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TRENDS IN CRASHWORTHINESS OF THE NEW ZEALAND VEHICLE FLEET BY YEAR OF MANUFACTURE: 1964 TO 2008:

SUPPLEMENT TO REPORT 297
VEHICLE SAFETY RATINGS ESTIMATED FROM POLICE REPORTED CRASH DATA: 2010 UPDATE

by

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Abstract:
Crashworthiness is an estimate of the occupant protection provided by a vehicle, namely the risk of a driver of a vehicle being killed or admitted to hospital when involved in a crash. The relationship was investigated between vehicle crashworthiness and both the year of manufacture and the year of first registration in New Zealand of New Zealand light passenger vehicles manufactured from 1964 to 2008 and crashing during 1991 to 2008. The latter analysis was aimed at assessing crashworthiness trends in the fleet of used imported vehicles in New Zealand whilst the former examined trends in the fleet as a whole. Crashworthiness was measured by a combination of injury severity (of injured drivers) and injury risk (of drivers involved in crashes). The ratings were adjusted for the sex and age of the driver, the speed limit at the crash location, the number of vehicles involved in the crash and the year in which the crash occurred. The crashworthiness rating estimates the risk of the driver being killed or admitted to hospital when involved in a crash, to a degree of accuracy represented by the confidence limits of the rating in each case.

Analysis of trends by year of vehicle manufacture showed statistically significant improvement in the crashworthiness of New Zealand light passenger vehicles over the years of manufacture studied. Most of the measured improvement occurred over the years of manufacture from 1983 to 2008. Over this period, the risk of death or serious injury to drivers reduced by over 84% for the fleet as a whole. During this period vehicle safety in New Zealand was affected by several competing effects: a general increase in both active and passive safety features in vehicles; increasing proportions of used imported vehicles entering the New Zealand fleet; and increases in the regulation of vehicle safety standards by the New Zealand Government.

Estimates of crashworthiness trends in the used import vehicle fleet by year of first registration in New Zealand from 1986 to 2008 showed statistically significant improvements in crashworthiness over these years. This analysis showed trends to improving crashworthiness of the fleet of used imported vehicles in New Zealand. There is some suggestion that improvements in crashworthiness of vehicles manufactured in the most recent years is much greater for vehicles sold new in NZ compared to those imported second hand. This offers some cause for concern and should be monitored closely.

The results of this report are based on a number of assumptions and warrant a number of qualifications that should be noted.

Key Words: (IRRD except when marked*)
Injury, Vehicle Occupant, Collision, Passenger Car Unit, Passive Safety System, Statistics

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EXECUTIVE SUMMARY

This report describes the update of New Zealand crashworthiness ratings by year of vehicle manufacture for 1964-2008 model vehicles. New Zealand crashworthiness ratings by year of manufacture were first developed and successfully applied in Newstead et al (2005a) for 1964-2002 model vehicles and subsequently updated in Newstead et al (2006) for 1964-2004 model vehicles, in Newstead et al (2007b) for 1964-2005 model vehicles, in Newstead et al (2008b) for 1964-2006 and in Newstead et al (2009b) for 1964-2007 model vehicles. Crashworthiness ratings of vehicles by year of first registration in New Zealand were also examined, focusing on the fleet of used imported vehicles sold in New Zealand. Crashworthiness ratings measure the relative risk of death or serious injury (hospitalisation) to drivers of vehicles involved in crashes. The estimates are derived from analysis of data on real crashes. The analysis in this study is based on data from police reports on injury crashes occurring in New Zealand during 1991-2008.

Crashworthiness is an estimate of the occupant protection provided by a vehicle, namely the risk of a driver of a vehicle being killed or admitted to hospital when involved in a crash. It is obtained from the product of injury severity (of injured drivers) and injury risk (of drivers involved in crashes) for the drivers of vehicles of the specified year of manufacture or specified year of first registration in New Zealand. The method of analysis that was first demonstrated in the study of Newstead et al (2005a) that gives unbiased estimates of injury risk from injury crash data where the total number of uninjured drivers is unknown was again used here. The method was used separately to obtain crashworthiness for vehicles by year of manufacture and by year of first registration in New Zealand.

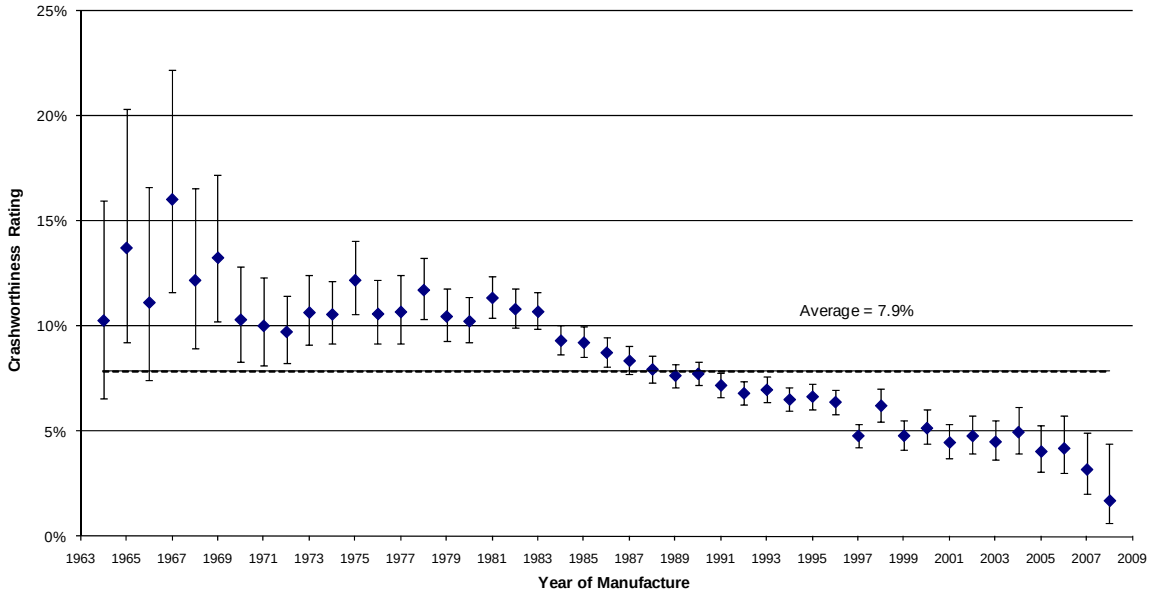
The injury risk estimates were based on crash data for 100,708 drivers involved in crashes between two vehicles in New Zealand during 1991-2008 where one or both drivers was injured and the vehicle was manufactured between 1964 and 2008. The injury severity estimates were based on crash data for 122,642 drivers injured in crashes in New Zealand during 1991-2008 and where the vehicle was manufactured between 1964 and 2008.

The injury risk ratings were adjusted for the sex and age of the driver, the speed limit at the crash location and the year in which the crash occurred. The injury severity ratings were also adjusted for the number of vehicles involved in the crash. These factors are known to be strongly associated with injury risk and injury severity. Adjustments were made via logistic regression analysis techniques with the aim of measuring the effects of vehicle factors alone, uncontaminated by other factors available in the data that affected crash severity and injury susceptibility. The degree of accuracy of the crashworthiness ratings is represented by the confidence limits of the rating in each case.

Analysis successfully estimated trends in the crashworthiness of the light passenger vehicle fleet (cars, station wagons, four wheel drives, vans and utilities) in New Zealand by both year of manufacture and year of first registration for used imports in New Zealand. Estimates of crashworthiness by year of vehicle manufacture for the New Zealand light passenger vehicle fleet as a whole along with 95% confidence limits are shown in Figure E1. Analysis of trends by year of vehicle manufacture show statistically significant improvement in the crashworthiness of New Zealand light passenger vehicles over the years of manufacture studied. The majority of the measured improvement occurred over the years of manufacture from 1983 to 2008. Over this period, the risk of death or serious injury to drivers in a crash reduced by around 84% for the fleet as a whole. During this period vehicle

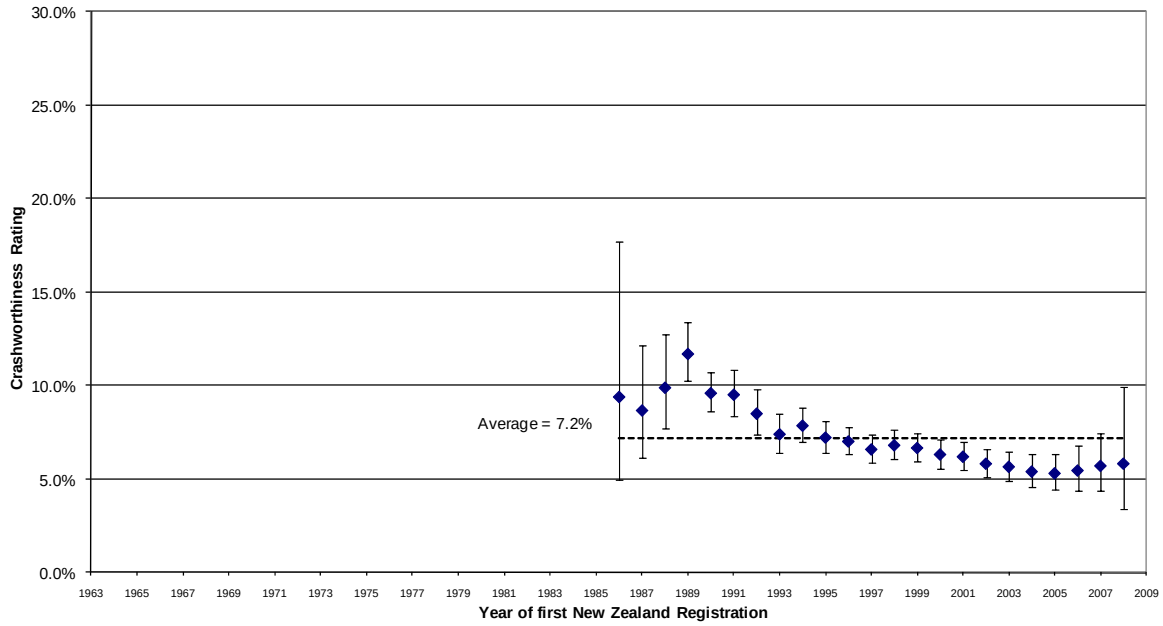
safety in New Zealand was affected by several competing effects: a general increase in both active and passive safety features in vehicles; increasing proportions of used imported vehicles entering the New Zealand fleet; and increases in the regulation of vehicle safety standards by the New Zealand Government.

Figure E1: *Crashworthiness by year of manufacture (with 95% confidence limits)*



Estimates of crashworthiness trends in the vehicle fleet by year of first registration in New Zealand from 1986 to 2008 were also obtained. The data for used imports are shown in Figure E2 along with 95% confidence limits. They showed a high crashworthiness rating (indicating poor occupant protection performance) of newly registered vehicles in the early 1990's, the years when used imports suddenly began to penetrate the market. This was followed by statistically significant improvements in crashworthiness over the later years of that decade. There is also some suggestion that improvements in crashworthiness of vehicles manufactured in the most recent years is much greater for vehicles sold new in NZ compared to those imported second hand. This offers some cause for concern and should be monitored closely.

Figure E2: *Crashworthiness by year of first registration in New Zealand (with 95% confidence limits): Used Imports*



The results and conclusions of this study are based on a number of assumptions and a number of qualifications should be noted.

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SUPPLEMENT TO REPORT xxx: VEHICLE SAFETY RATINGS ESTIMATED FROM POLICE REPORTED CRASH DATA: 2010 UPDATE

1. BACKGROUND AND AIMS

1.1 Crashworthiness Ratings

For nearly 2 decades, the Monash University Accident Research Centre (MUARC) has been involved in a program of research examining issues relating to vehicle safety in Australia and New Zealand through the analysis of mass crash data. A principal focus of the research has been to rate the relative performance of different vehicle models in preventing injury to their occupants in the event of a crash, commonly known as the crashworthiness of the vehicle. The crashworthiness ratings developed as part of the MUARC research rate the relative safety of vehicles by examining injury outcomes to drivers in real crashes. More specifically, the defined crashworthiness rating of a vehicle is a measure of the risk of death or serious injury to a driver of that vehicle when it is involved in a crash. This risk is estimated from large numbers of records of injury to drivers of that vehicle type involved in real crashes on the road.

Crashworthiness was measured in two components:

1. Probability of injury for drivers involved in tow-away crashes (injury risk)
2. Probability of serious injury (death or hospital admission) for injured drivers (injury severity).

Multiplying these two probabilities together formed the crashworthiness rating. This is a measure of the probability of serious injury for drivers involved in crashes. Measuring crashworthiness in two components reflecting risk and severity of injury was first developed by Folksam Insurance, which publishes the well-known Swedish ratings (Gustafsson et al 1989). In addition to the speed zone and driver sex, the Australian crashworthiness method of analysis adjusts for the effects of driver age and the number of vehicles involved, producing results with all those factors taken into account.

1.2 Crashworthiness by Year of Vehicle Manufacture

Another focus of the vehicle crashworthiness ratings study in Australia has been to track historical improvements in the average crashworthiness of the vehicle fleet by year of manufacture. The original study of Cameron et al (1994c) showed that the crashworthiness of passenger vehicles in Australia has improved over the years of manufacture 1964 to 1992 with rapid improvement over the years from about 1970 to 1979. Improvements were related to implementation of a number of Australian Design Rules (ADRs) for motor vehicle safety which previous research had shown to be effective in providing occupant protection. The study has been regularly updated with the most recent analysis covering Australian vehicles with years of manufacture from 1964 to 2007 (Newstead et al, 2009a).

Although New Zealand data have been combined with data from Australian states in producing the Used Car Safety Ratings since Newstead et al 2004b the information from New Zealand was not included in the estimates of crashworthiness by year of manufacture. This was because trends in crashworthiness by year of vehicle manufacture reflect the composition of a particular vehicle fleet in terms of the makes and models of vehicles in the fleet as well as the regulatory framework for vehicle safety in the country being examined.

The New Zealand and Australian vehicle fleets differ significantly in their mix of vehicle makes and models as well as the standards they were manufactured to meet. This is partly a result of the program of importing used vehicles into New Zealand (mainly from Japan) which began to have effect in 1987 when the percentage of used imports in new registrations in New Zealand rose from about 5% to about 13%. The levels of used imports rose again to about 50% over the next three years and at present about one half of the newly registered light vehicles are used imports although

this figure has been as high as two thirds in the mid 2000s. Since most newly registered vehicles in Australia are new, estimation of combined trends for the two countries by year of manufacture would not be particularly meaningful. There is also the problem that innovations and new safety standards potentially flow more slowly into a fleet such as that in New Zealand which allows the import of large numbers of second-hand (used) vehicles from other countries.

The regulatory framework governing vehicle safety in New Zealand is also quite different to that in place in Australia. Australia has a very active vehicle manufacturing industry and requires that all vehicles must be manufactured in compliance with the Australian Design Rules (ADRs), so the quality is controlled at manufacture. All new vehicles imported into the country, which account for the vast majority of new registrations in Australia, must also comply with the ADRs. By contrast New Zealand imports all its light vehicles and their quality is controlled at import. The various Land Transport Rules require that vehicles must have been manufactured in accordance with approved standards but they also provide a choice of equivalent standards, including ADRs, reflecting that the vehicles are sourced from different markets. Although both countries mandate many of the same standards, the timing of their implementation is quite different, which would be expected to lead to differences in crashworthiness by year of vehicle manufacture. For example, compliance with a frontal impact standard for occupant protection was implemented for cars manufactured after 1996 in Australia. A similar rule was only mandated for cars entering New Zealand after April 2002.

New Zealand crashworthiness ratings by year of manufacture were first developed and successfully applied in Newstead et al (2005a) for 1964-2002 model vehicles using a method of analysis that gives unbiased estimates of injury risk from injury crash data where the total number of uninjured drivers is unknown. It examined trends in crashworthiness both by year of manufacture and by year of first registration for the New Zealand light vehicle fleet. Reflecting differences in the mix of specific vehicle models in the New Zealand light vehicle fleet, crashworthiness trends by year of vehicle manufacture in New Zealand were shown to be substantially different to those observed in Australia. Whilst the largest gains in crashworthiness in Australia were measured during the 1970s years of manufacture, the bulk of the gains in crashworthiness of the New Zealand vehicle fleet have occurred since the mid 1980s. Over this period, the risk of death or serious injury to drivers in a crash reduced by around 55% for the fleet as a whole. Both levels of absolute crashworthiness and trends on a year of manufacture basis were similar for used imports and for vehicles sold new in New Zealand. The difference in observed trends between Australia and New Zealand is likely due to different patterns in the implementation of regulation governing vehicle safety performance between the two countries.

As was the case with the original study of crashworthiness by year of vehicle manufacture in Australia, this study set the basis for ongoing monitoring of crashworthiness trends by year of manufacture and first registration in the New Zealand vehicle fleet. Addition of further crash data from years after 2002 was recommended in the study to obtain estimates for years of manufacture and registration beyond 2002 and also to improve the statistical confidence on the estimates for the years previously covered. Updates also held the promise of providing a mechanism to evaluate the effect of vehicle safety rules and other interventions by the New Zealand Government. The New Zealand crashworthiness ratings were subsequently updated in Newstead et al (2006) for 1964-2004 model vehicles, in Newstead et al (2007b) for 1964-2005 model vehicles, in Newstead et al (2008b) for 1964-2006 model vehicles and in Newstead et al (2009b) for 1964-2007 model vehicles.

1.3 Project Aims

The aim of this project was to update the ratings previously published in Newstead et al (2009b) of New Zealand crashworthiness by year of manufacture for the New Zealand passenger vehicle fleet as a whole and by year of first registration for used vehicle imports in New Zealand by including

additional crash data from the year 2008 for New Zealand. The latter analysis aimed to assess the safety of the used imports brought into New Zealand in any particular year. The updated ratings focussed on light passenger vehicles including cars, station wagons, four wheel drive vehicles, passenger vans, and light commercial vehicles manufactured during 1964-2008 and crashing in New Zealand during 1991-2008.

2. CRASH DATA

Data from New Zealand used to produce the crashworthiness by year of manufacture published in the ratings of Newstead et al (2009b) covering vehicles manufactured over the period 1964-2007 and crashing during the years 1991-2007 was again used here. In addition, crash data for 2008 for New Zealand was obtained and integrated bringing the total period of crash data covered to 1991-2008. The methods of selecting appropriate cases from each data source will be detailed here.

Two sources of data from New Zealand were used The first was a crash file showing the registration, vehicle, driver and various crash characteristics for all police-reported crashes in New Zealand for the years 1991 to 2008. The second was registration data giving details of all crash-involved vehicles on the NZ register in each year from 1991 to 2008. Extracts from both data sources used in the estimation of vehicle safety ratings are described below.

2.1 Crash Data

NZ has an established database of police-reported crashes over many years. Amongst many other things, the data are used to produce the annual publication "Motor Accidents in New Zealand" summarising injury crashes in NZ (NZTA, 2009, for example). The crash data are stored in the Crash Analysis System (CAS) database managed by the New Zealand Ministry of Transport (MoT) and covers both injury and non-injury crashes. Whilst non-injury crashes are available from CAS, the reporting coverage of non-injury crashes in NZ is not as clear. The problem is that it is not mandatory for a non-injury crash to be reported to the Police so the number, nature and degree of vehicle damage, if any, are not known. Because of this, and because of problems with vehicle model identification documented by Voyce (2000), only injury crash data from New Zealand were available for estimating vehicle safety ratings.

To facilitate the use of NZ crash data in computing vehicle crashworthiness ratings, there were a number of key variables in the crash data supplied. These variables were required to represent the effects of non-vehicle factors on injury outcome in order to be able to estimate crashworthiness ratings that represented only the vehicle influences on injury outcome. The key variables available in the data were as follows.

- Year of crash (1991, 1992,…, 2008)
- Speed limit at crash location (<80km/h, >=80km/h)
- Number of vehicles involved (1, more than 1)
- Level of urbanisation of crash location (urban, rural)
- Driver age (<=25 years, 26-59 years, >=60 years)
- Driver gender (male, female)
- Injury level of driver (killed, hospitalised, other injury, not injured)

Data in CAS are stored as a relational database, comprising a series of linked tables with each covering a different theme related to a crash. The NZ MoT supplied details of the data fields available in the CAS system through a data dictionary of the database. Data from three tables, crash, person and vehicle, covered all the required data filed listed above. Linking data in the tables together was achieved using the crash identification number (crash_id), traffic unit identifier (ltsa_role) and person identifier (pers_id) fields.

Complete extracts of each data table for the years 1991 to 2008, without personal identifier information, were supplied for analysis. From these, it was possible to select the required data for analysis from the supplied tables. It is noted that each unit in the file did not necessarily represent a

vehicle that could be rated. A unit also included a motorcycle, bicyclist, pedestrian or heavy vehicle.

2.2 Registration Data

Information from the NZ motor vehicle register on vehicle make, model and year of manufacture was required to enhance the crash data for estimation of vehicle crashworthiness ratings. The New Zealand Transport Registry Centre (TRC) held the required data (see TRC, 2000, for an overview on registration data and the New Zealand vehicle fleet). Data was requested covering all vehicles appearing in the 1991-2007 New Zealand crash data with current or historical (archived) registration records. Registration records for vehicles appearing in the crash data were selected based on registration plate number, assuming the plate number had been recorded accurately by the police in the crash data.

Variables required from the registration database were selected based on information from the Pre-registration Procedures Manual supplied by TRC with reference to information required for accurate vehicle model decoding. Variables requested were as follows (with reference to the current version of the Pre-Registration Procedures Manual where available).

- Vehicle registration number (plate number)
- Vehicle Identification Number (VIN) (4-A-1)
- Vehicle Type (4-A-3)
- Registration Indicator (4-A-5)
- Date of Registration
- Date of First NZ Registration (4-A-6)
- Country of Previous Registration (4-A-7)
- Make (4-A-8)
- Model (4-A-8)
- Sub-model Name (4-A-8)
- Industry Model Code (4-A-8)
- Year of manufacture (4-A-8)
- Body Type (4-A-9)
- Country of Origin (4-A-10)
- Assembly Type (4-A-10)
- CC Rating (4-A-10)

Of the variables requested, a number were vital for clustering vehicles appearing in the New Zealand crash data for analysis by year of manufacture. These were vehicle type, year of manufacture, registration number, the date of registration, the date of first New Zealand registration and whether the vehicle was sold new in New Zealand, was a used import or re-registered. For some years there was some difference in the recording of year of manufacture and date of first registration anywhere but the errors are reported to be small.

One difficulty in retrieving vehicle registration information details for crashed vehicles based on only the registration plate number arose for registration plates that had been used on more than one vehicle model over time. It was not possible for the TRC to find the registration record that was current for a plate number just before the time the vehicle crashed. Instead, all records for the plate number of a crashed vehicle were retrieved from the registration system and archive. Where multiple records for a single plate number were provided, the most appropriate match based on the date of the crash, the date of registration and the date of first registration of the vehicle in New Zealand needed to be established. The process for doing so is described below. In some cases a registration record could not be found for a crashed vehicle. This was most likely because either the

registration plate details had been recorded incorrectly in the crash data or the vehicle was not registered. The total number of registration records is less than the number of units because registration records for some vehicles could not be identified along with some units being pedestrians and bicycles that are not registered.

2.3 Merging the Crash and Registration Data

The New Zealand registration and crash files were matched to provide full vehicle and crash information for each crash-involved unit. This required the vehicle details obtained from the registration files to be matched with the crash files based on the registration number. This process raises some unique difficulties. First, in some instances the same vehicle may have crashed more than once between 1991 and 2008 causing multiple records for the same vehicle to appear in the registration file. Selecting those cases where the date of registration, the date of first NZ registration, vehicle make, model and registration details were identical identified these cases. Multiple entries were then deleted from the registration file.

Second, it was possible that the same registration number may be associated with more than one vehicle over time and with multiple registrations of the same vehicle due to re-registration. If any of these vehicles were involved in a crash during the relevant period, all vehicles on the NZ register between 1991 and 2008 with the relevant registration numbers appeared as unique entries in the registration data file. In cases of multiple entries with the same registration number, it was necessary to identify which of the vehicles on the registration file best matched the vehicle involved in the crash as shown in the crash file. Registration details were matched to crashes by selecting the most recently registered vehicle prior to the accident date using both the date of the first New Zealand registration and the registration date of the vehicle.

Finally, in cases where the registration number was unknown or incomplete the crash and registration data could not be matched. This process of matching used here is an enhancement of that described in Newstead et al (2003) for matching New Zealand crash and registration data.

Only vehicles manufactured after 1964 and only entries coded as cars, station wagons, vans or utilities were relevant to the analysis. This left 229,221 light passenger vehicles for analysis from which the drivers' injury outcomes were used for estimation of the crashworthiness measure. Records on the uninjured drivers in the New Zealand injury crash data are incomplete because non-injury crashes in New Zealand, and hence uninjured driver details from these crashes, are not required to be reported. This meant driver injury risk could not be directly estimated from the available data. To overcome this limitation, a method of calculating injury risk from incomplete data was utilised. This injury risk estimator is referred to in Section 1.2 and described in Section 3 and involved matching two-vehicle crashes and comparing the injury outcome of the drivers in the two vehicles. The nature of the injury risk estimator means it only analyses two-car crashes in which the partner vehicle's driver has been injured, a subset of the total available data. Hence injury risk was estimated from the data on 100,708 drivers involved in a two-vehicle collision during 1991 to 2008 where the other driver was injured. This data set is referred to as the "involved drivers". Established methods were used for measuring the injury severity of injured drivers recorded in the data. The data on "injured drivers" covered 122,642 drivers who were injured in crashes in New Zealand during 1991-2008.

3. ANALYSIS

The crashworthiness rating (C) is a measure of the risk of serious injury to a driver of a car when it is involved in a crash. Following the method traditionally used by MUARC, it is defined to be the product of two probabilities (Cameron et al, 1992):

i) the probability that a driver involved in a crash is injured (injury risk), denoted by R; and
ii) the probability that an injured driver is hospitalised or killed (injury severity), denoted by S.

That is

$$C = R \times S.$$

Folksam Insurance, who publishes the well-known Swedish ratings, first measured crashworthiness in this way (Gustafsson et al, 1989). This method has previously been used to produce the Australian and New Zealand vehicle fleet crashworthiness ratings (for example Newstead et al, 2009a,b).

In the present study, each of the two components of the crashworthiness rating was obtained by logistic regression modelling techniques. Such techniques are able to simultaneously adjust for the effect of a number of factors (such as driver age and sex, number of vehicles involved, etc.) on probabilities such as the injury risk and injury severity.

For the analysis of both crashworthiness by year of manufacture and year of first registration for used imports (in New Zealand) of New Zealand light passenger vehicles another method is required. Because non-injury crashes are not reliably reported in the New Zealand crash data, injury risk cannot be measured directly from the data (as a simple ratio of injured drivers over total involved drivers) as it is in calculating the vehicle specific ratings of Newstead et al (2009a). The alternative of calculating the proportion of injured drivers amongst those involved in injury crashes results in a biased estimate of injury risk. To overcome these problems, an alternative measure of injury risk has been used here which is based on the paired comparison approach but leads to unbiased estimates. Newstead and Watson (2005a) give a description of the derivation of the injury risk estimator. It is further described in Cameron et al (2001) where it is also compared to more traditional estimators of injury risk that are also derived using the paired comparison approach but which have the problem of being biased.

Logistic regression models were used to adjust the injury risk and severity measures for the effects of possible factors other than those related to the vehicle that might have influenced the crash outcomes in terms of driver injury risk or severity. This was particularly important when the parameter of interest in the logistic regression, in this case the year of manufacture, was confounded with the non-vehicle factors. A stepwise procedure was used to identify which factors of those available in the data had an important influence on injury outcome. This was done without considering the year of manufacture in the model, as the aim was to determine which other factors were most likely to have had an influence across a broad spectrum of crashes. Furthermore, it was also not considered appropriate to interact vehicle year of manufacture with other factors in the logistic model. This is because it was not the aim of the analysis to investigate variation in relative vehicle crashworthiness by year of manufacture by the crash circumstance and occupant characteristics. Rather, the aim was to estimate the average crashworthiness by year of manufacture across all crash and occupant characteristics.

Logistic models were obtained separately for crashworthiness injury risk and crashworthiness injury severity because it was likely that the various factors would have different levels of influence on

these two probabilities. The factors considered during this stage of the analysis for both crashworthiness injury risk and crashworthiness injury severity were as follows.

- **sex:** driver sex (male, female)
- **age:** driver age (≤25 years; 26-59 years; ≥60 years)
- **speedzone:** speed limit at the crash location (<80 km/h; ≥80 km/h)
- **year:** year of crash (1987, 1988, … ,2008)

For crashworthiness injury severity the following factor was also considered.

- **nveh:** the number of vehicles involved (one vehicle; >1 vehicle)

These variables were chosen for consideration because they were part of the New Zealand database and are variables that have been shown to have significant relationship to injury outcome in the Australian and New Zealand combined vehicle safety ratings. Inclusion of the year of the crash in the logistic model was necessary to account for different long-term trends. All data was analysed using the Logistic Regression procedure (PROC LOGISTIC) of the SAS statistical package (SAS, 1989).

Crashworthiness injury risk and crashworthiness injury severity for individual years of vehicle manufacture or first registration were estimated after adding a variable representing year of manufacture to the terms identified as being statistically significant in each respective logistic model. The regression analyses were performed on 44 individual years of manufacture. A list of all years considered, with those with sufficient data for analysis indicated, is given in each of Appendices 1 and 2. For each year of manufacture or first registration, a 95% confidence interval for estimated injury risk and injury severity were obtained using methods described in Newstead and Watson (2005a).

The final combined ratings of vehicle crashworthiness are given by:

Crashworthiness Rating = Injury risk x Injury severity.

For a given year of manufacture, j, the crashworthiness rating, C_j, was therefore calculated as:

$$C_j = R_j \times S_j$$

where

R_j denotes the injury risk for year of manufacture j, and
S_j denotes the injury severity for year of manufacture j.

The 95% confidence limit for the crashworthiness rating was obtained using methods described in Newstead and Watson (2005a). Because each of the two estimated crashworthiness components have been adjusted for the effect of other factors by logistic regression prior to their incorporation into the combined ratings, the resultant crashworthiness rating is also intrinsically adjusted for the influence of these factors. It should be noted that the confidence interval for the combined rate reflects the variability in the year of manufacture or first year of registration only and not the variability in the other factors included in the logistic models.

4. RESULTS

4.1 Crashworthiness by Year of Manufacture of the New Zealand Vehicle Fleet

4.1.1 Injury Risk

Injury risk was estimated from the data on 100,708 drivers involved in a two-vehicle collision during 1991 to 2008. This reduced to 55,239 drivers where the other driver was injured. This data set is referred to as the "involved drivers". Because of missing values of some of the factors to be included in the logistic regression, and the exclusion of pre-1964 vehicles and unknown years, analysis was performed on data relating to 53,904 involved drivers, 22,883 of whom were injured.

The non-vehicle factors in the model for injury risk were determined from the variables described in Section 3. The following covariates and interactions were statistically significantly associated with injury risk and were included in the logistic regression models.

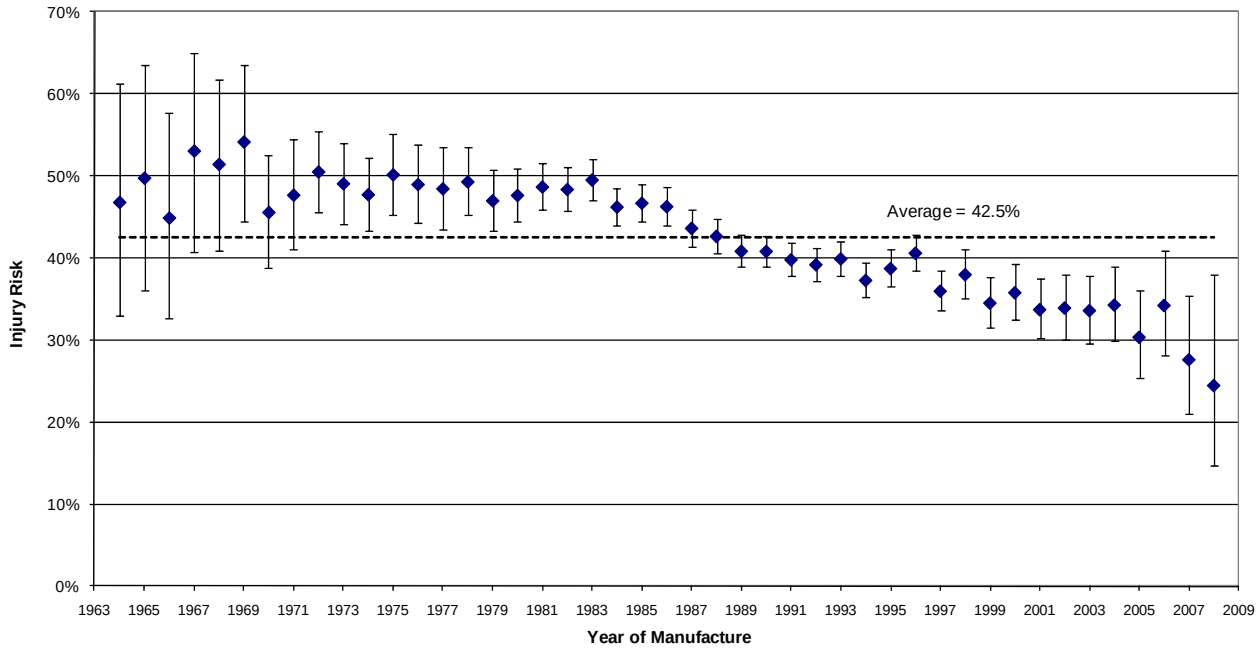
Base effect terms	First order interactions
Age	*Sex*Speedzone*
Sex	*Year*Speedzone*
Speedzone	
Year (of crash)	

No other variable or interaction term significantly improved the fit of each of the logistic models.

The overall (average) injury risk for involved drivers in matched two-vehicle casualty crashes in New Zealand where the opposing driver was injured was 42.5%. In other words, the estimated probability that a driver involved in a two-vehicle crash in New Zealand was injured where the colliding vehicle driver was also injured was 42.5%.

Appendix 1 gives the estimates of injury risk derived by logistic regression for each individual year of manufacture for all vehicles combined. The variability in the injury risk estimates relative to the year of manufacture can be seen from the width of the corresponding 95% confidence intervals. Figure 1 plots injury risk by year of vehicle manufacture with associated 95% confidence limits.

Figure 1: *Injury risk by year of manufacture (with 95% confidence limits)*



4.1.2 Injury Severity

The data on "injured drivers" covered 122,642 drivers who were injured in crashes in New Zealand during 1991-2008 (as described in Section 2.5). Because of missing values of some of the associated crash factors and the exclusion of pre-1964 vehicles and unknown years, logistic regression was performed on data relating to 119,840 injured drivers 22,228 of who were severely injured (killed or admitted to hospital).

Significant non-vehicle related factors identified in the logistic model are as follows.

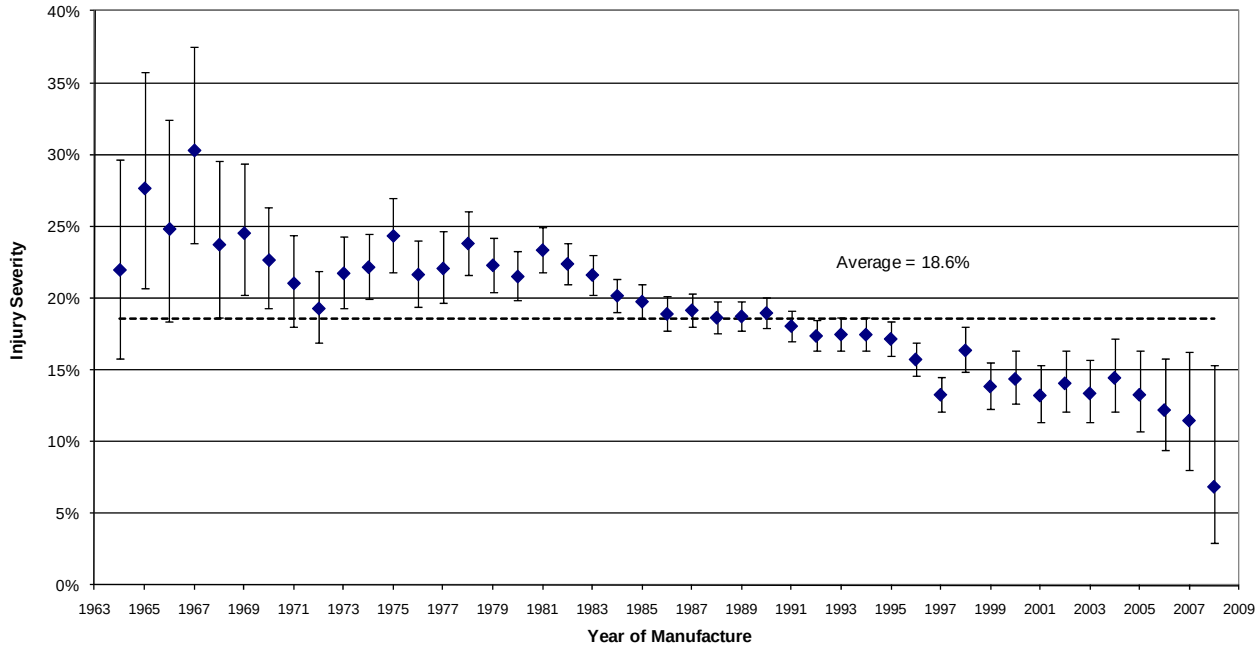
Base effect terms	First order interactions
Age	*Speedzone*Nveh*
Sex	*Age*Sex*
Nveh	*Age*Nveh*
Speedzone	*Age*Speedzone*
Year (of crash)	

No other variable or interaction term significantly improved the fit of the logistic model.

The overall (average) injury severity for injured drivers in all vehicles was 18.6%. In other words, the estimated probability that a driver injured in a crash was severely injured was 18.6%.

Appendix 1 gives the estimates of injury severity derived by logistic regression for the individual years of manufacture for all vehicles. The variability in the estimates of injury severity relative to year of manufacture can be seen from the width of the corresponding 95% confidence intervals. Figure 2 plots injury severity by year of vehicle manufacture with associated 95% confidence limits.

Figure 2: *Injury severity by year of manufacture (with 95% confidence limits)*



4.1.3 Crashworthiness by Year of Manufacture

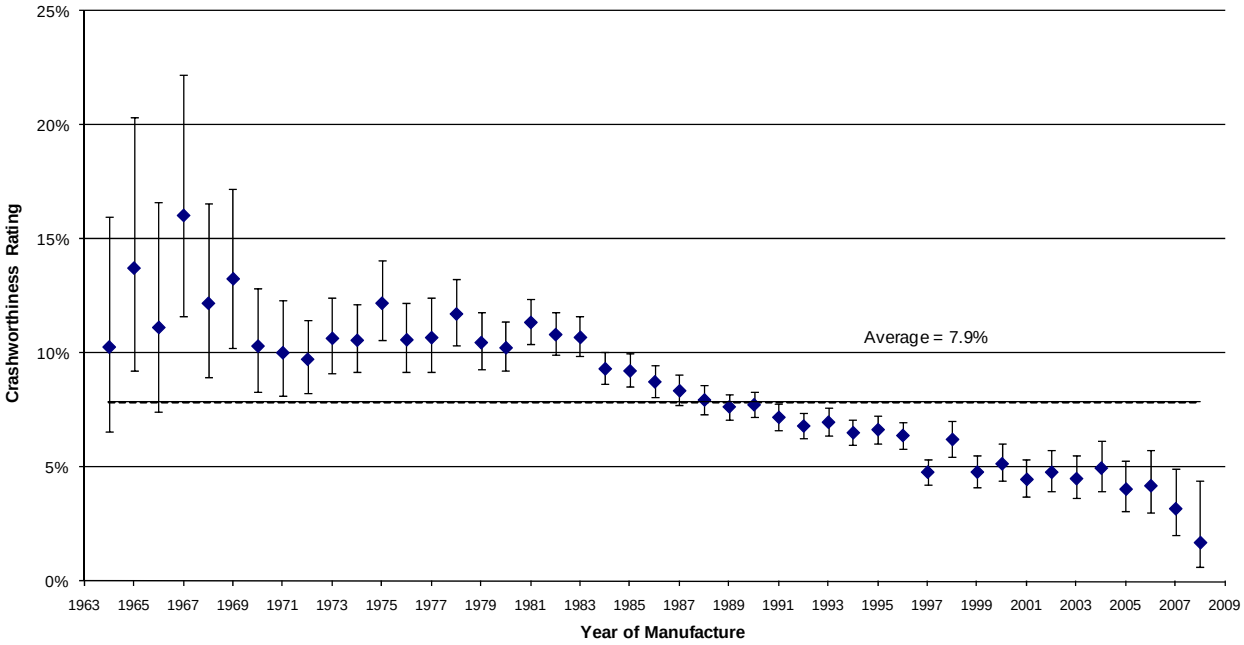
The crashworthiness estimates for each year of manufacture were obtained by multiplying the corresponding individual injury risk and injury severity estimates. Because each of the two components has been adjusted for the confounding factors, the resultant crashworthiness estimate is also intrinsically adjusted for their influence.

Appendix 1 gives the crashworthiness estimates and the associated 95% confidence intervals for each of the years of manufacture included in the analysis. Each estimate is expressed as a percentage, representing the relative number of drivers killed or admitted to hospital per 100 drivers involved in a crash.

The true risk of a driver being killed or admitted to hospital in a crash is only estimated by each figure, and as such each estimate has a level of uncertainty about it. This uncertainty is indicated by the confidence limits in Appendix 1. There is 95% probability that the confidence interval will cover the true risk of serious injury (death or hospital admission) to the driver of a vehicle of the particular year of manufacture.

The crashworthiness estimates and their confidence limits are plotted for each year of manufacture for all vehicles in Figure 3. The relatively wide confidence intervals observed on the estimates of crashworthiness for years of manufacture 1964 to 1969 and 2008 are a reflection of the smaller numbers of crashes involving vehicles manufactured in these years appearing in the data. Figure 3 shows general and significant improvement in vehicle crashworthiness with increasing year of manufacture over the years considered. Specifically, little improvement can be seen in the years 1964 to 1983 followed by rapid improvement over the period 1984 to 1995 with vehicles manufactured from 1988 being statistically significantly safer on average than those manufactured before 1983. With the exception of 1998, there is visual evidence of a decreasing trend in the period after 1995. Examination of the corresponding risk and severity plots for all vehicles in Figure 1 and 2 respectively show the improvements in crashworthiness with year of manufacture observed in Figure 3 are due to improvements in both injury risk and injury severity by year of vehicle manufacture.

Figure 3: *Crashworthiness by year of manufacture (with 95% confidence limits) for all vehicles (both new vehicles and used imports).*



4.1.4 Discussion on the analysis of Crashworthiness by Year of Manufacture of the New Zealand Vehicle Fleet

Before interpreting the results of the analysis, it is useful to give a brief summary of the history of the vehicle industry and its regulation in New Zealand.

For most of the twentieth century, starting with the General Motors assembly plant in 1926, New Zealand had a local vehicle industry. In the late 1980s, however, the face of the industry changed dramatically as a result of the progressive removal of import controls from all automotive products and reduction of tariffs on both vehicles and components. There seem to have been a number of motivating factors for the Government decision to allow used vehicles to be imported into New Zealand. One was to provide a wider source of relatively new and relatively affordable vehicles for New Zealand consumers (which in turn put pressure on new-vehicle prices). The need for this was highlighted by a trend towards an ageing vehicle fleet in New Zealand at that time. Another motivation for the used import program was to attempt to reduce the number of motorcycles in the New Zealand fleet. New motor cycle registrations had been at a high level during the 1970s and early 1980s and they were known to be a less safe means of transport than a car.

The 1990s saw a boom in the sale of used import vehicles in New Zealand along with a corresponding decline in the sales of new vehicles. Figures quoted in TRC(2000) show the percentage of used imports in annual vehicle registrations from 1960 to 1986 was generally well less than 10%. The period from 1987 onwards saw a sharp rise in this percentage and by 2002 around 68% of all vehicle registrations in a year were used imported vehicles. Annual registrations of vehicles sold new in New Zealand have shown a corresponding decline over the period from around 90,000 units in the early 1980s to around 60,000 units by the early 2000s. Under these economic constraints, by the late 1990s the local light-vehicle assembly industry had ceased operation.

The increase in the percentage of used import vehicle registrations in New Zealand is also reflected in crash data summaries such as NZMoT (2009). As was shown in Newstead and Watson (2005a) the proportion of crashed vehicles by year of first registration in New Zealand that are used imports

generally follows the trends expected from the registration statistics with rapid growth between 1987 and 2002.

The vast majority of the used light passenger vehicles imported into New Zealand come from Japan. Indeed, around 75-80% of all new registrations of both new and used vehicles in New Zealand are Japanese vehicles with Australian vehicles the next most prevalent at around 8% of new vehicle registrations.

Like most countries, New Zealand has a system of regulations to govern the safety of vehicles on the road. The earliest of these were the Traffic Regulations 1936 (TR36), updated in 1954 (TR54) and 1976 (TR76). For many years, the general focus of the Traffic Regulations was to set requirements for vehicles built in New Zealand. However, a separate set of regulations governing vehicle standards was developed in order to align New Zealand legislation with that of standard-setting bodies in the safety-conscious jurisdictions overseas from which the vehicles were sourced, namely Australia, Japan, UN/ECE and the USA. These Transport (Vehicle Standards) Regulations (1990) (VSRs) set out the technical standards with which motor vehicles must comply in order to be registered in New Zealand.

Over the period since 1990, the vehicle standards policy in New Zealand has been clarified by Government in consultation with the vehicle industry using the consultative rule-making procedure, and today the VSRs have been replaced by Land Transport Rules covering standards and safety requirements. In addition, the important Compliance Rule sets out requirements for inspection and certification of vehicles to ensure they meet the safety requirements at import and when on the road in New Zealand. Details of the vehicle standards requirements and legislation are available on the New Zealand Transport Agency web site (www.nzta.govt.nz)

It is with this history of vehicle safety standards regulation in New Zealand in mind that the analyses presented in this report should be interpreted. Because the analysis presented in this study is based on a census of all reported injury crashes in New Zealand over the period 1991 to 2008, they can be considered as representative estimates of the trends in secondary safety performance of the entire light passenger vehicle fleet in New Zealand.

Trends in estimated crashworthiness by year of vehicle manufacture for the New Zealand light passenger vehicle fleet as a whole show statistically significant improvement in crashworthiness in vehicles manufactured over the period 1964 to 2004. Estimates in Figure 3 show that the crashworthiness of vehicles manufactured in the 1960s was relatively poor, although the confidence limits on these estimates are relatively wide due to the small numbers of these vehicles in the available data. For vehicles manufactured during the 1970s, the crashworthiness estimates are relatively static showing no trend to improving or worsening crashworthiness. From about 1984 onwards, however, there is a consistent trend to improving crashworthiness by year of vehicle manufacture in the New Zealand fleet. Estimates suggest that the risk of driver death or serious injury in a crash in a vehicle manufactured in the early 21st century is about half that of the driver of an early 1980s vehicle.

Major legislative change in New Zealand governing vehicle safety standards only started to come into force from around 1990 through the VSRs and Land Transport Rules, particularly the Compliance Rule, which required proof of standards compliance if a vehicle was to enter the NZ fleet. It is also important to note that there was a revision to the Frontal Impact Rule on 1 April 2002, which now requires that a Class MA vehicle (passenger car) must have been manufactured in accordance with an approved frontal impact standard if it is to enter the New Zealand fleet. (Frontal impact protection systems of course contribute to improving vehicle crashworthiness). The crashworthiness ratings for 2003, 2004 and 2005 show an improvement in crashworthiness possibly as a result of the introduction of the new Frontal Impact Rule.

The estimates of vehicle crashworthiness by year of manufacture for the New Zealand fleet as a whole are an average of the estimates for vehicles sold new and the used imports. The average is weighted from the number of each registration type crashing for each year of manufacture.

As has been noted in analysing safety trends in the Australian vehicle fleet (Newstead and Cameron, 2001), the estimates of crashworthiness by year of vehicle manufacture for any particular year of manufacture reflect the composition of the fleet by market group and specific makes and models in that year. This comment certainly also applies to the analysis of the New Zealand vehicle fleet presented here.

4.2 Crashworthiness by Year of First Registration in New Zealand for Used Imports

A further analysis that is of great interest with respect to the used import program in New Zealand is the crashworthiness of the used-import subset of the vehicle fleet by year of first registration in New Zealand. The purpose of this analysis was to monitor trends in the average crashworthiness of used imports coming into New Zealand by year of import. This is in contrast to the year of manufacture analysis which examines trends in crashworthiness-related safety engineering improvements in vehicles over time.

Analysis of crashworthiness by year of first registration in New Zealand was carried out in the same way as for the year of manufacture analysis. The only fundamental difference was that the variable indicating year of manufacture in the analysis was replaced by the variable indicating year of first registration. Analysis by year of first registration in New Zealand has focused primarily on used import vehicles as the year of manufacture and first registration in New Zealand will generally be the same for vehicles sold new in New Zealand.

4.2.1 Injury Risk by Year of first Registration in New Zealand for Used Imports

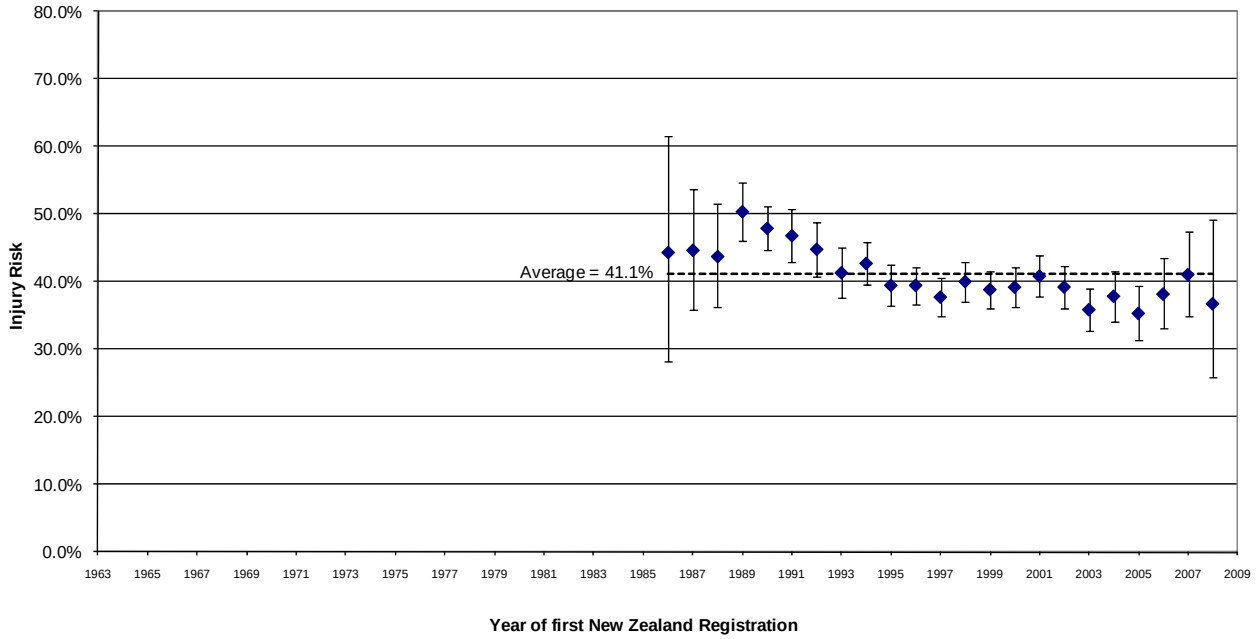
Injury risk was estimated from the data on 36,209 drivers of used imported vehicles involved in a two-vehicle collision during 1991 to 2008. This reduced to 20,131 drivers where the other driver was injured. This is the used import subset of the same data used for the analysis by year of first registration. Because of missing values of some of the factors to be included in the logistic regression, and the exclusion of pre-1964 vehicles and unknown years of first registration, analysis was performed on data relating to 19,471 involved drivers, 8,000 of who were injured.

The following non-vehicle related terms were statistically significantly associated with injury risk in the logistic models for the analysis of used imports.

Base effect terms	First order interactions
Age	*Sex * Speedzone*
Sex	
Speedzone	
Year (of crash)	

The resulting estimates of injury risk by year of first registration for used imported vehicles are plotted along with 95% confidence limits in Figure 4. Full details of the estimates are given in Appendix 2.

Figure 4: *Injury risk by year of first registration in New Zealand (with 95% confidence limits) for used imports.*



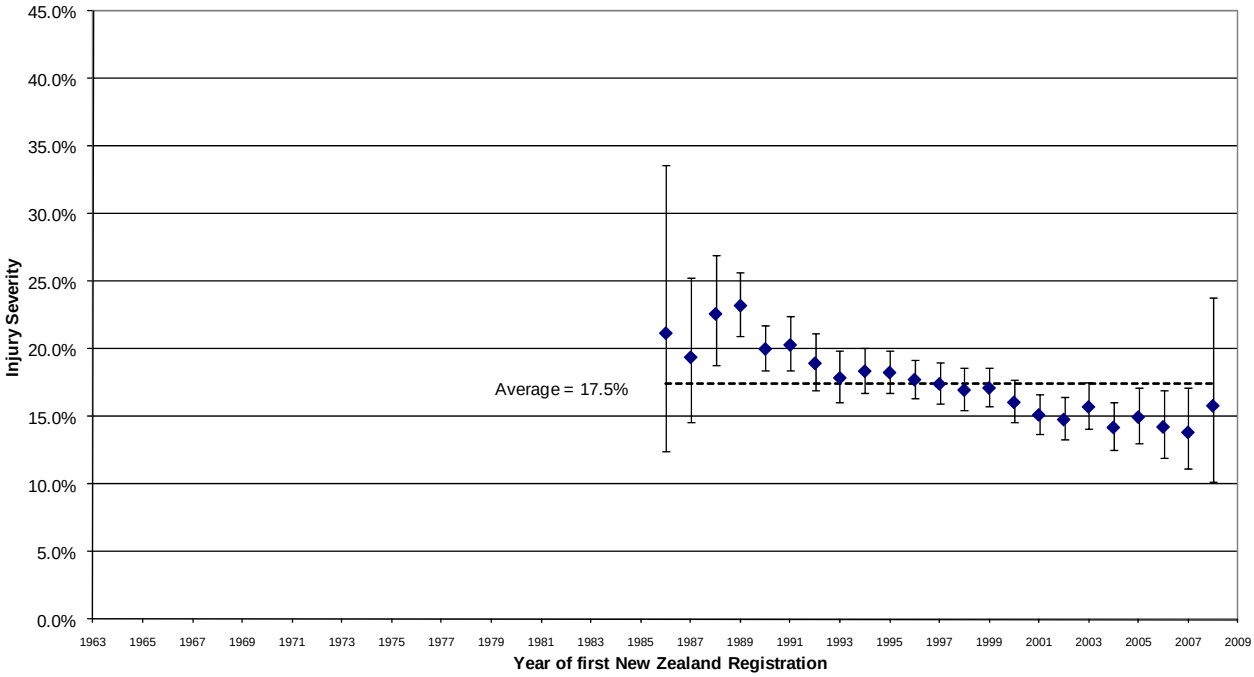
4.2.2 Injury Severity by Year of first Registration in New Zealand for Used Imports

Injury severity by year of first registration in New Zealand for used imports was estimated from the data on 44,049 drivers who were injured in crashes in New Zealand during 1991-2008, a subset of the data used in the analysis by year of manufacture. After exclusion of cases with missing values of some of the associated crash factors and the exclusion of pre-1964 vehicles and unknown years, logistic regression was performed on data relating to 42,849 injured drivers 7,480 of who were severely injured (killed or admitted to hospital). Non-vehicle related covariates and interactions included in the injury severity logistic regression model are as follows.

Base effect terms	First order interactions
Age	*Speedzone*Nveh*
Sex	*Age*Sex*
Speedzone	*Age*Nveh*
Nveh	
Year (of crash)	

The resulting estimates of injury severity by year of first registration for used imports are plotted along with 95% confidence limits in Figure 5. Full details of the estimates are given in Appendix 2.

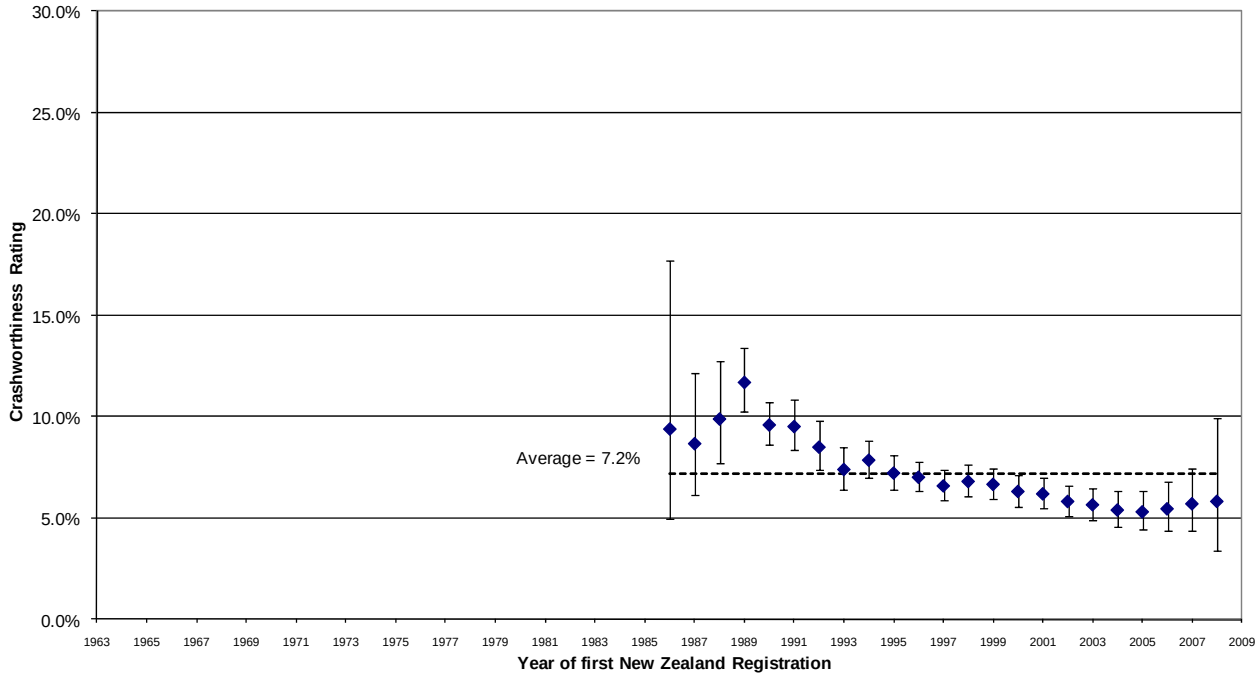
Figure 5: *Injury severity by year of first registration in New Zealand (with 95% confidence limits) for used imports.*



4.2.3 Crashworthiness by Year of First Registration in New Zealand for Used Imports

Estimates of crashworthiness by year of vehicle first registration in New Zealand for used imports were obtained by multiplying the corresponding estimates of injury risk and injury severity presented previously. The resulting crashworthiness estimates and their 95% confidence limits are presented in full in Appendix 2. Plots of the estimates and their 95% confidence limits are in Figure 6. Interpretation of the estimates is the same as for the analysis by year of manufacture presented previously.

Figure 6: *Crashworthiness by year of first registration in New Zealand (with 95% confidence limits) for used imports*



4.2.4 Discussion on the analysis of Crashworthiness by Year of First Registration in New Zealand for Used Imports

Analysis of trends in vehicle crashworthiness by year of first registration in New Zealand of the used import vehicle fleet has aimed to assess the average crashworthiness of second hand vehicles being imported into New Zealand in each calendar year and assess the impact of the second hand import program on the overall safety of all vehicles registered in New Zealand each year.

Estimates of crashworthiness trends in the used import subset of the vehicle fleet by year of first registration in New Zealand from 1986 to 2008 showed improvement in crashworthiness with time, over the years of first registration analysed. There is some suggestion that vehicles in the last six years of importation, 2003 to 2008, have reached a plateau in crashworthiness performance compared to the continued improvement estimated for new vehicles. However, this should again be tempered by the overlapping confidence limits on the estimates.

If the age profile of used import vehicles was fixed for each year of first registration in New Zealand and the vehicle type mix of the used imports reflected that of new vehicles of the same years of manufacture, it would be expected that the estimates of crashworthiness by year of first registration in New Zealand would mirror those of vehicles sold new. The only difference would be a shift in the estimates equal to the average age of the used import vehicles at their time of first registration in New Zealand. Whilst vehicles up to about 12 years old are imported, with some even older than that, the majority of used imports are in the range from 3 to 9 years old when imported, with the median age being around 6 years. NZ MoT statistics show that the age of the used imported vehicles registered in New Zealand each year has been fairly static over the last few years with an average age around 6 years. From April 2002, all vehicles newly registered in New Zealand were required to comply with frontal impact occupant protection standards, as compared to only vehicles manufactured from March 1999 in the previous rule. The modified rule made it difficult to import used vehicles manufactured before 1996, the date after which Japanese domestic vehicles

manufactured had to meet the Japanese frontal impact standard accepted under the New Zealand rule. This appears to have had little effect on average used import age overt he last 5 years.

Previous analysis of Newstead and Watson (2005a) showed that the used imported vehicles being brought into New Zealand were as safe on average as the vehicles sold new in New Zealand when compared on a year of manufacture basis. It pointed out that because the used vehicles are on average 6 years old when entering the country, the safety benefits of the latest vehicle technologies take 6 years longer to be seen in the New Zealand fleet than if the vehicles were sold new in New Zealand. The current analysis suggests that the new vehicle fleet is also more crashworthy on an age for age basis which highlights a further concern about the safety of the used imported vehicles. The differential in apparent safety between the new and used imported vehicles continues to need careful monitoring.

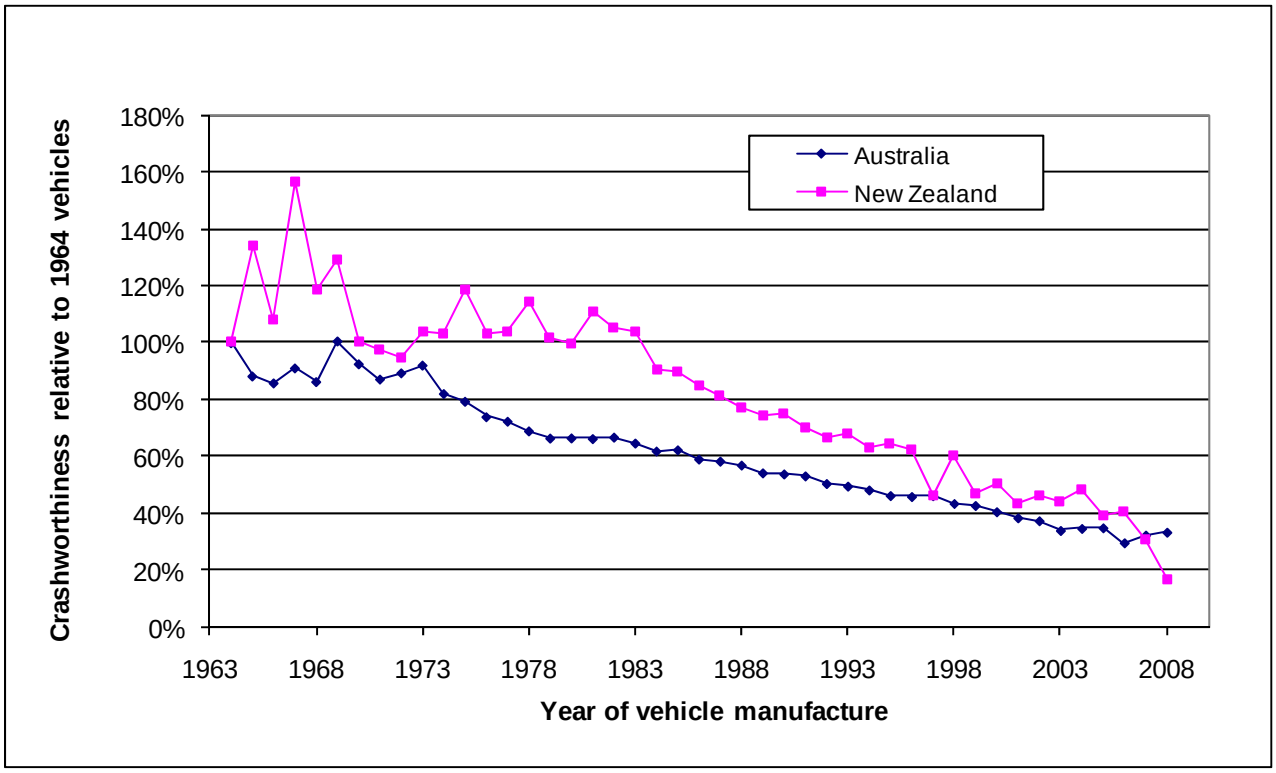
4.3 Comparison of Crashworthiness by Year of Manufacture for the Australian and New Zealand Vehicle Fleets

Because of the similarity between the types of vehicles in the Australian and New Zealand vehicle fleets, it is interesting to compare the relative trends in safety improvement between the vehicle fleets of the two countries. This comparison is also of interest to determine if the quite different strategies for vehicle safety regulation adopted in the two countries have led to fundamental difference in the patterns of vehicle safety improvement from year to year. One difficulty in making this comparison occurs because the measure of crashworthiness by year of manufacture used in each jurisdiction was scaled differently, reflecting the differences in the available data. Unfortunately the estimates from each country cannot be scaled to a common basis for comparison because the average absolute injury risk cannot be calculated from the injury-only crash data available from New Zealand (see Newstead and Watson, 2005a for a full explanation). This means that comparisons between absolute crashworthiness cannot be made between the two countries. However, because the analysis method used here provides unbiased estimates of relative crashworthiness between each year of manufacture, as does the method used to analyse the Australian data, comparisons in relative changes in crashworthiness by year of manufacture can be made between the two countries.

Using 1964 as the base year the relative change in crashworthiness by year of vehicle manufacture is shown in Figure 7 for both Australia and New Zealand. Crashworthiness by year of vehicle manufacture in Australia showed an improvement of around 35% between the end of the 1960s and the end of the 1970s in response to the introduction of a program of new Australian Design Rules concerning vehicle safety. After a relative plateau in the early 1980s a further steady improvement of about 29% in vehicle crashworthiness has been estimated between 1985 and 2008. This means that the average risk of death or serious injury to a driver in a crash in an Australian vehicle manufactured in 2008 is on average about 67% less than that of a vehicle manufactured in the 1960s. The crashworthiness of New Zealand vehicles manufactured in the 1960s was also poor compared to subsequent years. However, whilst consistent improvement in crashworthiness was seen in vehicles manufactured in the 1970s, New Zealand had little improvement in crashworthiness of vehicles manufactured during the 1970s and first half of the 1980s. Only since years of manufacture from about 1984 has New Zealand seen consistent and dramatic improvements in average vehicle crashworthiness. In fact, the crashworthiness of New Zealand vehicles manufactured from the early 1980s to 2007 has improved by about the same amount as the total improvement seen in Australian vehicles over the period from 1964 to 2005. There is some suggestion that the NZ vehicle fleet has improved its crashworthiness for 2008 year of manufacture vehicles compared to Australia. The 2008 estimates are however based on relatively small quantities of data and so should be treated with caution. Continued monitoring of this relative trend

is recommended to see if the 2008 diversion of trends between the 2 countries is robust before looking for reasons driving the divergence.

Figure 7: *Crashworthiness by year of vehicle manufacture as a percentage of 1964 vehicle crashworthiness: Australia and New Zealand.*



The key difference in crashworthiness improvement by year of vehicle manufacture between Australia and New Zealand then appears not to be the magnitude of the improvement but the relative timing of the improvement. The greatest improvements in Australia were observed during the 1970s, the period during which the greatest numbers of new regulations concerning vehicle safety were introduced. Although improvements have also been estimated in Australia after these years of manufacture they have occurred at a slower rate. In contrast the greatest improvement in crashworthiness has been observed in New Zealand for vehicles manufactured from the mid 1980s to 2008. This is also the period in which the greatest movement in introducing vehicle safety regulations in the form of the VSRs and Land Transport Rules took place. Estimated trends from both countries suggest that regulation of vehicle standards is one of the best ways to achieve the biggest gains in vehicle safety performance.

5. CONCLUSIONS

Analysis presented in this report has been able to further quantify the long-term trends in the crashworthiness of light passenger vehicles (cars, station wagons, four wheel drives and vans) in New Zealand both by year of vehicle manufacture and year of first registration in New Zealand for used imports. Crashworthiness is a measure of the relative risk of death or serious injury (hospital admission) to vehicle drivers given involvement in a crash.

Years of vehicle manufacture from 1964 to 2008 have been considered through analysis of police reported data on crashes involving injury in New Zealand over the period 1991 to 2008. This study further updates the study by Newstead and Watson (2005a), Newstead et al (2006), Newstead et al (2007b), Newstead et al (2008b) and Newstead et al (2009b) to include year 2008 for years of manufacture and year of first registration for used imports. It shows similar patterns of improvements in crashworthiness with analysis of trends by year of vehicle manufacture showing statistically significant improvement in the crashworthiness of New Zealand light passenger vehicles over the years of manufacture studied. Most of the measured improvement occurred over the years of manufacture from 1983 to 2008. Over this period, the risk of death or serious injury to drivers in a crash reduced by around 84% for the fleet as a whole. This period corresponded largely with the period over which significant increases in vehicle safety regulation took place in New Zealand.

Estimates of crashworthiness trends in the used import subset of the vehicle fleet by year of first registration in New Zealand were also updated to include vehicles imported over the period from 1986 to 2008. Estimates showed improvement in crashworthiness with time for the years of first registration analysed. Absolute levels of crashworthiness and improvements by year of first registration paralleled those seen in the analysis by year of manufacture but occurred some 6 years later, a lag equivalent to the average age of the used imported vehicles over the study period. There is also some suggestion that improvements in crashworthiness of vehicles manufactured in the most recent years is much greater for vehicles sold new in NZ compared to those imported second hand. This offers some cause for concern and should be monitored closely.

6. ASSUMPTIONS AND QUALIFICATIONS

The results and conclusions presented in this report are based on a number of assumptions and warrant a number of qualifications that the reader should note. These are listed in the following sections.

6.1 Assumptions

It has been assumed that:

- New Zealand Police crash reports accurately recorded driver injury, hospitalisation and death.
- Crashed vehicle registration numbers were recorded accurately on Police crash reports and that they correctly identified the crashed vehicles in the New Zealand vehicle registers.
- The adjustments for driver sex, age, speed zone, the number of vehicles involved and the state and year in which the crash occurred removed the influences of the other main factors available in the data that affected crash severity and injury susceptibility.
- The form of the logistic models used to relate injury risk and injury severity with the available factors influencing these outcomes (including the year of manufacture) was correct.

6.2 Qualifications

The results and conclusions warrant at least the following qualifications:

- Only driver crash involvements and injuries have been considered. Passengers occupying the same model cars may have had different injury outcomes.
- Some models with the same name through the 1982-2007 years of manufacture may have varied substantially in their construction, specification and mass. Although there should be few such models in these updated results, the rating score calculated for these models may give a misleading impression and should be interpreted with caution.
- Other factors not collected in the data (e.g. crash impact severity) may differ between the models and may affect the results. However, earlier analysis has suggested that the different rating scores are predominantly due to vehicle factors alone (Cameron et al 1992).

REFERENCES

Broughton, J. (1994) *The theoretical basis for comparing the accident record of car models*, Project Report 70, Safety and Environment Resource Centre, Transport Research Laboratory, Crowthorne, Berkshire, U.K.

Broughton, J. (1996) 'The theoretical basis for comparing the accident record of car models', *Accident Analysis and Prevention*, Vol. 28, No. 1, pp. 89-99.

Cameron, M. H. (1987) 'The effectiveness of Australian Design Rules aimed at occupant protection', *Proceedings, seminar on Structural Crashworthiness and Property Damage Accidents*, Department of Civil Engineering, Monash University, Melbourne, Australia.

Cameron, M.H., Mach, T., Neiger, D., Graham, A., Ramsay, R., Pappas, M. & Haley, J. (1992a) 'Vehicle Crashworthiness Ratings in Australia', *Proceedings, International Conference on the Biomechanics of Impacts*, Verona, Italy, pp. 105-119.

Cameron, M.H., Mach, T. & Neiger, D. (1992b) *Vehicle Crashworthiness Ratings: Victoria 1983-90 and NSW 1989-90 Crashes - Summary Report*, Report No. 28, Monash University Accident Research Centre, Melbourne, Australia.

Cameron, M.H., Finch, C.F. & Le, T. (1994a) *Vehicle Crashworthiness Ratings: Victoria and NSW Crashes During 1987-92 - Summary Report*, Report No. 55, Monash University Accident Research Centre, Melbourne, Australia.

Cameron, M.H., Finch, C.F. & Le, T. (1994b) *Vehicle Crashworthiness Ratings: Victoria and NSW Crashes During 1987-92 - Technical Report*, Report No. 58, Monash University Accident Research Centre, Melbourne, Australia.

Cameron, M.H., Newstead, S.V., Le, T. & Finch, C. (1994c) *Relationship between vehicle crashworthiness and year of manufacture*, Report No. 94/6 Royal Automobile Club of Victoria Ltd, Melbourne, Australia.

Cameron, M.H., Finch, C., Newstead, S., Le, T., Graham, A., Griffiths, M., Pappas, M. & Haley, J. (1995) 'Measuring Crashworthiness: Make/Model Ratings and the Influence of Australian Design Rules for Motor Vehicle Safety', *Proceedings, International Conference on the Biomechanics of Impacts*, Brunnen, Switzerland, pp. 297-310.

Cameron, M.H., Newstead, S.V. & Le, C.M. (1998) 'Rating the aggressivity of Australian passenger vehicles towards other vehicle occupants and unprotected road users', *Proceedings, International IRCOBI Conference on the Biomechanics of Impact*, Gothenborg, Sweden.

Green, P. (1990) *Victorian Road Accident Database: Frequency Tables for Accident Data Fields: 1988*, Accident Studies Section, VicRoads, Melbourne, Australia.

Gustafsson, H., Hagg, A., Krafft, M., Kullgren, A., Malmstedt, B., Nygren, A. & Tingvall, C. (1989) *Folksam Car Model Safety Rating 1989-90*, Folksam, Stockholm, Sweden.

Hollowell, W.T. & Gabler, H.C. (1996) 'NHTSA's Vehicle Aggressivity and Compatibility Research Program', *Proceedings, Fifteenth International Technical Conference on the Enhanced Safety of Vehicles*, Melbourne, Australia.

Hosmer, D.W. & Lemeshow, S. (1989) *Applied Logistic Regression,* Wiley, New York.

Newstead, S., Cameron, M. & Skalova, M. (1996) *Vehicle Crashworthiness Ratings: Victoria and NSW Crashes During 1987-94,* Report No. 92, Monash University Accident Research Centre, Melbourne, Australia.

Newstead, S., Cameron, M. & Le, C.M. (1997) *Vehicle Crashworthiness Ratings and Crashworthiness by Year of Manufacture: Victoria and NSW crashes during 1987-95,* Report No. 107, Monash University Accident Research Centre, Melbourne, Australia.

Newstead, S., Cameron, M. & Le, C.M. (1998) *Vehicle Crashworthiness Ratings and Crashworthiness by Year of Manufacture: Victoria and NSW crashes during 1987-96,* Report No. 128, Monash University Accident Research Centre, Melbourne, Australia.

Newstead, S., Cameron, M.H. & Le, C.M. (1999) *Vehicle Crashworthiness Ratings and Crashworthiness by Year of Manufacture: Victoria and NSW Crashes During 1987-97, Queensland Crashes During 1991-96,* Report No. 150, Monash University Accident Research Centre, Melbourne, Australia.

Newstead, S., Cameron, M.H. & Le, C.M. (2000a) *Vehicle Crashworthiness Ratings and Crashworthiness by Year of Manufacture: Victoria and NSW Crashes During 1987-98 Queensland Crashes During 1991-98,* Report No. 171, Monash University Accident Research Centre, Melbourne, Australia.

Newstead, S. (2000b). *Review of the New Zealand Land Transport Safety Authority feasibility study into producing crashworthiness ratings for New Zealand vehicles*. Report to the New Zealand Land Transport Safety Authority, Monash University Accident Research Centre, Melbourne, Australia.

Newstead, S. & Cameron, M. (2001), 'Trends in Australian vehicle crashworthiness by year of vehicle manufacture within vehicle market groups', *Proceedings of the 2001 IRCOBI Conference,* Isle of Man, UK.

Newstead, S., Cameron, M., Watson, L. and Delaney, A. (2003a) *Vehicle Crashworthiness Ratings and Crashworthiness by Year of Manufacture: Victoria and NSW Crashes During 1987-2000 Queensland and Western Australian Crashes During 1991-2000,* Report No. 196, Monash University Accident Research Centre, Melbourne, Australia.

Newstead, S., Delaney, A. and Watson, L. (2003b) *Vehicle safety ratings estimated from combined Australian and New Zealand real crash data: Pilot Study,* Report No. 203, Monash University Accident Research Centre, Melbourne, Australia.

Newstead, S., Watson, L. and. Cameron, M. (2004a) *Trends in aggressivity of the Australian light vehicle fleet by year of manufacture and market group: 1964 to 2000,* Report No. 214, Monash University Accident Research Centre, Melbourne, Australia.

Newstead, S., Cameron, M., and Watson, L. (2004b) *Vehicle Crashworthiness Ratings and Crashworthiness by Year of Manufacture: Victoria and NSW Crashes During 1987-2002 Queensland, Western Australian and New Zealand Crashes During 1991-2002,* Report No. 222, Monash University Accident Research Centre, Melbourne, Australia.

Newstead, S., Watson, L., Delaney, A. and. Cameron, M. (2004c) *Crashworthiness and aggressivity of the Australian light vehicle fleet by major crash type,* Report No. 227, Monash University Accident Research Centre, Melbourne, Australia.

Newstead, S. and Watson, L. (2005a) *Trends in crashworthiness of the New Zealand vehicle fleet by year of manufacture: 1964 to 2002,* Report No. 238, Monash University Accident Research Centre, Melbourne, Australia.

Newstead, S., Cameron, M., and Watson, L. (2005b) *Vehicle safety ratings estimated from police reported crash data: 2005 update Australian and New Zealand crashes during 1987-2003,* Report No. 241, Monash University Accident Research Centre, Melbourne, Australia.

Newstead, S., Cameron, M., and Watson, L. (2006) *Vehicle safety ratings estimated from police reported crash data: 2006 update Australian and New Zealand crashes during 1987-2004,* Report No. 248, Monash University Accident Research Centre, Melbourne, Australia.

Newstead, S., Watson, L., and Cameron, M. (2007a) *Vehicle safety ratings estimated from police reported crash data: 2007 update Australian and New Zealand crashes during 1987-2005,* Report No. 266, Monash University Accident Research Centre, Melbourne, Australia.

Newstead, S., Watson, L., and Cameron, M. (2007b) *Trends in crashworthiness of the New Zealand vehicle fleet by year of manufacture: 1964 to 200: Supplementary to report 266 vehicle safety ratings estimated from police reported crash data: 2007 update Australian and New Zealand crashes during 1987-2005,* Report No. 266 Supplement, Monash University Accident Research Centre, Melbourne, Australia.

Newstead, S., Watson, L., and Cameron, M. (2008a) *Vehicle safety ratings estimated from police reported crash data: 2008 update Australian and New Zealand crashes during 1987-2006,* Report No. 280, Monash University Accident Research Centre, Melbourne, Australia.

Newstead, S., Watson, L., and Cameron, M. (2008b) *Trends in crashworthiness of the New Zealand vehicle fleet by year of manufacture: 1964 to 2006: Supplementary to report 280 vehicle safety ratings estimated from police reported crash data: 2008 update Australian and New Zealand crashes during 1987-2006,* Report No. 280 Supplement, Monash University Accident Research Centre, Melbourne, Australia.

Newstead, S., Watson, L., and Cameron, M. (2009a) *Vehicle safety ratings estimated from police reported crash data: 2009 update Australian and New Zealand crashes during 1987-2008,* Report No. 287, Monash University Accident Research Centre, Melbourne, Australia.

Newstead, S., Watson, L., and Cameron, M. (2009b) *Trends in crashworthiness of the New Zealand vehicle fleet by year of manufacture: 1964 to 2007: Supplementary to report 287 vehicle safety ratings estimated from police reported crash data: 2009 update Australian and New Zealand crashes during 1987-2007,* Report No. 287 Supplement, Monash University Accident Research Centre, Melbourne, Australia.

NZMoT (2009) *Motor Accidents in New Zealand 2008, Statistical Statement Calendar Year 2008,* Transport Monitoring, New Zealand Ministry of Transport, Wellington, New Zealand.

Pappas, M. (1993) *NSW Vehicle Occupant Protection Ratings Documentation,* Report to NRMA Ltd. and Road Safety Bureau, Roads and Traffic Authority, Sydney, NSW.

Road Safety Council of Western Australia (2001) *Reported road crashes in Western Australia, 2000,* Road Safety Council of Western Australia, Office of Road Safety, Perth, Australia.

Robinson, T. (2000a) *Vehicle crashworthiness feasibility study. Clustering guide and methodology* Land Transport Safety Authority, Wellington, New Zealand.

Robinson, T. (2000b) *Assessment of the fit between the New Zealand fleet and MUARC classes* Land Transport Safety Authority, Wellington, New Zealand.

SAS Inc. (1989) *SAS STAT Users Guide, Version 6, Fourth Edition, Volume 2*. Carey, NC: SAS Institute.

Social Development Committee (1990) *Inquiry into Vehicle Occupant Protection,* Parliament of Victoria, Melbourne, Australia.

TRC (2000) *New Zealand Motor Vehicle Registration Statistics 2000* Transport Registry Centre, Land Transport Safety Authority, Palmerston North, New Zealand.

Voyce, T. (2000) *Crashworthiness study - data entry* Land Transport Safety Authority, Wellington, New Zealand.

APPENDIX 1

CRASHWORTHINESS, INJURY RISK AND INJURY SEVERITY ESTIMATES BY YEAR OF VEHICLE MANUFACTURE FOR THE NEW ZEALAND VEHICLE FLEET

CRASHWORTHINESS INJURY RISK BY YEAR OF MANUFACTURE FOR ALL NEW ZEALAND VEHICLES

Year of Manufacture	Coefficient of Car Model	Standard Error of Coefficient	Pr(Risk) %	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Width of Confidence Interval
AVERAGE	**-0.3043**		**42.45**			
1964	0.1771	0.2976	46.83	32.95	61.21	28.26
1965	0.2955	0.2884	49.78	36.03	63.56	27.53
1966	0.1004	0.2637	44.92	32.72	57.76	25.04
1967	0.4278	0.2531	53.08	40.79	65.01	24.22
1968	0.3625	0.2158	51.46	40.98	61.80	20.82
1969	0.4722	0.1992	54.19	44.46	63.61	19.15
1970	0.1277	0.1436	45.60	38.75	52.62	13.87
1971	0.2122	0.1372	47.70	41.07	54.41	13.34
1972	0.3259	0.1010	50.54	45.60	55.47	9.86
1973	0.2681	0.1017	49.10	44.14	54.07	9.93
1974	0.2145	0.0921	47.76	43.28	52.27	8.98
1975	0.3118	0.1002	50.19	45.29	55.08	9.79
1976	0.2641	0.0975	49.00	44.24	53.77	9.52
1977	0.2434	0.1012	48.48	43.56	53.43	9.88
1978	0.2771	0.0840	49.32	45.22	53.43	8.21
1979	0.1848	0.0774	47.02	43.26	50.81	7.54
1980	0.2110	0.0671	47.67	44.40	50.96	6.55
1981	0.2521	0.0577	48.70	45.88	51.52	5.64
1982	0.2400	0.0546	48.39	45.73	51.07	5.34
1983	0.2862	0.0528	49.55	46.96	52.13	5.17
1984	0.1541	0.0459	46.25	44.03	48.50	4.47
1985	0.1731	0.0475	46.73	44.42	49.05	4.63
1986	0.1561	0.0467	46.30	44.04	48.58	4.55
1987	0.0492	0.0460	43.66	41.45	45.89	4.43
1988	0.0094	0.0448	42.68	40.55	44.84	4.29
1989	-0.0652	0.0402	40.87	38.98	42.78	3.81
1990	-0.0662	0.0396	40.84	38.98	42.73	3.75
1991	-0.1084	0.0428	39.83	37.83	41.85	4.02
1992	-0.1336	0.0425	39.22	37.26	41.23	3.97
1993	-0.1039	0.0455	39.94	37.82	42.09	4.28
1994	-0.2146	0.0453	37.31	35.26	39.41	4.15
1995	-0.1534	0.0485	38.75	36.52	41.03	4.51
1996	-0.0752	0.0471	40.63	38.42	42.87	4.45
1997	-0.2712	0.0547	36.00	33.57	38.50	4.94
1998	-0.1848	0.0640	38.01	35.10	41.01	5.91
1999	-0.3350	0.0696	34.54	31.53	37.69	6.16
2000	-0.2796	0.0743	35.80	32.53	39.22	6.69
2001	-0.3705	0.0839	33.74	30.17	37.51	7.34
2002	-0.3615	0.0893	33.94	30.14	37.97	7.84
2003	-0.3756	0.0950	33.63	29.61	37.90	8.30
2004	-0.3454	0.1028	34.31	29.92	38.98	9.06
2005	-0.5248	0.1290	30.38	25.31	35.98	10.67
2006	-0.3477	0.1444	34.25	28.19	40.88	12.69
2007	-0.6580	0.1837	27.64	21.04	35.38	14.34
2008	-0.8218	0.3236	24.49	14.67	37.95	23.27

CRASHWORTHINESS INJURY SEVERITY BY YEAR OF VEHICLE MANUFACTURE FOR ALL VEHICLES

Year of Manufacture	Coefficient of Car Model	Standard Error of Coefficient	Pr(Severity) %	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Width of Confidence Interval
AVERAGE	**-1.4797**		**18.55**			
1964	0.2107	0.2076	21.94	15.76	29.69	13.93
1965	0.5155	0.1924	27.60	20.73	35.73	15.00
1966	0.3695	0.1928	24.78	18.42	32.47	14.05
1967	0.6439	0.1655	30.24	23.86	37.49	13.62
1968	0.3105	0.1532	23.70	18.70	29.55	10.85
1969	0.3538	0.1265	24.49	20.20	29.36	9.16
1970	0.2501	0.1031	22.63	19.28	26.36	7.07
1971	0.1556	0.0984	21.01	17.99	24.39	6.40
1972	0.0469	0.0813	19.27	16.91	21.87	4.96
1973	0.1968	0.0753	21.71	19.30	24.32	5.02
1974	0.2218	0.0673	22.13	19.94	24.49	4.55
1975	0.3436	0.0708	24.30	21.84	26.95	5.10
1976	0.1918	0.0692	21.62	19.41	24.01	4.60
1977	0.2167	0.0742	22.05	19.65	24.65	5.00
1978	0.3149	0.0616	23.78	21.66	26.04	4.38
1979	0.2295	0.0565	22.27	20.41	24.24	3.83
1980	0.1838	0.0520	21.49	19.82	23.26	3.44
1981	0.2894	0.0447	23.32	21.79	24.92	3.13
1982	0.2350	0.0420	22.36	20.97	23.82	2.86
1983	0.1900	0.0408	21.59	20.27	22.98	2.71
1984	0.1026	0.0370	20.15	19.01	21.34	2.33
1985	0.0772	0.0384	19.74	18.58	20.96	2.39
1986	0.0224	0.0396	18.89	17.73	20.11	2.38
1987	0.0387	0.0388	19.14	17.99	20.34	2.35
1988	0.0052	0.0379	18.63	17.53	19.78	2.25
1989	0.0112	0.0347	18.72	17.71	19.77	2.07
1990	0.0265	0.0344	18.95	17.94	20.01	2.07
1991	-0.0337	0.0373	18.04	16.99	19.15	2.16
1992	-0.0808	0.0379	17.36	16.32	18.45	2.13
1993	-0.0734	0.0409	17.46	16.34	18.65	2.31
1994	-0.0743	0.0404	17.45	16.34	18.62	2.28
1995	-0.0953	0.0439	17.15	15.96	18.41	2.45
1996	-0.1990	0.0434	15.73	14.63	16.89	2.26
1997	-0.3969	0.0533	13.28	12.12	14.53	2.41
1998	-0.1521	0.0589	16.36	14.84	18.00	3.16
1999	-0.3478	0.0694	13.85	12.31	15.56	3.25
2000	-0.3047	0.0759	14.38	12.64	16.31	3.67
2001	-0.4013	0.0870	13.23	11.39	15.31	3.92
2002	-0.3299	0.0888	14.07	12.09	16.31	4.21
2003	-0.3889	0.0959	13.37	11.34	15.70	4.36
2004	-0.2987	0.1050	14.45	12.09	17.19	5.10
2005	-0.3971	0.1233	13.28	10.73	16.31	5.58
2006	-0.4928	0.1508	12.21	9.38	15.75	6.37
2007	-0.5623	0.2047	11.49	7.99	16.24	8.24
2008	-1.1247	0.4556	6.89	2.94	15.30	12.36

CRASHWORTHINESS BY YEAR OF VEHICLE MANUFACTURE
FOR ALL VEHICLES

Year of Manufacture	Pr(Risk) %	Pr(Severity) %	Serious injury rate per 100 drivers involved	Overall rank order	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Width of Confidence Interval
AVERAGE	**42.45**	**18.55**	**7.87**				
1964	46.83	21.94	10.28	29	6.59	16.02	19.70
1965	49.78	27.60	13.74	44	9.27	20.37	24.85
1966	44.92	24.78	11.13	38	7.45	16.65	20.33
1967	53.08	30.24	16.05	45	11.60	22.21	26.66
1968	51.46	23.70	12.20	41	8.97	16.59	19.82
1969	54.19	24.49	13.27	43	10.24	17.19	20.22
1970	45.60	22.63	10.32	30	8.29	12.84	14.87
1971	47.70	21.01	10.02	27	8.15	12.33	14.21
1972	50.54	19.27	9.74	26	8.28	11.45	12.90
1973	49.10	21.71	10.66	34	9.14	12.43	13.95
1974	47.76	22.13	10.57	32	9.19	12.15	13.53
1975	50.19	24.30	12.20	42	10.57	14.08	15.71
1976	49.00	21.62	10.59	33	9.17	12.24	13.66
1977	48.48	22.05	10.69	35	9.18	12.45	13.96
1978	49.32	23.78	11.73	40	10.36	13.28	14.65
1979	47.02	22.27	10.47	31	9.31	11.78	12.94
1980	47.67	21.49	10.24	28	9.22	11.38	12.41
1981	48.70	23.32	11.36	39	10.39	12.41	13.38
1982	48.39	22.36	10.82	37	9.95	11.78	12.65
1983	49.55	21.59	10.70	36	9.86	11.61	12.45
1984	46.25	20.15	9.32	25	8.64	10.05	10.73
1985	46.73	19.74	9.22	24	8.53	9.97	10.67
1986	46.30	18.89	8.75	23	8.07	9.47	10.14
1987	43.66	19.14	8.36	22	7.72	9.05	9.69
1988	42.68	18.63	7.95	21	7.35	8.60	9.20
1989	40.87	18.72	7.65	19	7.12	8.22	8.76
1990	40.84	18.95	7.74	20	7.21	8.31	8.85
1991	39.83	18.04	7.19	18	6.65	7.77	8.31
1992	39.22	17.36	6.81	16	6.29	7.37	7.89
1993	39.94	17.46	6.97	17	6.41	7.59	8.16
1994	37.31	17.45	6.51	14	5.98	7.10	7.63
1995	38.75	17.15	6.65	15	6.06	7.29	7.87
1996	40.63	15.73	6.39	13	5.84	6.99	7.54
1997	36.00	13.28	4.78	8	4.27	5.36	5.87
1998	38.01	16.36	6.22	12	5.49	7.04	7.76
1999	34.54	13.85	4.79	9	4.13	5.55	6.20
2000	35.80	14.38	5.15	11	4.40	6.03	6.78
2001	33.74	13.23	4.46	5	3.71	5.36	6.11
2002	33.94	14.07	4.78	7	3.95	5.77	6.59
2003	33.63	13.37	4.50	6	3.67	5.52	6.35
2004	34.31	14.45	4.96	10	3.98	6.18	7.16
2005	30.38	13.28	4.03	3	3.07	5.30	6.27
2006	34.25	12.21	4.18	4	3.04	5.76	6.90
2007	27.64	11.49	3.18	2	2.04	4.93	6.06
2008	24.49	6.89	1.69	1	0.65	4.40	5.44

APPENDIX 2

CRASHWORTHINESS, INJURY RISK AND INJURY SEVERITY ESTIMATES BY YEAR OF FIRST NEW ZEALAND VEHICLE REGISTRATION FOR USED IMPORT VEHICLES

CRASHWORTHINESS INJURY RISK BY YEAR OF FIRST NEW ZEALAND VEHICLE REGISTRATION FOR USED IMPORT VEHICLES

Year of first registration	Coefficient of Car Model	Standard Error of Coefficient	Pr(Risk) %	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Width of Confidence Interval
AVERAGE YEAR	**-0.3604**		**41.09**			
1986	0.1325	0.3581	44.33	28.30	61.63	33.34
1987	0.1457	0.1850	44.65	35.96	53.69	17.74
1988	0.1081	0.1601	43.73	36.21	51.54	15.32
1989	0.3757	0.0880	50.38	46.08	54.68	8.60
1990	0.2770	0.0671	47.92	44.65	51.20	6.55
1991	0.2330	0.0796	46.82	42.96	50.72	7.75
1992	0.1517	0.0834	44.80	40.80	48.87	8.07
1993	0.0094	0.0775	41.31	37.69	45.04	7.35
1994	0.0664	0.0662	42.70	39.56	45.90	6.34
1995	-0.0682	0.0644	39.45	36.48	42.50	6.02
1996	-0.0681	0.0581	39.45	36.76	42.20	5.44
1997	-0.1418	0.0608	37.70	34.95	40.54	5.59
1998	-0.0446	0.0627	40.01	37.10	42.99	5.89
1999	-0.0945	0.0594	38.82	36.09	41.62	5.52
2000	-0.0794	0.0649	39.18	36.19	42.25	6.06
2001	-0.0112	0.0642	40.82	37.81	43.89	6.07
2002	-0.0784	0.0686	39.20	36.05	42.45	6.40
2003	-0.2222	0.0704	35.83	32.73	39.06	6.34
2004	-0.1364	0.0812	37.83	34.17	41.64	7.47
2005	-0.2461	0.0881	35.29	31.45	39.32	7.87
2006	-0.1226	0.1130	38.15	33.08	43.50	10.42
2007	-0.0017	0.1344	41.04	34.85	47.53	12.68
2008	-0.1842	0.2610	36.71	25.80	49.17	23.37

CRASHWORTHINESS INJURY SEVERITY BY YEAR OF FIRST NEW ZEALAND VEHICLE REGISTRATION FOR USED IMPORT VEHICLES

Year of first registration	Coefficient of Car Model	Standard Error of Coefficient	Pr(Severity) %	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Width of Confidence Interval
AVERAGE	**-1.5536**		**17.46**			
1986	0.2411	0.3232	21.21	12.50	33.65	21.15
1987	0.1309	0.1737	19.42	14.64	25.31	10.67
1988	0.3244	0.1198	22.63	18.79	27.00	8.22
1989	0.3591	0.0675	23.25	20.97	25.69	4.72
1990	0.1699	0.0544	20.04	18.39	21.80	3.42
1991	0.1883	0.0636	20.34	18.39	22.43	4.04
1992	0.1022	0.0694	18.98	16.97	21.16	4.18
1993	0.0304	0.0674	17.90	16.04	19.92	3.88
1994	0.0639	0.0573	18.40	16.77	20.14	3.37
1995	0.0572	0.0539	18.30	16.77	19.93	3.16
1996	0.0215	0.0496	17.77	16.39	19.23	2.84
1997	-0.00004	0.0543	17.46	15.98	19.04	3.07
1998	-0.0320	0.0560	17.00	15.51	18.61	3.10
1999	-0.0212	0.0517	17.15	15.76	18.64	2.88
2000	-0.0975	0.0586	16.10	14.60	17.71	3.10
2001	-0.1684	0.0573	15.16	13.77	16.66	2.89
2002	-0.1952	0.0622	14.82	13.35	16.43	3.08
2003	-0.1230	0.0657	15.75	14.12	17.54	3.42
2004	-0.2422	0.0745	14.24	12.54	16.11	3.57
2005	-0.1810	0.0812	15.00	13.08	17.14	4.06
2006	-0.2394	0.1028	14.27	11.98	16.92	4.94
2007	-0.2723	0.1272	13.87	11.15	17.13	5.97
2008	-0.1168	0.2579	15.84	10.19	23.78	13.58

CRASHWORTHINESS BY YEAR OF FIRST NEW ZEALAND VEHICLE REGISTRATION FOR USED IMPORT VEHICLES

Year of first registration	Pr(Risk) %	Pr(Severity) %	Serious injury rate per 100 drivers involved	Overall rank order	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Width of Confidence Interval
AVERAGE	**41.09**	**17.46**	**7.17**				
1986	44.33	21.21	9.40	19	4.99	17.72	12.73
1987	44.65	19.42	8.67	18	6.17	12.18	6.01
1988	43.73	22.63	9.90	22	7.68	12.75	5.07
1989	50.38	23.25	11.71	23	10.26	13.38	3.12
1990	47.92	20.04	9.60	21	8.61	10.71	2.10
1991	46.82	20.34	9.52	20	8.37	10.84	2.47
1992	44.80	18.98	8.50	17	7.37	9.80	2.43
1993	41.31	17.90	7.39	15	6.43	8.51	2.08
1994	42.70	18.40	7.86	16	6.98	8.84	1.86
1995	39.45	18.30	7.22	14	6.43	8.10	1.67
1996	39.45	17.77	7.01	13	6.31	7.79	1.48
1997	37.70	17.46	6.58	10	5.87	7.38	1.52
1998	40.01	17.00	6.80	12	6.05	7.65	1.60
1999	38.82	17.15	6.66	11	5.96	7.43	1.47
2000	39.18	16.10	6.31	9	5.57	7.14	1.56
2001	40.82	15.16	6.19	8	5.48	6.98	1.50
2002	39.20	14.82	5.81	6	5.09	6.63	1.54
2003	35.83	15.75	5.65	4	4.91	6.49	1.59
2004	37.83	14.24	5.39	2	4.59	6.32	1.73
2005	35.29	15.00	5.29	1	4.44	6.31	1.87
2006	38.15	14.27	5.44	3	4.37	6.79	2.42
2007	41.04	13.87	5.69	5	4.37	7.42	3.05
2008	36.71	15.84	5.81	7	3.41	9.92	6.52