
Region 4	173	248
Region 5	111	153

2.3 EXPLANATORY DATA

To develop a reliable model to estimate the expected levels of road trauma there is a need to have a good understanding of the ways in which certain factors affect trends in road crashes. These factors may include road safety initiatives, Police enforcement, economic, social and environmental factors. When these factors are taken into account a more reliable model estimating the expected levels of road trauma can be developed. Once an explanatory model has been developed, a comparison of the actual crash levels with the expected levels can be made.

For this analysis, the potential explanatory factors included road safety initiatives such as drink-driving enforcement and speed-related enforcement; the supporting publicity

accompanying each type of enforcement; economic factors; demographic factors; social factors and environmental factors.

2.3.1 Police Traffic Offence and Operations Data

Traffic offence data from various sources for the period January 1989-December 1997 was collected to help provide links with casualty crash trends for each Region. These data sources are described below.

Penalty Notice Offence Data

This data covers all traffic offences, apart from serious and repeat drink-driving offences. Penalty Notices are prepared by Operations Department Police, who represent 70% of the Force. For this study, data from this source has been obtained for the period July 1992 to December 1997.

The penalty notice offence data consists of the date of the offence, the date the penalty notice was issued, the offence code and the suburb/town where the offence occurred. The time of the offence was unavailable in computerised format.

The suburb/town variable was used to determine in which Region each offence occurred.

Over 100 different types of offence codes were recorded. These were grouped under the following broad categories:

- Large vehicle offences
- Speeding offences
- Failing to give way or stop offences
- Failing to keep left and diverging offences
- Overtaking offences
- Incorrect signalling or turning offences
- Headlight offences
- Incorrect safety procedures
- Drink-driving offences (0.01-0.15g/100ml)
- Licensing and registration offences
- Signals offences
- Bicycle offences
- Pedestrian offences
- Miscellaneous offences.

For the modelling of monthly crash numbers, the penalty notice offence data was modelled as both total offences and as the following six separate broad offence types:

- i. Speeding offences
- ii. Unsafe action and headlight offences
- iii. Stop/Give-way offences and signal offences

- iv. Restraint/Helmet offences
- v. Drink-drive offences
- vi. License and registration offences.

However, inconclusive results were obtained when the offences were modelled as separate offence categories.

Traffic Operations Group (TOG) Offence Data

The Traffic Operations Group (TOG) represents about 7% of the Police Force, and focuses mainly on traffic offences. The number of offences detected (by type) and hours spent on different traffic enforcement activities are recorded by the TOG Police on TOG Individual and Group Effectiveness Analysis forms. MUARC has received this data from the Victoria Police for the period April 1990-December 1997 at the District level. The data was grouped into the new Police regions (as defined in section 2.2) using the District variable.

For each Police shift the following information is recorded on the database:

- date of the shift,
- vehicle type used,
- Police station of the officer,
- time of the shift,
- type of offence (denoted by an offence code),
- the number of penalty notices and briefs issued for that offence, and
- the hours spent by the officer on patrol.

Over 40 different offence codes are recorded, with the offences grouped into the following broad categories:

- Alcohol offences
- Speed offences
- Traffic offences
- Behaviour offences
- Vehicle offences
- Mobile radar offences (since May 1995)
- Laser offences (since January 1997)
- Other (e.g. bicycle, parking, drug-driving offences)
- Number of preliminary breath tests (PBTs) given.

The majority of these offences (i.e. alcohol, speed, traffic, behaviour, vehicle) are a sub-set of the Penalty Notice Offence data, so the TOG offences were not modelled together with the Penalty Notice Offences in the analysis.

Speed Camera Data

Data relating to speed camera offences was obtained by MUARC from the Traffic Camera Office of the Victoria Police. This database contains the number of speed-camera Traffic Infringement Notices (TINs) issued per month as well as the monthly number of hours of speed camera operations for the period August 1990-December 1997. This data is available at a Police District level. Using the District field, the speed camera data was grouped into the five new regions for the analysis.

Random Breath Test Data

The monthly number of random breath tests (RBTs) conducted through booze bus operations in Victoria at a District Level was available for the period July 1993-December 1997, whilst the number of car-based RBTs per District was available for the period July 1993-January 1996. Police did not record random breath test data conducted through car-based operations after January 1996. However, as an approximation for the February 1996-December 1997 car-based RBTs, car breath test data (a mix of random and non-random) was used. This data was available at a District level from the TOG offence database.

It should be noted that for the period January 1989-June 1993, random breath test data was available only at the metropolitan and rural level, but both car-based and bus-based RBTs were available per month.

2.3.2 Mass Media Publicity Supporting the Enforcement

In addition to the enforcement data, mass-media publicity that accompanied the enforcement was considered as a potential explanatory factor. The publicity covered a variety of themes, namely speed, drink-driving, fatigue, motorcycle safety, seat belts and concentration. The publicity was quantified in terms of television exposure, measured weekly using Target Audience Ratings Points (TARPs). Weekly TARPs were obtained for the period November 1989- December 1997 for both Melbourne and rural areas of Victoria. The advertising awareness of television viewers was measured by a function of TARPs called “Adstock” (Broadbent, 1979) which represents the audience’s retained awareness of current and past levels of advertising.

Adstock for each region was calculated using weighted Melbourne and rural Victoria estimates of Adstock, i.e. weighted according to the population of each region. Speed-related and drink-drive Adstock for each region were then considered as possible explanatory factors to explain road trauma trends.

It should be noted that the ‘half-life’³ estimates used to calculate the Adstock functions were based on the findings in Shtifelman et al (1998b). For drink-driving Adstock, 4-week and 3-week half-lives were assumed for Melbourne and rural Victoria, respectively. However, for speed-related Adstock, 4-week and 5-week half-lives were assumed for Melbourne and rural Victoria, respectively.

³ ‘Half-life’ is defined as the number of weeks after which only half the audience is aware of the advertising message.

2.3.3 Economic and Social Factors

A variety of other influential factors (apart from enforcement data and supporting publicity) were used to help provide links with casualty crashes. These factors included vehicle kilometres travelled, alcohol sales and labour force data. Most of these factors were not available at a District level – only at a metropolitan/rural level or statewide level.

Vehicle kilometres of travel

Total fuel sales can be used as a proxy for vehicle travel in studies that require some measure of exposure to risk. However this measure does not take into account changing efficiencies in its usage that affects total possible travel from a given quantity of fuel. It would be better to use an absolute measure of total vehicle travel. MUARC developed a method to estimate total vehicle travel in Victoria by combining both monthly fuel sales and travel estimates given by the ABS Surveys of Motor Vehicle Usage (Gantzer et al, 1995). Because total fuel sales are only given at a state level, total vehicle travel estimates used in the modelling analysis were only available for Victoria as a whole, so the same monthly estimates of travel during 1989-1997 were used for each region.

Unemployment rate

A large number of variables exist which may reflect the state of the economy, including real average weekly earnings, unemployment rates, number of persons employed in the work force, building approvals and consumer sentiment index.

Most economic data is provided on an annual or quarterly basis, and either at a national or state level. For this analysis we require economic data to be used at a monthly level, and at a District level if available. It is possible to smooth or interpolate data provided at say a quarterly level into monthly frequencies, however such “smoothing” may result in poor covariates being fitted in a model. For this reason, only the unemployment rate was used as a possible explanatory factor in the model. Previous research (Cameron et al, 1993 and Thoresen et al, 1992) have shown that the unemployment rate is an appropriate indicator to use in seeking relationships with road trauma.

For the period 1989-1997, the monthly unemployment rate (i.e. percentage of the work force unemployed) was classified by statistical local area according to Australian Bureau of Statistics (ABS) definitions. Each Police region was then matched with the ABS statistical local areas to give the categories presented in Table 2.2. The ABS statistical local areas were grouped to correspond with the new regions for the analysis as shown in Table 2.2.

Table 2.2: Comparison of Statistical Local Areas (Australian Bureau of Statistics classifications) with Police Regions

Statistical Local Area (ABS classifications)	Police Region
<ul style="list-style-type: none"> ▪ Inner Western Melbourne ▪ Southern Melbourne 	Region 1
<ul style="list-style-type: none"> ▪ Barwon Western (1992 onwards) ▪ South Western (pre-1992) ▪ Central Highlands (1992 onwards) ▪ North Western (pre-1992) ▪ Outer Western Melbourne 	Region 2
<ul style="list-style-type: none"> ▪ Northern (pre-1992) ▪ Loddon-Campaspe Mallee (1992 onwards) ▪ North Western Melbourne ▪ North Eastern Melbourne 	Region 3
<ul style="list-style-type: none"> ▪ Northern (pre-1992) ▪ Goulburn Ovens Murray (1992 onwards) ▪ Outer Eastern Melbourne ▪ Inner Eastern Melbourne 	Region 4
<ul style="list-style-type: none"> ▪ Mornington Peninsula ▪ Mornington (pre-1992) ▪ South Eastern (1992 onwards) ▪ Eastern (pre-1992) ▪ Gippsland (1992 onwards) 	Region 5

Alcohol sales

Previous research modelling road trauma trends in Victoria has found that the level of alcohol sales in that state has a strong positive relationship with the number of serious casualty crashes occurring during high alcohol hours of the week (Cameron et al, 1993, Thoresen et al, 1992). For this study, the number of alcohol sales was considered to be an important social factor in modelling casualty crashes during high alcohol hours of the week. The measure of alcohol sales used is the monthly value of retail alcohol trade in Victoria in millions of dollars deflated by the tobacco and alcohol component of the Consumer Price Index for the Melbourne capital city area.

Alcohol sales per month were available for the period January 1989-December 1997, but were only available for Victoria as a whole so could not be disaggregated by region.

3. STATISTICAL MODELLING METHODS

3.1 BACKGROUND

Statistical regression analyses used by MUARC in the past have been successful in linking monthly numbers of random breath tests and speed camera TINs with monthly serious casualty crashes in two regions of Victoria (Melbourne and rural Victoria), after first stratifying the crashes by time of week, and including another road safety program (TAC advertising) and two socio-economic factors in the analysis (Cameron et al 1994, Newstead et al 1995, 1998). Thus it is feasible to include a number of traffic enforcement inputs/outputs in the proposed relationships at the Region level, and also include additional enforcement inputs/outputs if more powerful statistical tools are used (refer section 3.3).

A number of studies have found that multiplicative models, rather than additive models, fitted to explanatory variables best represent road trauma trends in Victoria (Cameron et al. 1992a, 1992b, 1993). The method of analysis used has been multivariate log linear regression, and involves relating road safety measures, economic, social and environmental factors, along with general trend and monthly variation to the observed crash series via a regression equation. This technique has proven to be valuable in modelling the effects of road safety programs and other factors on the level of serious casualty crashes in Victoria.

The major reason for using log-linear regression methods is that these methods assume that the probability of a crash under certain joint conditions (say A, B, C, etc.) is equal to the probability of a crash under condition A times the probability of a crash under condition B times the probability of a crash under condition C and so on.

This approach was used for this study. Each variable was transformed into natural logarithms to stabilise the variances of the series around the means, to allow interpretation of parameter estimates as elasticities, and to ensure that the mean number of crashes for each factor predicted from the fitted model will be positive.

For the study, multivariate structural time-series or 'state-space' methods were used to fit models to the data to represent casualty crashes occurring during high and low alcohol times of the week in each Police Region for the period January 1989-December 1997 (described in greater detail in section 3.3).

3.2 STATISTICAL REGRESSION METHODS

A comprehensive review of published studies in English, from 1990 to approximately 1996, covering statistical relationships between road trauma and other factors, was undertaken by Scuffham (1998) as part of his Ph.D. thesis.

Scuffham noted that three types of method had been used for statistical time series analysis:

- Integrated autoregressive moving-average (ARIMA) methods (where any trends over time are accounted for by differencing the series to remove the trend);
- Econometric time-series models (where trends are treated as deterministic; so-called ‘fixed-effects’ models);
- Stochastic trend models (where trends are flexible; the trend effects are modelled as having stochastic variation).

MUARC used the ARIMA method for its evaluation of the crash effects of the RBT ‘booze buses’ and the new speed camera program during their first year of operation in each case during the early 1990’s (Cameron et al 1992a, 1992b). This method was abandoned in favour of the more-flexible econometric time-series analysis methods during the later stages of the same studies. The econometric methods allowed a greater range of ‘other’ influential factors to be taken into account, in addition to the effect of the countermeasure under evaluation.

Later, the econometric methods were further extended to link monthly crash variations with variations in random breath tests and speed camera TINs, as well as other influential factors (Cameron et al, 1994; Newstead et al, 1995 & 1998). While these methods have been successful, they assume that the effects of the enforcement operations and other factors have fixed relations over the time period modelled, which was the seven years 1990-1996 in the most recent analysis (Newstead et al, 1998). Serious doubts about this assumption were expressed in Cameron et al (1999). The stochastic trend models have potentially more flexibility in this regard.

‘State-space’ models including stochastic trend parameters were used for this study and are described in the next section.

3.3 STATE-SPACE MODELS

3.3.1 Definition

Time series models with stochastic trends are a more flexible family of models than econometric or traditional ‘fixed-effects’ models in that they allow certain parameters to have stochastic (random) variation from one period of observation to the next. Stochastic trend models are often defined, using the ‘state-space’ model. The name comes from the representation of the model in ‘state-space’ form, consisting of:

- A *measurement* equation, representing the observed ‘state’ of the dependent variables as a function of the explanatory factors; one part of the explanatory factors being unobserved model components, representing level, trend and seasonality effects in the dependent variable itself; the other part, factors representing interventions and other explanatory variables, and
- *Transition (or state)* equations, representing the model structure, describing the unobserved model components at time t as a function of their values on time $t-1$.

The essential feature of time series models, represented by the transition equation is, that they use the fact that the state of a developing process (in this case the number of crashes) at time t , is (partly) dependent on the state of the process at time $t-1$.

Thus state-space models retain the strength of econometric models in that they allow a wide variety of functional forms and factors to be used to explain variations in road trauma series. They avoid the rigidity of ARIMA models and allow factors other than time to be included as explanatory terms.

3.3.2 Historical Background

State-space models were probably first used in a road safety context by Harvey & Durbin (1986), who used the-then new approach to evaluate the effects of the British seat belt wearing legislation on road casualties. They modelled monthly casualties from 1969 to 1984 using a state equation including level, trend, seasonality and an intervention effect due to the law.

Scuffham (1998) developed state-space models for quarterly variations in fatal crashes and fatal crash rates per kilometre travelled in New Zealand from 1970 to 1994. His models included terms representing level, trend, seasonality, interventions (speed limit increase, oil crises, seat belt law) and a range of socio-economic variables (e.g. unemployment rate, income per capita, beer consumption per capita, and alcohol and petrol tax rates). The most satisfactory models were those obtained for the fatal crash rate series rather than the frequency of fatal crashes.

The Dutch SWOV Institute for Road Safety Research has experimented with the application of state-space models to data on fatalities and hospital admissions (two sources: police reports and hospital records) of car occupants aged 25 to 49 at the quarterly level (Bijleveld & Oppe, 1998). The models appear to be very adaptive to short-term changes in the casualty series and hence appear suitable for short-term forecasting (one to two years). State-space models have the advantage that it is possible to decompose the model into components representing the separate contributions of each term in the model. This attribute is valuable if the models are established for explanatory purposes.

In summary the key features of 'state-space' modelling techniques that make them potentially more powerful for the purpose of developing models of casualty crashes at the Police Region level are:

- (i) The parameters of the 'state-space' models can have stochastic variation that can represent real variation over time. The 'fixed-effects' models used by MUARC to date may suffer by their implicit need to average the estimation of the model parameters over the full period of the data, which has been 1990-1996 in the most recent analysis.
- (ii) The state-space models are capable of representing time-series data, which is also cross-sectional in nature, in one unified model structure. MUARC work to date in general has developed models independently for each crash sub-set (by region, time of week and/or road user group) without capitalising on the

possibility of common relationships with explanatory variables, and the additional statistical power which such a framework may provide. However, it was not possible to consider one unified model structure in this study because of the computer memory limitations of the statistical software STAMP 5.0 used for the modelling procedures. It is hoped that this limitation will be overcome in the near future.

‘State-space’ models (with random effects) are thus considered to produce better estimators of time series data than ‘fixed-effects’ models.

For this evaluation, multivariate ‘state-space’ modelling techniques were used to fit models to the casualty crashes occurring during high and low alcohol times of the week in each Police region. All variables (both crashes and explanatory factors) were transformed into natural logarithms.

3.3.3 Form of a State-Space model

The ‘state-space’ model as applied consists of the following components, which can be used to explain monthly trends in crashes.

- i. Time-dependent components (i.e. a trend component and/or a seasonal component with random variation);
- ii. Explanatory factors (e.g. advertising levels, enforcement variables, socio-economic factors);
- iii. An intervention component where necessary (e.g. an impulse function and/or a step function);
- iv. An error term.

3.3.4 Impulse and Step Functions

State-space modelling techniques allow inferences to be made about known events such as the intervention effect of a road safety policy (Scuffham, 1998). In his thesis, Scuffham said that interventions can have different effects on a time series such as one-off effects (impulse functions) or effects that induce a shift in the level of the series (step-functions). Identification of outliers or structural breaks indicates points where an unobserved or poorly measured factor had an effect on the series being modelled. To estimate the magnitude of the effect, assuming that the effect was caused by a change in Police enforcement, TAC advertising or other road safety policies, an intervention function (as described above) can be used. The definition and interpretation of structural breaks and outliers is detailed below.

3.3.5 Definition of Structural Breaks and Outliers

In ‘state-space’ modelling, structural breaks and outliers are observations that indicate where the predicted monthly number of crashes was substantially different from the observed crashes during that month.

In the road safety field, structural breaks or outliers are usually associated with the introduction of a new road safety law, the introduction or change of an enforcement strategy or the launch of a new advertising campaign. The accurate use of structural breaks and outliers can indicate if the effect of an explanatory factor on road trauma is due to a particular introduction or merely to the monthly fluctuation of that factor.

Observations such as structural breaks indicate whether there has been an increase or a decrease in the average number of crashes to a new semi-permanent level (i.e. until another unobserved factor causes a further shift in the crash average). To account for a structural break, a *step function* should be included in the model.

Observations such as outliers indicate whether there has been an increase or a decrease in crashes during a single month. Generally, the level of crashes reverts back to the previous month's level. To account for an outlier, an *impulse function* should be included in the model.

Structural breaks and outliers should be taken into consideration only if they can be explained. Observations that cannot be explained should remain in the model as part of the unexplained variation (or randomness). If structural breaks or outliers that *can be* explained are not taken into consideration, then the underlying statistical assumptions of the model may be violated or the parameter estimates may be biased. The effects of structural breaks or outliers may also confound the effects of explanatory factors; thus if structural breaks or outliers are taken into consideration, different results may be obtained.

If the inclusion of a step or an impulse function does not improve the fit of the model, or if any of the model's underlying statistical assumptions have been violated, then these structural breaks and outliers should remain in the model as part of the unexplained variation or randomness.

The modelling results presented in Chapter 4 have taken into account impulse and step functions, where appropriate. Unusual monthly observations that cannot be explained remain in the model as part of the unexplained variation or randomness.

3.3.6 The Amount of Explainable Variation of a State-Space Model

The amount of explainable variation (or R^2) achieved by 'state-space' models cannot be directly compared to the amount of explainable variation produced by traditional linear regression techniques (Shtifelman et al, 1998a). By its nature, 'state-space' modelling allows for stochastic (random) variation in both the trend and seasonal components of the model. This will result in a much better fit on the observations modelled. However, the uncertainty about the forecast is comparable to 'fixed-effect' models because within the model, random effects are also possible in the future but at unpredictable moments.

In addition, the model can include an intervention component to account for structural breaks and outliers. Inclusion of these components can achieve a statistically reliable model with strong explanatory and predictive power as well as minimal error. Also in this case it will be difficult to forecast new structural breaks or outliers, however, it

would be expected that a 'state-space' model would yield higher explanatory power than a traditional regression model because the inclusion of the extra components making up the 'state-space' model gives better estimates of the effects of those factors that can be foreseen.

'State-space' modelling techniques also allow for the checking of the 'fit' of the model each time a new explanatory factor is added to the model. Nevertheless, a certain degree of over-fitting may still occur because of the large number of explanatory factors that are included in the model to adequately describe the observed series of crashes.

As an example for this evaluation, during low alcohol times of the week in Region 1, there was on average 168 Police-reported casualty crashes per month. In addition, the average annual growth rate in vehicle kilometres travelled for Victoria during January 1989 to December 1997 was estimated to be 2%.

For the length of the series (i.e. 108 months), the proportion of explainable variation in road trauma trends should vary between 15% and 40% using traditional linear regression techniques (Shtifelman et al, 1998a), assuming an average of 168 crashes per month and an average growth rate in vehicle kilometres travelled of 2%. Using the same assumptions, the proportion of explainable variation achieved by 'state-space' modelling would be expected to be greater than 40%. However, current research has yet to identify the theoretical proportion of explainable variation achieved by state-space modelling techniques.

The detailed results obtained when 'state-space' modelling techniques were applied are given in Appendix B and summarised in Chapter 4.

4. MODELLING RESULTS

For each Police region two ‘state-space’ models were fitted to the data. The first model considered monthly casualty crashes that occurred during High Alcohol Hours (HAH) of the week, and the second model considered crashes that occurred during Low Alcohol Hours (LAH) of the week.

The explanatory factors included in each model for each Region were:

- Monthly number of random breath tests (RBTs) – conducted through both patrol car and Booze bus operations.
- Monthly number of speed camera Traffic Infringement Notices (TINs)
- Monthly number of Penalty Notice offences⁴
- Speed-related advertising awareness per month (measured by Adstock)
- Drink-driving⁵ advertising awareness per month (measured by Adstock)
- Monthly unemployment rate
- Monthly alcohol sales in Victoria
- Monthly vehicle kilometres of travel in Victoria.

The following ‘lagged’ variables were also included in the models to correct for possible auto-correlation in the residual observations.

- The previous month’s number of RBTs (car and bus), i.e. RBTs ‘lagged’ by one month;
- The previous month’s number of speed-camera TINs, i.e. speed camera TINs ‘lagged’ by one month;
- The previous month’s unemployment rate, i.e. the unemployment rate ‘lagged’ by one month.

The general aim was to develop relationships connecting monthly casualty crashes in each region with monthly variations in variables representing the exposure, enforcement activity and other factors measured in each region. It was expected that the estimated models would reveal the relative contribution of an increase in each enforcement operation to reducing the risk of casualty crashes, after the effects of exposure changes and other factors had been taken into account.

In addition to the ‘state-space’ modelling results, the observed monthly number of casualty crashes occurring during high and low alcohol times of the week for the period January 1989-December 1997 are also depicted graphically for each Police Region in the following sections of this report.

⁴ Penalty Notice Offences consist of ‘speeding’ offences, ‘unsafe action’ offences, ‘headlight’ offences, ‘failing to stop or give-way offences’, ‘signal offences’, ‘restraint/helmet’ offences, ‘drink-drive’ offences and ‘licence/registration’ offences.

⁵ Drink-driving Adstock was considered to be relevant only during high alcohol times of the week. Hence it was only included as a potential explanatory factor in the HAH crash models.

4.1 REGION 1

4.1.1 Observed Monthly Crash Trends

Figures 4.1 and 4.2 display the monthly number of casualty crashes that occurred in Region 1 during January 1989-December 1997 for HAH and LAH of the week, respectively.

There has been a downward trend in crashes during January 1989-January 1993 for both HAH and LAH casualty crashes for Region 1 (Figures 4.1 and 4.2). However, there was a slight upward trend in crashes after January 1993. In addition, the monthly number of crashes was generally fewer during the HAH of the week.

Figure 4.1: Monthly casualty crashes during HAH of the week in REGION 1, January 1989-December 1997

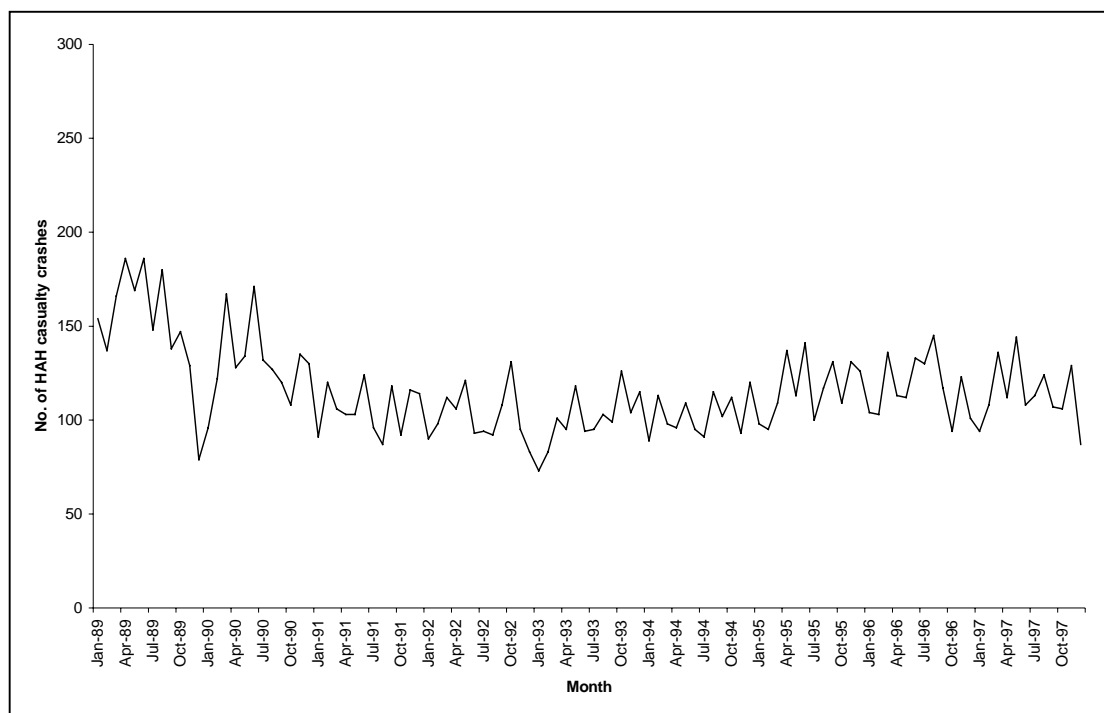
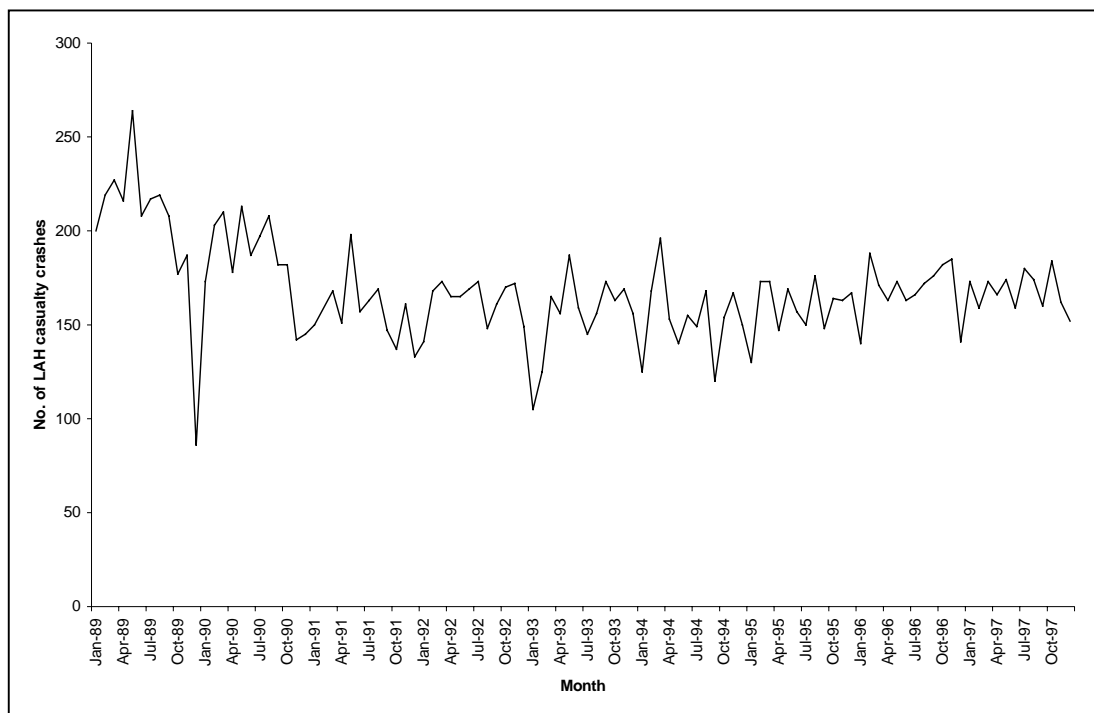


Figure 4.2: Monthly casualty crashes during LAH of the week in REGION 1, January 1989-December 1997



4.1.2 Explanatory Factors Affecting Crashes

Table 4.1 displays the explanatory factors affecting casualty crashes during high alcohol hours (HAH) and low alcohol hours (LAH) of the week in Region 1, together with the estimated coefficient of the factor and corresponding 80% confidence limits for this estimate. The confidence interval gives the range of values in which the true value of the parameter estimate lies with 80% certainty.

More detailed results depicting significant impulse and step functions can be found in Appendix B (Tables B1 and B2).

Amongst the Police enforcement variables, increases in the monthly number of speed camera traffic infringement notices (TINs) and increases in the monthly number of penalty notice offences issued were both associated with decreases in HAH casualty crashes in Region 1.

Similarly during LAH of the week, increases in the monthly number of random breath tests and increases in the previous month's speed camera TINs were associated with casualty crash reductions in Region 1. However, increases in the monthly number of speed camera TINs were not associated with crash reductions for this region. Interpretation of the parameter estimates (particularly those with positive signs)

should be made with caution, since the positive coefficient may be a result of collinearity⁶ between two or more explanatory variables.

Table 4.1: Effects of enforcement, associated publicity and socio-economic factors on HAH and LAH casualty crashes in Police REGION 1: January 1989-December 1997

REGION 1 Explanatory Factor	Estimated coefficient of logged factor	80% confidence limit	Significance level (two-sided)
HAH Crashes (R² : 59%)⁷			
▪ Speed camera TINs	-0.03046	(-0.05094, -0.00998)	0.0596
▪ Penalty Notice offences	-0.02440	(-0.04104, -0.00776)	0.0632
▪ Speed-related Adstock	-0.03826	(-0.06198, -0.01454)	0.0414
▪ Alcohol sales	-0.62989	(-1.08286, -0.17692)	0.0778
▪ Previous month's unemployment rate	-0.23839	(-0.40524, -0.07154)	0.0701
LAH Crashes (R² : 54%)			
▪ RBTs (car & bus)	-0.19104	(-0.26802, -0.11406)	0.0020
▪ Speed camera TINs	0.02083	(0.00372, 0.03794)	0.1220
▪ Previous month's speed camera TINs	-0.02244	(-0.04012, -0.00476)	0.1071
▪ Speed-related Adstock	0.01983	(0.00866, 0.03100)	0.0252
▪ Unemployment rate	-0.21623	(-0.36975, -0.06271)	0.0742
▪ Previous month's unemployment rate	0.22001	(0.07050, 0.36952)	0.0624

4.2 REGION 2

4.2.1 Observed Monthly Crash Trends

Figures 4.3 and 4.4 display the monthly number of casualty crashes that occurred in Region 2 during January 1989-December 1997 for HAH and LAH of the week, respectively.

For Region 2 there has been a steady decrease in the monthly number of HAH casualty crashes during January 1989-October 1992, whereas after October 1992 the crash trends have remained relatively stable (Figure 4.3). This trend was also evident for LAH casualty crashes (Figure 4.4).

⁶ A potential problem that may arise in the 'fixed-effects' as well as in the 'state-space' modelling process is linear dependency (collinearity) between pairs or groups of explanatory variables. This problem occurs when the variation patterns between factors are similar during the evaluation period. The linear dependency amongst predictors may affect the precision of the estimated coefficients in the model. Thus, it may be difficult to interpret the parameter estimates of variables that are collinear.

⁷ R² denotes the explanatory power of the fitted model, i.e. the percentage of variation that has been accounted for by the model.

Figure 4.3: Monthly casualty crashes during HAH of the week in REGION 2, January 1989-December 1997

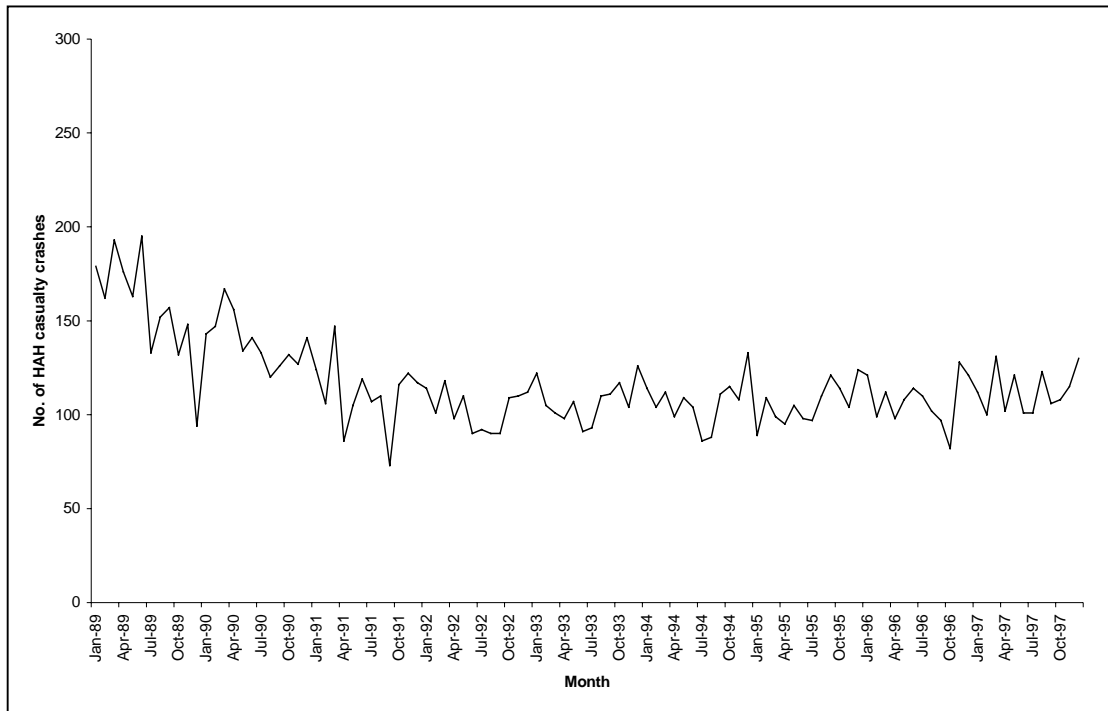
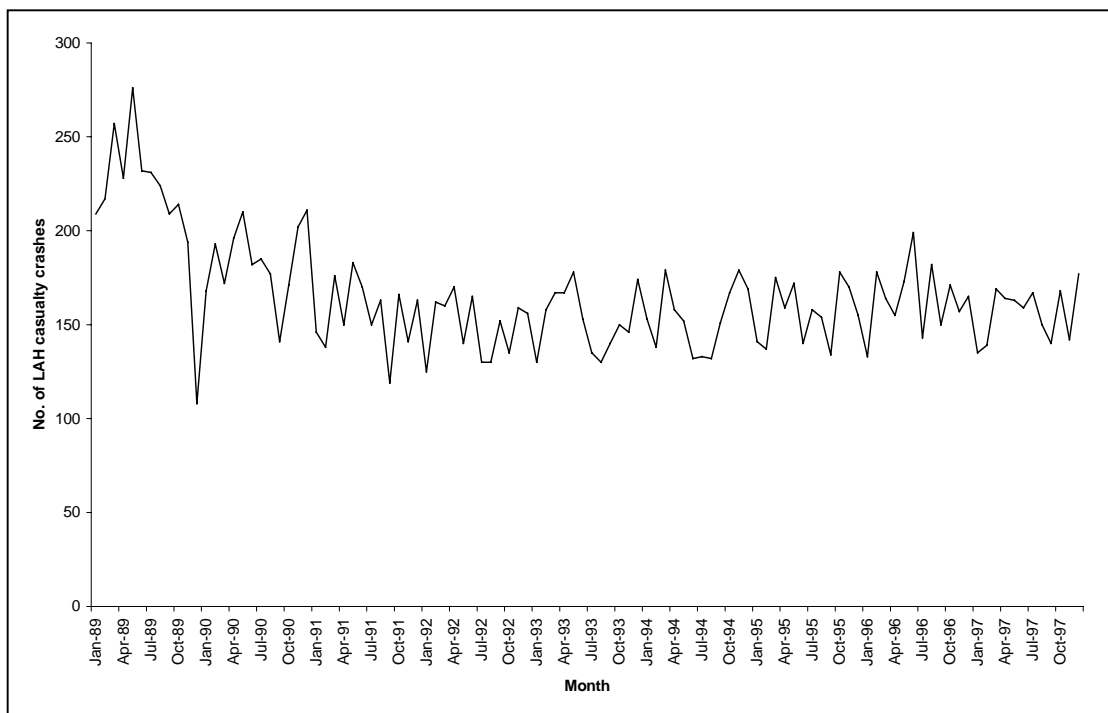


Figure 4.4: Monthly casualty crashes during LAH of the week in REGION 2, January 1989-December 1997



4.2.2 Explanatory Factors Affecting Crashes

Table 4.2 displays the explanatory factors affecting casualty crashes during high alcohol hours (HAH) and low alcohol hours (LAH) of the week in Region 2, together with the estimated coefficient of the factor and corresponding 80% confidence limits for this estimate. The confidence interval gives the range of values in which the true value of the parameter estimate lies with 80% certainty.

More detailed results depicting significant impulse and step functions can be found in Appendix B (Tables B3 and B4).

For Region 2, increases in the monthly levels of speed camera TINs, the monthly number of random breath tests and the monthly number of penalty notice offences issued were associated with reductions in casualty crashes during high alcohol times of the week for the period January 1989-December 1997. Similarly during low alcohol times of the week, increases in both the monthly number of RBTs and in the monthly number of speed camera TINs were associated with casualty crash reductions. An increase in the previous month's number of RBTs was also associated with a crash reduction for region 2.

Table 4.2: Effects of enforcement, associated publicity and socio-economic factors on HAH and LAH casualty crashes in Police REGION 2: January 1989-December 1997

REGION 2 Explanatory Factor	Estimated coefficient of logged factor	80% confidence limit	Significance level (two-sided)
HAH Crashes (R² : 53%)			
▪ Speed camera TINs	-0.03622	(-0.06393, -0.00851)	0.0973
▪ RBTs (car and bus)	-0.14959	(-0.24622, -0.05296)	0.0503
▪ Penalty Notice offences	-0.01509	(-0.02872, -0.00146)	0.1592
LAH Crashes (R² : 70%)			
▪ RBTs (car & bus)	-0.09584	(-0.16419, -0.02749)	0.0756
▪ Previous month's RBTs	-0.08938	(-0.15322, -0.02554)	0.0760
▪ Speed camera TINs	-0.02848	(-0.04868, -0.00828)	0.0741
▪ Vehicle kilometres travelled	0.67421	(0.21518, 1.13324)	0.0629
▪ Previous month's unemployment rate	0.19298	(0.02783, 0.35813)	0.1376

4.3 REGION 3

4.3.1 Observed Monthly Crash Trends

Figures 4.5 and 4.6 display the monthly number of casualty crashes that occurred in Region 3 during January 1989-December 1997 for HAH and LAH of the week, respectively.

Figure 4.5: Monthly casualty crashes during HAH of the week in REGION 3, January 1989-December 1997

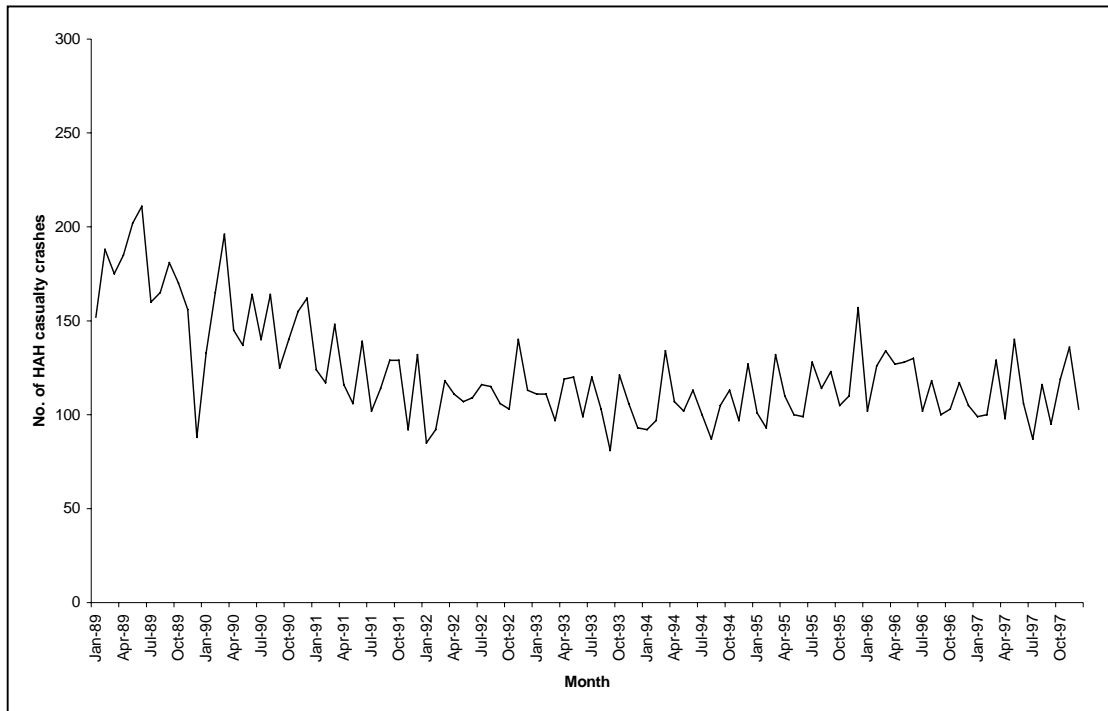
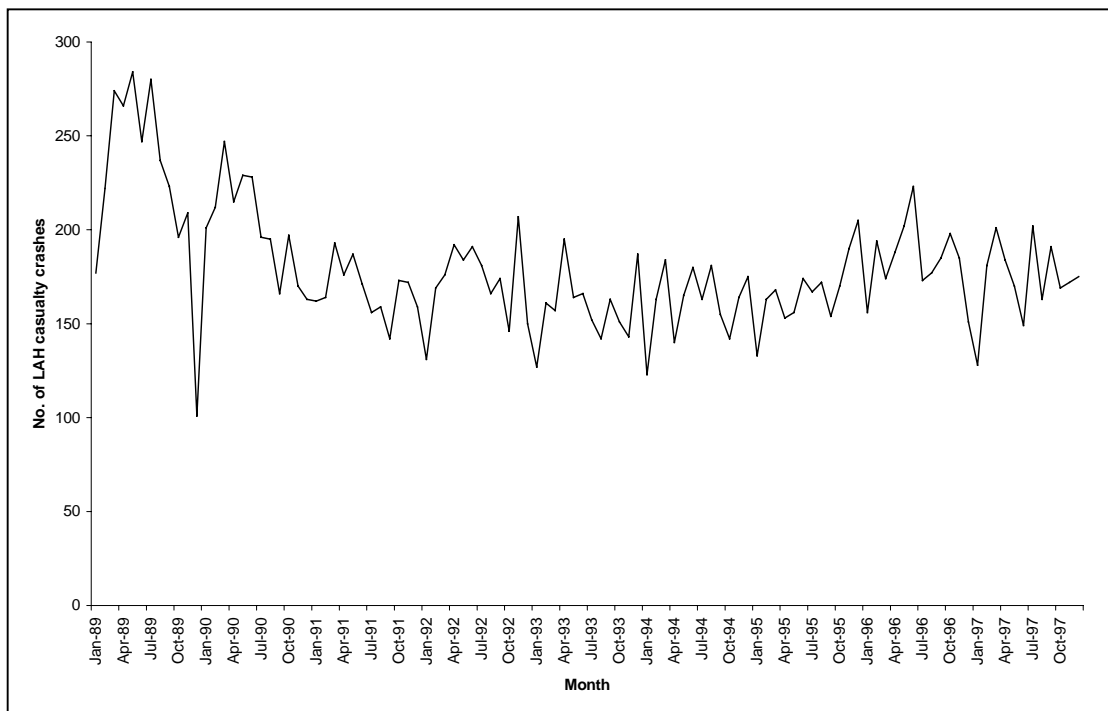


Figure 4.6: Monthly casualty crashes during LAH of the week in REGION 3, January 1989-December 1997



There has been a steady reduction in the monthly number of HAH casualty crashes during January 1989-October 1993, with a slight increase after October 1993 for Region 3. A similar pattern was observed for LAH casualty crashes.

4.3.2 Explanatory Factors Affecting Crashes

Table 4.3 displays the explanatory factors affecting casualty crashes during high alcohol hours (HAH) and low alcohol hours (LAH) of the week in Region 3, together with the estimated coefficient of the factor and corresponding 80% confidence limits for this estimate. The confidence interval gives the range of values in which the true value of the parameter estimate lies with 80% certainty.

More detailed results depicting significant impulse and step functions can be found in Appendix B (Tables B5 and B6).

Table 4.3: Effects of enforcement, associated publicity and socio-economic factors on HAH and LAH casualty crashes in Police REGION 3: January 1989-December 1997

REGION 3 Explanatory Factor	Estimated coefficient of logged factor	80% confidence limit	Significance level (two-sided)
HAH Crashes (R^2 : 55%)			
▪ Previous month's RBTs (car and bus)	-0.12957	(-0.24184, -0.01730)	0.1425
▪ Drink-driving Adstock	-0.02804	(-0.04900, -0.00710)	0.0899
▪ Unemployment rate	-0.36232	(-0.61668, -0.10796)	0.0712
LAH Crashes (R^2 : 67%)			
▪ Speed camera TINs	-0.01948	(-0.03684, -0.00212)	0.1536
▪ Vehicle kilometres of travel	0.63249	(0.12120, 1.14378)	0.1162

In Region 3 during January 1989-December 1997, an increase in the previous month's number of RBTs was associated with a decrease in casualty crashes for high alcohol times of the week, whilst an increase in the monthly number of speed camera TINs was associated with a decrease in LAH casualty crashes.

4.4 REGION 4

4.4.1 Observed Monthly Crash Trends

Figures 4.7 and 4.8 display the monthly number of casualty crashes that occurred in Region 4 during January 1989-December 1997 for HAH and LAH of the week, respectively.

For Region 4, a steady decrease in HAH casualty crashes occurred during January 1989-April 1992, however after April 1992 the monthly crash trends remained fairly stable (Figure 4.7). For LAH casualty crashes, a general downward trend occurred during January 1989-January 1993 (Figure 4.8).

Figure 4.7: Monthly casualty crashes during HAH of the week in REGION 4, January 1989-December 1997

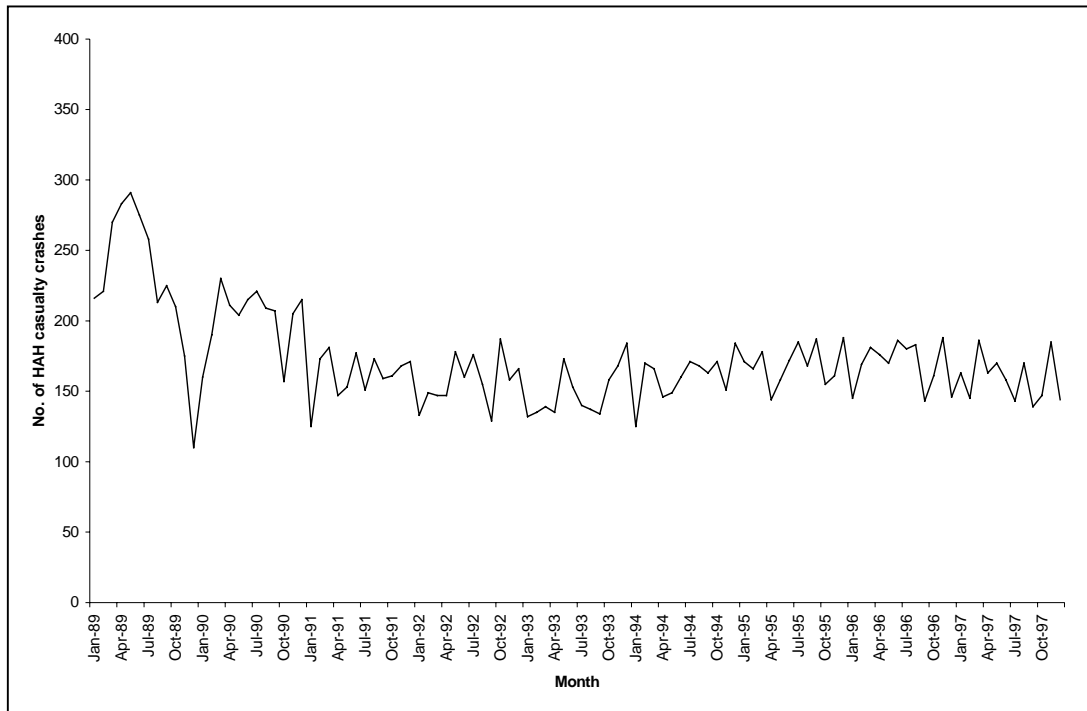
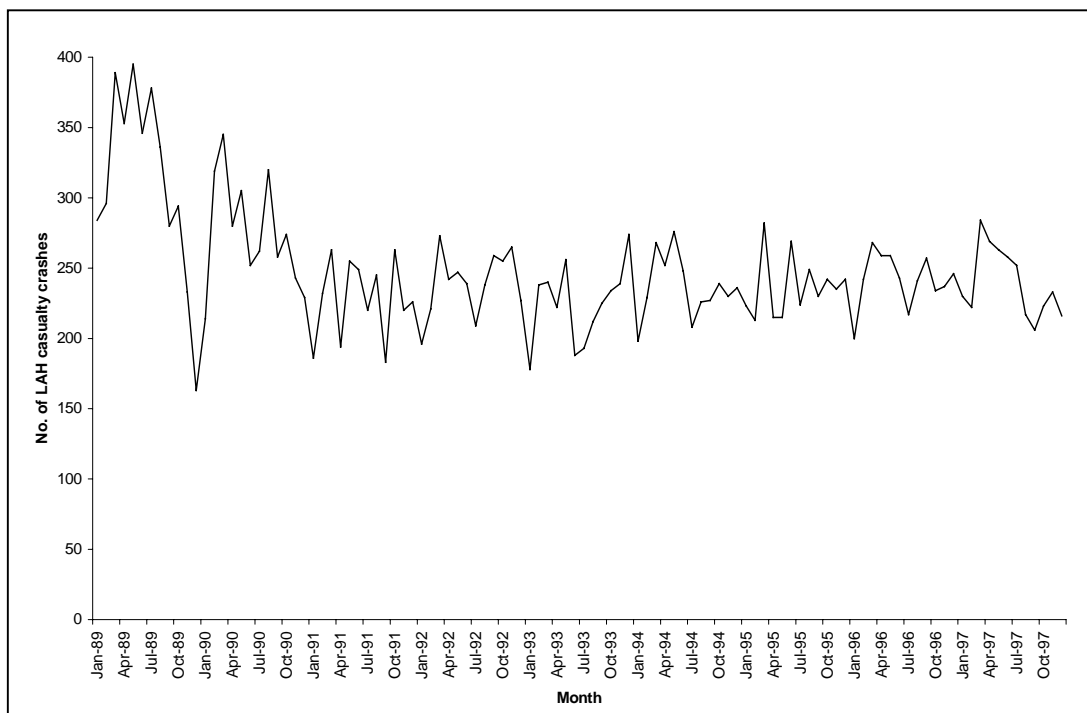


Figure 4.8: Monthly casualty crashes during LAH of the week in REGION 4, January 1989-December 1997



4.4.2 Explanatory Factors Affecting Crashes

Table 4.4 displays the explanatory factors affecting casualty crashes during high alcohol hours (HAH) and low alcohol hours (LAH) of the week in Region 4, together with the estimated coefficient of the factor and corresponding 80% confidence limits for this estimate. The confidence interval gives the range of values in which the true value of the parameter estimate lies with 80% certainty.

More detailed results depicting significant impulse and step functions can be found in Appendix B (Tables B7 and B8).

For Region 4 an increase in the previous month's number of RBTs was associated with a decrease in casualty crashes during high alcohol times of the week. However, during low alcohol times of the week, both the current month's number of RBTs and the previous month's number of RBTs were associated with crash reductions in Region 4.

Table 4.4: Effects of enforcement, associated publicity and socio-economic factors on HAH and LAH casualty crashes in Police REGION 4: January 1989-December 1997

REGION 4 Explanatory Factor	Estimated coefficient of logged factor	80% confidence limit	Significance level (two-sided)
HAH Crashes (R² : 62%)			
▪ Previous month's RBTs (car and bus)	-0.10130	(-0.19157, -0.01103)	0.1538
▪ Drink-driving Adstock	-0.02163	(-0.03716, -0.00610)	0.0777
▪ Alcohol sales	0.54104	(-0.58946, -0.15235)	0.1307
▪ Previous month's unemployment rate	-0.37090	(0.08644, 0.99564)	0.0323
LAH Crashes (R² : 62%)			
▪ RBTs (car and bus)	-0.14626	(-0.22047, -0.07205)	0.0132
▪ Previous month's RBTs (car and bus)	-0.15376	(-0.22953, -0.07799)	0.0108
▪ Unemployment rate	0.18974	(0.02420, 0.35539)	0.1452
▪ Vehicle kilometres of travel	0.54142	(0.05656, 1.02629)	0.1557

4.5 REGION 5

4.5.1 Observed Monthly Crash Trends

Figures 4.9 and 4.10 display the monthly number of casualty crashes that occurred in Region 5 during January 1989-December 1997 for HAH and LAH of the week, respectively.

For Region 5 there has been a steady reduction in both HAH and LAH monthly crashes during January 1989-October 1993. After October 1993 there was evidence of an increase in crashes until December 1997.

Figure 4.9: Monthly casualty crashes during HAH of the week in REGION 5, January 1989-December 1997

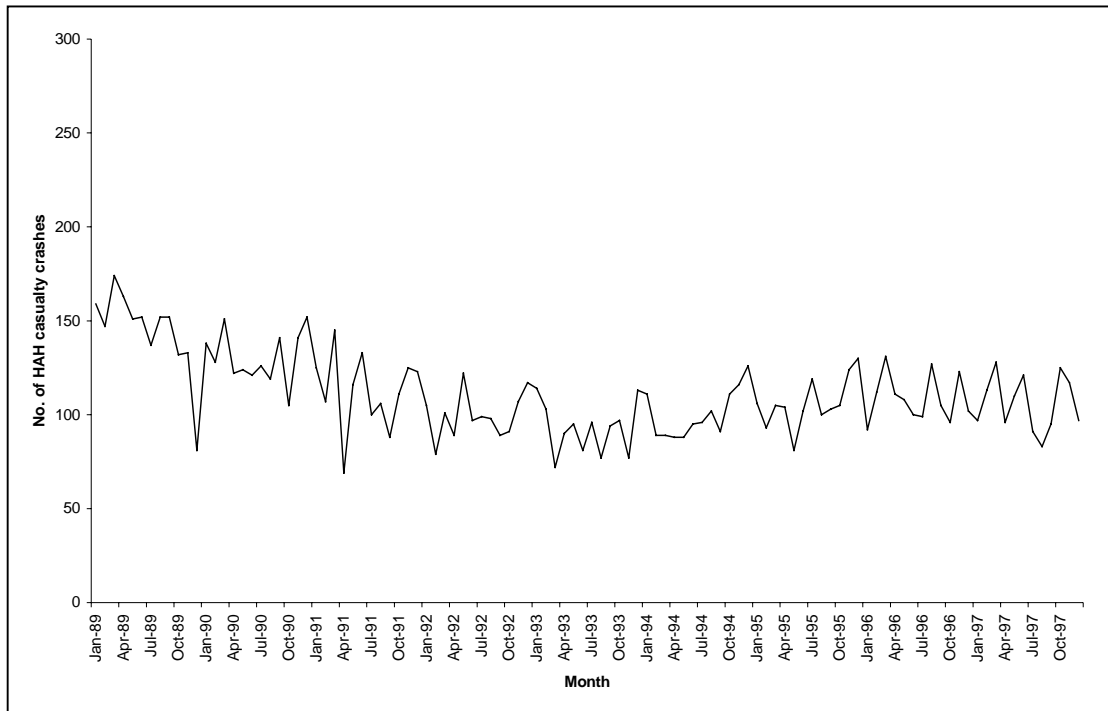
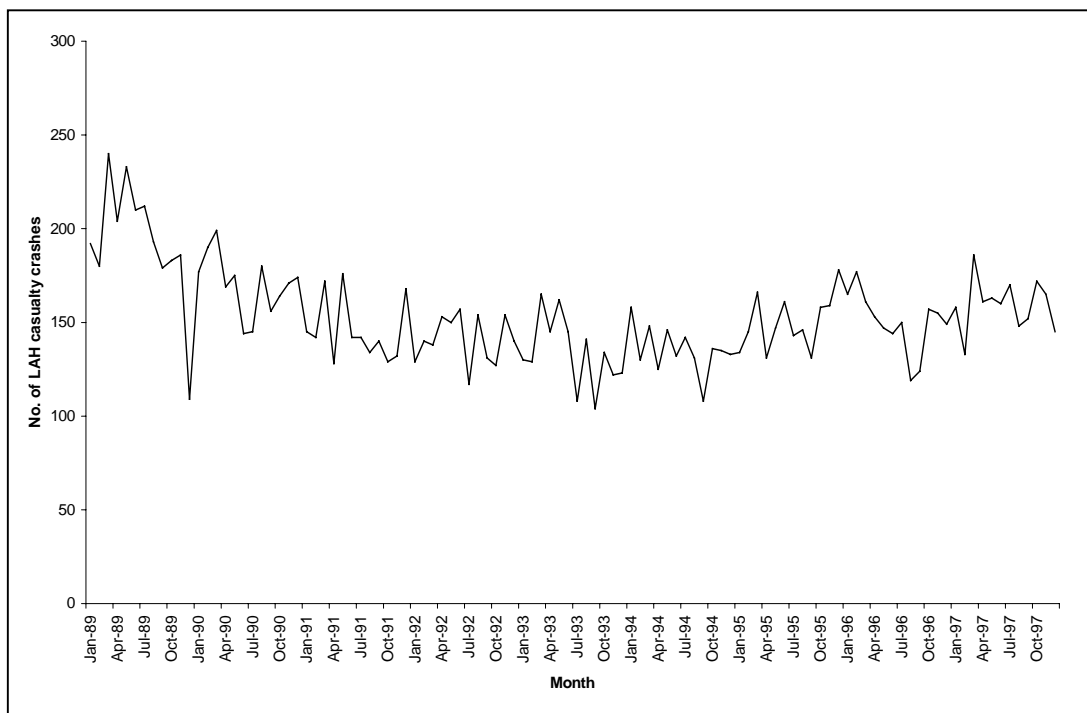


Figure 4.10: Monthly casualty crashes during LAH of the week in REGION 5, January 1989-December 1997



4.5.2 Explanatory Factors Affecting Crashes

Table 4.5 displays the explanatory factors affecting casualty crashes during high alcohol hours (HAH) and low alcohol hours (LAH) of the week in Region 5, together with the estimated coefficient of the factor and corresponding 80% confidence limits for this estimate. The confidence interval gives the range of values in which the true value of the parameter estimate lies with 80% certainty.

More detailed results depicting significant impulse and step functions can be found in Appendix B (Tables B9 and B10).

Table 4.5: Effects of enforcement, associated publicity and socio-economic factors on HAH and LAH casualty crashes in Police REGION 5: January 1989-December 1997

REGION 5 Explanatory Factor	Estimated coefficient of logged factor	80% confidence limit	Significance level (two-sided)
HAH Crashes (R² : 45%)			
▪ Speed camera TINs	-0.12966	(-0.18822, -0.07110)	0.0056
▪ Previous month's speed camera TINs	0.14672	(0.08593, 0.20751)	0.0026
▪ RBTs (car and bus)	-0.15199	(-0.26554, -0.03844)	0.0895
▪ Previous month's RBTs (car and bus)	-0.12918	(-0.23072, -0.02764)	0.1063
▪ Drink-driving Adstock	-0.02684	(-0.04565, -0.00803)	0.0706
▪ Speed-related Adstock	0.02396	(0.00486, 0.04307)	0.1112
LAH Crashes (R² : 62%)			
▪ Speed camera TINs	0.02639	(0.00912, 0.04367)	0.0531
▪ RBTs (car and bus)	-0.13136	(-0.20466, -0.05806)	0.0238

In Region 5, increases in the monthly number of speed camera TINs and in the monthly number of RBTs were associated with reductions in crashes occurring during high alcohol times of the week. An increase in the previous month's number of RBTs was also associated with a decrease in HAH casualty crashes, but an increase in the previous month's number of speed camera TINs was *not* associated with a crash reduction.

During low alcohol times of the week in Region 5, an increase in the monthly number of RBTs was associated with a decrease in the number of casualty crashes. However, there was no evidence that an increase in the monthly number of speed camera TINs was associated with a decrease in LAH casualty crashes.

The parameters of the enforcement variables that were associated with crash reductions (as shown in Tables 4.1 to 4.5), will be used to develop an index to monitor traffic enforcement outcome levels for each Police Region in the next chapter.

5. ESTIMATION OF INDICES

As discussed in section 1.3, the general aim was to develop relationships connecting monthly casualty crashes in each Region with monthly variations in variables representing the exposure, enforcement activity and other factors measured in each Region. The analysis gives the relative contribution of an increase in each enforcement operation to reducing the risk of casualty crashes in each Region, after the effects of exposure changes and other factors have been taken into account.

The coefficients measuring the relative contribution of each enforcement operation, specific to each Region, formed the basis of an index which allow the overall contribution to traffic safety produced by the mix of enforcement activities in each Region to be assessed and compared between Regions.

5.1 FORM OF THE INDEX

5.1.1 Structural Form of Relationship

The relationship between casualty crashes and explanatory factors during time t was assumed to have the following form.

$$\begin{aligned} Crashes_t = & a*(exposure\ factor_t)^b \\ & *(RBTs_t)^c *(speed\ camera\ TINS_t)^d *(Penalty\ notice\ offences_t)^e \\ & *(mobile\ radar\ hours_t)^f *(laser\ hours_t)^g \\ & *(other\ factor_t)^h *..... *(other\ factor_t)^z. \end{aligned}$$

The only terms in this equation that were relevant to the calculation of the index were the enforcement factors. This is because the other variables or factors represent either the total potential for crashes (i.e. exposure such as population size or vehicle travel) or represent the effects of other, non-enforcement factors on risk (i.e. unemployment rate, road safety advertising, alcohol sales) that are beyond the control of traffic police management.

Pragmatically, therefore, the index can be expressed as:

$$\begin{aligned} Index_t = & (RBTs_t)^a *(speed\ camera\ TINS_t)^b *(Penalty\ notice\ offences_t)^c \\ & *(mobile\ radar\ hours_t)^d *(laser\ hours_t)^e. \end{aligned}$$

The parameters relating to RBTs, speed camera TINs and Penalty Notice offences were determined by the regression modelling methods given in Chapter 4 because there was sufficient historical data to allow for this type of estimation. However, the parameters relating to mobile radar and laser hours of operation were estimated from independent evaluation studies since the data for these types of operations covered a period of one year only (for laser operations) and a period of less than three years (for mobile radar operations).

There was also a need to make the index independent of scale so that Regions could be compared. This involved re-expressing the index in terms of *ratios* of Police activity. The enforcement activity (hours or offences) achieved during a particular month was divided by the monthly average of a base period (e.g. the previous year) so that the indices developed for each region would be on the same scale and therefore be comparable.

Thus the index for each Region r had the following form:

$$Index_{r,t} = \left(\frac{RBTests_{r,t}}{RBTests_{r,0}} \right)^a * \left(\frac{SCTins_{r,t}}{SCTins_{r,0}} \right)^b * \left(\frac{PNOffences_{r,t}}{PNOffences_{r,0}} \right)^c * \left(\frac{MMRhrs_{r,t}}{MMRhrs_{r,0}} \right)^d \\ * \left(\frac{LASERhrs_{r,t}}{LASERhrs_{r,0}} \right)^e * \left(\frac{RBTests_{r,t-1}}{RBTests_{r,0}} \right)^f * \left(\frac{SCTins_{r,t-1}}{SCTins_{r,0}} \right)^g$$

Where

- $Index_{r,t}$ refers to the value of the index for Region r during month t
- $RBTests_{r,t}$ gives the observed number of random breath tests achieved in Region r during month t
- $RBTests_{r,0}$ gives the observed number of random breath tests achieved in Region r per month on average during a base period (taken as the year 1997 in the worked examples in section 5.2)
- $SCTins_{r,t}$ gives the observed number of speed camera traffic infringement notices issued in Region r during month t
- $SCTins_{r,0}$ gives the observed number of speed camera traffic infringement notices issued in Region r per month on average during a base period
- $PNOffences_{r,t}$ gives the observed number of Penalty Notice Offences issued in Region r during month t
- $PNOffences_{r,0}$ gives the observed number of Penalty Notice Offences issued in Region r per month on average during a base period.
- $MMRhrs_{r,t}$ gives the observed number of hours of mobile radar (MMR) operations achieved in Region r during month t
- $MMRhrs_{r,0}$ gives the observed number of hours of mobile radar (MMR) operations achieved in Region r per month on average during a base period
- $LASERhrs_{r,t}$ gives the observed number of hours of laser operations achieved in Region r during month t

- $LASERhrs_{r,0}$ gives the observed number of hours of laser operations achieved in Region r per month on average during a base period
- $RBTests_{r,t-1}$ gives the observed number of random breath tests achieved in Region r during the previous month $t-1$
- $SCTins_{r,t-1}$ gives the observed number of speed camera traffic infringement notices issued in Region r during the previous month $t-1$.

5.1.2 Parameters estimated from state-space models

The parameters a , b , c , d , e , f , and g in the above equation represent the value (crash reduction) of an increase in the number of hours of operation or infringements issued for a particular type of enforcement for Region r . These values are also known as ‘elasticities’ and have been estimated from the state-space models given in Chapter 4, with the exception of d and e which have been estimated from non-regression studies evaluating mobile radar and laser enforcement (Diamantopoulou et al 1998b, and Harrison et al, 1999).

The elasticities a , b , c , f and g were region-specific estimates, whilst the d and e estimates relating to mobile radar and laser hours, respectively, were fixed for all regions.

The estimated elasticities a , b , c , f and g were obtained from Tables 4.1, 4.2, 4.3, 4.4 and 4.5 in the previous chapter and correspond with the estimated coefficient of the appropriate explanatory variable given in each table.

Thus, percentage increases in enforcement activity (e.g. hours or offences) appropriately weighted by the estimated elasticities (e.g. a) were the principal discriminators between regions.

5.1.3 Parameter for Mobile radar activity

The functional form of the relationship between crashes and mobile radar hours was assumed to be:

$$Casualty\ crashes = A * (mobile\ radar\ hours)^b$$

where A represents the combined effect of all other factors in that month and b represents the special effect of the mobile radar enforcement for a particular month.

This relationship was used to estimate the elasticity d relating to mobile radar hours based on the crash reduction found in a MUARC study that evaluated the effect of mobile radar enforcement on crashes in Victoria (Diamantopoulou et al, 1998b). This study found a net 9.6% reduction in casualty crashes occurring one to four days after mobile radar enforcement was present in rural areas of Victoria during July 1995-June 1997. During this period, 83,604 hours of mobile radar operations were achieved.

Using the estimated net 9.6% crash reduction, an elasticity of **-0.0088575** (i.e. an estimate of d) was determined. This elasticity gives the relative contribution of an increase in the number of mobile radar hours to reducing the risk of casualty crashes for each Region.

It should be noted that because the net 9.6% reduction was only found for rural areas (and because mobile radar activity predominantly occurs in rural Victoria), mobile radar enforcement was not included in the estimated index for Region 1 which consists only of metropolitan areas.

5.1.4 Parameter for Laser Operations

A similar method was used to estimate the elasticity e relating to laser operations with the functional form of the relationship between crashes and laser hours assumed to be:

$$\text{Casualty crashes} = A * (\text{laser hours})^b$$

where A represents the combined effect of all other factors in that month and b represents the special effect of the laser enforcement for a particular month.

A recent MUARC evaluation of the effects of laser speed-detection devices on crashes (Harrison et al, 1999) found evidence of an 8.3% reduction in casualty crashes when laser enforcement was present during January-December 1997. A total of 15,027 hours of laser operations were achieved during this period.

Using the total hours of laser operations achieved and the estimated net 8.3% crash reduction, an elasticity of **-0.0089558** (i.e. an estimate of e) was determined. This elasticity gives the relative contribution of an increase in the number of laser hours to reducing the risk of casualty crashes for each Region.

5.2 INDEX CALCULATION EXAMPLE

An example of the calculation of the index is given below for Region 2. The index has been calculated for January 1998, with the elasticity estimates obtained from Table 4.2 (Chapter 4). It should be noted that the elasticity for the RBT component of the index is made up of the addition of the HAH and LAH coefficient estimates given in Table 4.2, as is the elasticity for the speed camera TINs component of the index.

$$\begin{aligned}
Index_{2,Jan98} = & \left(\frac{RBTests_{2,Jan98}}{RBTests_{2,1997}} \right)^{-0.14959-0.09584} * \left(\frac{SCTins_{2,Jan98}}{SCTins_{2,1997}} \right)^{-0.03622-0.02848} \\
& * \left(\frac{PNOffences_{2,Jan98}}{PNOffences_{2,1997}} \right)^{-0.01509} * \left(\frac{MMRhrs_{2,Jan98}}{MMRhrs_{2,1997}} \right)^{-0.00886} \\
& * \left(\frac{LASERhrs_{2,Jan98}}{LASERhrs_{2,1997}} \right)^{-0.008956} * \left(\frac{RBTests_{2,Dec97}}{RBTests_{2,Dec96-Nov97}} \right)^{-0.08938} .
\end{aligned}$$

Thus,

$$\begin{aligned}
Index_{2,Jan98} = & \left(\frac{45,551}{37,883} \right)^{-0.24543} * \left(\frac{8,627}{9,373} \right)^{-0.0647} * \left(\frac{9,198}{6,682} \right)^{-0.01509} * \left(\frac{1,585}{1,524} \right)^{-0.00886} \\
& * \left(\frac{378}{309} \right)^{-0.008956} * \left(\frac{52,131}{36,799} \right)^{-0.08938} \\
= & 0.924985.
\end{aligned}$$

Because the index is related to crash outcomes, the smaller the index the better the performance of the police region with respect to crash reductions. However, to make the index more practical to interpret, the index was inverted and expressed as a percentage in order to monitor the region's performance during a particular month, compared with what would be expected if there had been no change in traffic enforcement effectiveness. This modified index was denoted by $Index^*_{r,t}$ and defined as follows:

$$Index^*_{r,t} = 100 * \left(\frac{1}{Index_{r,t}} \right).$$

In the above example, the index for January 1998 for region 2 was expressed as:

$$\begin{aligned}
Index^*_{2,Jan98} = & 100 * \left(\frac{1}{Index_{2,Jan98}} \right) \\
= & 100 * \left(\frac{1}{0.924985} \right) \\
= & 100 * (1.081099) \\
= & 108.1.
\end{aligned}$$

Thus during January 1998 the performance of region 2 was 8% above what would have been expected on average during 1997.

The same procedure was attempted for the other regions to give an index for January 1998 which measured the particular region's performance against expected levels. Table 5.1 and Figure 5.1 depict the January 1998 index for each of the five regions.

As can be seen from Figure 5.1 and Table 5.1, during January 1998 the performance of Region 1 was 4.4% better than average; the performance of Region 2 was 8.1% better than average; the performance of Region 3 was 3.3% better than average; the performance of Region 4 was 4.9% better than average and the performance of Region 5 was 8% better than average.

Thus in January 1998, all regions performed better than what was expected on average, with regions 2 and 5 performing the best.

For **all regions combined** the index was estimated as 105.7 – i.e. the performance for Victoria was 5.7% better than average. The 'all regions combined' index was estimated by taking the average of the five regions' monthly index estimate shown in Table 5.1, and inverting this average to express the index as a percentage.

Figure 5.1 Index for January 1998 for each Police Region

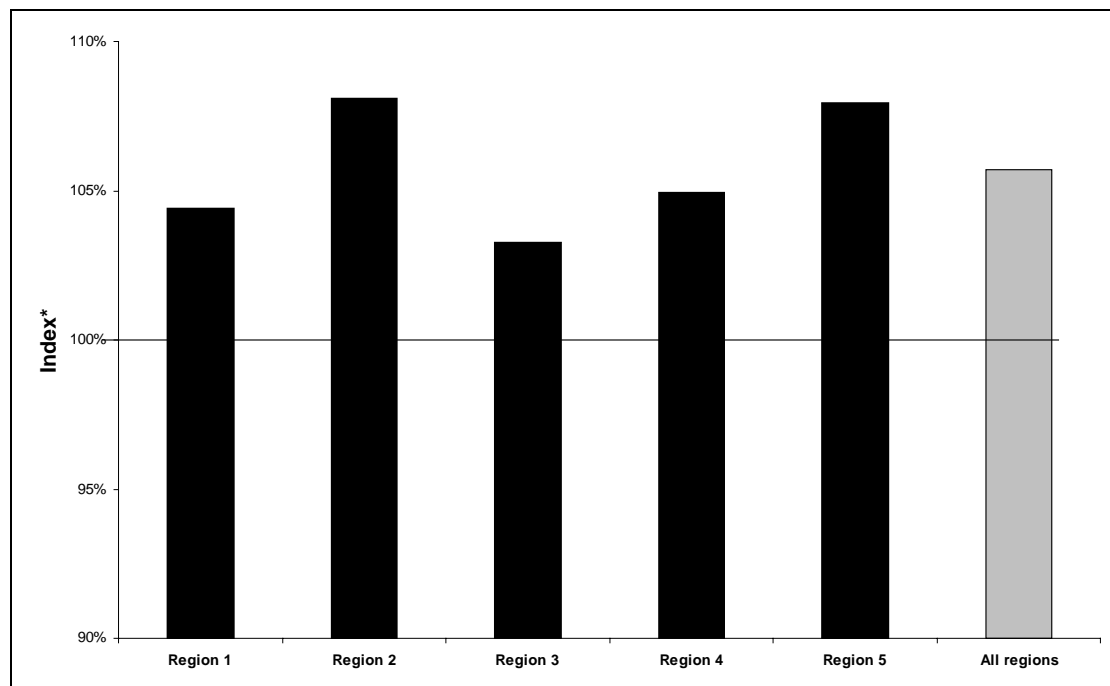


Table 5.1: Index for January 1998 for each Police Regions

Region	Enforcement	Jan98 frequency	Elasticity	Index	Index*
1	<ul style="list-style-type: none"> ▪ Speed camera TINs ▪ Penalty notice offences ▪ RBTs (car & bus) ▪ Laser hours ▪ Previous month's speed camera TINs 	11,497 5,238 38,345 327 11,147 ⁸	-0.00963 -0.0244 -0.19104 -0.008956 -0.02244	0.957862	104.4
2	<ul style="list-style-type: none"> ▪ Speed camera TINs ▪ Penalty notice offences ▪ RBTs (car & bus) ▪ Laser hours ▪ Mobile radar hours ▪ Previous month's RBTs 	8,627 9,198 45,551 378 1,585 52,131 ⁸	-0.0647 -0.01509 -0.24543 -0.008956 -0.008858 -0.08938	0.924985	108.1
3	<ul style="list-style-type: none"> ▪ Speed camera TINs ▪ Laser hours ▪ Mobile radar hours ▪ Previous month's RBTs 	10,008 479 1,409 56,939 ⁸	-0.01948 -0.008956 -0.008858 -0.12957	0.968238	103.3
4	<ul style="list-style-type: none"> ▪ RBTs (car & bus) ▪ Laser hours ▪ Mobile radar hours ▪ Previous month's RBTs 	35,570 334 830 34,494 ⁸	-0.14626 -0.008956 -0.008858 -0.25506	0.952865	104.9
5 ⁹	<ul style="list-style-type: none"> ▪ Speed camera TINs ▪ Mobile radar hours ▪ RBTs (car & bus) ▪ Laser hours ▪ Previous month's RBTs 	5,739 842 38,025 373 40,036 ⁸	-0.10327 -0.008858 -0.28335 -0.008956 -0.12918	0.926250	108.0

5.3 MONTHLY PERFORMANCE OF EACH REGION DURING FEBRUARY–DECEMBER 1998

The same procedure that was used to determine traffic enforcement output levels for each Region against expected levels for January 1998 was applied for each month through February 1998 to December 1998 inclusive. Detailed results of the calculations are given in Appendix C, whilst Table 5.2 depicts the monthly index for each region during February-December 1998.

Figure 5.2 depicts the monthly index graphically for each region during January-December 1998, whilst figure 5.3 gives the monthly index for all regions combined.

During April, June, October and December each region had performed below that expected (Figure 5.2). For the other months, some regions performed above average in a particular month whilst others performed below average.

With the exception of the first three months of 1998, the performance of all regions combined was below average during 1998 (Figure 5.3).

⁸ Frequency refers to the month previous to January 1998 (i.e. December 1997 frequency)

⁹ The previous month's speed camera TINs was found to be a significant factor for region 5 but was not associated with a crash reduction, hence was not considered in the development of the index.

Table 5.2: Monthly Index for each Police Region, February-December 1998

Region	Month	Index	Index*
1	February 1998	1.00347	99.7
	March 1998	1.01053	99.0
	April 1998	1.04835	95.4
	May 1998	1.02242	97.8
	June 1998	1.05368	94.8
	July 1998	1.05197	95.1
	August 1998	1.02741	97.3
	September 1998	1.06065	94.3
	October 1998	1.04014	96.1
	November 1998	1.04187	96.0
	December 1998	1.02461	97.6
	2	February 1998	0.95507
March 1998		0.98754	101.3
April 1998		1.02824	97.3
May 1998		0.99071	100.9
June 1998		1.03292	96.8
July 1998		1.05126	95.1
August 1998		0.99007	101.0
September 1998		1.04227	95.9
October 1998		1.00170	99.8
November 1998		1.06227	94.1
December 1998		1.06036	94.3
3		February 1998	0.99672
	March 1998	1.00958	99.1
	April 1998	1.01386	98.6
	May 1998	1.03607	96.5
	June 1998	1.02977	97.1
	July 1998	1.03562	96.6
	August 1998	1.04033	96.1
	September 1998	1.00449	99.6
	October 1998	1.01283	98.7
	November 1998	0.98869	101.1
	December 1998	1.02168	97.9
	4	February 1998	0.95997
March 1998		0.98342	101.7
April 1998		1.00752	99.3
May 1998		1.03291	96.8
June 1998		1.01665	98.4
July 1998		1.01763	98.3
August 1998		1.01613	98.4
September 1998		0.98424	101.6
October 1998		1.04557	95.6
November 1998		1.04243	95.9
December 1998		1.04880	95.4
5		February 1998	0.94651
	March 1998	0.97924	102.1
	April 1998	1.04581	95.6
	May 1998	0.97272	102.8
	June 1998	1.03815	96.3
	July 1998	0.99865	100.1
	August 1998	0.98349	101.7
	September 1998	1.00980	99.0
	October 1998	1.04797	95.4
	November 1998	1.08076	92.5
	December 1998	1.09012	91.7

Figure 5.2 Monthly Index for each Police Region, January-December 1998

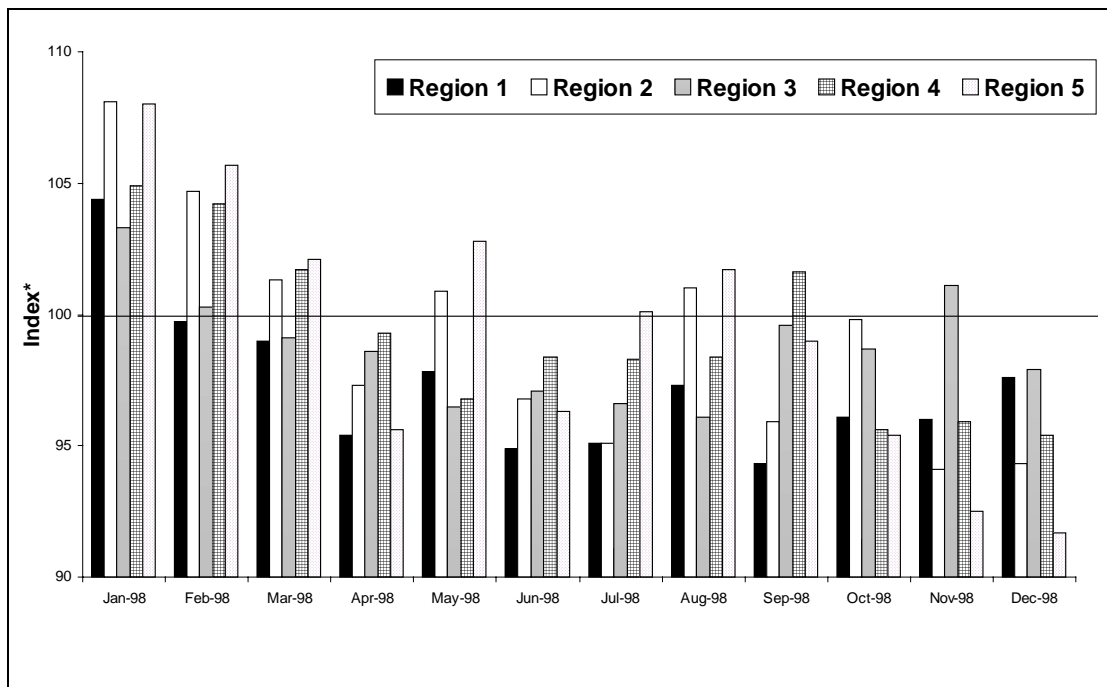
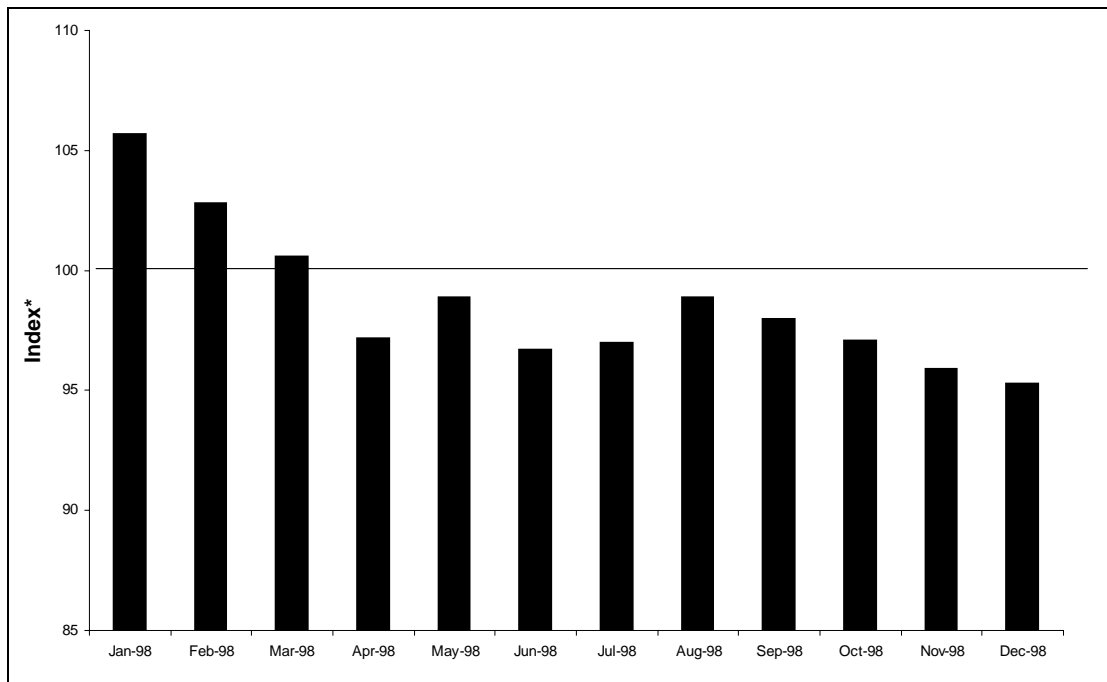


Figure 5.3 Monthly Index for all Regions combined, January-December 1998



6. TESTING THE INDEX AGAINST CRASH OUTCOMES

Whilst the indices developed in Chapter 5 for each Region indicated the relative performance of that Region per month there was a need to test each index against actual road safety performance achieved during 1998.

6.1 METHOD

A comparison against actual road safety performance per month for each Region relative to the expected crash levels was made.

The expected crash levels were found by projecting each of the 'state-space' regional models developed in Chapter 4 ahead into the months of 1998. The models 'ignored' the enforcement activity achieved during 1998 by keeping the monthly enforcement levels at a constant value (i.e. the monthly average of the previous year, 1997, was used). This method assumed that there had been no change in enforcement levels from the previous year. The actual levels of all other relevant factors achieved per month during 1998 were included in the projected models. These factors included time, seasonality and non-enforcement factors such as advertising levels and unemployment rates.

These projections then gave the number of casualty crashes *expected* to have occurred per month assuming there had there been *no change* in the levels of enforcement during 1998 for each Region. The projected crashes were based on the time-series models developed for 1989-1997.

The expected crash frequencies were then compared with the observed number of casualty crashes that occurred in each Region during a particular month. If the ratio of the observed crashes to the expected crashes was less than 1 then the actual crash outcomes were better than what was expected – that is, fewer crashes were observed that month than what was forecast. But if the crash ratio was greater than 1, then more crashes were observed that month than was forecast.

If the developed index does in fact reflect the relative road safety contribution of a mix of Police operations in each Region, then the differences between the expected and observed crashes should be reflected in the index.

6.2 REGION 1

Table 6.1 gives the expected and observed number of casualty crashes per month for Region 1 during both LAH and HAH of the week. To obtain the total number of casualty crashes per month, the number of HAH and LAH crashes were added.

The percentage crash change is also given in the table and was calculated as follows:

$$\% \text{ crash change} = (\text{crash ratio} - 1) * 100,$$

where

$$\text{crash ratio} = (\text{observed crashes}/\text{expected crashes}).$$

One standard error confidence limits for the expected number of crashes, the crash ratio and the % crash change are also given in the Table 6.1.

Table 6.1: REGION 1. % Casualty Crash Change per month with one standard error confidence limits, January-December 1998

LAH CASUALTY CRASHES								
Month of crash	Crash frequencies		One standard error confidence limits for expected crashes		Crash Ratio	% crash change	One standard error confidence limits for % crash change	
	Observed	Expected	Lower	Upper			Lower	Upper
Jan 98	141	148	130	166	0.952	-4.8	-15.2	8.4
Feb 98	158	192	168	216	0.823	-17.7	-26.7	-6.2
Mar 98	172	176	154	198	0.978	-2.2	-13.1	11.9
Apr 98	159	159	139	180	0.998	-0.2	-11.6	14.4
May 98	173	173	150	195	1.003	0.3	-11.3	15.3
Jun 98	183	173	150	196	1.056	5.6	-6.7	21.7
Jul 98	150	161	139	182	0.934	-6.6	-17.6	7.9
Aug 98	170	180	156	205	0.942	-5.8	-17.1	9.0
Sep 98	141	161	139	183	0.876	-12.4	-23.0	1.6
Oct 98	171	179	154	204	0.953	-4.7	-16.3	10.7
Nov 98	179	180	155	206	0.993	-0.7	-12.9	15.5
Dec 98	137	163	140	186	0.842	-15.8	-26.3	-1.9
HAH CASUALTY CRASHES								
Month of crash	Crash frequencies		One standard error confidence limits for expected crashes		Crash Ratio	% crash change	One standard error confidence limits for % crash change	
	Observed	Expected	Lower	Upper			Lower	Upper
Jan 98	110	95	81	109	1.16	16.0	1.2	35.9
Feb 98	99	92	78	107	1.07	7.3	-7.2	27.2
Mar 98	120	121	101	141	0.99	-1.0	-15.1	18.8
Apr 98	113	101	84	119	1.11	11.3	-5.3	35.0
May 98	119	111	91	131	1.07	7.2	-9.5	31.4
Jun 98	107	105	85	125	1.02	2.3	-14.1	26.6
Jul 98	117	102	81	122	1.15	15.2	-3.9	43.9
Aug 98	110	102	81	123	1.08	7.6	-10.8	35.5
Sep 98	115	104	82	126	1.11	10.9	-8.5	40.8
Oct 98	128	98	77	119	1.31	30.8	7.4	67.2
Nov 98	112	110	85	135	1.02	1.8	-16.8	31.1
Dec 98	109	98	76	120	1.11	11.1	-9.5	43.9
ALL CASUALTY CRASHES								
Month of crash	Crash frequencies		One standard error confidence limits for expected crashes		Crash Ratio	% crash change	One standard error confidence limits for % crash change	
	Observed	Expected	Lower	Upper			Lower	Upper
Jan 98	251	243	220	266	1.03	3.3	-5.6	14.0
Feb 98	257	284	257	312	0.90	-9.6	-17.6	0.1
Mar 98	292	297	267	327	0.98	-1.7	-10.7	9.3
Apr 98	272	261	234	288	1.04	4.3	-5.5	16.3
May 98	292	284	253	314	1.03	3.0	-7.0	15.3
Jun 98	290	278	247	308	1.04	4.4	-5.9	17.2
Jul 98	267	262	233	292	1.02	1.9	-8.5	14.8
Aug 98	280	283	250	315	0.99	-1.0	-11.1	11.8
Sep 98	256	265	233	296	0.97	-3.3	-13.5	9.7
Oct 98	299	277	244	310	1.08	7.9	-3.6	22.3
Nov 98	291	290	255	326	1.00	0.3	-10.6	14.1
Dec 98	246	261	229	293	0.94	-5.7	-16.1	7.5

6.2.1 Comparison of current month's performance with current month's crashes

To compare the % crash change per month with the developed index, the monthly index given in Table 5.2 was expressed as a percentage indicating the Region's performance during that month, i.e.

$$\text{Regional Performance} = (\text{Index}^* - 100) \%$$

For example, during January 1998 the index for Region 1 was 104.4, indicating that the performance of Region 1 was 4.4% better than average.

Table 6.2 and Figure 6.1 give the % crash change per month for Region 1 with one standard error confidence limits and that Region's performance (as quantified by the index). The comparison of the index with the % crash change was made for all crashes (separate comparisons for HAH and LAH crashes were not made).

For the index to reflect actual crash outcomes either one of the two scenarios below should occur:

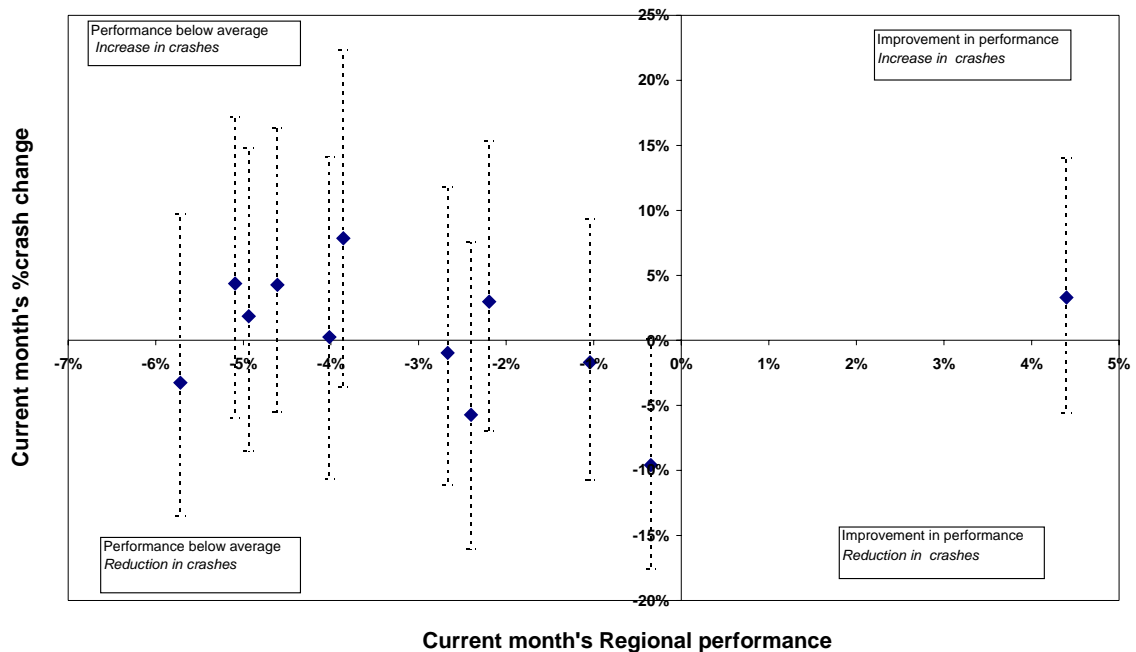
- i. a reduction in crashes per month (i.e. %crash change < 0%) corresponding with an improvement in the region's performance during that month (i.e. regional performance > 0%) or
- ii. an increase in crashes per month (i.e. %crash change > 0%) corresponding with a worsening in the region's performance during that month (i.e. regional performance < 0%).

Thus, the majority of the points in Figure 6.1 should be either in the upper left-hand corner or in the lower right-hand corner.

Table 6.2: REGION 1. Comparison of current month's regional performance with current month's % casualty crash change, January-December 1998

Month of casualty crash	Index*	Region Performance (%)	% Crash Change	One standard error confidence limits for % crash change	
				Lower	Upper
Jan 98	104.4	4.4	3.3	-5.6	14.0
Feb 98	99.7	-0.3	-9.6	-17.6	0.1
Mar 98	99.0	-1.0	-1.7	-10.7	9.3
Apr 98	95.4	-4.6	4.3	-5.5	16.3
May 98	97.8	-2.2	3.0	-7.0	15.3
Jun 98	94.8	-5.1	4.4	-5.9	17.2
Jul 98	95.1	-4.9	1.9	-8.5	14.8
Aug 98	97.3	-2.7	-1.0	-11.1	11.8
Sep 98	94.3	-5.7	-3.3	-13.5	9.7
Oct 98	96.1	-3.9	7.9	-3.6	22.3
Nov 98	96.0	-4.0	0.3	-10.6	14.1
Dec 98	97.6	-2.4	-5.7	-16.1	7.5

Figure 6.1: REGION 1. Comparison of current month's performance with current month's casualty crashes, January-December 1998



As depicted in Figure 6.1, for Region 1:

- A 'below average' performance and a crash *increase* occurred during *six* months of 1998.
- A 'below average' performance and a crash *reduction* occurred during *five* months of 1998. However, with 68% certainty, the crash reductions during these months could have been associated with **crash risk increases** (as indicated by the upper confidence limit placed on the appropriate crash estimate).
- Thus with 68% certainty (i.e. one standard error confidence limits), there were *11* months in 1998 where Region 1's performance was below what was expected and the **crash risk** may have increased.
- An 'above average' performance and a crash *increase* occurred during *one* month of 1998. However this crash increase had a negative lower confidence limit so potentially could also been a **crash risk reduction** with 68% certainty.

Thus, during most of the months of 1998, the performance of Region 1 *was below average* coinciding with **possible increases in crash risk** for those months (when the range of % crash change values covered by the confidence limits was taken into consideration). There was only *one* month in 1998 where the region was performing *above average* and a **reduction in crash risk** could have occurred.

6.2.2 Comparison of current month's performance with next month's crashes

A potential problem with comparing the current month's regional performance with the current month's crashes is that some of the crashes may have occurred before the Police operations took place in that month. Thus a better comparison may be the comparison between the current month's regional performance (as quantified by the index) and the *next* month's changes in crash frequencies. If the current month's performance were better than average then one would expect the *next* month's crashes to be reduced. But if the current's month's performance were below average then the crashes would be expected to increase in the *next* month.

Table 6.3 and Figure 6.2 compare the current month's index with the next month's % crash changes for Region 1.

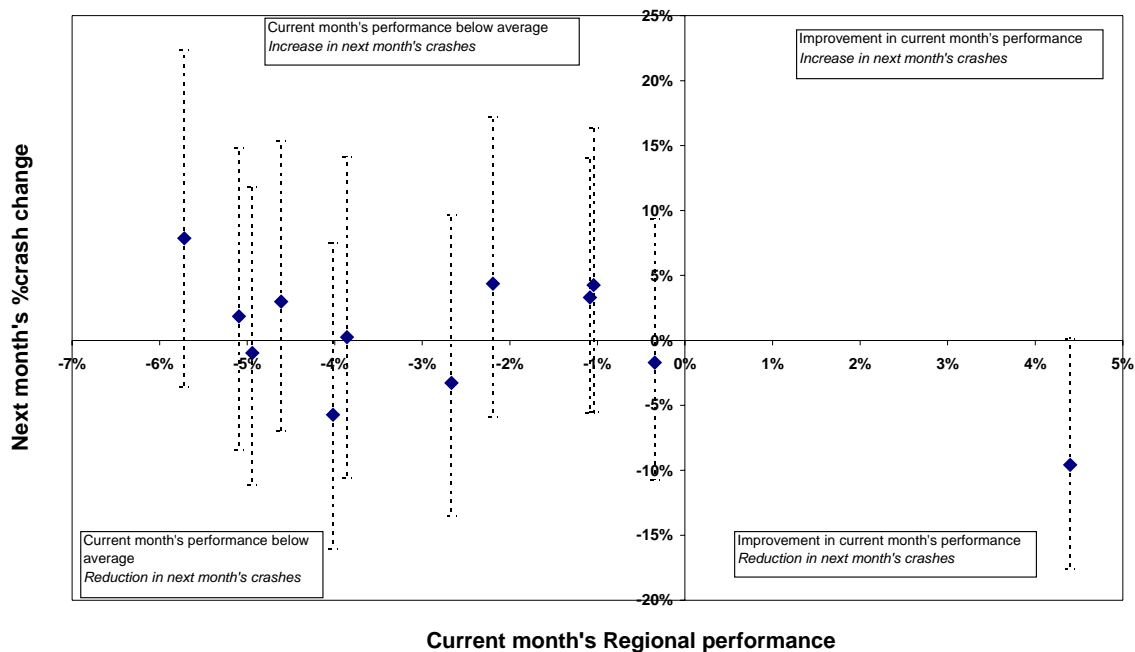
As depicted in Figure 6.2, for Region 1:

- A current month 'above average' performance and a crash *reduction* in the following month occurred *once* during 1998.
- A current month 'below average' performance and a crash *increase* in the following month occurred *seven* times during 1998.
- A current month 'below average' performance and a crash *reduction* in the following month occurred *four* times during 1998. However the crash reductions during these months could have been associated with **crash risk increases** (as indicated by the upper confidence limit placed on the appropriate crash estimate).
- Thus, with 68% certainty, during most of the months of 1998, the performance of Region 1 was *below average* coinciding with **possible increases in crash risk** during the following month (this occurred for 11 months when the confidence limits of the % crash risk change were considered).

Table 6.3: REGION 1. Comparison of current month's regional performance with NEXT month's % casualty crash change, January-December 1998

Month of casualty crash	Index* (previous month)	Region Performance (%)	% Crash Change	One standard error confidence limits for % crash change	
				Lower	Upper
Jan 98	98.9	-1.1	3.3	-5.6	14.0
Feb 98	104.4	4.4	-9.6	-17.6	0.1
Mar 98	99.7	-0.3	-1.7	-10.7	9.3
Apr 98	99.0	-1.0	4.3	-5.5	16.3
May 98	95.4	-4.6	3.0	-7.0	15.3
Jun 98	97.8	-2.2	4.4	-5.9	17.2
Jul 98	94.8	-5.1	1.9	-8.5	14.8
Aug 98	95.1	-4.9	-1.0	-11.1	11.8
Sep 98	97.3	-2.7	-3.3	-13.5	9.7
Oct 98	94.3	-5.7	7.9	-3.6	22.3
Nov 98	96.1	-3.9	0.3	-10.6	14.1
Dec 98	96.0	-4.0	-5.7	-16.1	7.5

Figure 6.2: REGION 1. Comparison of current month's performance with NEXT month's casualty crashes, January-December 1998



6.2.3 Summary

During 1998 for Region 1, the monthly index was not inconsistent with the estimated casualty crash risk outcomes of that month for:

- 6 months of the year (i.e. *half* of 1998)
- 12 months of the year (i.e. *all* of 1998- when the confidence limits of the % crash risk change were considered).

And, the monthly index was not inconsistent with the *next* month's estimated casualty crash risk outcomes for:

- 8 months of the year (i.e. *two thirds* of 1998)
- 12 months of the year (i.e. *all* of 1998 - when the confidence limits of the % crash risk change were considered).

Hence, for Region 1 during 1998, the index (which measured the Region's performance per month) reflected the next month's casualty crash risk outcomes better or more frequently than the current month's casualty crash risk outcomes.

6.3 REGION 2

Table 6.4 gives the expected and observed number of casualty crashes per month for Region 2 together with the percentage crash change. One standard error confidence limits for the expected number of crashes, the crash ratio and the % crash change are also given in the table.

Table 6.4: REGION 2. % Casualty Crash Change per month with one standard error confidence limits, January-December 1998

LAH CASUALTY CRASHES								
Month of crash	Crash frequencies		One standard error confidence limits for expected crashes		Crash Ratio	% crash change	One standard error confidence limits for % crash change	
	Observed	Expected	Lower	Upper			Lower	Upper
Jan 98	146	137	123	151	1.07	6.7	-3.0	18.6
Feb 98	146	167	143	191	0.87	-12.7	-23.7	1.9
Mar 98	166	169	139	199	0.98	-1.9	-16.6	19.2
Apr 98	137	180	143	217	0.76	-23.8	-36.7	-4.2
May 98	152	166	128	204	0.92	-8.4	-25.4	18.8
Jun 98	147	161	121	202	0.91	-9.0	-27.2	21.5
Jul 98	141	161	117	205	0.88	-12.5	-31.1	20.1
Aug 98	124	151	107	195	0.82	-18.0	-36.4	15.4
Sep 98	150	158	109	206	0.95	-4.9	-27.2	37.1
Oct 98	173	168	113	222	1.03	3.3	-21.9	52.4
Nov 98	168	163	108	218	1.03	2.9	-23.1	55.4
Dec 98	122	193	125	260	0.63	-36.7	-53.2	-2.2
HAH CASUALTY CRASHES								
Month of crash	Crash frequencies		One standard error confidence limits for expected crashes		Crash Ratio	% crash change	One standard error confidence limits for % crash change	
	Observed	Expected	Lower	Upper			Lower	Upper
Jan 98	90	128	110	145	0.71	-29.5	-37.9	-18.5
Feb 98	88	105	89	121	0.84	-16.1	-27.1	-1.3
Mar 98	103	124	105	144	0.83	-17.1	-28.2	-1.8
Apr 98	101	107	91	124	0.94	-6.0	-18.8	11.5
May 98	106	124	105	144	0.85	-14.7	-26.3	1.3
Jun 98	83	114	96	132	0.73	-27.0	-37.0	-13.3
Jul 98	89	104	87	120	0.86	-14.0	-25.8	2.2
Aug 98	89	115	96	133	0.78	-22.3	-33.0	-7.6
Sep 98	81	113	95	131	0.71	-28.6	-38.4	-15.0
Oct 98	104	112	94	130	0.93	-7.1	-19.8	10.5
Nov 98	113	124	104	143	0.91	-8.6	-21.2	8.6
Dec 98	103	133	112	154	0.78	-22.3	-33.0	-7.7
ALL CASUALTY CRASHES								
Month of crash	Crash frequencies		One standard error confidence limits for expected crashes		Crash Ratio	% crash change	One standard error confidence limits for % crash change	
	Observed	Expected	Lower	Upper			Lower	Upper
Jan 98	236	265	243	287	0.89	-10.8	-17.6	-2.7
Feb 98	234	272	244	301	0.86	-14.0	-22.2	-3.9
Mar 98	269	293	258	329	0.92	-8.3	-18.2	4.3
Apr 98	238	287	247	328	0.83	-17.1	-27.4	-3.6
May 98	258	290	247	333	0.89	-11.1	-22.5	4.3
Jun 98	230	275	231	320	0.84	-16.4	-28.0	-0.4
Jul 98	230	265	218	311	0.87	-13.1	-26.1	5.5
Aug 98	213	266	218	313	0.80	-19.9	-32.0	-2.5
Sep 98	231	271	220	323	0.85	-14.8	-28.4	5.2
Oct 98	277	279	223	336	0.99	-0.9	-17.7	24.5
Nov 98	281	287	228	346	0.98	-2.1	-18.7	23.0
Dec 98	225	325	254	396	0.69	-30.8	-43.2	-11.5

6.3.1 Comparison of current month's performance with current month's crashes

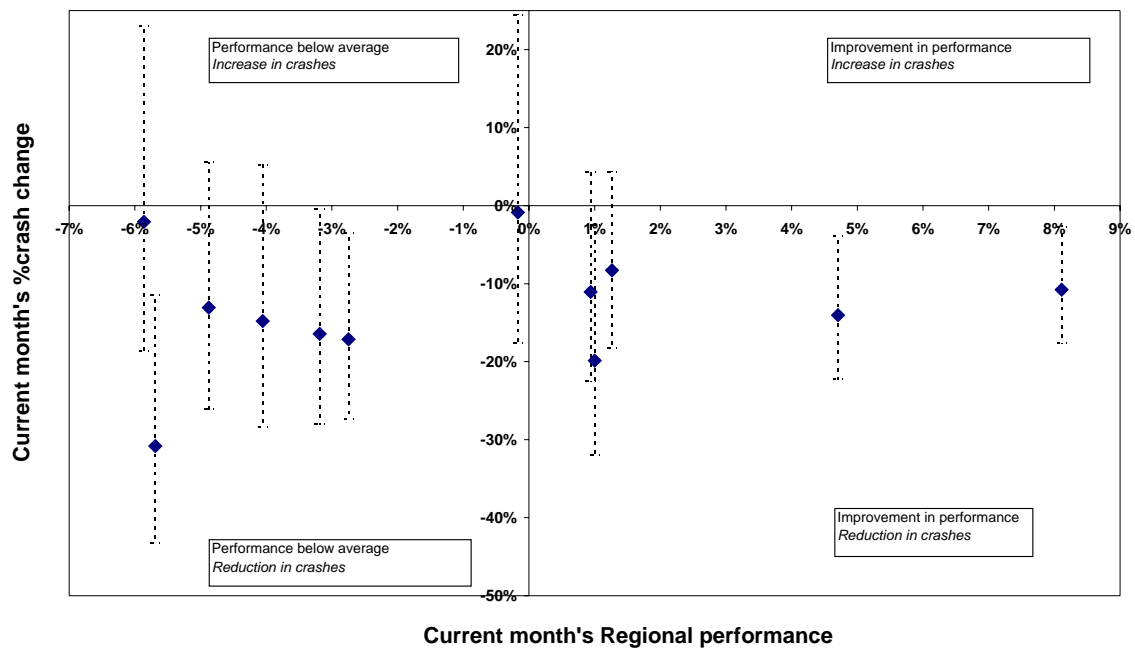
Table 6.5 and Figure 6.3 give the % crash change per month for Region 2 with one standard error confidence limits, and that Region's performance (as quantified by the index).

For the index to reflect actual crash outcomes, the majority of the points in Figure 6.3 should be either in the upper left-hand corner or in the lower right-hand corner.

Table 6.5: REGION 2. Comparison of current month's regional performance with current month's % casualty crash change, January-December 1998

Month of casualty crash	Index*	Region Performance (%)	% Crash Change	One standard error confidence limits for % crash change	
				Lower	Upper
Jan 98	108.1	8.1	-10.8	-17.6	-2.7
Feb 98	104.7	4.7	-14.0	-22.2	-3.9
Mar 98	101.3	1.3	-8.3	-18.2	4.3
Apr 98	97.3	-2.7	-17.1	-27.4	-3.6
May 98	100.9	0.9	-11.1	-22.5	4.3
Jun 98	96.8	-3.2	-16.4	-28.0	-0.4
Jul 98	95.1	-4.9	-13.1	-26.1	5.5
Aug 98	101.0	1.0	-19.9	-32.0	-2.5
Sep 98	95.9	-4.1	-14.8	-28.4	5.2
Oct 98	99.8	-0.2	-0.9	-17.7	24.5
Nov 98	94.1	-5.9	-2.1	-18.7	23.0
Dec 98	94.3	-5.7	-30.8	-43.2	-11.5

Figure 6.3: REGION 2. Comparison of current month's performance with current month's casualty crashes, January-December 1998



As depicted in Figure 6.3, for Region 2:

- An ‘above average’ performance and a *reduction* in crashes occurred during *five* months of 1998.
- A ‘below average’ performance and a *reduction* in crashes occurred during *seven* months of 1998. However, with 68% certainty, the crash reductions during *four* of these months could have been associated with **crash risk increases** (as indicated by the upper confidence limit placed on the appropriate crash estimate).

Thus, during five months of 1998, the performance of Region 2 was *above average* coinciding with **possible reductions in crash risk** for those months. There were four months in 1998 where the region was performing *below average* and an **increase in crash risk** could have occurred (when the confidence limits of the % crash risk change were taken into consideration).

6.3.2 Comparison of current month’s performance with next month’s crashes

Table 6.6 and Figure 6.4 compare the current month’s regional performance with the next month’s casualty crashes.

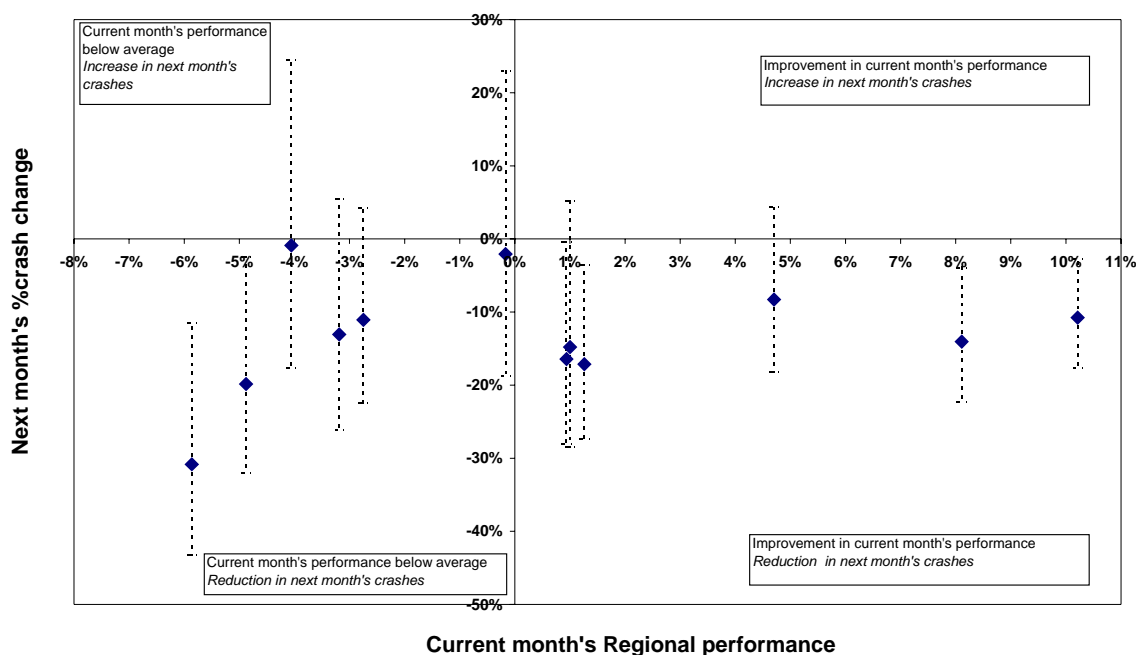
As depicted in Figure 6.4 for Region 2:

- A current month ‘*above average*’ performance and a crash *reduction* in the following month occurred *six* times during 1998.
- A current month ‘*below average*’ performance and a crash *reduction* in the following month occurred *six* times during 1998. However the crash reductions during *four* of these months could have been associated with **crash risk increases** (as indicated by the upper confidence limit placed on the appropriate crash estimate).
- Thus, with 68% certainty, during *four* of the months of 1998, the performance of Region 2 was *below average* coinciding with possible *increases* in crash risk during the following month.

Table 6.6: REGION 2. Comparison of current month’s regional performance with NEXT month’s % casualty crash change, January-December 1998

Month of casualty crash	Index* (Previous month)	Region Performance (%)	% Crash Change	One standard error confidence limits for % crash change	
				Lower	Upper
Jan 98	110.2	10.2	-10.8	-17.6	-2.7
Feb 98	108.1	8.1	-14.0	-22.2	-3.9
Mar 98	104.7	4.7	-8.3	-18.2	4.3
Apr 98	101.3	1.3	-17.1	-27.4	-3.6
May 98	97.3	-2.7	-11.1	-22.5	4.3
Jun 98	100.9	0.9	-16.4	-28.0	-0.4
Jul 98	96.8	-3.2	-13.1	-26.1	5.5
Aug 98	95.1	-4.9	-19.9	-32.0	-2.5
Sep 98	101.0	1.0	-14.8	-28.4	5.2
Oct 98	95.9	-4.1	-0.9	-17.7	24.5
Nov 98	99.8	-0.2	-2.1	-18.7	23.0
Dec 98	94.1	-5.9	-30.8	-43.2	-11.5

Figure 6.4: REGION 2. Comparison of current month's performance with NEXT month's casualty crashes, January-December 1998



6.3.3 Summary

During 1998 for Region 2, the monthly index was not inconsistent with the estimated casualty crash risk outcomes of that month for:

- 5 months of the year (i.e. 42% of 1998)
- 9 months of the year (i.e. 75% of 1998- when the confidence limits of the % crash risk change were considered).

And, the monthly index was not inconsistent with the *next* month's estimated casualty crash risk outcomes for:

- 6 months of the year (i.e. *half* of 1998)
- 10 months of the year (i.e. 83% of 1998 - when the confidence limits of the % crash risk change were considered).

Hence, for Region 2 during 1998, the index (which measured the Region's performance per month) reflected the next month's estimated casualty crash risk outcomes better or more frequently than the current month's casualty crash risk outcomes.

6.4 REGION 3

Table 6.7 gives the expected and observed number of casualty crashes per month in Region 3 together with the percentage crash change. One standard error confidence limits for the expected number of crashes, the crash ratio and the % crash change are also given in the table.

Table 6.7: REGION 3. % Casualty Crash Change per month with one standard error confidence limits, January-December 1998

LAH CASUALTY CRASHES								
Month of crash	Crash frequencies		One standard error confidence limits for expected crashes		Crash Ratio	% crash change	One standard error confidence limits for % crash change	
	Observed	Expected	Lower	Upper			Lower	Upper
Jan 98	161	144	127	161	1.12	11.8	-0.2	26.9
Feb 98	176	191	158	224	0.92	-7.9	-21.3	11.1
Mar 98	206	187	148	227	1.10	10.1	-9.1	39.6
Apr 98	197	188	142	234	1.05	4.8	-15.8	38.7
May 98	205	194	141	247	1.06	5.7	-17.0	45.6
Jun 98	200	190	133	247	1.05	5.3	-19.1	50.5
Jul 98	203	194	131	257	1.05	4.7	-20.9	55.0
Aug 98	213	182	119	245	1.17	17.1	-13.0	79.2
Sep 98	172	188	119	257	0.92	-8.4	-33.0	44.8
Oct 98	206	180	110	250	1.14	14.4	-17.5	86.5
Nov 98	214	185	110	260	1.16	15.5	-17.7	94.0
Dec 98	191	193	112	275	0.99	-1.3	-30.5	70.7
HAH CASUALTY CRASHES								
Month of crash	Crash frequencies		One standard error confidence limits for expected crashes		Crash Ratio	% crash change	One standard error confidence limits for % crash change	
	Observed	Expected	Lower	Upper			Lower	Upper
Jan 98	100	94	78	110	1.06	6.0	-9.3	27.6
Feb 98	139	106	85	126	1.31	31.5	10.2	62.9
Mar 98	131	127	100	154	1.03	3.1	-14.8	30.5
Apr 98	133	114	89	140	1.17	16.5	-4.7	49.9
May 98	126	122	93	150	1.03	3.4	-16.2	34.8
Jun 98	126	120	90	150	1.05	5.0	-16.0	39.9
Jul 98	147	99	75	124	1.48	48.1	18.6	97.0
Aug 98	119	108	80	135	1.11	10.6	-11.8	48.4
Sep 98	124	102	76	129	1.21	21.3	-3.7	63.9
Oct 98	165	117	86	148	1.41	40.8	11.3	91.4
Nov 98	137	122	89	155	1.12	12.1	-11.7	53.4
Dec 98	146	117	85	149	1.24	24.5	-2.2	71.3
ALL CASUALTY CRASHES								
Month of crash	Crash frequencies		One standard error confidence limits for expected crashes		Crash Ratio	% crash change	One standard error confidence limits for % crash change	
	Observed	Expected	Lower	Upper			Lower	Upper
Jan 98	261	238	215	262	1.09	9.5	-0.3	21.4
Feb 98	315	297	258	335	1.06	6.1	-6.1	22.0
Mar 98	337	314	266	362	1.07	7.3	-6.8	26.5
Apr 98	330	302	250	355	1.09	9.2	-7.0	32.2
May 98	331	316	256	376	1.05	4.8	-12.0	29.5
Jun 98	326	310	246	375	1.05	5.1	-13.0	32.7
Jul 98	350	293	226	361	1.19	19.4	-3.0	55.2
Aug 98	332	289	221	358	1.15	14.7	-7.3	50.4
Sep 98	296	290	216	364	1.02	2.1	-18.6	37.0
Oct 98	371	297	221	373	1.25	24.8	-0.6	67.8
Nov 98	351	307	226	389	1.14	14.2	-9.8	55.6
Dec 98	337	311	223	398	1.08	8.5	-15.4	51.1

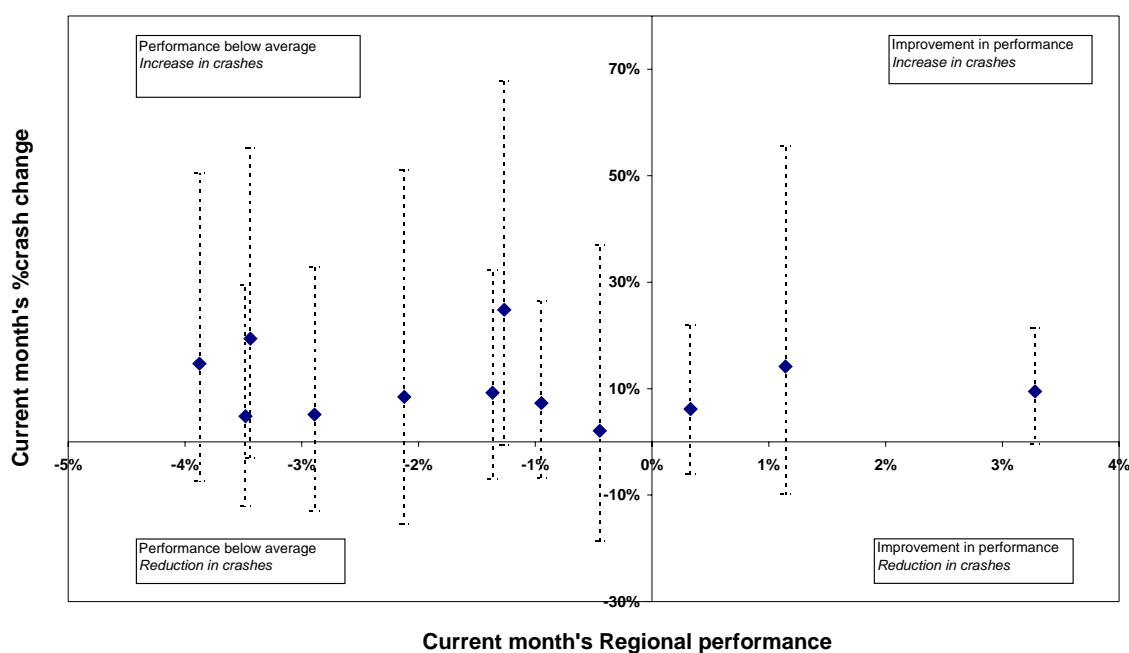
6.4.1 Comparison of current month's performance with current month's crashes

Table 6.8 and Figure 6.5 give the % crash change per month for Region 3 with one standard error confidence limits, and that Region's performance (as quantified by the index). For the index to reflect actual crash outcomes, the majority of the points in Figure 6.5 should be either in the upper left-hand corner or in the lower right-hand corner.

Table 6.8: REGION 3. Comparison of current month's regional performance with current month's % casualty crash change, January-December 1998

Month of casualty crash	Index*	Region Performance (%)	% Crash Change	One standard error confidence limits for % crash change	
				Lower	Upper
Jan 98	103.3	3.3	9.5	-0.3	21.4
Feb 98	100.3	0.3	6.1	-6.1	22.0
Mar 98	99.1	-0.9	7.3	-6.8	26.5
Apr 98	98.6	-1.4	9.2	-7.0	32.2
May 98	96.5	-3.5	4.8	-12.0	29.5
Jun 98	97.1	-2.9	5.1	-13.0	32.7
Jul 98	96.6	-3.4	19.4	-3.0	55.2
Aug 98	96.1	-3.9	14.7	-7.3	50.4
Sep 98	99.6	-0.4	2.1	-18.6	37.0
Oct 98	98.7	-1.3	24.8	-0.6	67.8
Nov 98	101.1	1.1	14.2	-9.8	55.6
Dec 98	97.9	-2.1	8.5	-15.4	51.1

Figure 6.5: REGION 3. Comparison of current month's performance with current month's casualty crashes, January-December 1998



As depicted in Figure 6.5, for Region 3:

- A '*below average*' performance and an *increase* in crashes occurred during *nine* months of 1998.
- An '*above average*' performance and an *increase* in crashes occurred during *three* months of 1998. However, with 68% certainty, the crash increases during these months could also have been associated with **crash risk reductions** (as indicated by the lower confidence limit placed on the appropriate crash estimate).

Thus, during *nine* months of 1998, the performance of Region 3 was *below average* coinciding with *increases* in crashes for those months. There were *three* months in 1998 when the region was performing better than expected and a possible reduction in crash risk could have occurred (when the range of % crash change values covered by the confidence limits was taken into consideration).

6.4.2 Comparison of current month's performance with next month's crashes

Table 6.9 and Figure 6.6 compare the current month's regional performance with the next month's casualty crashes for Region 3.

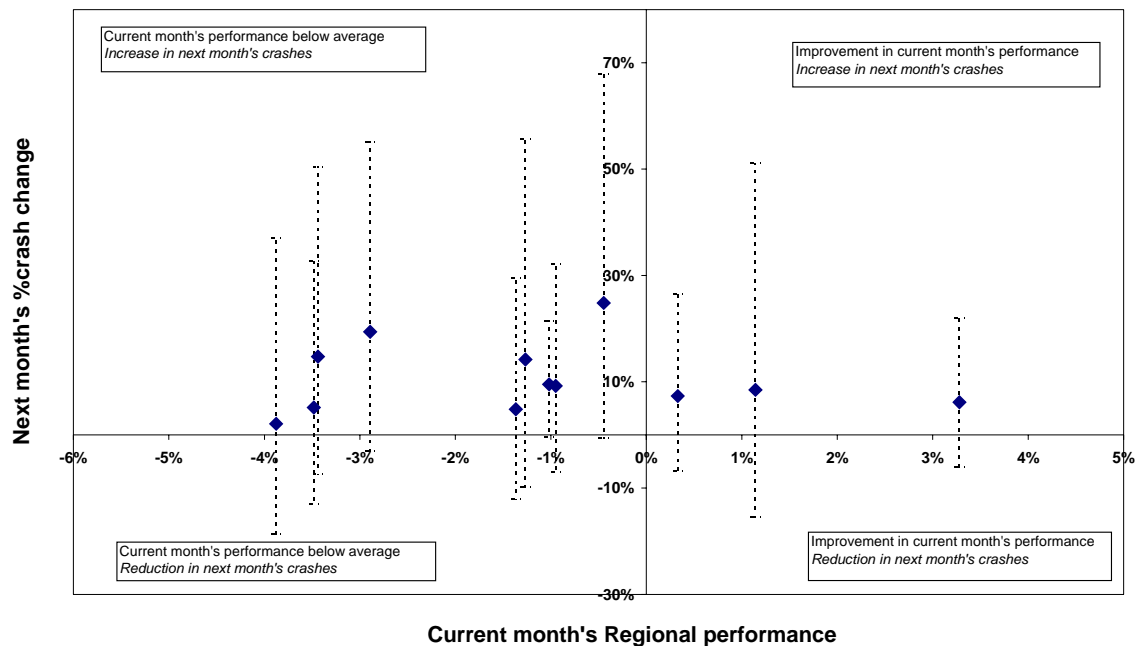
As depicted in Figure 6.6, for Region 3:

- A current month '*below average*' performance and a crash *increase* in the following month occurred *nine* times during 1998.
- A current month '*above average*' performance and a crash *increase* in the following month occurred *three* times during 1998. However the crash increases during these months could have been associated with **crash risk reductions** (as indicated by the lower confidence limit placed on the appropriate crash estimate).
- Thus, with 68% certainty, during *three* months of 1998, the performance of Region 3 was *above average* coinciding with possible *reductions* in crash risk during the following month.

Table 6.9: REGION 3. Comparison of current month's regional performance with NEXT month's % casualty crash change, January-December 1998

Month of casualty crash	Index* (previous month)	Region Performance (%)	% Crash Change	One standard error confidence limits for % crash change	
				Lower	Upper
Jan 98	99.0	-1.0	9.5	-0.3	21.4
Feb 98	103.3	3.3	6.1	-6.1	22.0
Mar 98	100.3	0.3	7.3	-6.8	26.5
Apr 98	99.1	-0.9	9.2	-7.0	32.2
May 98	98.6	-1.4	4.8	-12.0	29.5
Jun 98	96.5	-3.5	5.1	-13.0	32.7
Jul 98	97.1	-2.9	19.4	-3.0	55.2
Aug 98	96.6	-3.4	14.7	-7.3	50.4
Sep 98	96.1	-3.9	2.1	-18.6	37.0
Oct 98	99.6	-0.4	24.8	-0.6	67.8
Nov 98	98.7	-1.3	14.2	-9.8	55.6
Dec 98	101.1	1.1	8.5	-15.4	51.1

Figure 6.6: REGION 3. Comparison of current month's performance with NEXT month's casualty crashes, January-December 1998



6.4.3 Summary

During 1998 for Region 3, the monthly index was not inconsistent with the estimated casualty crash risk outcomes of that month for:

- 9 months of the year (i.e. 75% of 1998)
- 12 months of the year (i.e. *all* of 1998- when the confidence limits of the % crash risk change were considered).

And, the monthly index was not inconsistent with the *next* month's estimated casualty crash risk outcomes for:

- 9 months of the year (i.e. 75% of 1998)
- 12 months of the year (i.e. *all* of 1998 - when the confidence limits of the % crash risk change were considered).

Hence, for Region 3 during 1998, the index (which measured the Region's performance each month) reflected the next month's casualty crash risk outcomes as well and as frequently as the current month's casualty crash risk outcomes.

6.5 REGION 4

Table 6.10 gives the expected and observed number of casualty crashes per month for Region 4 together with the percentage crash change. One standard error confidence limits for the expected number of crashes, the crash ratio and the % crash change are also given in the table.

Table 6.10: REGION 4. % Casualty Crash Change per month with one standard error confidence limits, January-December 1998

LAH CASUALTY CRASHES								
Month of crash	Crash Frequencies		One standard error confidence limits for expected crashes		Crash Ratio	% crash change	One standard error confidence limits for % crash change	
	Observed	Expected	Lower	Upper			Lower	Upper
Jan 98	168	207	185	229	0.81	-19.0	-26.8	-9.3
Feb 98	203	211	186	236	0.96	-3.8	-14.0	9.2
Mar 98	238	267	232	302	0.89	-10.8	-21.1	2.5
Apr 98	179	236	203	269	0.76	-24.2	-33.5	-11.8
May 98	219	238	202	273	0.92	-7.9	-19.9	8.3
Jun 98	199	237	200	274	0.84	-16.0	-27.5	-0.3
Jul 98	194	210	175	245	0.92	-7.8	-20.9	10.6
Aug 98	197	220	182	258	0.90	-10.5	-23.7	8.3
Sep 98	192	228	187	269	0.84	-15.7	-28.6	2.9
Oct 98	204	226	183	268	0.90	-9.5	-23.7	11.2
Nov 98	228	232	188	277	0.98	-1.9	-17.7	21.5
Dec 98	213	231	186	277	0.92	-7.9	-23.0	14.6
HAH CASUALTY CRASHES								
Month of crash	Crash Frequencies		One standard error confidence limits for expected crashes		Crash Ratio	% crash change	One standard error confidence limits for % crash change	
	Observed	Expected	Lower	Upper			Lower	Upper
Jan 98	134	145	128	162	0.92	-7.8	-17.3	4.4
Feb 98	136	152	133	171	0.89	-10.6	-20.4	1.9
Mar 98	170	173	150	195	0.98	-1.5	-12.8	13.1
Apr 98	130	146	126	166	0.89	-10.9	-21.5	3.1
May 98	145	168	144	192	0.86	-13.8	-24.4	0.4
Jun 98	118	166	142	191	0.71	-29.0	-38.1	-16.8
Jul 98	138	150	127	173	0.92	-8.1	-20.3	8.3
Aug 98	135	179	151	207	0.75	-24.6	-34.9	-10.6
Sep 98	147	155	130	180	0.95	-5.0	-18.3	13.4
Oct 98	150	154	128	180	0.97	-2.8	-16.7	16.8
Nov 98	114	168	139	197	0.68	-32.2	-42.2	-18.1
Dec 98	127	159	131	188	0.80	-20.3	-32.3	-3.2
ALL CASUALTY CRASHES								
Month of crash	Crash Frequencies		One standard error confidence limits for expected crashes		Crash Ratio	% crash change	One standard error confidence limits for % crash change	
	Observed	Expected	Lower	Upper			Lower	Upper
Jan 98	302	353	325	380	0.86	-14.3	-20.6	-7.0
Feb 98	339	363	332	394	0.93	-6.6	-14.0	2.1
Mar 98	408	440	398	481	0.93	-7.2	-15.2	2.4
Apr 98	309	382	343	420	0.81	-19.1	-26.5	-10.0
May 98	364	406	363	449	0.90	-10.4	-18.9	0.2
Jun 98	317	403	358	448	0.79	-21.4	-29.2	-11.6
Jul 98	332	361	319	402	0.92	-7.9	-17.5	4.1
Aug 98	332	399	352	447	0.83	-16.8	-25.7	-5.6
Sep 98	339	382	334	431	0.89	-11.4	-21.3	1.4
Oct 98	354	380	330	429	0.93	-6.8	-17.5	7.1
Nov 98	342	401	347	454	0.85	-14.6	-24.6	-1.5
Dec 98	340	391	337	444	0.87	-13.0	-23.4	0.8

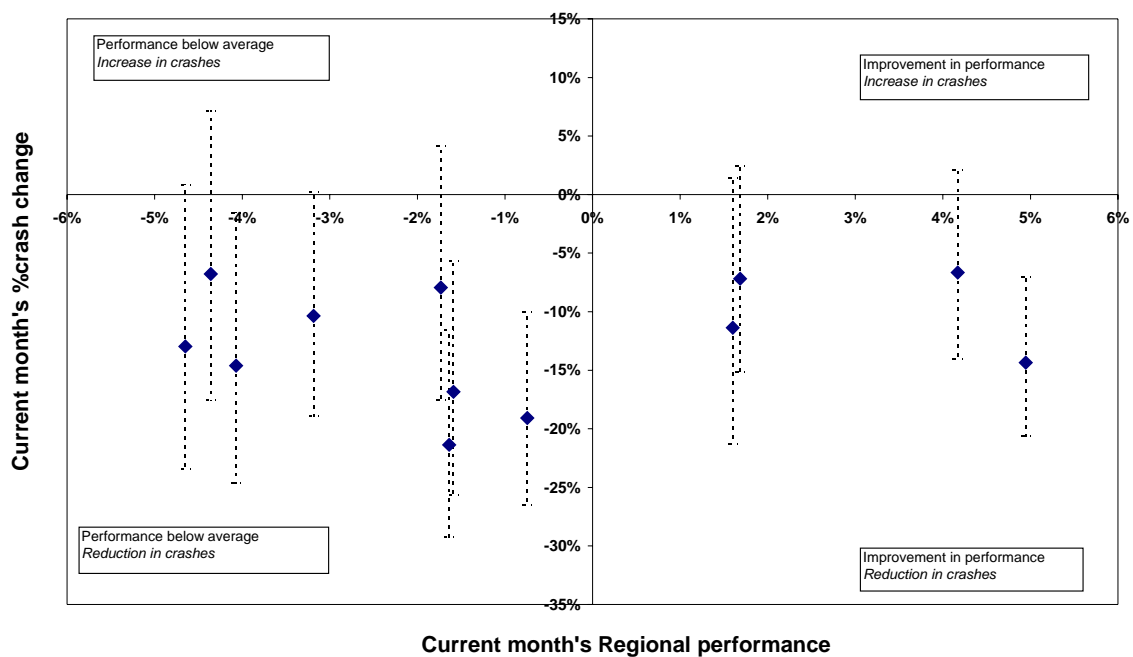
6.5.1 Comparison of current month's performance with current month's crashes

Table 6.11 and Figure 6.7 give the % crash change per month for Region 4 with one standard error confidence limits, and that Region's performance (as quantified by the index). For the index to reflect actual crash outcomes, the majority of the points in Figure 6.7 should be either in the upper left-hand corner or in the lower right-hand corner.

Table 6.11: REGION 4. Comparison of current month's regional performance with current month's % casualty crash change, January-December 1998

Month of casualty crash	Index*	Region Performance (%)	% Crash Change	One standard error confidence limits for % crash change	
				Lower	Upper
Jan 98	104.9	4.9	-14.3	-20.6	-7.0
Feb 98	104.2	4.2	-6.6	-14.0	2.1
Mar 98	101.7	1.7	-7.2	-15.2	2.4
Apr 98	99.3	-0.7	-19.1	-26.5	-10.0
May 98	96.8	-3.2	-10.4	-18.9	0.2
Jun 98	98.4	-1.6	-21.4	-29.2	-11.6
Jul 98	98.3	-1.7	-7.9	-17.5	4.1
Aug 98	98.4	-1.6	-16.8	-25.7	-5.6
Sep 98	101.6	1.6	-11.4	-21.3	1.4
Oct 98	95.6	-4.4	-6.8	-17.5	7.1
Nov 98	95.9	-4.1	-14.6	-24.6	-1.5
Dec 98	95.4	-4.6	-13.0	-23.4	0.8

Figure 6.7: REGION 4. Comparison of current month's performance with current month's casualty crashes, January-December 1998



As depicted in Figure 6.7, for Region 4:

- An *'above average'* performance and a *reduction* in crashes occurred during *four* months of 1998.
- A *'below average'* performance and a *reduction* in crashes occurred during *eight* months of 1998. However, with 68% certainty, the crash reductions during *four* of these months could have been associated with **crash risk increases** (as indicated by the upper confidence limit placed on the appropriate crash estimate).

Thus, during four months of 1998, the performance of Region 4 was above average coinciding with reductions in crashes for those months. There were also four months in 1998 when the region was performing below average and a possible increase in crash risk could have occurred (this occurred when the range of % crash change values covered by the confidence limits was taken into consideration).

6.5.2 Comparison of current month's performance with next month's crashes

Table 6.12 and Figure 6.8 compare the current month's regional performance with the next month's casualty crashes for Region 4.

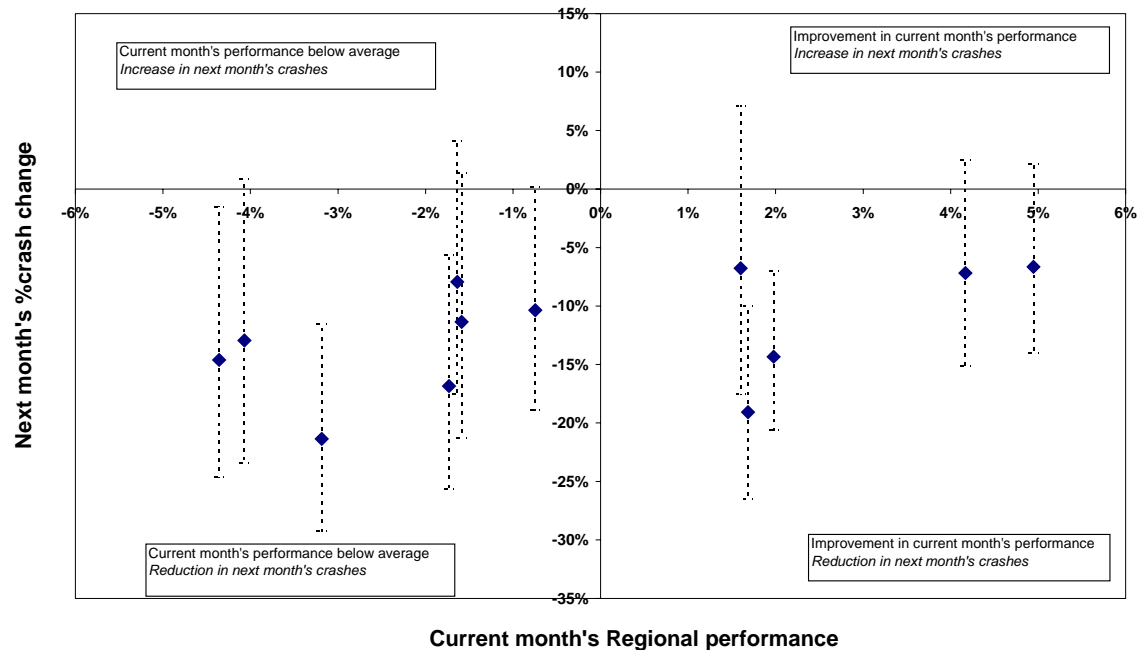
As depicted in Figure 6.8, for Region 4:

- A current month *'above average'* performance and a crash *reduction* in the following month occurred *five* times during 1998.
- A current month *'below average'* performance and a crash *reduction* in the following month occurred *seven* times during 1998. However the crash reductions during *four* of these months could have been associated with **crash risk increases** (as indicated by the upper confidence limit placed on the appropriate crash estimate).
- Thus, with 68% certainty, during *four* months of 1998, the performance in Region 4 was *below average* coinciding with **possible increases in crash risk** during the following month.

Table 6.12: REGION 4. Comparison of current month's regional performance with NEXT month's % casualty crash change, January-December 1998

Month of casualty crash	Index* (previous month)	Region Performance (%)	% Crash Change	One standard error confidence limits for % crash change	
				Lower	Upper
Jan 98	102.0	2.0	-14.3	-20.6	-7.0
Feb 98	104.9	4.9	-6.6	-14.0	2.1
Mar 98	104.2	4.2	-7.2	-15.2	2.4
Apr 98	101.7	1.7	-19.1	-26.5	-10.0
May 98	99.3	-0.7	-10.4	-18.9	0.2
Jun 98	96.8	-3.2	-21.4	-29.2	-11.6
Jul 98	98.4	-1.6	-7.9	-17.5	4.1
Aug 98	98.3	-1.7	-16.8	-25.7	-5.6
Sep 98	98.4	-1.6	-11.4	-21.3	1.4
Oct 98	101.6	1.6	-6.8	-17.5	7.1
Nov 98	95.6	-4.4	-14.6	-24.6	-1.5
Dec 98	95.9	-4.1	-13.0	-23.4	0.8

Figure 6.8: REGION 4. Comparison of current month's performance with NEXT month's casualty crashes, January-December 1998



6.5.3 Summary

During 1998 for Region 4, the monthly index was not inconsistent with the estimated casualty crash risk outcomes of that month for:

- 4 months of the year (i.e. *one third* of 1998)
- 8 months of the year (i.e. *two thirds* of 1998- when the confidence limits of the % crash risk change were considered).

And, the monthly index was not inconsistent with the *next* month's estimated casualty crash risk outcomes for:

- 5 months of the year (i.e. *42%* of 1998)
- 9 months of the year (i.e. *75%* of 1998 - when the confidence limits of the % crash risk change were considered).

Hence, for Region 4 during 1998, the index (which measured the Region's performance each month) reflected the next month's casualty crash risk outcomes better and more frequently than the current month's casualty crash risk outcomes.

6.6 REGION 5

Table 6.13 gives the expected and observed number of casualty crashes per month for Region 5 together with the percentage crash change. One standard error confidence limits for the expected number of crashes, the crash ratio and the % crash change are also given in the table.

Table 6.13: REGION 5. % Casualty Crash Change per month with one standard error confidence limits, January-December 1998

LAH CASUALTY CRASHES								
Month of crash	Crash Frequencies		One standard error confidence limits for expected crashes		Crash Ratio	% crash change	One standard error confidence limits for % crash change	
	Observed	Expected	Lower	Upper			Lower	Upper
Jan 98	167	170	150	190	0.98	-1.6	-12.0	11.6
Feb 98	171	158	139	178	1.08	8.1	-3.8	23.4
Mar 98	192	189	164	213	1.02	1.6	-10.1	16.8
Apr 98	160	160	139	182	1.00	-0.2	-12.1	15.4
May 98	167	176	151	201	0.95	-5.2	-16.9	10.3
Jun 98	165	163	140	187	1.01	1.0	-11.8	18.2
Jul 98	172	155	132	179	1.11	10.8	-3.6	30.4
Aug 98	159	153	130	177	1.04	3.7	-10.2	22.6
Sep 98	147	150	126	173	0.98	-1.8	-15.2	16.8
Oct 98	172	164	137	191	1.05	4.9	-9.8	25.3
Nov 98	184	175	145	204	1.05	5.4	-9.6	26.5
Dec 98	156	173	143	202	0.90	-9.7	-22.9	8.8
HAH CASUALTY CRASHES								
Month of crash	Crash Frequencies		One standard error confidence limits for expected crashes		Crash Ratio	% crash change	One standard error confidence limits for % crash change	
	Observed	Expected	Lower	Upper			Lower	Upper
Jan 98	143	104	86	121	1.38	38.0	18.3	65.7
Feb 98	113	101	82	120	1.12	12.1	-5.9	38.4
Mar 98	135	122	97	147	1.11	10.8	-8.2	39.6
Apr 98	132	100	79	122	1.32	31.6	8.1	68.1
May 98	118	103	79	126	1.15	15.1	-6.3	49.0
Jun 98	115	106	81	131	1.08	8.4	-12.3	42.0
Jul 98	94	92	69	114	1.03	2.5	-17.7	35.9
Aug 98	110	97	72	121	1.14	13.9	-9.1	52.7
Sep 98	109	107	79	135	1.02	1.8	-19.3	38.0
Oct 98	136	112	82	143	1.21	21.0	-4.6	65.5
Nov 98	118	127	92	163	0.93	-7.4	-27.4	27.7
Dec 98	129	112	81	144	1.15	15.0	-10.1	59.5
ALL CASUALTY CRASHES								
Month of crash	Crash Frequencies		One standard error confidence limits for expected crashes		Crash Ratio	% crash change	One standard error confidence limits for % crash change	
	Observed	Expected	Lower	Upper			Lower	Upper
Jan 98	310	273	247	300	1.13	13.4	3.4	25.6
Feb 98	284	259	232	287	1.10	9.6	-0.9	22.6
Mar 98	327	311	276	346	1.05	5.2	-5.5	18.6
Apr 98	292	261	230	291	1.12	12.0	0.2	27.0
May 98	285	279	245	313	1.02	2.3	-8.9	16.5
Jun 98	280	269	235	304	1.04	3.9	-7.9	19.2
Jul 98	266	247	215	279	1.08	7.7	-4.8	24.0
Aug 98	269	250	216	284	1.08	7.6	-5.3	24.6
Sep 98	256	257	220	293	1.00	-0.3	-12.7	16.4
Oct 98	308	276	236	317	1.11	11.5	-2.7	30.5
Nov 98	302	302	256	348	1.00	-0.01	-13.1	17.8
Dec 98	285	285	242	328	1.00	0.01	-13.1	17.8

6.6.1 Comparison of current month's performance with current month's crashes

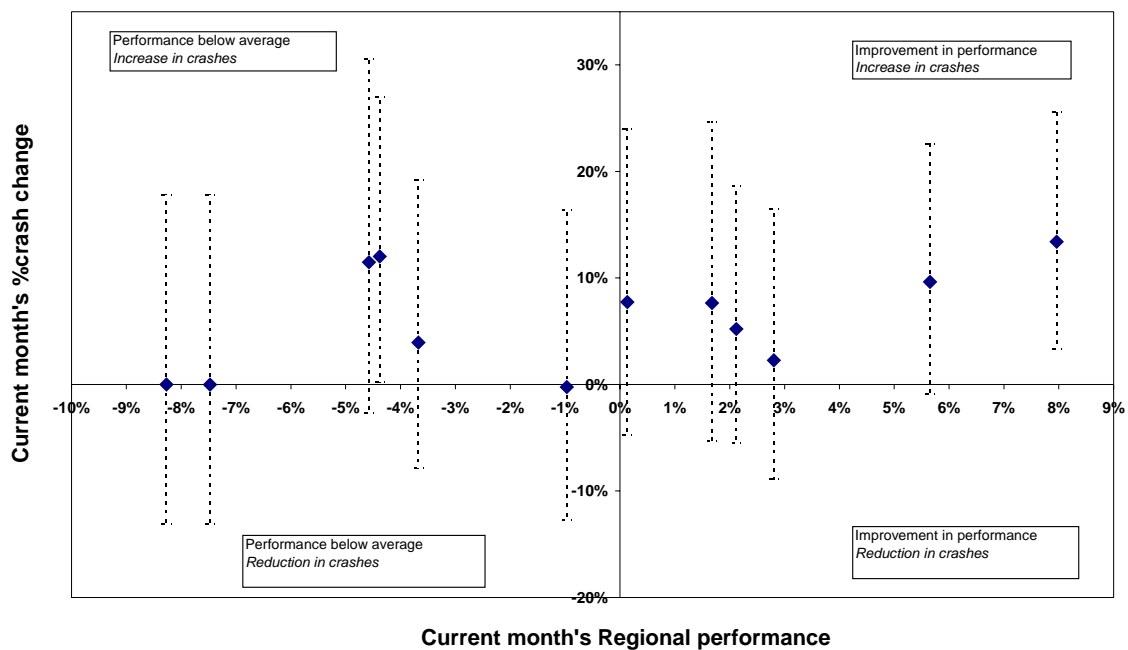
Table 6.14 and Figure 6.9 give the % crash change per month for Region 5 with one standard error confidence limits, and that Region's performance (as quantified by the index).

For the index to reflect actual crash outcomes, the majority of the points in Figure 6.9 should be either in the upper left-hand corner or in the lower right-hand corner.

Table 6.14: REGION 5. Comparison of current month's regional performance with current month's % casualty crash change, January-December 1998

Month of casualty crash	Index*	Region Performance (%)	% Crash Change	One standard error confidence limits for % crash change	
				Lower	Upper
Jan 98	8.0	108.0	13.4	3.4	25.6
Feb 98	5.7	105.7	9.6	-0.9	22.6
Mar 98	2.1	102.1	5.2	-5.5	18.6
Apr 98	-4.4	95.6	12.0	0.2	27.0
May 98	2.8	102.8	2.3	-8.9	16.5
Jun 98	-3.7	96.3	3.9	-7.9	19.2
Jul 98	0.1	100.1	7.7	-4.8	24.0
Aug 98	1.7	101.7	7.6	-5.3	24.6
Sep 98	-1.0	99.0	-0.3	-12.7	16.4
Oct 98	-4.6	95.4	11.5	-2.7	30.5
Nov 98	-7.5	92.5	-0.01	-13.1	17.8
Dec 98	-8.3	91.7	0.01	-13.1	17.8

Figure 6.9: REGION 5. Comparison of current month's performance with current month's casualty crashes, January-December 1998



As depicted in Figure 6.9, for Region 5:

- A '*below average*' performance and an *increase* in crashes occurred during *four* months of 1998.
- A '*below average*' performance and a *reduction* in crashes occurred during *two* months of 1998. However, with 68% certainty, the crash reductions during these months could potentially have been associated with **crash risk increases** (as indicated by the upper confidence limit placed on the appropriate crash estimate).
- An '*above average*' performance and an *increase* in crashes occurred during *six* months of 1998. However, the crash increases during *five* of these months could have been associated with **crash risk reductions** (as indicated by the lower confidence limit placed on the appropriate crash estimate).

Thus, with 68% certainty, during *five* months of 1998, the performance of Region 5 was *above average* coinciding with possible *reductions* in crash risk. There were also *six* months when the performance of Region 5 was *below average* coinciding with possible *increases* in crash risk during these months.

6.6.2 Comparison of current month's performance with next month's crashes

Table 6.15 and Figure 6.10 compare the current month's regional performance with the next month's casualty crashes for Region 5.

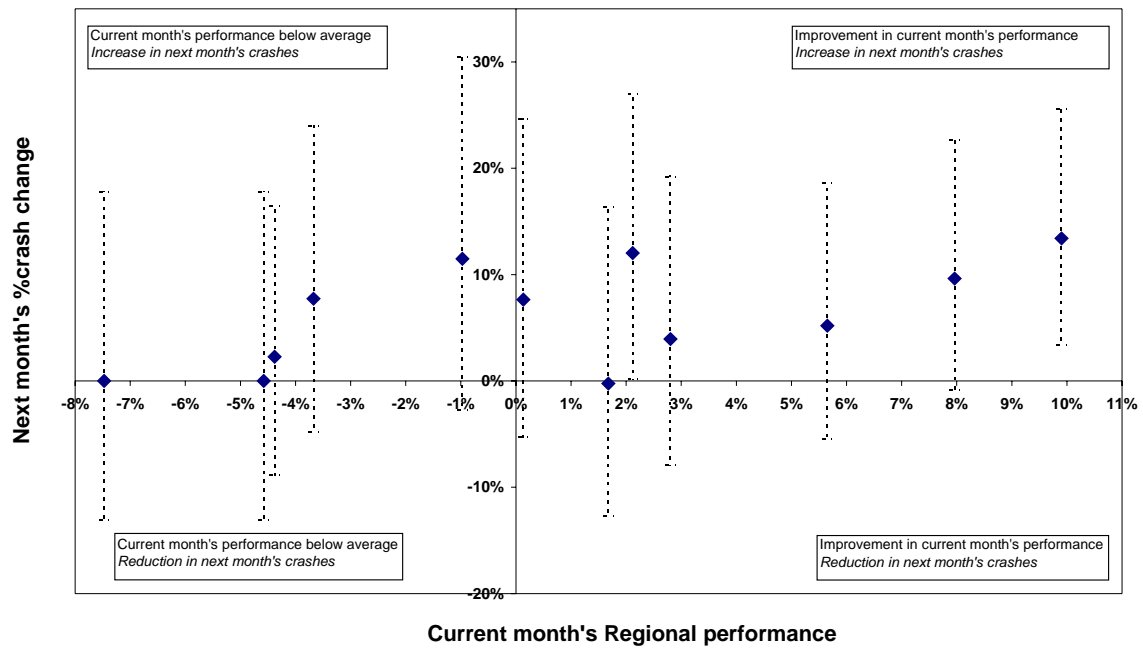
As shown in Figure 6.10, for Region 5:

- A current month '*above average*' performance and a crash *reduction* in the following month occurred *once* during 1998.
- A current month '*above average*' performance and a crash *increase* in the following month occurred *six* times during 1998. However the crash increases during *four* of these months could have been associated with **crash risk reductions** (as indicated by the lower confidence limit placed on the appropriate crash estimate).
- Thus, with 68% certainty, during *five* months of 1998, the performance in Region 5 was *above average* coinciding with a possible *reduction* in crash risk during the following month.
- A current month '*below average*' performance and a crash *increase* in the following month occurred *four* times during 1998.
- A current month '*below average*' performance and a crash *reduction* in the following month occurred *once* during 1998. However this crash reduction could have been associated with a crash risk increase (as indicated by the upper confidence limit placed on the appropriate crash estimate).
- Thus, during *five* months of 1998, the performance of Region 5 was *below average* coinciding with a possible *increase* in crash risk during the following month.

Table 6.15: REGION 5. Comparison of current month's regional performance with NEXT month's % casualty crash change, January-December 1998

Month of casualty crash	Index* (previous month)	Region Performance (%)	% Crash Change	One standard error confidence limits for % crash change	
				Lower	Upper
Jan 98	9.9	109.9	13.4	3.4	25.6
Feb 98	8.0	108.0	9.6	-0.9	22.6
Mar 98	5.7	105.7	5.2	-5.5	18.6
Apr 98	2.1	102.1	12.0	0.2	27.0
May 98	-4.4	95.6	2.3	-8.9	16.5
Jun 98	2.8	102.8	3.9	-7.9	19.2
Jul 98	-3.7	96.3	7.7	-4.8	24.0
Aug 98	0.1	100.1	7.6	-5.3	24.6
Sep 98	1.7	101.7	-0.3	-12.7	16.4
Oct 98	-1.0	99.0	11.5	-2.7	30.5
Nov 98	-4.6	95.4	-0.01	-13.1	17.8
Dec 98	-7.5	92.5	0.01	-13.1	17.8

Figure 6.10: REGION 5. Comparison of current month's performance with NEXT month's casualty crashes, January-December 1998



6.6.3 Summary

During 1998 for Region 5, the monthly index was not inconsistent with the estimated casualty crash risk outcomes of that month for:

- 4 months of the year (i.e. *one third* of 1998)
- 11 months of the year (i.e. 92% of 1998- when the confidence limits of the % crash risk change were considered).

And, the monthly index was not inconsistent with the *next* month's estimated casualty crash risk outcomes for:

- 5 months of the year (i.e. 42% of 1998)
- 10 months of the year (i.e. 83% of 1998 - when the confidence limits of the % crash risk change were considered).

Hence, for Region 5 during 1998, the index (which measured the Region's performance each month) reflected the next month's casualty crash risk outcomes about the same and as frequently as the current month's casualty crash risk outcomes.

6.7 ALL REGIONS COMBINED

The observed and expected number of casualty crashes per month for each Region were combined to give the overall crash ratio and percentage crash change for Victoria (Table 6.16). The index for each Region was also combined to give a statewide average per month.

Table 6.16: ALL REGIONS. % Casualty Crash Change per month with one standard error confidence limits, January-December 1998

ALL CASUALTY CRASHES			One standard error confidence limits for expected crashes		Crash Ratio	% crash change	One standard error confidence limits for % crash change	
Month of crash	Crash Frequencies		Lower	Upper			Lower	Upper
	Observed	Expected						
Jan 98	1360	1372	1317	1427	0.99	-0.9	-4.7	3.3
Feb 98	1429	1475	1406	1545	0.97	-3.1	-7.5	1.6
Mar 98	1633	1655	1569	1741	0.99	-1.3	-6.2	4.1
Apr 98	1441	1493	1406	1580	0.97	-3.5	-8.8	2.5
May 98	1530	1574	1477	1671	0.97	-2.8	-8.4	3.6
Jun 98	1443	1536	1435	1637	0.94	-6.0	-11.8	0.6
Jul 98	1445	1427	1325	1529	1.01	1.2	-5.5	9.0
Aug 98	1426	1487	1380	1594	0.96	-4.1	-10.5	3.3
Sep 98	1378	1465	1352	1578	0.94	-5.9	-12.7	1.9
Oct 98	1609	1510	1391	1629	1.07	6.6	-1.2	15.7
Nov 98	1567	1587	1460	1715	0.99	-1.3	-8.6	7.4
Dec 98	1433	1572	1437	1708	0.91	-8.9	-16.1	-0.3

6.7.1 Comparison of current month's performance with current month's crashes

Table 6.17 and Figure 6.11 give the % crash change per month for all Regions combined with one standard error confidence limits, and the combined Regional performance (as quantified by the index).

For the index to reflect actual crash outcomes, the majority of the points in Figure 6.11 should be either in the upper left-hand corner or in the lower right-hand corner.

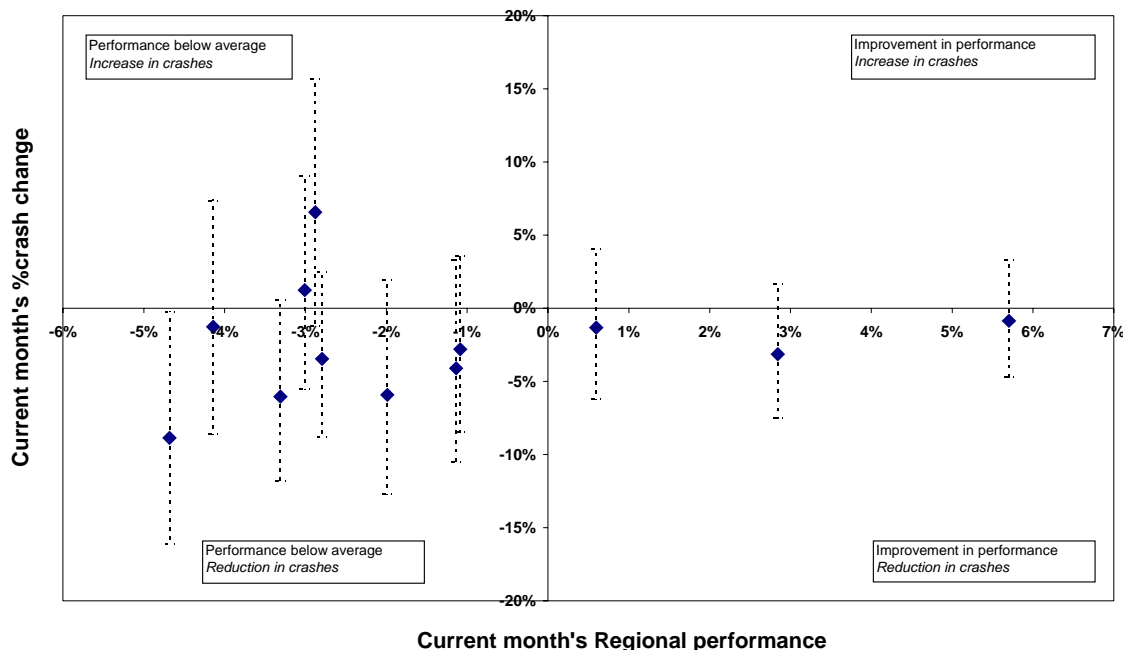
As shown in Figure 6.11, for all the regions combined:

- An ‘*above average*’ performance and a *reduction* in crashes occurred during *three* months of 1998.
- A ‘*below average*’ performance and an *increase* in crashes occurred during *two* months of 1998.
- A ‘*below average*’ performance and a *reduction* in crashes occurred during *seven* months of 1998. However, with 68% certainty, the crash reductions during *six* of these months could potentially have been associated with **crash risk increases** (as indicated by the upper confidence limit placed on the appropriate crash estimate).
- Thus, with 68% certainty, during *eight* months of 1998, the performance of the combined Regions was *below average* coinciding **with possible increases in crash risk** during these months.

Table 6.17: ALL REGIONS. Comparison of current month’s regional performance with current month’s % casualty crash change, January-December 1998

Month of casualty crash	Index*	Region Performance (%)	% Crash Change	One standard error confidence limits for % crash change	
				Lower	Upper
Jan 98	105.7	5.7	-0.9	-4.7	3.3
Feb 98	102.8	2.8	-3.1	-7.5	1.6
Mar 98	100.6	0.6	-1.3	-6.2	4.1
Apr 98	97.2	-2.8	-3.5	-8.8	2.5
May 98	98.9	-1.1	-2.8	-8.4	3.6
Jun 98	96.7	-3.3	-6.0	-11.8	0.6
Jul 98	97.0	-3.0	1.2	-5.5	9.0
Aug 98	98.9	-1.1	-4.1	-10.5	3.3
Sep 98	98.0	-2.0	-5.9	-12.7	1.9
Oct 98	97.1	-2.9	6.6	-1.2	15.7
Nov 98	95.9	-4.1	-1.3	-8.6	7.4
Dec 98	95.3	-4.7	-8.9	-16.1	-0.3

Figure 6.11: ALL REGIONS. Comparison of current month's performance with current month's casualty crashes, January-December 1998



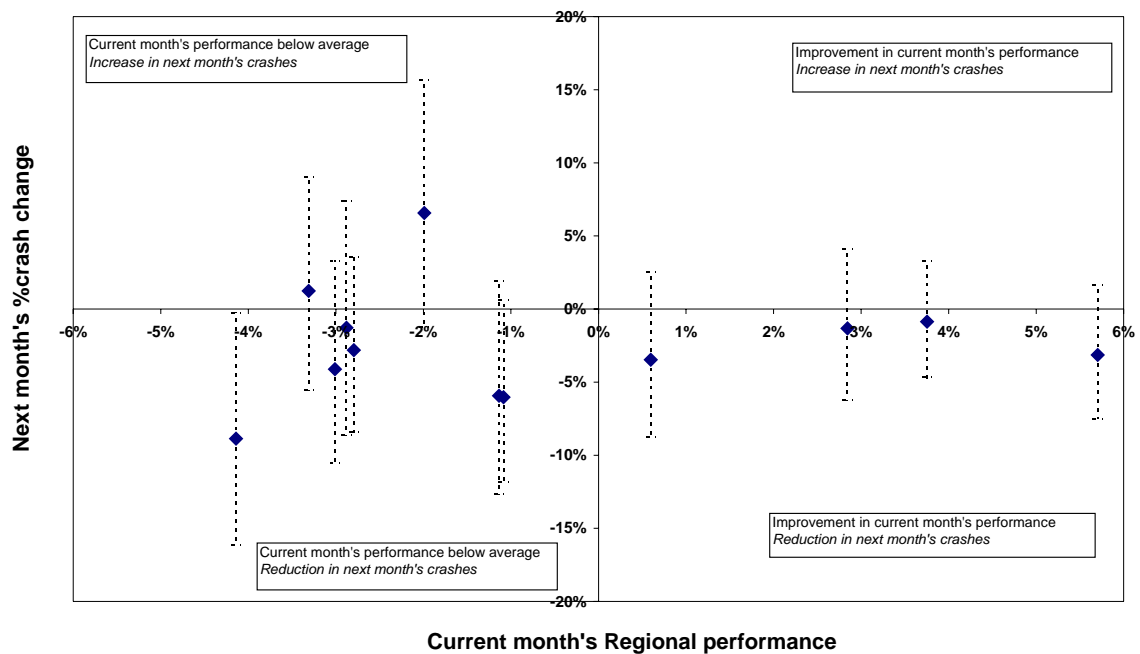
6.7.2 Comparison of current month's performance with next month's crashes

Table 6.18 and Figure 6.12 compare the current month's regional performance with the next month's casualty crashes for the combined Regions.

Table 6.18: ALL REGIONS. Comparison of current month's regional performance with NEXT month's % casualty crash change, January-December 1998

Month of casualty crash	Index*	Region Performance (%)	% Crash Change	One standard error confidence limits for % crash change	
				Lower	Upper
Jan 98	103.8	3.8	-0.9	-4.7	3.3
Feb 98	105.7	5.7	-3.1	-7.5	1.6
Mar 98	102.8	2.8	-1.3	-6.2	4.1
Apr 98	100.6	0.6	-3.5	-8.8	2.5
May 98	97.2	-2.8	-2.8	-8.4	3.6
Jun 98	98.9	-1.1	-6.0	-11.8	0.6
Jul 98	96.7	-3.3	1.2	-5.5	9.0
Aug 98	97.0	-3.0	-4.1	-10.5	3.3
Sep 98	98.9	-1.1	-5.9	-12.7	1.9
Oct 98	98.0	-2.0	6.6	-1.2	15.7
Nov 98	97.1	-2.9	-1.3	-8.6	7.4
Dec 98	95.9	-4.1	-8.9	-16.1	-0.3

Figure 6.12: ALL REGIONS. Comparison of current month's performance with NEXT month's casualty crashes, January-December 1998



As shown in Figure 6.12, for the combined Regions:

- A current month 'above average' performance and a *reduction* in crashes in the following month occurred *four* times during 1998.
- A current month 'below average' performance and an *increase* in crashes in the following month occurred *two* times during 1998.
- A current month 'below average' performance and a *reduction* in crashes in the following month occurred *six* times during 1998. However the crash reductions during *five* of these months could have been associated with **crash risk increases** (as indicated by the upper confidence limit placed on the appropriate crash estimate).
- Thus, with 68% certainty, during *seven* months of 1998, the performance of the combined Regions was *below average* coinciding with a possible *increase* in crash risk during the following month.

6.7.3 Summary

During 1998 for the combined Regions, the monthly index was not inconsistent with the estimated casualty crash risk outcomes of that month for:

- 5 months of the year (i.e. 42% of 1998)
- 11 months of the year (i.e. 92% of 1998- when the confidence limits of the % crash risk change were considered).

And, the monthly index was not inconsistent with the *next* month's estimated casualty crash risk outcomes for:

- 6 months of the year (i.e. *half* of 1998)
- 11 months of the year (i.e. 92% of 1998 - when the confidence limits of the % crash risk change were considered).

Hence, for the combined Regions during 1998, the index (which measured the Regional performance each month) reflected the next month's casualty crash risk outcomes better and more frequently than the current month's casualty crash risk outcomes.

7. DISCUSSION

7.1 DEVELOPMENT OF THE INDEX

The Victoria Police requested MUARC to develop a procedure that would measure traffic enforcement outcome levels against expected levels for each Victoria Police Region. This followed a MUARC review of a Police internally developed index, which had been established to measure the effectiveness of Police Districts in meeting their road safety objectives.

The purpose of this study was to develop relationships connecting monthly casualty crashes in each of the five Police Regions with monthly variations in variables representing exposure, enforcement activity and other factors measured in each Region.

These relationships were achieved using 'state-space' time-series regression modelling techniques. These models are a more flexible family of models than econometric or traditional 'fixed-effects' models in that they allow certain parameters to have stochastic (random) variation from one period of observation to the next. The 'fixed-effects' models used by MUARC to date may suffer because they assume the effects of the enforcement operations and other factors have fixed relations over the time period modelled, which was the nine years 1989-1997 in this study.

The models developed revealed the relative contribution of an increase in each enforcement operation to reducing the risk of casualty crashes in each Region after the effects of exposure changes and other factors had been taken into account. The coefficients (obtained from the regression models in most cases) measured the relative contribution of each enforcement operation, specific to each Region, and formed the basis of an index which allowed the overall contribution to traffic safety produced by the mix of enforcement activities in each Region to be assessed and compared between Regions.

The relationship between casualty crashes and explanatory factors during time t was assumed to have the following form:

$$\text{Crashes}_t = a * (\text{exposure factor}_t)^b * (\text{enforcement factors}_t)^c * (\text{other factors affecting risk}_t)^d.$$

However, the only terms in this equation that were relevant to the calculation of the index were the enforcement factors. This is because the other variables or factors represent either the total potential for crashes (i.e. exposure such as population or vehicle travel) or represent the effects of other, non-enforcement factors on risk (i.e. unemployment rate, road safety advertising, alcohol sales) that are beyond the control of traffic police management.

Pragmatically, therefore, the index was expressed as:

$$Index_t = (random\ breath\ tests_t)^a * (speed\ camera\ traffic\ infringement\ notices_t)^b \\ * (penalty\ notice\ offences_t)^c * (mobile\ radar\ hours_t)^d * (laser\ hours_t)^e.$$

The parameters relating to random breath tests (RBTs), speed camera traffic infringement notices (TINs) and Penalty Notice offences were found by regression methods (i.e. using ‘state-space’ modelling techniques) because there was sufficient historical data to allow for this type of estimation. However, the parameters relating to mobile radar and laser hours of operation were estimated from independent evaluation studies since the data for these types of operations covered a period of one year (for laser operations) and under three years (for mobile radar operations).

There was also a need to make the index independent of scale so that Regions could be compared. This involved re-expressing the index in terms of *ratios* of Police activity. The enforcement activity (hours or offences) achieved during a particular month was divided by the monthly average of a base period (e.g. the previous year) so that the indices developed for each Region would be on the same scale and therefore be comparable.

7.2 INDEX INTERPRETATION AND RESULTS

An index for each Region was developed for the months January-December 1998 using the monthly average during 1997 as the base period. There was some variation found in the monthly indices both between and within Regions. For example, during January 1998 each Region performed better than what would have been expected on average during 1997, with Region 2 and Region 5 performing best amongst all Regions. However, during April, June, October and December each Region performed below what was expected on average for 1997. For the other months, some regions performed above average in a particular month whilst others performed below average.

When considering the overall index (i.e. for all regions combined – based on the five regions’ average), the estimated index has shown that relative to the previous year (1997), the Police performed better than average during the *first quarter of 1998*, but decreased their performance for the rest of the year. It should be noted, however, that some regions performed better than average during some of the later months of 1998.

Although the Police performance, as reflected by the index, was below average for most of 1998, the index should still be considered as a valuable tool for Police. This is because each Region’s developed index consists of *negative* parameters relating to all or some of the following enforcement operations – the number of random breath tests, the number of speed camera TINs issued, the number of penalty notice offences issued, the hours of mobile radar operations and the hours of laser operations.

The parameters or coefficients of these operations measured the relative contribution of an increase in each enforcement operation, specific to each Region, to reducing the casualty crash risk per Region. Because the parameters were, in most circumstances, negative, then this suggests that Police should *increase* their operations of that type of enforcement in a particular Region to reduce the risk of casualty crashes. For example, an increase in the levels of a particular type of enforcement (e.g. the number

of RBTs) in a specific Region (e.g. Region 4) is associated with a reduction in casualty crash risk.

Thus, the value of the index to the Police is that it indicates which enforcement operations Police should increase their resources in per Region to reduce the risk of casualty crash in that Region.

7.3 TESTING THE INDEX AGAINST CRASH OUTCOMES

Although the indices developed for each Region during January-December 1998 have face value in that they can be assessed and compared, they needed to be tested against actual road safety performance. This was achieved by comparing the actual crash frequencies in a particular month with the expected levels (projected from the estimated models).

The testing of the index against crash outcomes per month appeared to work best when Police were performing better than average (as measured by the index), with reductions in casualty crash risk occurring in most cases. This was even more evident when the current month's index was compared with the *next month's* crash risk outcomes. But since Police performance was better than expected only during the first quarter of 1998, there was little opportunity during 1998 for the index to reflect actual casualty crash reductions.

For the months of 1998, when there were fewer crashes observed that month than were forecast by the model, then a % casualty crash reduction was estimated to have occurred. Thus there were fewer crashes observed than were expected to have occurred had there been no change in the levels of enforcement on the previous year on average, since the forecasts have assumed the previous year's monthly average for the values of the enforcement variables. If the observed number of crashes in a particular month were less than the forecast number of crashes this would suggest that Police were performing better than the previous year on average (i.e. this is reflected in an estimated index value above 100). However, since there were few months in 1998 when the Police performance *was* better than the previous year, then the opportunity for the index to reflect actual crash reductions was limited.

When the Police performance was below average, the index did not reflect casualty crash risk as well as it did when the performance was above average. During the months when the performance was below average, a mix of casualty crash risk increases and casualty crash risk reductions occurred. This may have been because Police performance was better in 1997 (the comparison year) than in 1998. Possibly 1998 was not a year when the levels of Police enforcement (e.g. the number of speed camera TINs issued or the number of random breath tests achieved) were more than those achieved during 1997 on average – this is reflected in the index, and hence the crash risk outcomes.

When the Police performance was below that which was expected, a corresponding increase in casualty crash risk should theoretically have occurred – i.e. there should have been more crashes observed than forecast. But this did not always happen during 1998. There were a number of months in 1998, when there were fewer crashes

observed than expected, and the Police performance was below average that month. This was still evident when the Police performance was compared with the next month's crash outcomes.

Thus the index appears to reflect actual casualty crash outcomes better when the Police were performing above average – reflected in reductions in casualty crash risk. This was not as evident when Police were performing below average – this was reflected in both increases and decreases in the casualty crash risk.

8. CONCLUSION

The index developed for each Region for the months January-December 1998 found some variation both between and within Regions. During January, each Region performed better than what would have been expected on average during 1997. However, during April, June, October and December each Region performed below what was expected on average.

When considering the overall index (i.e. for all regions combined – based on the five regions' average), the estimated index has shown that relative to the previous year (1997), the Police performed better than average during the first quarter of 1998, but decreased their performance for the rest of the year.

Although the Police performance, as reflected by the index, was below average for most of 1998, the index should still be considered as a valuable tool for Police. This is because each Region's developed index consists of negative parameters relating to all or some of the following enforcement operations – the number of random breath tests, the number of speed camera TINs issued, the number of penalty notice offences issued, the hours of mobile radar operations and the hours of laser operations. Since the parameters are negative, Police should increase their operations of that type of enforcement in a particular Region to reduce the risk of casualty crashes.

Thus, the value of the index to the Police is that it specifies which enforcement operations Police should increase their resources in per Region to reduce the risk of casualty crash in that Region.

Even though the indices developed for each Region had face value in that they could be assessed and compared, they needed to be tested against actual road safety performance. This was achieved by comparing the observed crash frequencies per month during January-December 1998 with the expected levels (projected from the estimated models).

This testing procedure appeared to work best when Police were performing better than average (as measured by the index), with reductions in casualty crash risk occurring in most cases. This was even more evident when the current month's index was compared with the next month's crash risk outcomes. However, when Police were performing below average, the index did not reflect casualty crash outcomes as well as it did when the performance was above average – both increases and decreases in casualty crash risk occurred.

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APPENDIX A

Composition of each new Police Region in terms of Police Districts and Sub-Districts

TABLE A1
REGION 1: MELBOURNE (inner & south)

Police Station	Police District	Police Sub-District
CARLTON	A	ACA
COLLINGWOOD	A	ACL
BURKE STREET	A	ACP
CITY WEST	A	ACW
EAST MELBOURNE	A	AEM
FITZROY	A	AFZ
MELBOURNE	A	AML
RICHMOND	A	ARM
ROYAL PARK	A	ARP
RUSSELL STREET	A	ARS
VICTORIA DOCK	A	AVD
ELWOOD	B	BEL
PORT MELBOURNE	B	BPM
PRAHRAN	B	BPR
ST KILDA	B	BSK
SOUTH MELBOURNE	B	BSM
ST KILDA ROAD	B	BSR
BENTLEIGH EAST	C	CBE
BENTLEIGH	C	CBN
BRIGHTON	C	CBT
BEAUMARIS	C	CBU
CAULFIELD	C	CCF
CORPORATE CRIME	C	CCG
CHELtenham	C	CCH
ELSTERNWICK	C	CEK
GLENHUNTLY	C	CGH
MURRUMBEENA	C	CMA
MOORABBIN	C	CMB
MURRUMBEENA OLD	C	CMU
MALVERN	C	CMV
SANDRINGHAM	C	CSN
CHELSEA	D	DCS
MORDIALLOC	D	DMC

TABLE A2**REGION 2: Melbourne (west) and Rural Victoria (west & south-west)**

Police Station	Police District	Police Sub-District
KEILOR DOWNS	I	IKD
ST. ALBANS	I	ISA
ALTONA NORTH	J	JAN
BACCHUS MARSH	J	JBM
FOOTSCRAY	J	JFC
KINGSVILLE	J	JKV
LAVERTON	J	JLV
MELTON	J	JML
MAIDSTONE	J	JMS
NEWPORT	J	JNP
SUNSHINE	J	JSN
WERRIBEE	J	JWB
WILLIAMSTOWN	J	JWT
YARRAVILLE	J	JYV
ANGLESEA	K	KAS
BIRREGURRA	K	KBG
BARWON HEADS	K	KBH
BANNOCKBURN	K	KBK
CORIO	K	KCI
DRYSDALE	K	KDR
GEELONG	K	KGL
INVERLEIGH	K	KIV
LARA	K	KLA
LORNE	K	KLN
MEREDITH	K	KMD
OCEAN GROVE	K	KOG
PORTARLINGTON	K	KPA
QUEENSCLIFF	K	KQC
ROKEWOOD	K	KRK
TORQUAY	K	KTY
WINCHELSEA	K	KWN
APOLLO BAY	L	LAB
BEEAC	L	LBC
BEECH FOREST	L	LBF
BALMORAL	L	LBL
BRANXHOLME	L	LBX
COBDEN	L	LCB
COLERAINE	L	LCL
COLAC	L	LCO
CAMPERDOWN	L	LCP
CRESSY	L	LCR
CASTERTON	L	LCS
CAVENDISH	L	LCV
DARTMOOR	L	LDA
DUNKELD	L	LDK
FOREST	L	LFO
HAMILTON	L	LHA
HEYWOOD	L	LHW
KOROIT	L	LKT
LISMORE	L	LLM
MACARTHUR	L	LMC
MORTLAKE	L	LMK
MERINO	L	LMO

Table A2 continued....

TABLE A2		
REGION 2: Melbourne (west) and Rural Victoria (west & south-west)		
Police Station	Police District	Police Sub-District
PORT CAMPBELL	L	LPC
PORT FAIRY	L	LPF
PENSHURST	L	LPH
PORTLAND	L	LPL
SKIPTON	L	LSK
TIMBOON	L	LTB
TERANG	L	LTR
WARRNAMBOOL	L	LWB
ARARAT	M	MAR
APSLEY	M	MAS
AVOCA	M	MAV
BALLARAT	M	MBA
BEAUFORT	M	MBF
BALLAN	M	MBL
BUNINYONG	M	MBY
CRESWICK	M	MCK
CLUNES	M	MCL
DAYLESFORD	M	MDF
DIMBOOLA	M	MDM
EDENHOPE	M	MEH
ELMHURST	M	MEL
GOROKE	M	MGK
GORDON	M	MGN
HALLS GAP	M	MHG
HORSHAM	M	MHM
HARROW	M	MHW
JEPARIT	M	MJP
KANIVA	M	MKN
LAKE BOLAC	M	MLB
LANDSBOROUGH	M	MLD
LEARMONTH	M	MLM
LINTON	M	MLT
LEXTON	M	MLX
MURTOA	M	MMT
MINYIP	M	MMY
NATIMUK	M	MNK
NHILL	M	MNL
RAINBOW	M	MRB
RUPANYUP	M	MRP
ST ARNAUD	M	MSA
SKIPTON	M	MSK
SMYTHESDALE	M	MSM
STAWELL	M	MSW
WARRACKNABEAL	M	MWK
WILLAURA	M	MWR
BEULAH	N	NBH
HOPETOUN	N	NHT
WOOMELNAG	N	NOW
SPEED	N	NSP
DUNOLLY	O	ODY
MARYBOROUGH	O	OMB
TRENTHAM	O	OTM

TABLE A3
REGION 3: Melbourne (northern) and Rural Victoria (north-west & north)

Police Station	Police District	Police Sub-District
EPPING	H	HEP
MILL PARK	H	HMP
NORTHCOTE	H	HNC
PRESTON EAST	H	HPE
PRESTON	H	HPR
RESERVOIR	H	HRV
THOMASTOWN	H	HTT
WHITTLESEA	H	HWS
AVONDALE HEIGHTS	I	IAH
BROADMEADOWS	I	IBS
BRUNSWICK	I	IBW
CRAIGIEBURN	I	ICB
CAMBELFIELD	I	ICF
COBURG	I	ICG
FLEMINGTON	I	IFM
GISBORNE	I	IGS
MACEDON	I	IMC
MOONEE PONDS	I	IMP
RIDDELLS CREEK	I	IRC
SUNBURY	I	ISB
AIRPORT	I	ITM
WESTMEADOWS	I	IWM
DONALD	M	MDD
BIRCHIP	N	NBP
CULGOA	N	NCU
KOONDROOK	N	NKK
KERANG	N	NKR
LAKE BOGA	N	NLB
MERBEIN	N	NMB
MILDURA	N	NMD
MANANGATANG	N	NMG
MURRAYVILLE	N	NMV
NYAH WEST	N	NNW
OUYEN	N	NOY
PIANGIL	N	NPG
QUAMBATOOK	N	NQM
REDCLIFFS	N	NRC
ROBINVALE	N	NRV
SWAN HILL	N	NSH
SEA LAKE	N	NSL
UNDERBOOL	N	NUB
WERRIMULL	N	NWM
WYCHEPROOF	N	NWP
AXEDALE	O	OAX
BENDIGO	O	OBO
BOORT	O	OBT
BRIDGEWATER	O	OBW
COHUNA	O	OCH
CASTLEMAINE	O	OCM
CHARLTON	O	OCN
COBRAM	O	OCO
DOOKIE	O	ODK
ECHUCA	O	OEC
EAGLEHAWK	O	OEK

Table A3 continued....

TABLE A 3		
REGION 3: Melbourne (northern) and Rural Victoria (north-west & north)		
Police Station	Police District	Police Sub-District
ELMORE	O	OEL
GUNBOWER	O	OGB
GOORNONG	O	OGN
HEATHCOTE	O	OHC
INGLEWOOD	O	OIW
KYABRAM	O	OKB
KANGAROO FLAT	O	OKF
KATAMATITE	O	OKT
KYNETON	O	OKY
LANCEFIELD	O	OLF
MALDON	O	OML
MOOROOPNA	O	OMR
MURCHISON	O	OMS
MITIAMO	O	OMT
MALMSBURY	O	OMY
NUMURKAH	O	ONM
NEWSTEAD	O	ONS
NATHALIA	O	ONT
PYRAMID HILL	O	OPH
ROCHESTER	O	ORC
RIDDELLS CREEK	O	ORK
ROMSEY	O	ORM
RUSHWORTH	O	ORW
RAYWOOD	O	ORY
SHEPPARTON	O	OSH
ST JAMES	O	OSJ
STANHOPE	O	OSP
TARNAGULLA	O	OTG
TUNGAMAH	O	OTH
TONGALA	O	OTN
TATURA	O	OTT
WEDDERBURN	O	OWB
WOODEND	O	OWE
YARRAWONGA	P	PYW

TABLE A4**REGION 4: Melbourne (eastern) and Rural Victoria (north-east)**

Police Station	Police District	Police Sub-District
CLAYTON	C	CCY
OAKLEIGH	C	COL
BORONIA	F	FBO
BELGRAVE	F	FBV
BAYSWATER	F	FBW
CROYDON	F	FCR
FENTREE GULLY	F	FFG
HEALESVILLE	F	FHV
KNOX	F	FKN
LILYDALE	F	FLD
MT EVELYN	F	FME
MONBULK	F	FMK
MOOROOLBARK	F	FMO
OLINDA	F	FOL
RINGWOOD	F	FRW
WARBURTON	F	FWB
YARRA GLEN	F	FYG
YARRA JUNCTION	F	FYJ
ASHBURTON	G	GAN
BURWOOD	G	GBD
BOX HILL	G	GBH
BALWYN	G	GBN
CAMBERWELL	G	GCL
DONCASTER	G	GDC
GLEN WAVERLEY	G	GGW
HAWTHORN	G	GHW
KEW	G	GKW
MOUNT WAVERLEY	G	GMW
NUNAWADING	G	GNG
WARRANTYTE	G	GWD
DIAMOND CREEK	H	HDC
ELTHAM	H	HEL
GREENSBOROUGH	H	HGB
HURSTBRIDGE	H	HHB
HEIDELBERG	H	HHL
HEIDELBERG WEST	H	HHT
PYALONG	O	OPY
ALEXANDRA	P	PAX
BETHANGA	P	PBA
BROADFORD	P	PBF
BENALLA	P	PBN
BRIGHT	P	PBR
BEECHWORTH	P	PBW
CHILTERN	P	PCH
CORRYONG	P	PCY
DEDERANG	P	PDD
EILDON	P	PEL
EUROA	P	PEU
GLENROWAN	P	PGR
JAMIESON	P	PJM
KILMORE	P	PKL
MT BEAUTY	P	PMB
MYRTLEFORD	P	PMD

Table A4 continued....

TABLE A4		
REGION 4: Melbourne (eastern) and Rural Victoria (north-east)		
Police Station	Police District	Police Sub-District
MANSFIELD	P	PMF
MITTA MITTA	P	PMM
MARYSVILLE	P	PMV
MOYHU	P	PMY
NAGAMBIE	P	PNG
RUTHERGLEN	P	PRG
SEYMOUR	P	PSY
TALLANGATTA	P	PTG
TANGAMBALANGA	P	PTM
VIOLET TOWN	P	PVT
WODONGA	P	PWA
WHITFIELD	P	PWF
WALWA	P	PWL
WANGARATTA	P	PWN
WOODS POINT	P	PWP
WALLAN	P	PWW
YEA	P	PYA
YACKANDANDAH	P	PYK

TABLE A5
REGION 5: Melbourne (south-eastern) and Rural Victoria (east & south-east)

Police Station	Police District	Police Sub-District
DROMANA	D	DDR
FRANKSTON	D	DFK
HASTINGS	D	DHS
MORNINGTON	D	DMT
ROSEBUD	D	DRD
RYE	D	DRY
SEAFORD	D	DSF
SORRENTO	D	DSO
SPRINGVALE	D	DSV
BERWICK	E	EBK
BUNYIP	E	EBU
CRANBOURNE	E	ECN
COWES	E	ECW
DANDENONG	E	EDG
DOVETON	E	EDV
KOO WEE RUP	E	EKW
LANG LANG	E	ELL
NARRE WARREN	E	ENW
PAKENHAM	E	EPK
SAN REMO	E	ESR
WONTHAGGI	E	EWI
EMERALD	F	FEM
BENDOC	Q	QBC
BRIAGOLONG	Q	QBG
BAIRNSDALE	Q	QBL
BOOLARRA	Q	QBR
BRUTHEN	Q	QBT
BUCHAN	Q	QBU
CHURCHILL	Q	QCH
CANN RIVER	Q	QCR
DROUIN	Q	QDR
FOSTER	Q	QFS
HEYFIELD	Q	QHF
INVERLOCH	Q	QIV
KORUMBURRA	Q	QKM
LAKES ENTRANCE	Q	QLE
LEONGATHA	Q	QLG
LOCH	Q	QLO
MALLACOOTA	Q	QMC
MAFFRA	Q	QMF
MIRBOO NORTH	Q	QMN
MOE	Q	QMO
MORWELL	Q	QMW
MEENIYAN	Q	QMY
NEERIM SOUTH	Q	QNS
ORBOST	Q	QOB
OMEO	Q	QOM
ERICA RAWSON	Q	QRN
ROSEDALE	Q	QRS
SALE	Q	QSA
SWIFTS CREEK	Q	QSC
STRATFORD	Q	QST
TRAFALGAR	Q	QTF

Table A5 continued.....

TABLE A5 REGION 5: Melbourne (south-eastern) and Rural Victoria (east & south-east)		
Police Station	Police District	Police Sub-District
TRARALGON	Q	QTL
TOORA	Q	QTR
WARRAGUL	Q	QWG
YARRAGON	Q	QYG
YARRAM	Q	QYM

APPENDIX B

STATE-SPACE MODELS:

DETAILED RESULTS FOR EACH REGION during

- 1. High Alcohol Hours of the week**
- 2. Low Alcohol Hours of the week**

TABLE B1: Effects of explanatory factors on the number of all reported casualty crashes during high alcohol times of the week in Region 1.

Significant factors	Parameter Estimate	p-value
Speed Camera TINs	-0.030460	0.0596
Penalty notice offences	-0.024403	0.0632
Speed related Adstock	-0.038262	0.0414
Alcohol Sales	-0.62989	0.0778
Crashes lagged one month	-0.25735	0.0125
Unemployment rate lagged one month	-0.23839	0.0701
Impulse function for Dec-89	-0.51224	0.0003
Step-function for April-90 launch of Speeding campaign ¹⁰	0.31494	0.1010
Level component	17.102	0.0443
April	-0.059493	0.0373
July	0.061263	0.0350
May	0.058361	0.0602
June	-0.036050	0.1426

The explanatory power of the model was 59%.

¹⁰ It should be noted that this coefficient estimate does not have a negative sign. The effect related to the launch date of the speed related publicity could be correlated with the speed-related Adstock variable itself, and therefore could lead to a wrong sign. However, this step function should still be a part of the model because it significantly contributes to the explanatory power and improves the fit of the model.

TABLE B2: Effects of explanatory factors on the number of all reported casualty crashes during low alcohol times of the week in Region 1.

Significant Factors	Parameter Estimate	P-value
August	-0.055672	0.0269
Unemployment Rate	-0.21623	0.0742
Unemployment Rate lagged 1 month	0.22001	0.0624
Speed camera TINs	0.020825	0.1220
Speed camera TINs lagged 1 month	-0.022439	0.1071
Number of total RBTs	-0.19104	0.0020
Speed related Adstock	0.019833	0.0252
Crashes lagged 2 months	-0.15193	0.1430
Crashes lagged 3 months	-0.20574	0.0443
Impulse Function for February 1993	-0.36661	0.0014

The explanatory power of the model was 54%.

TABLE B3: Effects of explanatory factors on the number of all reported casualty crashes during high alcohol times of the week in Region 2.

Significant factors	Parameter Estimate	p-value
Level Component	14.897	0.0674
Slope Component	0.0045948	0.0417
January	0.077079	0.1155
February	0.062244	0.0813
Speed Camera TINs	-0.036219	0.0973
Total number of Random Breath Tests	-0.14959	0.0503
Crashes lagged 1 month	-0.44595	0.0003
Crashes lagged 2 months	-0.18659	0.1112
Crashes lagged 5 months	0.20615	0.0866
Total Penalty Notice Offences	-0.015091	0.1592

The explanatory power of the model was 53%.

TABLE B4: Effects of explanatory factors on the number of all reported casualty crashes during low alcohol times of the week in Region 2.

Significant factors	Parameter Estimate	p-value
Level Component	8.7660	0.1383
January	-0.061011	0.0228
February	0.050699	0.0813
March	0.031754	0.1443
April	-0.039905	0.0303
May	0.027056	0.0410
September	0.019929	0.0114
November	0.011819	0.0258
Kilometres Travelled	0.67421	0.0629
Number of Speed Camera TINs	-0.028481	0.0741
Number of Random Breath Tests	-0.095844	0.0756
Unemployment Rate lagged 1 month	0.19298	0.1376
Number of Random Breath Tests lagged 1 month	-0.089384	0.0760
Crashes lagged 1 month	-0.84820	0.0001
Crashes lagged 2 months	-0.51053	0.0001
Crashes lagged 3 months	-0.25944	0.0143
Crashes lagged 4 months	-0.23495	0.0240
Crashes lagged 5 months	-0.32983	0.0021
Crashes lagged 6 months	-0.18216	0.0447
Step-function for Dec-89	-0.72719	0.0001
Step-function for Feb-91 ¹¹	-0.43266	0.0002

The explanatory power of the model was 70%.

¹¹ A step function was included to account for the high levels of speedrelated publicity that occurred at the beginning of year 1991.

TABLE B5: Effects of explanatory factors on the number of all reported casualty crashes during high alcohol times of the week in Region 3.

Significant factors	Parameter Estimate	p-value
Level Component	18.629	0.0551
October	0.026548	0.1060
Unemployment rate	-0.36232	0.0712
Drink-Driving Adstock	-0.028036	0.0899
Number of Random Breath tests (lagged 1 month)	-0.12957	0.1425
Crashes lagged 1 month	-0.49814	0.0001
Crashes lagged 2 months	-0.45329	0.0006
Crashes lagged 3 months	-0.20751	0.1232
Crashes lagged 4 months	-0.22447	0.0808

The explanatory power of the model was 55%.

TABLE B6: Effects of explanatory factors on the number of all reported casualty crashes during low alcohol times of the week in Region 3.

Significant factors	Parameter Estimate	p-value
Level Component	8.8721	0.1428
January	-0.12965	0.0001
February	-0.064846	0.0606
June	-0.029568	0.0294
July	0.028896	0.0057
September	0.016073	0.0621
Crashes lagged 1 month	-0.88392	0.0001
Crashes lagged 2 months	-0.57846	0.0001
Crashes lagged 3 months	-0.50826	0.0001
Crashes lagged 4 months	-0.36764	0.0001
Kilometres travelled	0.63249	0.1162
Number of speed camera TINs	-0.019483	0.1536
Step-function for Dec-89	-0.77089	0.0001

The explanatory power of the model was 67%.

TABLE B7: Effects of explanatory factors on the number of all reported casualty crashes during high alcohol times of the week in Region 4.

Significant factors	Parameter Estimate	p-value
June	-0.055568	0.0020
August	-0.035398	0.0289
Alcohol Sales	0.54104	0.1307
Drink-Driving Adstock	-0.021629	0.0777
Unemployment rate lagged one month	-0.37090	0.0323
Number of Random Breath tests lagged one month	-0.10130	0.1538
Crashes lagged one month	-0.13930	0.1450
Crashes lagged 4 months	-0.23798	0.0169
Crashes lagged 8 months	-0.25284	0.0245
Impulse Function for Dec-89	-0.67173	0.0001

The explanatory power of the model was 62%.

TABLE B8: Effects of explanatory factors on the number of all reported casualty crashes during low alcohol times of the week in Region 4.

Significant factors	Parameter Estimate	p-value
January	-0.045976	0.0611
April	-0.037066	0.0933
June	-0.033696	0.0730
July	0.035282	0.0609
Total Number of Random Breath Tests	-0.14626	0.0132
Total Number of Random Breath Tests lagged 1 month	-0.15376	0.0108
Crashes lagged 4 months	-0.22208	0.0137
Impulse function for Dec-89	-0.47191	0.0001
Unemployment Rate	0.18974	0.1452
Number of Kilometres Travelled	0.54142	0.1557

The explanatory power of the model was 62%.

TABLE B9: Effects of explanatory factors on the number of all reported casualty crashes during high alcohol times of the week in Region 5.

Significant Factors	Parameter Estimate	P-value
January	0.086898	0.1462
February	0.092208	0.0443
Number of Speed camera TINs	-0.12966	0.0056
Number of Speed camera TINs lagged 1 month	0.14672	0.0026
Number of total RBTs	-0.15199	0.0895
Number of total RBTs lagged 1 month	-0.12918	0.1063
Drink-drive Adstock	-0.026838	0.0706
Speed Adstock	0.023964	0.1112
Crashes lagged 1 month	-0.35092	0.0011
Crashes lagged 2 months	-0.46973	0.0001
Crashes lagged 3 months	-0.24611	0.0266
Crashes lagged 4 months	-0.31743	0.0029
Impulse Function for August 1990	0.98460	0.0119

The explanatory power of the model was 45%.

TABLE B10: Effects of explanatory factors on the number of all reported casualty crashes during low alcohol times of the week in Region 5.

Significant Factors	Parameter Estimate	P-value
February	0.088279	0.0001
June	-0.024092	0.0886
October	0.032098	0.0259
Number of Speed camera TINs	0.026393	0.0531
Number of total RBTs	-0.13136	0.0238
Crashes lagged 1 month	-0.29269	0.0062
Step-function for Dec-89	-0.26119	0.0081

The explanatory power of the model was 62%.

APPENDIX C

DEVELOPMENT OF MONTHLY INDEX FOR EACH POLICE REGION

December 1997 to December 1998

DEVELOPMENT OF INDEX: DECEMBER 1997

REGION	enforcement variable	DEC 1997 frequency	1997 monthly average	ratio	elasticity	term	index	inverse
one	speed camera TINs	11147	9754.917	1.142706	-0.00963	0.998716	1.0109737	0.989145
	penalty notice offences	4340	4563.4167	0.951042	-0.0244	1.001226		
	RBTs	30891	31687.5833	0.974861	-0.19104	1.004876		
	previous month's (Nov 97) speed camera TINs	8785	9728.333	0.903032	-0.02244	1.002291		
	laser hours	249	381.5	0.652687	-0.0089558	1.003828		
two	speed camera TINs	9544	9373.083	1.018235	-0.0647	0.998832	0.9073456	1.102116
	RBTs	52131	37882.75	1.376114	-0.24543	0.924634		
	penalty notice offences	7401	6682.0833	1.107589	-0.01509	0.998459		
	previous month's (Nov 97) RBTs	43255	36798.8333	1.175445	-0.08938	0.985656		
	laser hours	361	309.16667	1.167655	-0.0089558	0.998613		
	mmr hours	1581	1523.58333	1.037685	-0.0088575	0.999672		
three	speed camera TINs	11282	11218.58	1.005653	-0.01948	0.99989	1.0102827	0.989822
	previous month's RBTs (Nov 97)	40459	44282.83333	0.91365	-0.12957	1.011177		
	laser hours	520	515.333	1.009056	-0.0089558	0.999919		
	mmr hours	1216	1052.333	1.155528	-0.0088575	0.99872		
four	RBTs	34494	31251.75	1.103746	-0.14626	0.985666	0.9805983	1.019786
	previous month's (Nov 97) RBTs	32026	30713.41667	1.042736	-0.25506	0.989383		
	laser hours	332	404.91667	0.819922	-0.0089558	1.00178		
	mmr hours	461	703.25	0.655528	-0.0088575	1.003748		
five	speed camera TINs	6918	6292.167	1.099462	-0.10327	0.990256	0.9099015	1.09902
	RBTs	40036	31717.41667	1.262272	-0.28335	0.936135		
	previous month's (Nov 97) RBTs	36435	31296.91667	1.164172	-0.12918	0.980555		
	laser hours	333	351	0.948718	-0.0089558	1.000472		
	mmr hours	607	644.75	0.94145	-0.0088575	1.000535		
ALL REGIONS							0.9638204	1.037538

DEVELOPMENT OF INDEX: JANUARY 1998

REGION	enforcement variable	Jan 98 frequency	1997 monthly average	ratio	elasticity	term	index	inverse
one	speed camera TINs	11497	9754.917	1.178585	-0.00963	0.998419	0.9578619	1.043992
	penalty notice offences	5238	4563.4167	1.147824	-0.0244	0.996642		
	RBTs	38345	31687.5833	1.210095	-0.19104	0.964224		
	previous month's (Dec 97) speed camera TINs	11147	9728.333	1.145828	-0.02244	0.996950		
	laser hours	327	381.5	0.857143	-0.0089558	1.001381		
two	speed camera TINs	8627	9373.083	0.920402	-0.0647	1.005381	0.9249847	1.081099
	RBTs	45551	37882.75	1.202421	-0.24543	0.955766		
	penalty notice offences	9198	6682.0833	1.376517	-0.01509	0.99519		
	previous month's (Dec 97) RBTs	52131	36798.8333	1.416648	-0.08938	0.969349		
	laser hours	378	309.16667	1.222641	-0.0089558	0.998201		
	mmr hours	1585	1523.58333	1.040311	-0.0088575	0.99965		
three	speed camera tins TINs	10008	11218.58	0.892092	-0.01948	1.002227	0.9682375	1.032804
	previous month's RBTs (Dec 97)	56939	44282.83333	1.285803	-0.12957	0.967953		
	laser hours	479	515.333	0.929496	-0.0089558	1.000655		
	mmr hours	1409	1052.333	1.33893	-0.0088575	0.997418		
four	RBTs	35570	31251.75	1.138176	-0.14626	0.981248	0.9528647	1.049467
	previous month's (Dec 97) RBTs	34494	30713.41667	1.123092	-0.25506	0.970825		
	laser hours	334	404.91667	0.824861	-0.0089558	1.001726		
	mmr hours	830	703.25	1.180235	-0.0088575	0.998533		
five	speed camera TINs	5739	6292.167	0.912086	-0.10327	1.009548	0.9262502	1.079622
	RBTs	38025	31717.41667	1.198868	-0.28335	0.949905		
	previous month's (Dec 97) RBTs	40036	31296.91667	1.279231	-0.12918	0.968689		
	laser hours	373	351	1.062678	-0.0089558	0.999456		
	mmr hours	842	644.75	1.305933	-0.0088575	0.997639		
ALL REGIONS							0.9460398	1.057038

DEVELOPMENT OF INDEX: FEBRUARY 1998

REGION	enforcement variable	Feb 98 frequency	1997 monthly average	ratio	elasticity	term	index	inverse
one	speed camera TINS	12613	9754.917	1.292989	-0.00963	0.997529	1.0034695	0.996543
	penalty notice offences	5020	4563.4167	1.100053	-0.0244	0.997676		
	RBTs	30404	31687.5833	0.959493	-0.19104	1.007931		
	previous month's (Jan 98) speed camera TINS	11497	9728.333	1.181806	-0.02244	0.996259		
	laser hours	241	381.5	0.631717	-0.0089558	1.004122		
two	speed camera TINS	10790	9373.083	1.151169	-0.0647	0.990933	0.9550739	1.047039
	RBTs	40128	37882.75	1.059268	-0.24543	0.985968		
	penalty notice offences	7216	6682.0833	1.079903	-0.01509	0.998841		
	previous month's (Jan 98) RBTs	45551	36798.83333	1.237838	-0.08938	0.98111		
	laser hours	427	309.16667	1.381132	-0.0089558	0.997112		
	mmr hours	1457	1523.58333	0.956298	-0.0088575	1.000396		
three	speed camera TINS	12343	11218.58	1.100228	-0.01948	0.998141	0.9967188	1.003292
	previous month's RBTs (Jan 98)	46045	44282.83333	1.039793	-0.12957	0.994957		
	laser hours	345	515.333	0.66947	-0.0089558	1.0036		
	mmr hours	1048	1052.333	0.995882	-0.0088575	1.000037		
four	RBTs	32920	31251.75	1.053381	-0.14626	0.992423	0.9599714	1.041698
	previous month's (Jan 98) RBTs	35570	30713.41667	1.158126	-0.25506	0.963249		
	laser hours	269	404.91667	0.664334	-0.0089558	1.003669		
	mmr hours	662	703.25	0.941344	-0.0088575	1.000536		
five	speed camera TINS	8158	6292.167	1.296533	-0.10327	0.973538	0.9465102	1.056513
	RBTs	32452	31717.41667	1.02316	-0.28335	0.993533		
	previous month's (Jan 98) RBTs	38025	31296.91667	1.214976	-0.12918	0.975159		
	laser hours	307	351	0.874644	-0.0089558	1.0012		
	mmr hours	498	644.75	0.772392	-0.0088575	1.00229		
ALL REGIONS							0.9723488	1.028438

DEVELOPMENT OF INDEX: MARCH 1998

REGION	enforcement variable	Mar 98 frequency	1997 monthly average	ratio	elasticity	term	index	inverse
one	speed camera TINs	11295	9754.917	1.157878	-0.00963	0.998589	1.0105301	0.98958
	penalty notice offences	5331	4563.4167	1.168204	-0.0244	0.996214		
	RBTs	28519	31687.5833	0.900006	-0.19104	1.020331		
	previous month's (Feb 98) speed camera TINs	12613	9728.333	1.296522	-0.02244	0.994190		
	laser hours	327	381.5	0.857143	-0.0089558	1.001381		
two	speed camera TINs	11505	9373.083	1.227451	-0.0647	0.986828	0.9875371	1.01262
	RBTs	36505	37882.75	0.963631	-0.24543	1.009134		
	penalty notice offences	7374	6682.0833	1.103548	-0.01509	0.998514		
	previous month's Feb 98 RBTs	40128	36798.83333	1.090469	-0.08938	0.992289		
	laser hours	298	309.16667	0.963881	-0.0089558	1.00033		
	mmr hours	1436	1523.58333	0.942515	-0.0088575	1.000525		
three	speed camera TINs	11908	11218.58	1.061453	-0.01948	0.998839	1.0095767	0.990514
	previous month's RBTs (Feb 98)	42829	44282.83333	0.967169	-0.12957	1.004335		
	laser hours	283	515.333	0.549159	-0.0089558	1.005382		
	mmr hours	940	1052.333	0.893253	-0.0088575	1.001		
four	RBTs	31835	31251.75	1.018663	-0.14626	0.997299	0.9834224	1.016857
	previous month's (Feb 98) RBTs	32920	30713.41667	1.071844	-0.25506	0.982459		
	laser hours	238	404.91667	0.587775	-0.0089558	1.004771		
	mmr hours	794	703.25	1.129044	-0.0088575	0.998926		
five	speed camera TINs	8554	6292.167	1.359468	-0.10327	0.968784	0.9792414	1.021199
	RBTs	30501	31717.41667	0.961648	-0.28335	1.011142		
	previous month's (Feb 98) RBTs	32452	31296.91667	1.036907	-0.12918	0.995329		
	laser hours	267	351	0.760684	-0.0089558	1.002453		
	mmr hours	521	644.75	0.808065	-0.0088575	1.001889		
ALL REGIONS							0.9940615	1.005974

DEVELOPMENT OF INDEX: APRIL 1998

REGION	enforcement variable	Apr 98 frequency	1997 monthly average	ratio	elasticity	term	index	inverse
one	speed camera TINs	8190	9754.917	0.839577	-0.00963	1.001685	1.0483515	0.953879
	penalty notice offences	4332	4563.4167	0.949289	-0.0244	1.001271		
	RBTs	25118	31687.5833	0.792676	-0.19104	1.045386		
	previous month's (Mar 98) speed camera TINs	11295	9728.333	1.161042	-0.02244	0.996655		
	laser hours	266	381.5	0.697248	-0.0089558	1.003235		
two	speed camera TINs	10833	9373.083	1.155756	-0.0647	0.990678	1.0282431	0.972533
	RBTs	32273	37882.75	0.851918	-0.24543	1.040118		
	penalty notice offences	6891	6682.0833	1.031265	-0.01509	0.999536		
	previous month's (Mar 98) RBTs	36505	36798.83333	0.992015	-0.08938	1.000717		
	laser hours	355	309.16667	1.148248	-0.0089558	0.998763		
	mmr hours	1731	1523.58333	1.136137	-0.0088575	0.99887		
three	speed camera TINs	10371	11218.58	0.924449	-0.01948	1.001531	1.0138577	0.986332
	previous month's RBTs (Mar 98)	41493	44282.83333	0.937	-0.12957	1.008467		
	laser hours	325	515.333	0.630666	-0.0089558	1.004137		
	mmr hours	1092	1052.333	1.037694	-0.0088575	0.999672		
four	RBTs	28229	31251.75	0.903277	-0.14626	1.01499	1.0075162	0.99254
	previous month's (Mar 98) RBTs	31835	30713.41667	1.036518	-0.25506	0.990894		
	laser hours	311	404.91667	0.768059	-0.0089558	1.002366		
	mmr hours	753	703.25	1.070743	-0.0088575	0.999395		
five	speed camera TINs	8054	6292.167	1.280004	-0.10327	0.974829	1.0458056	0.956201
	RBTs	25183	31717.41667	0.79398	-0.28335	1.067552		
	previous month's (Mar 98) RBTs	30501	31296.91667	0.974569	-0.12918	1.003333		
	laser hours	264	351	0.752137	-0.0089558	1.002554		
	mmr hours	719	644.75	1.115161	-0.0088575	0.999035		
							1.0287548	0.972049

DEVELOPMENT OF INDEX: MAY 1998

REGION	enforcement variable	MAY 98 frequency	1997 monthly average	ratio	elasticity	term	index	inverse
one	speed camera TINs	12312	9754.917	1.262133	-0.00963	0.997761	1.0224243	0.978068
	penalty notice offences	4007	4563.4167	0.87807	-0.0244	1.003178		
	RBTs	29364	31687.5833	0.926672	-0.19104	1.014655		
	previous month's (APR 98) speed camera TINs	8190	9728.333	0.841871	-0.02244	1.003870		
	laser hours	278	381.5	0.728702	-0.0089558	1.002838		
two	speed camera TINs	12122	9373.083	1.293278	-0.0647	0.983498	0.9907124	1.009375
	RBTs	38720	37882.75	1.022101	-0.24543	0.994649		
	penalty notice offences	5295	6682.0833	0.792418	-0.01509	1.003517		
	previous month's (APR 98) RBTs	32273	36798.83333	0.877011	-0.08938	1.011799		
	laser hours	368	309.16667	1.190296	-0.0089558	0.998441		
	mmr hours	1707	1523.58333	1.120385	-0.0088575	0.998994		
	speed camera TINs	12231	11218.58	1.090245	-0.01948	0.998318		
previous month's RBTs (APR 98)	34996	44282.83333	0.790284	-0.12957	1.030966			
laser hours	274	515.333	0.531695	-0.0089558	1.005673			
mmr hours	944	1052.333	0.897054	-0.0088575	1.000963			
four	RBTs	28557	31251.75	0.913773	-0.14626	1.013276	1.0329122	0.968136
	previous month's (APR 98) RBTs	28229	30713.41667	0.91911	-0.25506	1.021747		
	laser hours	404	404.91667	0.997736	-0.0089558	1.00002		
	mmr hours	916	703.25	1.302524	-0.0088575	0.997662		
five	speed camera TINs	9676	6292.167	1.537785	-0.10327	0.956532	0.9727242	1.028041
	RBTs	32686	31717.41667	1.030538	-0.28335	0.991513		
	previous month's (APR 98) RBTs	25183	31296.91667	0.804648	-0.12918	1.028475		
	laser hours	394	351	1.122507	-0.0089558	0.998966		
	mmr hours	784	644.75	1.215975	-0.0088575	0.998269		
ALL REGIONS							1.0109682	0.989151

DEVELOPMENT OF INDEX: JUNE 1998

REGION	enforcement variable	JUN 98 frequency	1997 monthly average	ratio	elasticity	term	index	inverse
one	speed camera TINs	11276	9754.917	1.15593	-0.00963	0.998606	1.0536765	0.949058
	penalty notice offences	5446	4563.4167	1.193404	-0.0244	0.995695		
	RBTs	22921	31687.5833	0.723343	-0.19104	1.063827		
	previous month's (MAY 98) speed camera TINs	12312	9728.333	1.265582	-0.02244	0.994729		
	laser hours	326	381.5	0.854522	-0.0089558	1.001409		
two	speed camera TINs	10109	9373.083	1.078514	-0.0647	0.995122	1.032923	0.968126
	RBTs	31411	37882.75	0.829164	-0.24543	1.047052		
	penalty notice offences	7360	6682.0833	1.101453	-0.01509	0.998543		
	previous month's (MAY 98) RBTs	38720	36798.83333	1.052207	-0.08938	0.995462		
	laser hours	338	309.16667	1.093261	-0.0089558	0.999202		
	mmr hours	1886	1523.58333	1.237871	-0.0088575	0.998112		
three	speed camera TINs	11027	11218.58	0.982923	-0.01948	1.000336	1.0297687	0.971092
	previous month's RBTs (MAY 98)	36345	44282.83333	0.820747	-0.12957	1.025926		
	laser hours	316	515.333	0.613196	-0.0089558	1.00439		
	mmr hours	1175	1052.333	1.116567	-0.0088575	0.999024		
four	RBTs	31229	31251.75	0.999272	-0.14626	1.000107	1.0166483	0.983624
	previous month's (MAY 98) RBTs	28557	30713.41667	0.929789	-0.25506	1.018741		
	laser hours	413	404.91667	1.019963	-0.0089558	0.999823		
	mmr hours	880	703.25	1.251333	-0.0088575	0.998016		
five	speed camera TINs	6578	6292.167	1.045427	-0.10327	0.995423	1.0381489	0.963253
	RBTs	26675	31717.41667	0.841021	-0.28335	1.050282		
	previous month's (MAY 98) RBTs	32686	31296.91667	1.044384	-0.12918	0.994406		
	laser hours	334	351	0.951567	-0.0089558	1.000445		
	mmr hours	796	644.75	1.234587	-0.0088575	0.998135		
ALL REGIONS							1.0342331	0.9669

DEVELOPMENT OF INDEX: JULY 1998

REGION	enforcement variable	JUL 98 frequency	1997 monthly average	ratio	elasticity	term	index	inverse
one	speed camera TINs	12883	9754.917	1.320667	-0.00963	0.997325	1.0519699	0.950598
	penalty notice offences	4701	4563.4167	1.030149	-0.0244	0.999275		
	RBTs	23515	31687.5833	0.742089	-0.19104	1.05864		
	previous month's (JUN 98) speed camera TINs	11276	9728.333	1.159089	-0.02244	0.996693		
	laser hours	365	381.5	0.95675	-0.0089558	1.000396		
two	speed camera TINs	8975	9373.083	0.957529	-0.0647	1.002812	1.0512597	0.95124
	RBTs	32620	37882.75	0.861078	-0.24543	1.037391		
	penalty notice offences	6848	6682.0833	1.02483	-0.01509	0.99963		
	previous month's (JUN 98) RBTs	31411	36798.83333	0.853587	-0.08938	1.01425		
	laser hours	377	309.16667	1.219407	-0.0089558	0.998225		
	mmr hours	1811	1523.58333	1.188645	-0.0088575	0.99847		
three	speed camera TINs	10661	11218.58	0.950299	-0.01948	1.000994	1.0356208	0.965604
	previous month's RBTs (JUN 98)	34698	44282.83333	0.783554	-0.12957	1.032109		
	laser hours	396	515.333	0.768435	-0.0089558	1.002362		
	mmr hours	1047	1052.333	0.994932	-0.0088575	1.000045		
four	RBTs	26485	31251.75	0.847473	-0.14626	1.024501	1.0176315	0.982674
	previous month's (JUN 98) RBTs	31229	30713.41667	1.016787	-0.25506	0.995763		
	laser hours	414	404.91667	1.022433	-0.0089558	0.999801		
	mmr hours	910	703.25	1.293992	-0.0088575	0.99772		
five	speed camera TINs	6655	6292.167	1.057664	-0.10327	0.994227	0.9986538	1.001348
	RBTs	33302	31717.41667	1.049959	-0.28335	0.986281		
	previous month's (JUN 98) RBTs	26675	31296.91667	0.85232	-0.12918	1.020857		
	laser hours	447	351	1.273504	-0.0089558	0.997837		
	mmr hours	661	644.75	1.025204	-0.0088575	0.99978		
ALL REGIONS							1.0310272	0.969907

DEVELOPMENT OF INDEX:AUGUST 1998

REGION	enforcement variable	AUG 98 frequency	1997 monthly average	ratio	elasticity	term	index	inverse
one	speed camera TINs	13051	9754.917	1.337889	-0.00963	0.997201	1.0274088	0.973322
	penalty notice offences	4301	4563.4167	0.942496	-0.0244	1.001446		
	RBTs	26439	31687.5833	0.834365	-0.19104	1.0352		
	previous month's (JUL 98) speed camera TINs	12883	9728.333	1.324276	-0.02244	0.993717		
	laser hours	377	381.5	0.988204	-0.0089558	1.000106		
two	speed camera TINs	9002	9373.083	0.96041	-0.0647	1.002617	0.9900742	1.010025
	RBTs	40302	37882.75	1.063862	-0.24543	0.984921		
	penalty notice offences	7883	6682.0833	1.179722	-0.01509	0.997509		
	previous month's (JUL 98) RBTs	32620	36798.83333	0.886441	-0.08938	1.010832		
	laser hours	443	309.16667	1.432884	-0.0089558	0.996784		
	mmr hours	2010	1523.58333	1.319258	-0.0088575	0.997549		
three	speed camera TINs	10406	11218.58	0.927568	-0.01948	1.001466	1.0403286	0.961235
	previous month's RBTs (JUL 98)	32805	44282.83333	0.740806	-0.12957	1.039639		
	laser hours	459	515.333	0.890686	-0.0089558	1.001037		
	mmr hours	1295	1052.333	1.230599	-0.0088575	0.998164		
four	RBTs	35208	31251.75	1.126593	-0.14626	0.982717	1.0161261	0.98413
	previous month's (JUL 98) RBTs	26485	30713.41667	0.862327	-0.25506	1.038502		
	laser hours	465	404.91667	1.148384	-0.0089558	0.998762		
	mmr hours	999	703.25	1.420547	-0.0088575	0.996895		
five	speed camera TINs	5652	6292.167	0.89826	-0.10327	1.011142	0.9834921	1.016785
	RBTs	33227	31717.41667	1.047595	-0.28335	0.986912		
	previous month's (JUL 98) RBTs	33302	31296.91667	1.064066	-0.12918	0.99201		
	laser hours	553	351	1.575499	-0.0089558	0.995937		
	mmr hours	851	644.75	1.319891	-0.0088575	0.997545		
ALL REGIONS							1.0114859	0.988644

DEVELOPMENT OF INDEX: SEPTEMBER 1998

REGION	enforcement variable	SEP 98 frequency	1997 monthly average	ratio	elasticity	term	index	inverse
one	speed camera TINs	13846	9754.917	1.419387	-0.00963	0.996633	1.0606514	0.942817
	penalty notice offences	4212	4563.4167	0.922993	-0.0244	1.001957		
	RBTs	22498	31687.5833	0.709994	-0.19104	1.067619		
	previous month's (AUG 98) speed camera TINs	13051	9728.333	1.341545	-0.02244	0.993428		
	laser hours	324	381.5	0.849279	-0.0089558	1.001464		
two	speed camera TINs	9465	9373.083	1.009806	-0.0647	0.999369	1.0422721	0.959442
	RBTs	30606	37882.75	0.807914	-0.24543	1.053745		
	penalty notice offences	6606	6682.0833	0.988614	-0.01509	1.000173		
	previous month's (AUG 98) RBTs	40302	36798.83333	1.095198	-0.08938	0.991905		
	laser hours	359	309.16667	1.161186	-0.0089558	0.998663		
	mmr hours	1710	1523.58333	1.122354	-0.0088575	0.998978		
three	speed camera TINs	12119	11218.58	1.080261	-0.01948	0.998497	1.0044892	0.995531
	previous month's RBTs (AUG 98)	42381	44282.83333	0.957053	-0.12957	1.005704		
	laser hours	443	515.333	0.859638	-0.0089558	1.001355		
	mmr hours	1186	1052.333	1.12702	-0.0088575	0.998941		
four	RBTs	26746	31251.75	0.855824	-0.14626	1.023033	0.9842416	1.016011
	previous month's (AUG 98) RBTs	35208	30713.41667	1.146339	-0.25506	0.965765		
	laser hours	492	404.91667	1.215065	-0.0089558	0.998257		
	mmr hours	889	703.25	1.264131	-0.0088575	0.997926		
five	speed camera TINs	6179	6292.167	0.982015	-0.10327	1.001876	1.0097951	0.9903
	RBTs	29399	31717.41667	0.926904	-0.28335	1.021741		
	previous month's (AUG 98) RBTs	33227	31296.91667	1.06167	-0.12918	0.992299		
	laser hours	641	351	1.826211	-0.0089558	0.994621		
	mmr hours	683	644.75	1.059325	-0.0088575	0.99949		
ALL REGIONS							1.0202899	0.980114

DEVELOPMENT OF INDEX: OCTOBER 1998

REGION	enforcement variable	OCT 98 frequency	1997 monthly average	ratio	elasticity	term	index	inverse
one	speed camera TINs	13281	9754.917	1.361467	-0.00963	0.997033	1.0401419	0.961407
	penalty notice offences	3834	4563.4167	0.84016	-0.0244	1.004259		
	RBTs	25410	31687.5833	0.801891	-0.19104	1.04308		
	previous month's (SEP 98) speed camera TINs	13846	9728.333	1.423265	-0.02244	0.992111		
	laser hours	249	381.5	0.652687	-0.0089558	1.003828		
two	speed camera TINs	11004	9373.083	1.174	-0.0647	0.989675	1.0016996	0.998303
	RBTs	38081	37882.75	1.005233	-0.24543	0.99872		
	penalty notice offences	6782	6682.0833	1.014953	-0.01509	0.999776		
	previous month's (SEP 98) RBTs	30606	36798.83333	0.831711	-0.08938	1.016606		
	laser hours	399	309.16667	1.290566	-0.0089558	0.997718		
	mmr hours	1631	1523.58333	1.070503	-0.0088575	0.999397		
three	speed camera TINs	11987	11218.58	1.068495	-0.01948	0.99871	1.0128315	0.987331
	previous month's RBTs (SEP 98)	40076	44282.83333	0.905001	-0.12957	1.013018		
	laser hours	407	515.333	0.789781	-0.0089558	1.002116		
	mmr hours	1179	1052.333	1.120368	-0.0088575	0.998994		
four	RBTs	28749	31251.75	0.919916	-0.14626	1.012284	1.0455718	0.956414
	previous month's (SEP 98) RBTs	26746	30713.41667	0.870825	-0.25506	1.035908		
	laser hours	491	404.91667	1.212595	-0.0089558	0.998275		
	mmr hours	805	703.25	1.144685	-0.0088575	0.998804		
five	speed camera TINs	6662	6292.167	1.058777	-0.10327	0.994119	1.047966	0.954229
	RBTs	26794	31717.41667	0.844772	-0.28335	1.048958		
	previous month's (SEP 98) RBTs	29399	31296.91667	0.939358	-0.12918	1.008114		
	laser hours	415	351	1.182336	-0.0089558	0.998501		
	mmr hours	775	644.75	1.202016	-0.0088575	0.998372		
ALL REGIONS							1.0296422	0.971211

DEVELOPMENT OF INDEX: NOVEMBER 1998

REGION	enforcement variable	NOV 98 frequency	1997 monthly average	ratio	elasticity	term	index	inverse
one	speed camera TINs	13058	9754.917	1.338607	-0.00963	0.997196	1.0418681	0.959814
	penalty notice offences	3948	4563.4167	0.865141	-0.0244	1.003541		
	RBTs	24983	31687.5833	0.788416	-0.19104	1.046463		
	previous month's (OCT 98) speed camera TINs	13281	9728.333	1.365188	-0.02244	0.993039		
	laser hours	310	381.5	0.812582	-0.0089558	1.00186		
two	speed camera TINs	10226	9373.083	1.090996	-0.0647	0.994381	1.0622706	0.94138
	RBTs	28080	37882.75	0.741234	-0.24543	1.076259		
	penalty notice offences	7171	6682.0833	1.073168	-0.01509	0.998935		
	previous month's (OCT 98) RBTs	38081	36798.83333	1.034843	-0.08938	0.996943		
	laser hours	418	309.16667	1.352022	-0.0089558	0.997303		
	mmr hours	1634	1523.58333	1.072472	-0.0088575	0.99938		
three	speed camera TINs	13432	11218.58	1.197299	-0.01948	0.996498	0.9886907	1.011439
	previous month's RBTs (OCT 98)	47221	44282.83333	1.06635	-0.12957	0.991711		
	laser hours	505	515.333	0.979949	-0.0089558	1.000181		
	mmr hours	1020	1052.333	0.969275	-0.0088575	1.000276		
four	RBTs	26257	31251.75	0.840177	-0.14626	1.025797	1.0424307	0.959296
	previous month's (OCT 98) RBTs	28749	30713.41667	0.93604	-0.25506	1.017002		
	laser hours	392	404.91667	0.9681	-0.0089558	1.00029		
	mmr hours	793	703.25	1.127622	-0.0088575	0.998937		
five	speed camera TINs	6910	6292.167	1.098191	-0.10327	0.990374	1.0807592	0.925275
	RBTs	25175	31717.41667	0.793728	-0.28335	1.067648		
	previous month's (OCT 98) RBTs	26794	31296.91667	0.856123	-0.12918	1.02027		
	laser hours	320	351	0.911681	-0.0089558	1.000828		
	mmr hours	577	644.75	0.894921	-0.0088575	1.000984		
ALL REGIONS							1.0432039	0.958585

DEVELOPMENT OF INDEX: DECEMBER 1998

REGION	enforcement variable	DEC 98 frequency	1997 monthly average	ratio	elasticity	term	index	inverse
one	speed camera TINs	15916	9754.917	1.631587	-0.00963	0.995297	1.0246077	0.975983
	penalty notice offences	5734	4563.4167	1.256515	-0.0244	0.994444		
	RBTs	24783	31687.5833	0.782104	-0.19104	1.048071		
	previous month's (NOV 98) speed camera TINs	13058	9728.333	1.342265	-0.02244	0.993416		
	laser hours	725	381.5	1.900393	-0.0089558	0.994266		
two	speed camera TINs	11758	9373.083	1.254443	-0.0647	0.98544	1.0603575	0.943078
	RBTs	29309	37882.75	0.773677	-0.24543	1.065003		
	penalty notice offences	9582	6682.0833	1.433984	-0.01509	0.994575		
	previous month's (NOV 98) RBTs	28080	36798.83333	0.763068	-0.08938	1.024464		
	laser hours	577	309.16667	1.866307	-0.0089558	0.994428		
	mmr hours	2101	1523.58333	1.378986	-0.0088575	0.997158		
three	speed camera TINs	13397	11218.58	1.19418	-0.01948	0.996549	1.0216807	0.978779
	previous month's RBTs (NOV 98)	35293	44282.83333	0.796991	-0.12957	1.029838		
	laser hours	686	515.333	1.331178	-0.0089558	0.997441		
	mmr hours	1309	1052.333	1.243903	-0.0088575	0.998069		
four	RBTs	28871	31251.75	0.92382	-0.14626	1.011657	1.0487997	0.953471
	previous month's (NOV 98) RBTs	26257	30713.41667	0.854903	-0.25506	1.040795		
	laser hours	601	404.91667	1.484256	-0.0089558	0.996469		
	mmr hours	735	703.25	1.045148	-0.0088575	0.999609		
five	speed camera TINs	7395	6292.167	1.175271	-0.10327	0.98346	1.0901204	0.91733
	RBTs	23744	31717.41667	0.748611	-0.28335	1.085499		
	previous month's (NOV 98) RBTs	25175	31296.91667	0.804392	-0.12918	1.028517		
	laser hours	520	351	1.481481	-0.0089558	0.996486		
	mmr hours	976	644.75	1.513765	-0.0088575	0.996334		
ALL REGIONS							1.0491132	0.953186