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The benefits of improved car secondary safety

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Abstract

The term 'secondary safety' refers to the protection that a vehicle provides its occupants when involved in an accident. This paper studies information from the British database of road accident reports between 1980 and 1998, to estimate the reduction in the number of occupant casualties over these years which may be attributed to improvements to secondary safety in cars.

The paper shows that the proportion of driver casualties who are killed or seriously injured (KSI) is lower for modern cars than for older cars. The reduction of this proportion is used to assess the improvement in secondary safety. Statistical models are developed to represent the proportion with 'year of first registration' as one of the independent variables, although only an incomplete assessment of the benefits of improved secondary safety can be made with the available data. The assessment compares the number of casualties that would have been expected if secondary safety had remained at the level found in cars first registered in 1980 with the actual casualty numbers. It is estimated that improved secondary safety reduced the number of drivers KSI by at least 19.7% in 1998, in comparison with what might have occurred if all cars had had that lower level of secondary safety. This figure relates to all cars on the road in 1998, and rises to 33%, when confined to the most modern cars (those which were first registered in 1998).

Keywords: Secondary safety; Crashworthiness; Severity proportion; Casualty reduction

1. Introduction

Various regulations have been introduced over at least 20 years with the aim of improving car secondary safety (also known as crashworthiness). Secondary safety refers to the protection that a car provides its occupants when involved in an accident, whereas primary safety refers to the features such as braking systems that should help the driver to avoid becoming involved in an accident. This paper examines accident data from 1980 to 1998 to assess the extent to which car occupant casualties have been reduced by the improved safety features of modern models. The data come from the British database of police reports (known as STATS19) of road accidents that involve personal injury or death.

This research was originally carried out for the UK Department for Transport, Local Government and the Regions (formerly, Department of the Environment, Transport and the Regions), as part of a project to investigate the numerical context for setting national casualty reduction targets for 2010 (Broughton et al., 2000). The original analyses have been revised and updated using accident data from 1997 and 1998.

In this paper, secondary safety is investigated via the proportion of injured car occupants who were killed or seriously injured (KSI) (the 'severity proportion') in any particular year. If secondary safety has improved over the years, then more modern cars should protect their occupants better than older cars in the accidents occurring in any particular year, so this proportion should be lower for newer cars. Other road safety measures may well have affected the proportions over the years, such as improvements to the road system, but these should affect all cars equally—irrespective of when they were manufactured. Thus, the benefits of improved secondary safety will be identified by separating the component of the severity proportion that relates to a car's newness from the component that relates to the year when the accident occurred. Newness will be represented by the year when the car was first registered, which is known in most cases from the STATS19 accident reports.

An accident-involved car may have been first registered 5 years or more after that model was first introduced, depending on the manufacturer's marketing strategy. The analyses will compare the secondary safety of the new cars sold in a year, rather than the new car models introduced in that year. Thus, the effects of any development in the 'state of the secondary safety art' will only be visible with a lag of some years.

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One key question which cannot be answered by studying the severity proportion is whether improved secondary safety might have affected the total number of car occupant casualties, not simply the proportion of fatal or serious casualties within a known casualty total. For example, a measure could reduce casualties of all severities to the same degree: the severity proportion would be unaffected, although the measure was effective. The STATS19 reports are only for accidents involving personal injury, and in UK there is no reliable source of national data for damage-only accidents. It does seem plausible that car design might be improved sufficiently for occupants to escape injury in accidents, where otherwise they would have been slightly injured, thereby reducing the total number. Indeed, the increase in seat belt wearing by roughly 50% in 1983, following implementation of the 1981 Transport Act, was equivalent to a sudden improvement in the secondary safety of half the car fleet. Broughton (1990) found that the increased wearing rate had reduced the number of casualties of each severity—so the casualty total had fallen. Rutherford et al. (1985) reached the same conclusion in an extensive hospital-based study.

Thus, the benefits of improved car secondary safety cannot be quantified fully by studying the severity proportion. Nonetheless, the equations for estimating the casualty benefits of improved secondary safety will be developed in a way that allows for the possibility that the car occupant casualty total may have been reduced, so that the sensitivity of the results to uncertainty over the effect on the casualty total can be tested.

Analyses will focus upon the driver casualties, principally because the number of passengers per car can vary and these variations might bias the results if passenger casualties were included. This is discussed more fully by Broughton (1996a).

Several methods have been developed in recent years to assess the secondary safety of cars by statistical analysis of road accident data. Broughton (1996a) described two of them, but showed that "the indices measure the relative secondary safety of current car models, but cannot evaluate the general progress in improving secondary safety. They compare models with the average for a particular year, but other measures are needed to determine whether this average changes over the years." This conclusion applies equally to the other assessment methods of which the author is aware. In contrast to these existing methods, this paper attempts to evaluate the 'general progress' by analysing data from accidents that occurred over almost two decades.

2. Exploratory data analysis

The source of the data used in this study is the STATS19 database of police reports of road accidents involving personal injury. The STATS19 reporting system has operated throughout UK since 1949; car driver casualty data for accidents that occurred in 1980–1998 have been analysed.

During this period, the British vehicle registration system incorporates a prefix or suffix to denote the year of first registration, and since 1979 this was reported by the police for accident-involved vehicles. More recently, the full vehicle registration mark has been reported by the police, and the date of first registration has been extracted from the details held by the national Driver and Vehicle Licensing Agency and added to the original STATS19 vehicle record. For this study, year of first registration has been taken from the licensing details from 1994. The year of first registration is known for most accident-involved cars: about 97% in the earlier years, but falling to about 90% in 1994–1998 when the registration mark is used.

Annual tables of car driver casualty data were extracted from the STATS19 database for 1980–1998. The reporting system uses three levels of casualty severity: killed (within 30 days), seriously injured, and slightly injured. Separate tables were extracted for 'killed', 'KSI' and 'all casualties'.

Previous research has shown that the severity proportions are influenced by the age and sex of the injured drivers, also whether the accidents occur on built-up (BU) or non built-up (NBU) roads, so these tables covered all combinations of year of first registration, driver sex, driver age ($<$25, 25–59, and $\geq$60 years), and type of road (BU/NBU). National accident statistics in UK describe a road with speed limit $\leq$40 mph as 'BU' and a road with a higher limit as 'NBU'; these terms are generally appropriate to local conditions because of the regulations that apply when setting speed limits.

The dataset for this study is substantial. It includes only those driver casualties for whom the necessary data were reported by the police: between 960 and 1464 driver fatalities, and between 70861 and 117647 driver casualties in each of the accident years.

Fig. 1 shows the results of an initial exploration of the data: the basic data have been aggregated considerably to prepare this and the next figure. It compares the proportion of injured car drivers who were KSI, by year of first registration of their cars. For accidents that occurred in 1997–1998, drivers of more modern cars were less severely injured than drivers of older cars, both on BU and on NBU roads. The same is found when looking back to accidents that occurred in 1989–1990, but the general severity of injuries was higher and higher still in accidents from 1981–1982. Thus, modern cars have lower severity proportions than older cars, but independent improvements in road safety have also reduced the severity of drivers' injuries.

These graphs may have been influenced in detail by differences related to newness of car in factors such as the age and sex of drivers, and the extent to which they are driven on NBU roads (where injuries tend to be more severe than on BU roads because of the higher speeds). The statistical models described here explicitly take account of these factors.

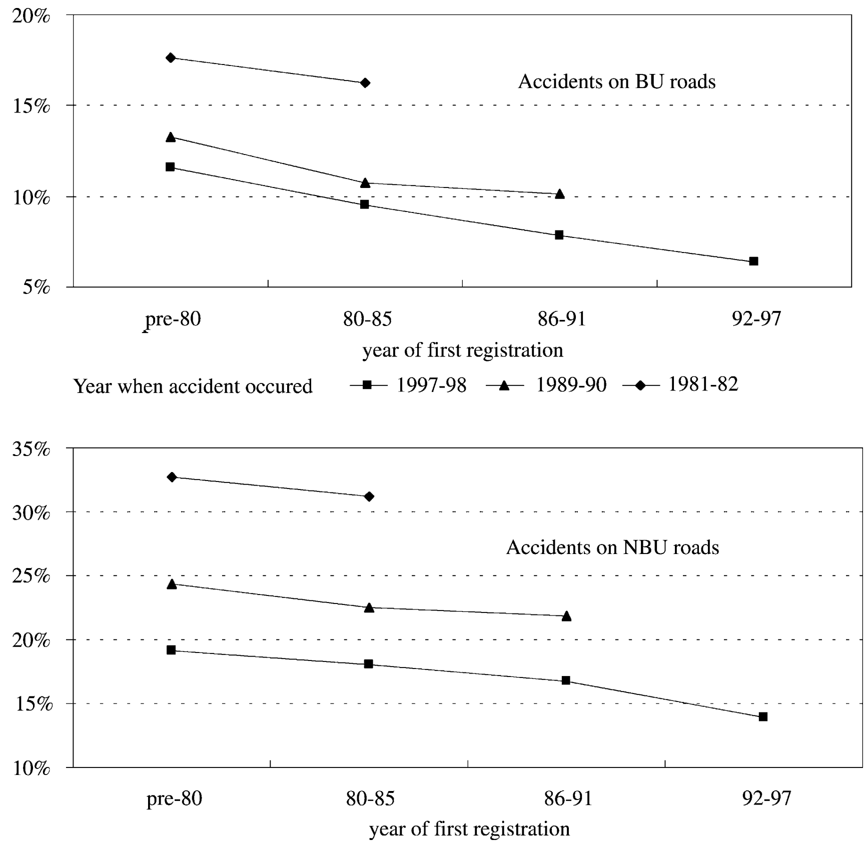

Fig. 1. Percentage of car driver casualties who were KSI in various years, by year of first registration of car.

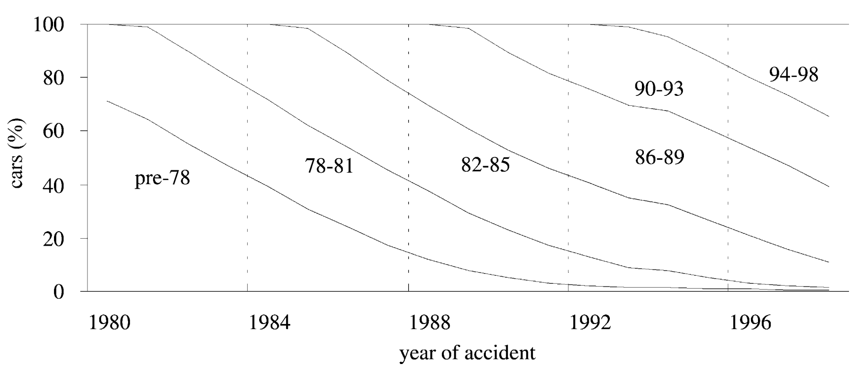

Fig. 2. Distribution of year of first registration of accident-involved cars, by year of accident.

The definition of the three STATS19 casualty severities has remained unchanged over these years. Nonetheless, it is possible that there have been local variations in reporting standards. Even if these had occurred, they should not influence the analyses of secondary safety since there is no reason to think that this would have occurred differentially by age of car.

Any benefits of improved secondary safety would be realised slowly, as older cars are progressively scrapped and replaced by more modern cars. This is illustrated by Fig. 2, which shows the distribution of year of first registration of accident-involved cars, by year of accident.

3. Statistical modelling

The previous section showed that there has been a general reduction in the severity of car drivers' injuries, as well as a reduction related to the year of first registration of the car. A statistical model is required to disentangle the two effects. The appropriate way to investigate the data in more detail is to develop logistic regression models for two dependent variables:

- P_1: proportion of injured drivers who were killed,
- P_2: proportion of injured drivers who were KSI.

The GLIM program (Francis et al., 1993) has been used to fit the model. In preliminary trials, the difference between BU and NBU roads was represented by a single term in the model, but rather better results were achieved using independent BU and NBU models. This suggests that the severity proportions have developed rather differently on BU and NBU roads, so parallel models were fitted for BU and NBU roads. The independent variables were:

Year of first registration	pre-1976	1976–1977	1978–1979	1980–1981	1982–1983	1984–1985	1986–1987	1988–1989	1990–1991	1992–1993	1994–1995	1996–1997	1998
Age (years) and sex	Males aged <25, 25–59, ≥60						females aged <25, 25–59, ≥60						
Year of accident	1980–1998												

The secondary variable of age/sex was included in the modelling to minimise bias. It is known, for example, that older drivers tend to be more seriously injured than younger drivers for physiological reasons. They are also more likely to drive older cars, so an analysis that failed to include age/sex by road type would probably exaggerate the effect of registration year. The registration years were treated separately in the first stage of the modelling.

It is helpful to examine the influence of an estimated coefficient from the logistic regression model by standardising on a certain casualty group and applying the coefficients for that group to calculate the modelled proportions. Fig. 3 presents results from this set of models, standardising upon men aged <25 years and calculating P_1 and P_2 for the various registration years. The P_1 graphs are accompanied by 95% confidence intervals calculated by GLIM; the intervals for the P_2 graphs are even tighter so they are not displayed. The exact details of the graphs for other groups of driver differ, but the general form and relativities are preserved.

The graphs show that the severity proportions are generally lower for more modern cars, indicating that secondary safety has improved, while the coefficients for 'year of accident' confirm that the severity proportion has tended to fall independently over the years due to other improvements in road safety. There are, however, clear differences between the graphs:

- the P_2 graphs fall steadily, with a more rapid fall on NBU roads after the 1990–1991 year cars;
- the P_1 graphs fall much more slowly at first, with a more rapid fall on NBU roads after the 1990–1991 year cars, but on BU roads, the more rapid fall began after the 1988–1989 year cars.

This suggests that design changes that took effect in the 1980s were effective in reducing serious casualties, but changes that could reduce fatal casualties took longer to develop. This is credible in view of the progressive changes made to the design of the typical new car. The 1980s saw the removal of sharp objects, such as unframed interior mirrors and hard switches, and the introduction of anti-burst door locks. The 1990s saw more fundamental engineering changes in response to new testing requirements which, however, appear more capable of preventing fatal injury in accidents.

Fig. 4 illustrates the consequences. In each pair of graphs, the solid line shows for each accident-year the proportion of drivers of 1980–1981 year cars who would have been KSI, while the broken line shows the corresponding proportion for drivers of newly-registered cars. The gap between the two may be interpreted as the benefit of improved secondary safety. The proportion of injured drivers who were killed only began to fall significantly about 1990, following some slight increases in the mid-1980s, while the fall began in the mid-1980s for the proportion KSI.

These initial models treated the registration years separately. In the next stage of modelling, the year of first registration was treated as a linear variable, i.e. it was assumed that the change in effect between one pair of years and the next was constant. The diagnostic statistics show that this is acceptable, and it simplifies the interpretation and application of the results. In fact, for three of the four series, the model included a second constant for newer cars, to allow for the more rapid falls shown in Fig. 3 for more modern cars. Only a single constant was used for P_2 on BU roads as the diagnostic statistics showed that the more elaborate model was not justified. Thus, the fitted models assumed that:

- P_1 on NBU roads: more rapid fall began after 1990–1991 year cars;
- P_1 on BU roads: more rapid fall began after 1988–1989 year cars;
- P_2 on NBU roads: more rapid fall began after 1990–1991 year cars;
- P_2 on BU roads: no increase.

A final model was fitted for each of these, with the following explanatory variables:

- age/sex of driver;
- year of accident;
- year of first registration (linear variable);
- additional effect of year of first registration (except P_2 on BU roads).

Coefficients from these models will be used for the main investigation. Each of the coefficients relating to year of first registration was highly significant. For example, from the model of P_2 on NBU roads, the *t*-statistic of year of first registration was −15.1, and −6.91 for the additional effect.

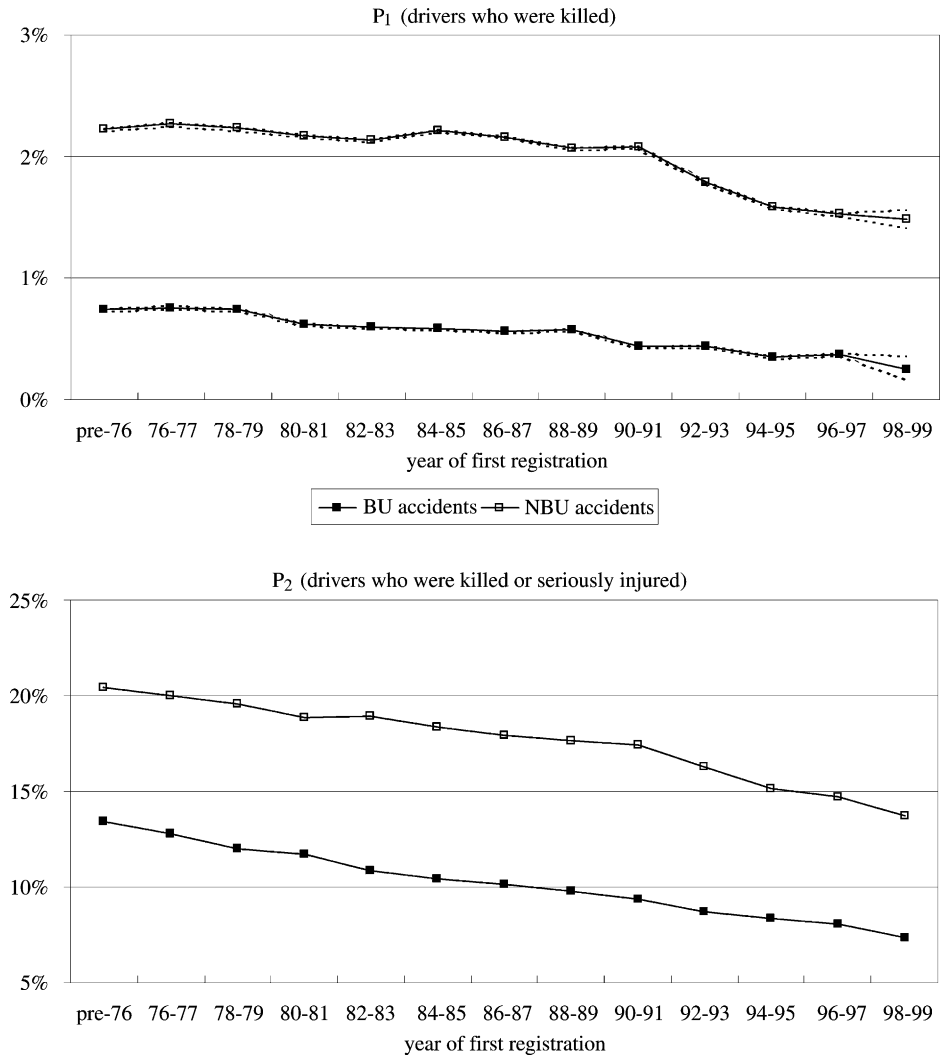

Fig. 3. Percentage of car driver casualties who were KSI (based on GLIM results standardised for male car drivers aged <25 years in accidents in 1998), 95% confidence intervals for P_1 also shown.

The four models fit the data well, although the fit could be improved by adding more driver age-bands since the severity proportions vary markedly by age and sex, as shown by the coefficients fitted with just the three bands selected. This has not been done since it would have virtually no effect on the registration year coefficients that are central to this study.

Tables 1 and 2 illustrate the results of this model, using young male and elderly female drivers as examples. Table 1 compares the estimated severity proportions in 1998 for 1980–1981 and 1998 year cars: these differences may be attributed to improved secondary safety. Table 2 compares the estimated severity proportions in 1980–1998 for 1980–1981 year cars: these differences may be attributed to other

Table 1
Modelled severity proportions for selected groups of drivers in accidents that occurred in 1998

	Year of first registration	P_1 (proportion killed)		P_2 (proportion KSI)	
		BU	NBU	BU	NBU
Men aged <25 years	1980–1981	0.0066	0.0220	0.116	0.192
	1998	0.0029	0.0130	0.076	0.136
Women aged ≥60 years	1980–1981	0.0078	0.0354	0.128	0.226
	1998	0.0034	0.0210	0.085	0.163

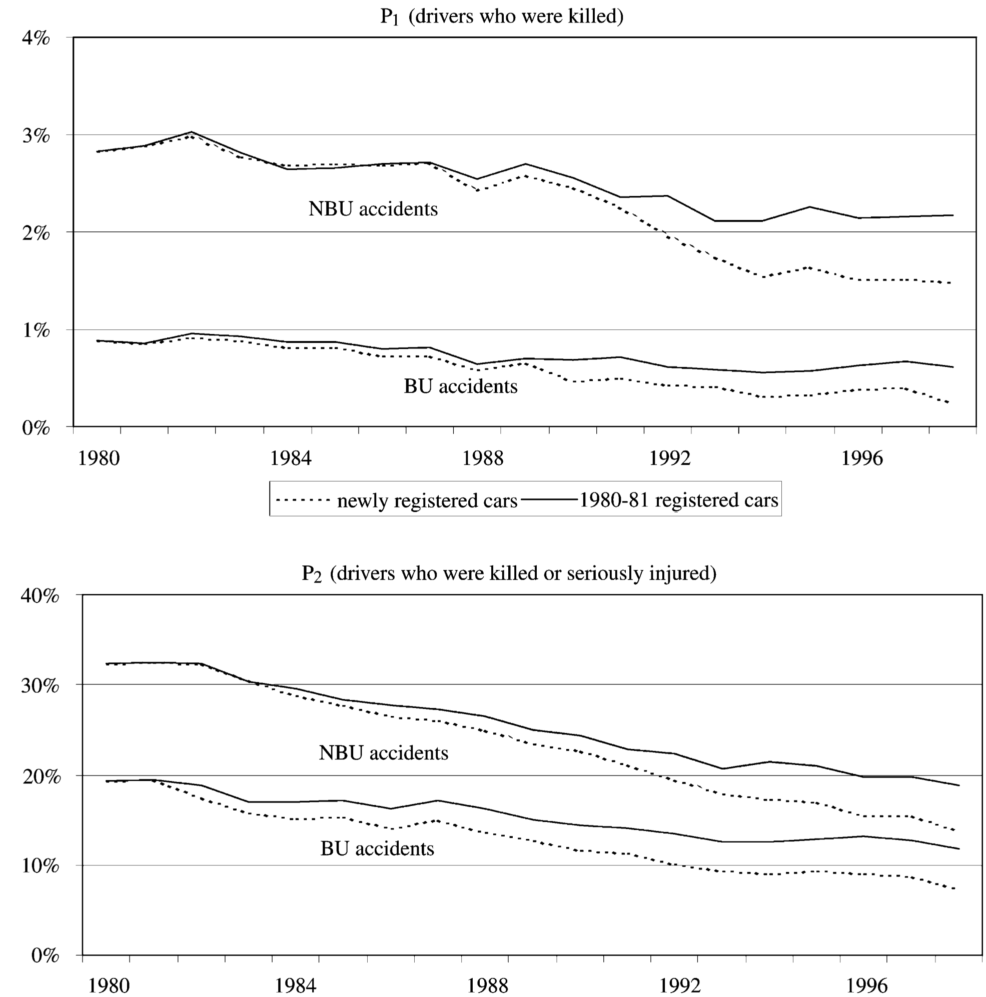

Fig. 4. Percentage of car driver casualties who were KSI, by year of accident (based on GLIM results standardised for male car drivers aged <25 years), comparing results for newly registered cars and cars first registered in 1980–1981.

improvements in road safety. The improvement in secondary safety between 1980–1981 and 1998 year cars appears to have reduced P_1, the proportion of drivers killed, by rather more than the other improvements in road safety between 1980 and 1998. The reverse is true of P_2, the proportion of drivers KSI. It is not, however, possible to make a full comparison of the two types of improvement since both may have affected the number of drivers who were actually injured.

Table 2
Modelled severity proportions for selected groups of drivers, cars first registered in 1980–1981

	Year of accident	P_1 (proportion killed)		P_2 (proportion KSI)	
		BU	NBU	BU	NBU
Men aged <25 years	1980	0.0094	0.0284	0.192	0.327
	1985	0.0091	0.0269	0.170	0.288
	1990	0.0071	0.0259	0.143	0.248
	1995	0.0060	0.0227	0.128	0.214
	1998	0.0066	0.0220	0.116	0.192
Women aged ≥60 years	1980	0.0111	0.0455	0.210	0.375
	1985	0.0108	0.0431	0.186	0.333
	1990	0.0084	0.0415	0.157	0.288
	1995	0.0071	0.0364	0.141	0.251
	1998	0.0078	0.0354	0.128	0.226

4. Estimated casualty benefits

The results of the GLIM modelling will now be used to reassess the car accidents from 1981–1998, and to estimate the number of extra casualties that would have been expected if secondary safety had not improved, but had remained at the level achieved by 1980–1981 year cars. It is assumed that the same accidents would still have occurred, but that more drivers would have been killed and seriously injured because of the lower level of secondary safety. The calculation is done for each year of accidents in turn: the modelling results are used to adjust the severity proportions of the more modern cars to match those of the cars which were first registered in 1980–1981, the 'base registration year': casualties in earlier cars are not affected. The extra casualties implied by the adjustments are then summed.

The equations for estimating these benefits will be developed in a way that allows for the possibility that the car driver casualty total may have been reduced by improvements in secondary safety. For greater clarity, the equations have not been indexed by the age and sex of driver and the type of road.

$C_i(y, m)$: number of drivers of cars first registered in year m, who are injured in year y, with severity range i (where $i = 1$ for killed, 2 for KSI, 3 for injured (any severity));
m': base registration year, i.e. the year of first registration by which subsequent improvements in secondary safety will be judged;
$C_i'(y, m)$: number of casualties that would have been expected in year m cars if secondary safety had remained at the level of year m' cars ($m > m'$);
$\rho(m)$: $C'_3(y, m)/C_3(y, m)$ for any y, so $\rho(m) = 1$ if improved secondary safety has not affected the casualty total, and $\rho(m) > 1$ if it has reduced the total;
1980–1981 will be used as the base registration year m'.

The key assumption is that if secondary safety had not improved since m', the severity proportions in year y for cars first registered in year m ($m > m'$) would have been equal to the proportions in year y for cars first registered in year m': earlier cars are not affected. Consequently, if $m > m'$,

$$\frac{C'_1(y, m)}{C'_3(y, m)} = \frac{C_1(y, m')}{C_3(y, m')}$$

and as it has been assumed that $C'_3(y, m) = C_3(y, m)\rho(m)$ then

$$\begin{aligned} C'_1(y, m) &= C_3(y, m)\rho(m)C_1(y, m')/C_3(y, m') \\ &= [C_1(y, m')/C_3(y, m')]C_1(y, m)\rho(m) \\ &\quad [C_1(y, m)/C_3(y, m)] \end{aligned}$$

However, if $m \le m'$, $C'_1(y, m) = C_1(y, m)$ as earlier cars are not affected.

There are corresponding equations for $C'_2(y, m)$.

The ratio of casualty severities $(C_1(y, m)/C_3(y, m))$ can be calculated for any m and y from the GLIM coefficients. Hence, if the function $\rho(y)$ were known from some independent source, the adjusted fatality numbers $\{C'_1(y, m)\}$ could be estimated, similarly the adjusted KSI numbers $\{C'_2(y, m)\}$. The total reductions due to improved secondary safety could then be estimated:

$$\sum_m (C'_1(y, m) - C_1(y, m)) \quad \text{(fewer fatalities)},$$

$$\sum_m (C'_2(y, m) - C_2(y, m)) \quad \text{(fewer KSI)},$$

$$\sum_m (C'_3(y, m) - C_3(y, m)) \quad \text{(fewer casualties in total)}.$$

The base assumption must be that $\rho(m) = 1$, i.e. that changes in secondary safety had no effect on the total number of casualties in a year. Three alternative assumptions about the assumed form of $\rho(m)$ will be tested:

R1: $\rho(m) = 1$ for each registration year;
R2: $\rho(m) = 1$ for $m \le m'$, ρ increases linearly for $m > m'$ and $\rho(1996) = 1.10$;
R3: $\rho(m) = 1$ for $m \le m'$, ρ increases linearly for $m > m'$ and $\rho(1996) = 1.20$.

There is little evidence to indicate the most appropriate form for the function ρ, although the evidence mentioned earlier that the increase in seat belt wearing in 1983 reduced the number of injury accidents suggests that R1 may be pessimistic. One indirect approach is to consider the adjusted rate of car driver casualties per vehicle-km that is implied by the various assumptions. The actual rate rose by an average of 0.5% per year between 1983–1996, so this is the rate for assumption R1. Assumption R2 implies that the car driver casualty rate would have risen by 0.9% per year if secondary safety had not improved, while R3 implies that the rate would have risen by 1.3% per year. Thus, as the value of $\rho(1996)$ rises above 1.0, there is a rapid increase in the implied annual rate of increase in the overall car driver casualty rate that would have been expected if secondary safety had not improved.

4.1. Results

Finally, the effects of improved secondary safety will be estimated using assumption R1. This provides lower limits for the actual effects, since if the casualty total had been reduced by improved secondary safety then the effects would have exceeded the estimates based on R1. The obvious way of expressing the estimated casualty reduction in a year as a rate is simply to divide the reduction by the actual number of casualties. This has the drawback that the reduction may well exceed the actual number, in which case the rate would exceed 100%. The preferred alternative is to calculate the proportion of the potential number of casualties that was

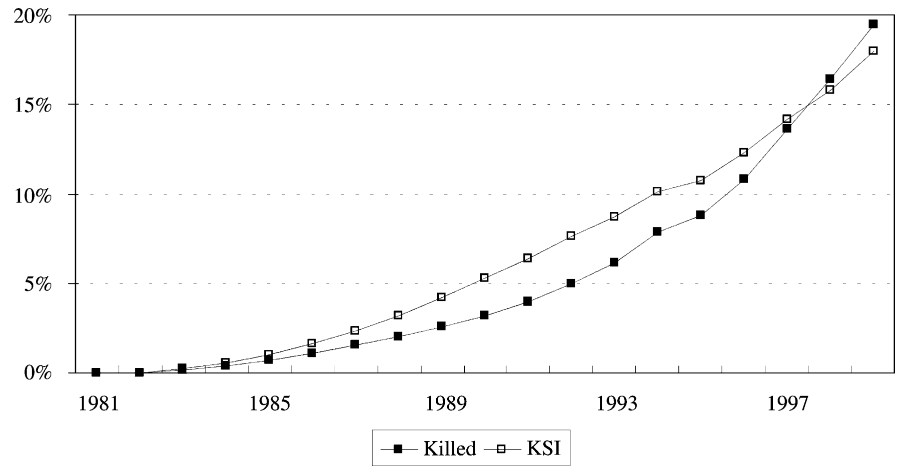

Fig. 5. Casualty benefits of improved secondary safety (assumption R1), by year of accident.

Table 3
Alternative estimates of the effects of secondary safety improvements since 1980, on the annual number of car driver casualties

		Actual number of casualties	Number expected if secondary safety had not improved			Extra casualties if secondary safety had not improved (%)		
			R1	R2	R3	R1	R2	R3
1990	Killed	1432	1493	1535	1578	4	7	10
	KSI	17403	19050	19594	20139	9	13	16
	All casualties	112848	112848	116074	119299	0	3	6
1998	Killed	1134	1401	1494	1587	24	32	40
	KSI	13841	17245	18386	19527	25	33	41
	All casualties	134789	134789	143709	152630	0	7	13

saved by the improvement, i.e.

$$\text{rate of reduction} = \frac{\text{estimated reduction}}{\text{estimated reduction} + \text{actual number}}$$

which measures the overall effectiveness of improved secondary safety.

Fig. 5 shows the estimated casualty reductions using assumption R1 (i.e. that there is no effect on the casualty total). The graphs show relatively steady improvements since about 1987; the slower rises in earlier years were the result of the large numbers of pre-1980 cars in use at that time.

By 1998, the reductions that may be attributed to improved secondary safety amounted to 19.1% of the potential number of car drivers who were killed, and 19.7% of car drivers KSI. These figures are averaged over the whole car fleet, and they rise to 44 and 33%, respectively, when the calculation is confined to the most modern cars, those that were first registered in 1998. These estimates use assumption R1, so the reductions may actually have been greater.

These estimates can be disaggregated by road type. The fatality reductions in 1998 were 29% on BU roads and 16% on NBU roads, while the KSI reductions were 21 and 19%, respectively. Thus, the effect has been proportionately less on NBU than on BU roads, which is explained by the slower proportional reductions of P_1 and P_2 on these roads as shown in Fig. 3. This suggests that it is more difficult to improve occupant protection effectively in high speed accidents. 37% of the total fatality reduction in 1998 occurred on BU roads, and 46% of the KSI reduction.

Table 3 illustrates the sensitivity of the estimated effects in 1990 and 1998 to the assumed form of $\rho(m)$. The final three columns in the table express the estimated casualty increases as percentages of the actual numbers.

5. Discussion

This paper has demonstrated that the proportion of injured car drivers who are KSI in modern cars is clearly less than in older cars. The only remaining question is whether it is reasonable to attribute the associated casualty reductions to the efforts of regulators and manufacturers to produce safer vehicles, or whether independent factors may have contributed to the reductions.

The only plausible candidate is vehicle mass. This is well known to influence secondary safety, since the laws of physics dictate that a heavy vehicle will tend to decelerate more slowly in an accident than a light one, leading to less severe injuries to its occupants. For example, Broughton

(1996b) calculated a safety index for car models using accident data from 1989–1992 and found that secondary safety improved almost linearly with increasing mass. Over the years covered by the data in the present study, there has been a trend towards heavier cars in UK—which raises the question of whether this trend may have contributed to the reduced severity ratios that have been measured by the statistical models. Observe that, although this trend has been partly caused by market forces, the need to meet increasingly strict regulations on secondary safety has also contributed.

There are two principal arguments that suggest that the trend towards heavier cars has not influenced the severity ratios. Firstly, Broughton (1996b) shows that mass has very similar effects on both:

- the proportion of car drivers involved in accidents who are KSI, and
- the proportion of car drivers involved in accidents who are injured (any severity).

This indicates that the effects of increasing mass on the numerator and denominator of the severity ratio cancel—leaving the ratio independent of mass. This has been confirmed by re-analysing the data from the earlier study: mass has no systematic influence on P_1 or P_2.

The second argument is more qualitative. The trend towards heavier cars has been steady, yet three of the four graphs in Fig. 3 had a pronounced change of slope about 1990–1991, and P_1 fell very little among earlier cars. Thus, the form of these graphs is not consistent with any plausible effect of increasing mass.

Hence, it is unlikely that other factors have contributed to the reduced severity proportions, so the estimated casualty reductions may credibly be attributed to the efforts to improve secondary safety in cars.

6. Conclusions

This paper has used car accident data from UK between 1980–1998 to estimate the effect on the number of driver casualties of the gradual improvement in the secondary safety features of the national car fleet. Simple analyses of data from individual years showed that the proportion of injured car drivers KSI is lower in more modern cars. Statistical models were developed to represent the proportion of car driver casualties who were KSI, with the 'year of first registration' of a car and 'year of accident' as two of the explanatory variables. The results from these models confirm that the proportion is lower among more modern cars, and it has been argued that this reduction can be used to assess the casualty reductions brought about by improved secondary safety.

The assessment that can be made with the available data is incomplete, since it is impossible to determine whether the improvement in secondary safety might have affected the total number of injured drivers. The minimum benefits have been assessed, however, by assuming that the total number has not been affected. The assessment compares the number of casualties that would have been expected if secondary safety had remained at the level found in cars first registered in 1980 with the actual casualty numbers. It is estimated that, of the casualties that would have occurred in 1998, if all cars had had that level of secondary safety, improved secondary safety reduced the number of drivers who were KSI by at least 19.7%. This figure relates to all cars on the road in 1998, and rises to 33% when confined to the most modern cars (those which were first registered in 1998). The benefits have been proportionately greater in accidents occurring on roads with speed limits of at most 40 mph.

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