TRENDS WITH ANCAP SAFETY RATINGS AND REAL-WORLD CRASH PERFORMANCE FOR VEHICLE MODELS IN AUSTRALIA

Michael Paine

David Paine

Australasian NCAP

Michael Case

RACV

Jack Haley

NRMA Motoring & Services

Craig Newland

Australian Automobile Association

Stuart Worden

New Zealand Transport Agency

Paper Number 13-0390

ABSTRACT

Since 1995 the Australasian New Car Assessment Program (ANCAP) has conducted a 64km/h offset crash test. In 1999 the test and rating protocols were aligned with Euro NCAP. This produces a rating out of 5 stars for front occupant (driver and front passenger) protection. In a separate program the crashworthiness of used cars in real-world crashes has been analysed under the Used Car Safety Rating (UCSR) scheme.

The ANCAP and UCSR ratings of more than 30 models on the Australian market can be tracked for more than a decade. This paper sets out the results of an analysis of these data and observations about the safety improvements to these models.

In general an improvement of one ANCAP star rating for a model is associated with a 20 to 25% reduction in risk of serious injury to the driver. It is likely that improvements from 3 stars or less to 4 stars are mostly associated with improved structure and restraints in frontal crashes. Improvements from 4 to 5 stars are mostly likely associated with improved head protection in side crashes.

It is only in the last few years that most popular models in Australia have reached a 5 star rating. Many of these vehicles are not yet covered by Used Car Safety Ratings because of the inherent delay in obtaining real-world crash data. It is therefore planned to repeat this analysis in 2014.

INTRODUCTION

The Australasian New Car Assessment Program has conducted consumer crash tests since the early 1990s. In 1999 ANCAP aligned its test and assessment protocols with Euro NCAP and began republishing applicable Euro NCAP results using a 5-star safety rating.

The Used Car Safety Ratings were developed by Monash University Accident Research Unit (MUARC) in the early 1990s. Police-reported accidents from Australia and New Zealand are analysed to derive estimates of crashworthiness for popular vehicle models. One key output from the analysis is a driver serious injury rate per reported crash for each vehicle model. Statistical techniques are used to account for influencing factors such as age and sex of driver, restraint usage and speed limit of road (Cameron and others 1992).

There is an inherent delay in the time taken to acquire real-world crash data. Furthermore, a sufficient numbers of crashes of a model need to occur in order for sample sizes to be adequate for statistical analysis. For these reasons the USCR do not usually provide reliable estimates of crashworthiness of popular new models until at least four years after the model is launched.

In general, as a vehicle model has been replaced the new model performs better in ANCAP tests than the replaced model (a notable exception was the Holden Barina in 2005). This paper sets out the results of an analysis of the change in ANCAP safety rating and UCSR crashworthiness for more than 30 models of passenger vehicles that have been sold in Australia since the mid-1990s.

RECENT ANCAP TRENDS

In the last few years there has been a dramatic improvement in the ANCAP safety ratings of new models. Figure 1 shows the proportion of rated new models for each star rating by year of rating.

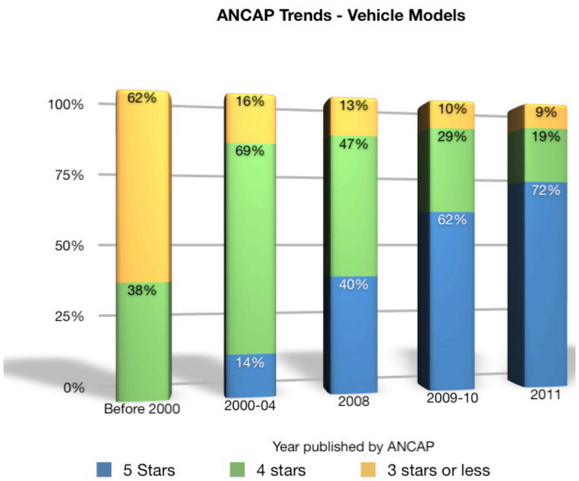

Figure 1. Trends with ANCAP ratings

Before 2000 there were no 5 star ratings and only 38% of models had a 4 star rating. By 2004 14% of models were 5 stars and a further 69% were 4 stars, meaning that the proportion with 3 stars or less had dropped from two-thirds to 16%. These improvements were largely due to improved performance in the offset crash test (Paine and others 2009).

The proportion of 5 star models increased from 14% in 2004 to 40% in 2008 and 72% in 2011. This is likely to be due to further improvements in frontal offset crash performance, but mainly due to the rapid introduction of head-protecting side airbags (e.g. inflatable side curtains), which are necessary for satisfactory performance in the side pole test (which has been an ANCAP 5-star requirement since 2004).

UCSR TRENDS

The 2012 UCSR update confirms a steady improvement in crashworthiness (i.e. reduction in risk of serious injury to the driver) over more than two decades. Compared with a mid 1980s model, a vehicle built between 2007 and 2010 typically has less than half the risk of driver serious injury (Newstead 2012).

It is notable that very few models introduced since 2007 have statistically meaningful crashworthiness ratings. As indicated above, there were simply too few reported crashes of these models for the 2012 UCSR update. This means that the UCSR analysis does not reflect the recent dramatic improvement in ANCAP safety ratings of popular models.

Another limitation for comparison with ANCAP is that, in effect, the Used Car Safety Ratings assume that all variants of a model have the same crashworthiness. However on numerous occasions ANCAP has published different safety ratings for variants of a model, mainly because the base model has fewer airbags.

PREVIOUS STUDIES THAT COMPARE NCAP PERFORMANCE WITH REAL-WORLD CRASHES

Lie and others (2001) compared Euro NCAP ratings with Folksam analysis of real-world crashes: *A correlation was found between Euro NCAP scoring and relative risk of serious and fatal injury as well as for the Folksam rating score (relative risk of fatality or permanent disability). No correlation between Euro NCAP scoring and relative risk of any injury was found.* It was estimated that the risk of a serious or fatal injury reduced by 12% for each Euro NCAP star rating.

Farmer (2004) compared how "good" and "poor" rated vehicles performed in real-world crashes. The study found a clear trend for better-rated vehicles to have a lower driver fatality risk, although the results were not uniform across all vehicle groups. In head-on crashes between similar vehicles the risk of a driver fatality was 74% lower for a good vehicle, compared with a poor vehicle.

Kullgren and others (2010) updated the 2004 study. Importantly good sample sizes were available for 5-star models. These were found to have a 68% lower risk of fatal injuries, compared with 2 star models. Serious/fatal injuries were 23% less and all injuries were 10% less. Figure 2 shows the results, with error bars.

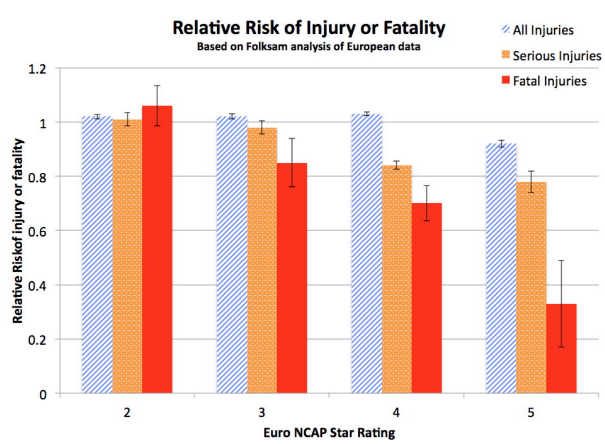

Figure 2. Euro NCAP injury risk analysis

Newstead and Scully (2012) examined whether adjustments to the way in which ANCAP scored the tests could produce better correlation with Used Car Safety Ratings. Statistically significant differences were found in the UCSR crashworthiness when 2-star vehicles were compared with 5-star vehicles. The correlation varied between types of vehicles. Some changes to the relative weights of the components of the ANCAP score were found to produce better correlation.

In 2009 the Insurance Institute for Highway Safety (IIHS) conducted a study of mechanisms of serious injury to occupants of vehicles that were rated "good" in the frontal offset test. (Brumbelow and Zuby 2009). This research resulted in the introduction of the small-overlap frontal offset test by IIHS. Severe chest injuries (AIS3+) were found to be the predominant serious injury in nearly all types of frontal crashes involving these vehicles.

Concern about chest injuries in frontal crashes, particularly with smaller female occupants, led to a recommendation that NHTSA introduces a 40km/h full frontal crash test, with more stringent chest compression limits (Diggs and Dalmotas 2007). To date this recommendation has not been implemented but NHTSA has introduced more crash tests with small adult female dummies.

Serious lower extremity injuries remain a concern with vehicles that have good NCAP ratings (Austin 2012). Morris (2006) reported that leg injuries accounted for 43% of the cost of all non-fatal frontal crashes with serious injuries (AIS 2+) and are "by far the most costly injury according to of UK willingness to pay study". Foot/ankle NCAP ratings (which are based on pedal displacement and footwell integrity) were found to have the closest correlation with real-world serious injuries.

In response to these research findings ANCAP proposes to introduce a minimum injury score for each body region as a condition for star ratings. This is intended to prevent a poor score for one body region being disguised by good scores for other body regions. The following analysis does not take this proposal into account.

METHODOLOGY

ANCAP ratings are available, or can be estimated, for many vehicle models sold in Australian since the mid-1990s. In general ratings are available when models are replaced and in most cases the new model has a better ANCAP star rating than the superseded model. Similarly, UCSR Crashworthiness estimates are available for many models over this period. It was therefore decided to compare the change in UCSR when a model improved its ANCAP star rating. This approach should help to minimise the effects of any uncontrolled confounding factors in UCSR, since the two models (old and new) can be expected to be similar in size and mass and the same type of drivers can be expected to be driving a particular model under similar road conditions (this may be optimistic but vehicle marketing attempts to achieve this outcome).

A list of vehicle models was developed where there was a change in ANCAP star rating between old and new models. Where possible UCSR crashworthiness values were obtained for these models and the change in crashworthiness was calculated. The appendix sets out the data for these models.

In some cases the models were built prior to 1999, when ANCAP commenced star ratings using the Euro NCAP protocols. However ANCAP began 64km/h offset tests in 1995 and data from these tests has been analysed to estimate star ratings for early models, using the points balance criteria of the current ANCAP system (i.e. a minimum score of 4.5 is required for a 3 star rating) and likely deductions that would have applied to these scores due to the application of modifiers such as loss of structural integrity.

RESULTS

Of the 35 models analysed:

- 32 models had data for the change from 3 stars or less to 4 stars (Figure 3)
- The average improvement in crashworthiness for these models was 22%
- All models except the Toyota Corolla improved in crashworthiness. The Corolla crashworthiness reduced by 10%
- The Holden Barina deteriorated from 4 stars in 2004 to 2 stars in 2005. The crashworthiness of the 4 star model was 15% better than the 2 star model.
- 11 models had data for the change from 4 stars to 5 stars (Figure 4)
- The average improvement in crashworthiness for these models was 35%
- 8 models had data for the change from 3 stars or less to 5 stars (Figure 5)
- The average improvement in crashworthiness for these models was 49%
- All of these models had intermediate 4 star models (shown in Figure 4).
- 16 of the models now have 5 star ANCAP ratings but crashworthiness ratings for these newer models were not available in the 2012 UCSR update.

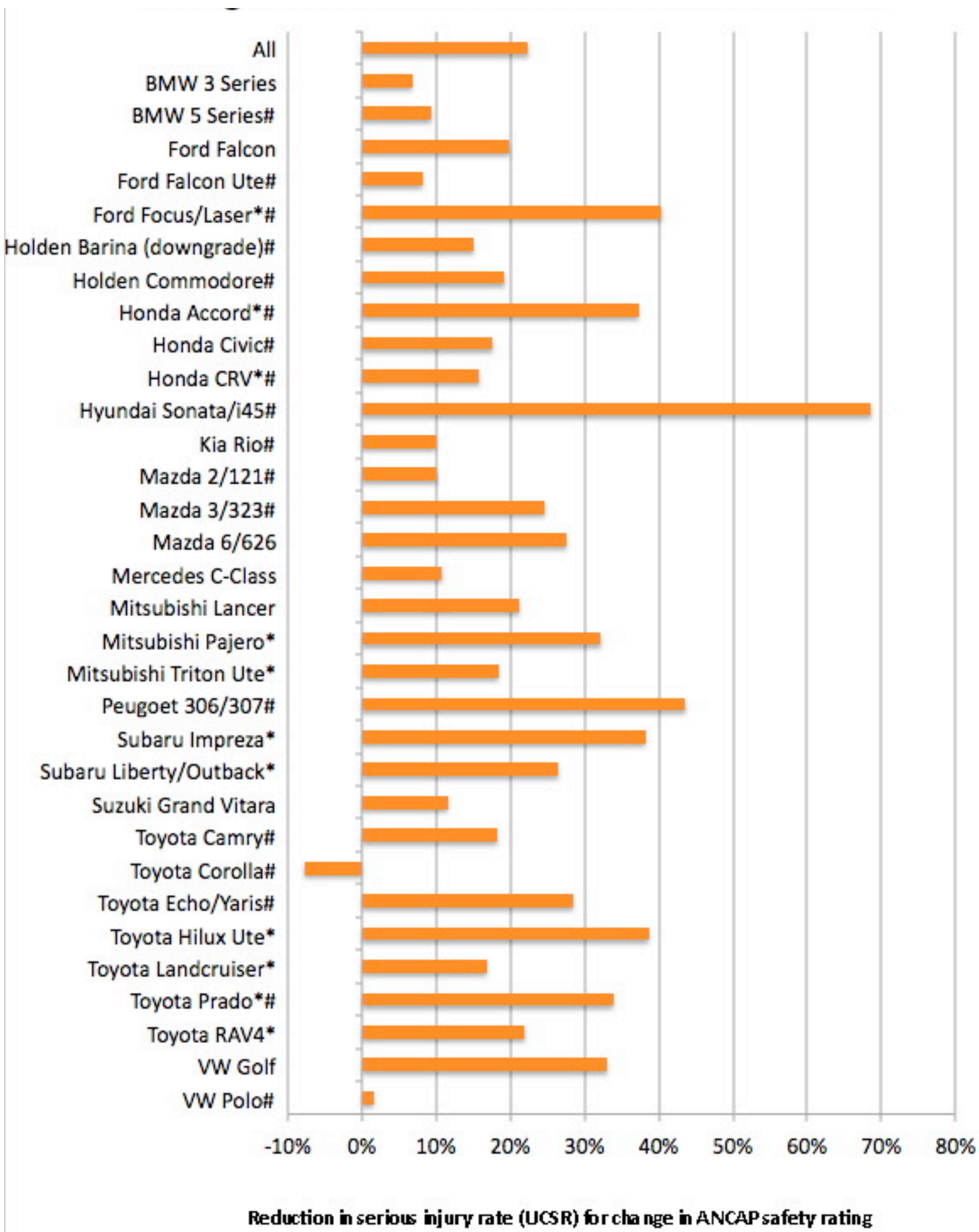

Figure 3. Change in crashworthiness: 3 stars or less to 4 stars

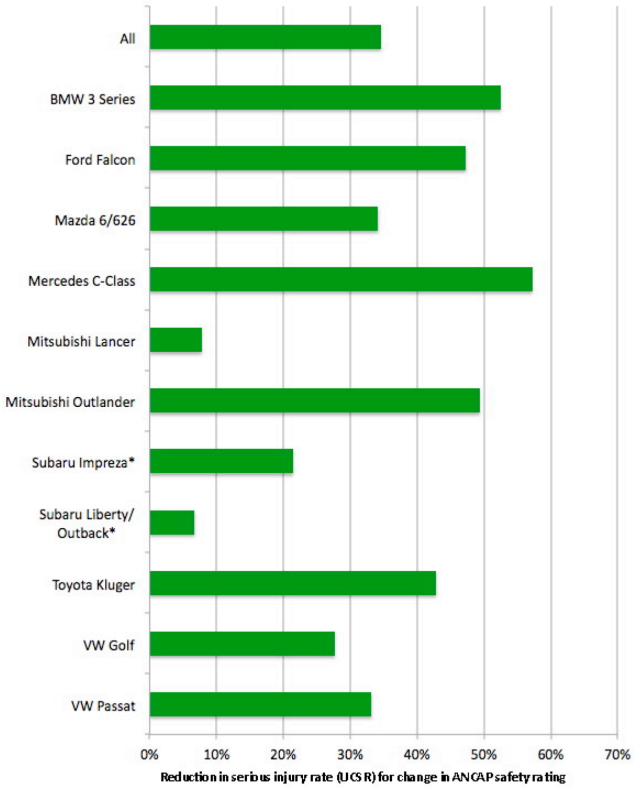

Figure 4. Changes in crashworthiness: 4 to 5 stars

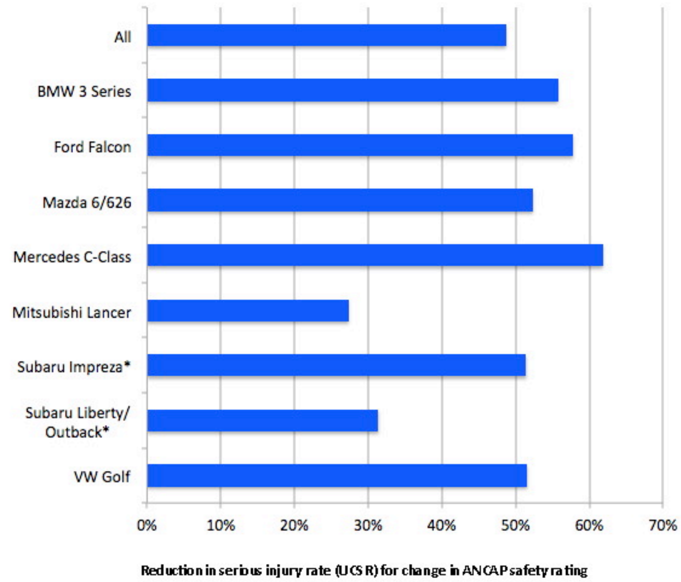

Figure 5. Change in crashworthiness: 3 stars or less to 5 stars

DISCUSSION

Researchers from MUARC have analysed the data collected for UCSR further to determine the potential savings if some groups of drivers drove safer vehicles than the ones in which they were killed or injured. Whelan and others (2009) conclude: "*if all young drivers involved in crashes were driving the safest car available, rather than the cars they usually drove, the road fatality and serious injury rate could be reduced by more than 80 per cent.*" Similar remarkable savings have been estimated for older drivers (Budd and others 2012). The apparent strong link between improved ANCAP star ratings and crashworthiness, as measured by UCSR reinforces the case for promoting safer vehicles. This is supported by European studies of injury risk and Euro NCAP star rating (Kullgren and others 2010)

It has been pointed out that many models have increased in kerb mass over time and that this may partly account for improvement in crashworthiness. For example Newstead and Scully (2012) point out an apparent relationship between crashworthiness and kerb mass.

Physics dictates that, in a two-vehicle collision, the lighter vehicle will experience a larger change in velocity than the heavier vehicle. This places a higher demand on the occupant protection system for the lighter vehicle. If the vehicle does not cope well with the higher forces then the occupants are at increased risk of serious injury, compared with the heavier vehicle. About 84% of crashes in which car drivers are injured are multi-vehicle crashes (Scully and Newstead 2009).

The models covered by this study have therefore been analysed for trends in kerb mass. For vehicles that have improved from 3 stars or less to 4 stars the average increase in kerb mass is 10%. For vehicles that have improved from 4 stars to 5 stars the average increase in kerb mass is 3%.

The observations about trends in occupant protection and structural performance noted by Paine and others (2009) suggest that the reduced risk of injury in newer models is largely due to major improvements in vehicle design and the addition of safety features such as head-protecting side airbags.

These safer vehicles tend to weigh slightly more than the models they replace. This effect needs to be taken into account when looking for a relationship between kerb mass and crashworthiness.

CONCLUSIONS

As measured by the USCR method, there is a strong reduction in the risk of serious injury to the driver each time that a model improves its ANCAP star rating.

On average the crashworthiness improves by 22% when a model improves from 3 stars or less to 4 stars and by 35% when a model improves from 4 stars to 5 stars. The average improvement from 3 stars or less to 5 stars is 49%.

In the past few years many models have improved to a 5 star ANCAP rating. It will be several years before the UCSR program gathers sufficient real-world crash data to determine reliable crashworthiness ratings for these models. Based on the few popular 5-star models that do have crashworthiness ratings, a remarkable reduction in serious injury risk can be expected from these newer models.

REFERENCES

Austin, R. A. (2012). *Lower Extremity Injuries and Intrusion in Frontal Crashes*. (Report No. DOT HS 811 578).

Brumbelow M and Zuby D (2009) *Impact and Injury Patterns in Frontal Crashes of Vehicles with Good Ratings for Frontal Crash Protection*, Proceedings of 21st ESV, Stuttgart

Budd L. Scully M, Newstead S. and Watson L (2012) *The potential crash and injury reduction benefits of safer vehicle choices for older drivers in Australia and New Zealand,* MUARC Report 315, October 2012.

Cameron M., Mach T. and Neiger D. (1992) *Vehicle Crashworthiness Ratings: Victoria 1983-90 and NSW 1989-90,* MUARC Report 028, March 1992.

Diggs K and Dalmotas D (2007) *Benefits of a low severity frontal crash test*, Proceedings of AAAM 2007.

Farmer C. (2004) *Relationships of frontal offset crash test results to real-world driver fatality rates*, Insurance Institute for Highway Safety, January 2004, Arlington.

Kullgren A., Lie A. and Tingvall C. (2010) *Comparison between Euro NCAP test results and real-world crash data*, Traffic Injury Prevention, 11:587-593, 2010

Lie A., Kullgren A. and Tingvall C (2001) *Comparison of Euro NCAP test results with Folksam car model safety ratings*, *Proceedings of 17th ESV,* Netherlands

Morris A, Welsh R, Barnes J and Frampton R (2006) *The nature, type and consequences of lower extremity injuries in front and side impacts in pre and post regulatory passenger cars*, Proceedings of 2006 IRCOBI.

Newstead S. and Scully J (2011) *Predicting the Used Car Safety Rating Crashworthiness from ANCAP Scores*, MUARC report for Vehicle Safety Reference Group, August 2011.

Newstead S., Watson L. and Cameron M. (2012) *Vehicle Safety Ratings from Police Reported Crash Data: 2012 Update*, MUARC Report 313, August 2012.

Paine M., Griffiths M., Haley J and Newland C. (2009) *Injury and structural trends during 12 years of NCAP frontal offset crash tests*, *Proceedings of 19th ESV,* Washington

Scully J. and Newstead S. (2007) *Premliminary evaluation of electronic stability control in Australasia,* MURAC Report 271, October 2007.

Whelan M., Scully J. and Newstead S. (2009) *Vehicle safety and young drivers: Stages 2& 3 analysis of young driver crash types and vehicle choice optimisation,* MUARC Report 292, November 2009.

APPENDIX

The following table has the raw data used in the analysis

	YEAR RANGE 1	ANCAP 1	UCSR 1	YEAR RANGE 2	ANCAP 2	UCSR 2	YEAR RANGE 3	ANCAP 3	UCSR 3
BMW 3 Series	92-98	3	3.41	99-06	4	3.18	05-10	5	1.51
BMW 5 Series#	96-03	3	2.25	04-10	4	2.04			
Ford Falcon	98-02	3	3.27	03-07	4	2.62	08-10	5	1.38
Ford Falcon Ute#	00-02	3	2.57	03-08	4	2.36			
Ford Focus/Laser*#	95-97	2	4.9	02-05	4	2.92			
Holden Barina (downgrade)#	05-10	2	4.13	01-06	4	3.51			
Holden Commodore#	97-02	3	3.38	02-07	4	2.73			
Honda Accord*#	94-98	2	3.57	03-07	4	2.24			
Honda Civic#	96-00	2	4.09	01-05	4	3.37			
Honda CRV*#	97-01	2	2.78	02-06	4	2.34			
Hyundai Sonata/i45#	98-01	2	4.21	05-10	4	1.32			
Kia Rio#	00-05	3	4.53	05-10	4	4.08			
Mazda 2/121#	97-02	2	4.73	02-07	4	4.25			
Mazda 3/323#	99-03	3	3.49	03-09	4	2.63			
Mazda 6/626	98-02	3	3.23	02-07	4	2.34	08-10	5	1.54
Mercedes C-Class	95-00	3	2.96	00-07	4	2.64	07-10	5	1.13
Mitsubishi Lancer	96-03	2	4.72	03-07	4	3.72	08-10	5	3.43
Mitsubishi Outlander				03-06	4	3.06	06-10	5	1.55
Mitsubishi Pajero*	92-99	3	3.23	00-06	4	2.19			
Mitsubishi Triton Ute*	96-06	2	2.56	06-10	4	2.09			
Peugoet 306/307#	94-01	3	2.89	01-09	4	1.63			
Subaru Impreza*	93-00	3	4.9	01-07	4	3.03	07-10	5	2.38
Subaru Liberty/Outback*	94-98	3	3.44	99-03	4	2.53	03-99	5	2.36
Suzuki Grand Vitara	99-05	3	3.12	05-08	4	2.76			
Toyota Camry#	98-02	3	3.35	02-06	4	2.74			
Toyota Corolla#	98-01	3	3.21	02-07	4	3.46			
Toyota Echo/Yaris#	99-05	3	4.6	05-10	4	3.29			
Toyota Hilux Ute*	98-02	3	2.95	05-10	4	1.81			
Toyota Kluger				03-07	4	2.94	07-10	5	1.68
Toyota Landcruiser*#	90-97	3	3.16	98--07	4	2.63			
Toyota Prado*#	96-03	2	2.63	03-09	4	1.74			
Toyota RAV4*	94-00	2	3.78	01-06	4	2.95			
VW Golf	93-98	3	3.18	99-04	4	2.13	04-10	5	1.54
VW Passat				98-06	4	2.2	06-10	5	1.47
VW Polo#	96-00	2	3.3	02-10	4	3.25			

* Model built prior to 1999. ANCAP star rating estimated from offset test score

Models that now have a 5-star rating but there is no UCSR score (as at July 2012)

The Subaru Forester was not included in the analysis because between 2002 and 2008 there were two ANCAP ratings - 5 stars for variants with head-protecting side airbags and 4 stars for variants without. The crashworthiness rating was 2.32 for all Foresters built during this period but the proportion of 5 star variants was unknown. A new model Forester, launched in 2008, was 5 stars for all variants. The early crashworthiness rating for this new model was 3.32 (i.e. substantially worse than the previous model) but the sample size was small and so the confidence interval was large. Also this was one of the first popular cars to have electronic stability control as standard and this might have an influence on the severity of crashes (see Scully and Newstead 2009).

Changes to vehicle kerb mass

A brief analysis has been undertaken to determine the change in vehicle kerb mass when vehicle models are updated. The following graph shows the results of this analysis. It is concluded that there is no discernable correlation between increase in kerb mass and crashworthiness for successive models.

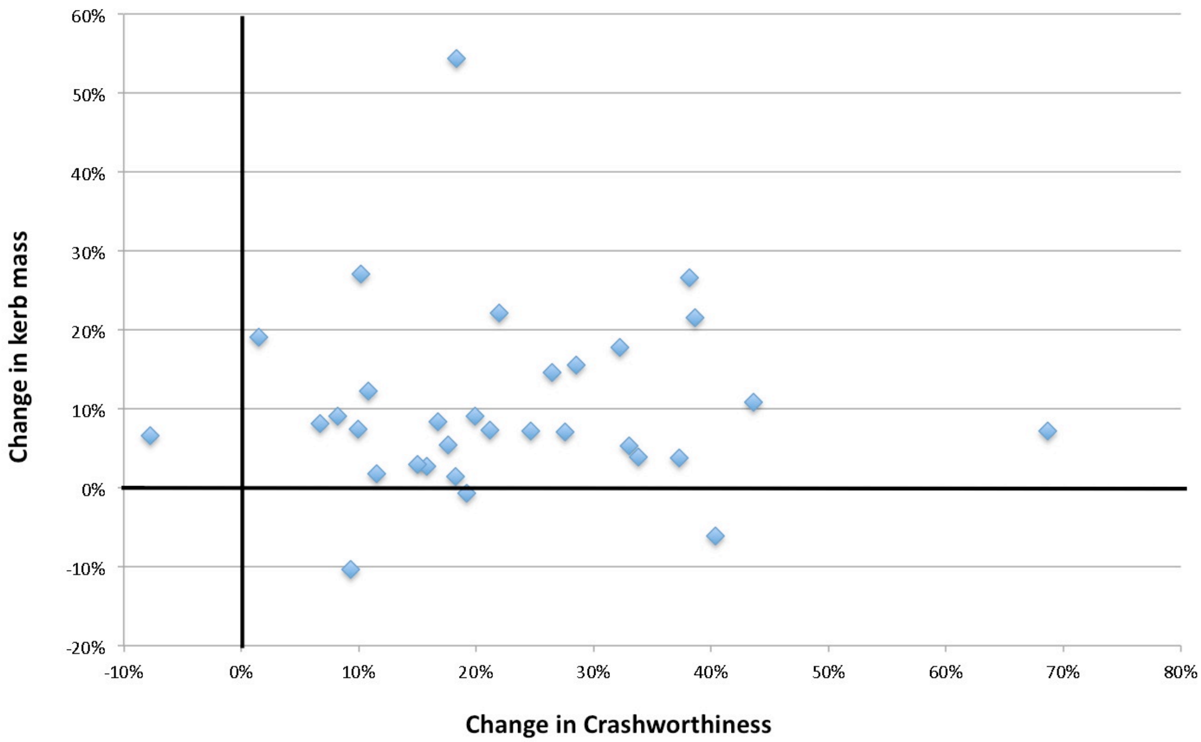

Figure 6. Scatter plot of change in crashworthiness and change in kerb mass for models that have changed from 3 stars or less to 4 stars in ANCAP rating