Analysis of the Effect of Bumper Involvement Criteria on Evaluating Bumper Performance

PAUL ABRAMSON, MARK YEDLIN, and E. NAPOLITANO

ABSTRACT

The analysis of insurance claim data has been an important technique used to assess the effectiveness of federal standards for automotive bumpers. Studies assessing each version of these standards since their inception in 1973 have used this technique. The identification of bumper-involved claims is an essential requirement in performing such studies. Recent changes in automotive design have complicated the process of identifying bumper involvement. Examined in this paper are several different damage criteria that are currently applicable toward identifying bumper-involved insurance claims. The implications of each of these criteria in influencing the results of claim analyses are presented. In addition, a new cost-effectiveness measure, E, which is the product of insurance claim proportion and the average repair cost of these claims, is developed to quantify the risk or expected expense of repairing a vehicle in the first year of ownership due to a low-speed accident. The usefulness of this measure in performing insurance claim analyses is demonstrated.

Federal Motor Vehicle Safety Standards are periodically selected for review. These reviews are designed to determine whether these standards are

1. Resulting in the reduction of accident frequency and injury severity;
2. Leading to benefits commensurate with the costs of complying with the standard; and
3. Not imposing unnecessary burdens on the economy, individuals, public or private organizations, or state and local government.

The bumper standard enacted by NHTSA is one of the standards that has been under continuing review.

This paper contains a description of an analysis of the performance of automotive bumpers designed to conform to NHTSA's standards for exterior protection for 5-mph impacts (1). This version of the standard was in effect for vehicles manufactured in model years 1980 through 1982. The analysis was performed by examining insurance claim data for these model years, and represents an extension of previous analyses (2-4) of the effectiveness of bumpers in minimizing crash damage. The previous analyses, made by KLD Associates, Incorporated, under contract to NHTSA, considered pre-1972, 1973, 1974-1978, 1979, and 1980 versions of the bumper standards. These analyses, and others [summarized by NHTSA (5)] showed the benefits of various versions of the bumper standards. Similar results were obtained in a study by the Highway Loss Data Institute (HLDT) in which a different data base was used (6).

In light of NHTSA's decision to modify the bumper standard from 5 mph to 2.5 mph effective with 1983 model year vehicles (7), this study provides a framework for examining the impacts of the newer 2.5 mph standard. In this study, the groundwork is laid for such an evaluation by providing a detailed assessment of the effects of the pre-1983, 5-mph standard.

The research contained in Abramson and Yedlin (1) examines the effects of many different factors on bumper performance. This paper focuses on how the damage criteria used to identify bumper involvement influences the evaluation of bumper performance. (Note: Data for this study were obtained from the State Farm Insurance Companies and represent a nationwide sample of insurance claims from their claim service centers.)

EXPERIMENTAL DESIGN

The aggregate sets of claims available for model years 1980-1982 were examined. Only claims involving 1-year-old vehicles where bumpers were either repaired or replaced were considered. An experiment was designed to address two issues: (a) whether there were any significant differences in the available aggregate claim data between model years, and (b) how the criteria used to identify bumper-involved claims influence the understanding of the data.

Two measures of effectiveness were employed to understand each of these issues. These included: (a) the proportion of property damage claims involving bumpers, and (b) the average repair cost of these claims. A cost-effectiveness measure, E, which is the product of the proportion of property damage claims and the average repair cost of these claims is also utilized in the analysis.

The two criteria used to identify bumper-involved claims included repair or replacement of (a) only the bumper face bar, and (b) either the face bar or the bumper fascia or both. The format of the data available for 1980 allowed consideration of the first criteria only. The 1981 and 1982 data permitted both criteria to be considered. Claims for each model year were stratified into four market classes: subcompact, compact, intermediate, and full size, and two impact points: front and rear.

For the proportion analysis, the number of front and rear bumper claims were aggregated for each market size class and for each model year period. The proportion of these claims, relative to the total of all property damage claims for that market class, was computed for each model year. No totaled vehicles were in the State Farm data, although both collision and liability claims were included. For each of the time-period comparisons (1980 versus 1981, 1981 versus 1982, and 1980 versus 1982), the

hypothesis test for differences in proportions was computed for each market class-impact point combination.

In total, four separate statistical comparisons were performed for the proportion analysis including (a) three model year comparisons using face bar damage as the involvement criteria, and (b) one comparison between the 1981 and 1982 data using face bar or fascia damage as the involvement criteria.

The same four statistical comparisons were performed for the analysis of average repair costs. In each case, the average repair cost was computed for each market class-impact point combination. The differences between average costs were statistically tested using the hypothesis test for the difference between means at a 5 percent confidence level.

PROPORTION ANALYSES

The results of the four statistical comparisons performed on bumper claim proportions are given in Table 1. This table gives the bumper claim proportions stratified by impact point and market class. Significant differences at the 5 percent confidence level are indicated. This table depicts comparisons of all available data for model years 1980-1982 examining both criteria for bumper involvement. Available sample sizes are given in Table 2.

Employing only face bar damage to identify bumper-involved claims, the table indicates no significant differences in the proportion of these claims between 1980 and 1981. Between 1981 and 1982, a significant reduction is noted for subcompact vehicles for both front and rear impacts. This reduction is also noted for the vehicle classification "All Classes" for 1981 and 1982 claims. This is no doubt due to the predominance of subcompact vehicles in the sample. The reduction in subcompact and All Classes claim proportion is also noted between 1980 and 1982. In addition, a significant reduction is shown for rear impacts of compact vehicles.

The reduction in subcompact claim proportion suggests differences in bumper design over the 1980-1982 period, particularly between 1981 and 1982 model year vehicles. Newer soft-face designs often employ a soft-cover (fascia) over the bumper face bar. These exterior surfaces are included within the bumper standards. By considering damage to the face bar only, claims involving damaged fascia without face bar damage are ignored. Only the more severe claims involving both fascia and face bar damage would be considered. If one hypothesizes an increase in the proportion of vehicles using soft-face designs in the 1982 sample, the face bar damage criteria would likely identify a smaller proportion of 1982 bumper damage.

Using a revised criteria in which bumper involvement implies damage to the face bar and/or fascia parts, the data in Table 1 indicate an increase in front-impact claim proportions for subcompacts and compact vehicles between 1981 and 1982. Again, the predominance of these market classes in the sample produces the same results for All Classes.

The two criteria for bumper involvement produce opposite results. This tends to strengthen the suspicion that the proportion of vehicles with hard and soft face designs differs between the 1981 and 1982 samples.

It appears that considering only face bar damage would result in an underestimation of the bumper involvement for 1982 vehicles. Considering face bar or fascia damage suggests the possibility that newer soft face designs may actually increase bumper involvement. Due to new soft-cover designs, either of these two criteria may overstate bumper involvement relative to the bumper protection standards. This occurs because the standards are expressed in terms of exterior damage. In some bumper designs, an air gap exists between the fascia and the face bar. An impact might be imparted to damage the face bar but the fascia may rebound to its original shape. As an exterior standard, no damage would be observed and such impacts would pass the standard. However, since the face bar was damaged, a claim for such an impact would be considered as bumper-involved by either the face bar or face bar-fascia damage criteria used in this study.

To more closely reflect the bumper standards, more detailed criteria would be needed. This exterior damage criteria would consider only fascia damage for soft cover designs and only face bar damage for traditional designs. However, for purposes of analyzing the factors influencing bumper performance, the criteria utilized by this study are considered more appropriate.

TABLE 1 Summary of Claim Proportion Analyses

Vehicle Size and Involvement Criteria	Model Year	Claims by Vehicles of Designated Size (% of total)		Total Bumper-Related Accidents
		Front	Rear	
Subcompact vehicles				
Face bar	1980	21.2	11.5	32.7
	1981	20.7	10.1	30.8
	1982	16.0[a,b]	7.2[a,b]	23.1[a,b]
Face bar-fascia damage	1981	28.1	13.5	41.6
	1982	31.1[b]	14.0	45.1
Compact vehicles				
Face bar	1980	21.5	14.8	36.2
	1981	22.2	13.7	35.9
	1982	23.0	12.1[a]	35.1
Face bar-fascia damage	1981	29.0	16.4	45.4
	1982	32.4[b]	15.7	48.1
Intermediate vehicles				
Face bar	1980	25.5	14.4	40.0
	1981	22.4	17.6	40.0
	1982	23.0	17.4	40.4
Face bar-fascia damage	1981	23.1	18.4	41.6
	1982	24.0	18.5	42.5
Full-size vehicles				
Face bar	1980	23.4	21.9	45.3
	1981	22.7	18.0	40.6
	1982	21.0	17.4	38.0
Face bar-fascia damage	1981	22.7	18.8	41.4
	1982	20.7	17.4	38.0
All classes				
Face bar	1980	21.7	13.0	34.8
	1981	21.4	12.2	33.7
	1982	17.9[a,b]	8.8[a,b]	26.8[a,b]
Face bar-fascia damage	1981	27.8	15.1	42.9
	1982	31.0[b]	14.6	45.6[b]

[a]Difference in claim proportions relative to 1980 claims is significant at a 5 percent confidence level.
[b]Difference in claim proportions relative to 1981 claims using same involvement criteria is significant at a 5 percent confidence level.

REPAIR COST ANALYSES

Table 3 gives the comparisons performed on average repair costs. This table is presented in a format similar to that employed for the proportion analyses in Table 1.

Table 3 gives the cost comparison for the model-year claim data available from 1980 through 1982. Costs for claims using both the face bar and face bar-fascia damage criteria for bumper involvement are presented. All costs are presented in 1982 dollars and adjusted for inflation.

Using only the face bar criteria, the data in Table 3 indicate that intermediate vehicles experienced a significant increase in average repair costs

TABLE 2 Sample Sizes for Proportion and Repair Cost Analyses

Vehicle Size and Involvement Criteria	Model Year	Sample Sizes		Total Bumper-Related Accidents	All Claims
		Front	Rear		
Subcompact vehicles					
Face bar	1980	578	315	893	2,730
	1981	1,021	501	1,522	4,934
	1982	914	410	1,324	5,722
Face bar-fascia damage	1981	1,388	666	2,054	4,934
	1982	1,779	802	2,581	5,722
Compact vehicles					
Face bar	1980	288	198	486	1,341
	1981	688	424	1,112	3,099
	1982	424	224	648	1,847
Face bar-fascia damage	1981	899	508	1,407	3,099
	1982	599	289	888	1,847
Intermediate vehicles					
Face bar	1980	108	61	169	423
	1981	216	170	386	966
	1982	66	50	116	287
Face bar-fascia damage	1981	224	178	402	966
	1982	69	53	122	287
Full-size vehicles					
Face bar	1980	32	30	62	137
	1981	29	23	52	128
	1982	25	21	46	121
Face bar-fascia damage	1981	29	24	53	128
	1982	25	21	46	121
All classes					
Face bar	1980	1,006	604	1,610	4,631
	1981	1,954	1,118	3,072	9,132
	1982	1,429	705	2,134	7,977
Face bar-fascia damage	1981	2,540	1,376	3,916	9,132
	1982	2,472	1,165	3,637	7,977

for front-impact claims between 1980 and 1981. However, this may be a statistical aberration because costs in 1982 are similar to those in 1980. No other significant changes are noted in Table 3 throughout the period between 1980 and 1982. This is true not only in aggregate but for each market class and impact point regardless of the criteria used to determine bumper involvement.

TABLE 3 Summary of Repair Cost Analyses

Vehicle Size and Involvement Criteria	Model Year	Average Repair Costs at 9.36% Inflation Rate (1982 dollars)		Average All Bumper-Related Accidents
		Front	Rear	
Subcompact vehicles				
Face bar	1980	1,365	874	1,191
	1981	1,368	934	1,225
	1982	1,388	951	1,253
Face bar-fascia damage	1981	1,332	897	1,184
	1982	1,299	883	1,170
Compact vehicles				
Face bar	1980	1,349	844	1,144
	1981	1,384	859	1,184
	1982	1,387	959	1,239
Face bar-fascia damage	1981	1,317	839	1,144
	1982	1,307	911	1,178
Intermediate vehicles				
Face bar	1980	1,289	907	1,151
	1981	1,566[a]	1,035	1,331[a]
	1982	1,361	985	1,199
Face bar-fascia damage	1981	1,550	1,050	1,328
	1982	1,373	993	1,207
Full-size vehicles				
Face bar	1980	1,959	1,242	1,612
	1981	2,568	1,048	1,882
	1982	1,901	1,266	1,611
Face bar-fascia damage	1981	2,568	1,044	1,864
	1982	1,901	1,266	1,611
All classes				
Face bar	1980	1,371	886	1,189
	1981	1,413	923	1,234
	1982	1,396	966	1,253
Face bar-fascia damage	1981	1,354	898	1,193
	1982	1,309	902	1,178

[a]Difference in claim costs relative to 1980 claims is significant at a 5 percent confidence level.

COST-EFFECTIVENESS MEASURE

To obtain a measure of the relative cost-effectiveness of the 1980, 1981, and 1982 bumpers, the following figure of merit has been derived. For any given stratification S, let N_S represent the total number of vehicles in that strata for a given year. The product $P \times C \times N_S$, where P is the proportion of vehicles of type S reporting a bumper-involved accident and C is the average cost per vehicle of Type S to repair the resulting damage, represents an estimate of the total cost of repairing vehicles of type S that have been involved in bumper accidents for the given year. Normalizing this total cost over all vehicles in strata S yields:

$$E = (P \times C \times N_S = P \times C)/N_S$$

where E represents a measure of cost-effectiveness or risk, in dollars, associated with stratification S. In other words, E represents the repair cost for bumper-involved accidents averaged over all vehicles, N_S, in stratification S. This value E can then be interpreted as a measure of the risk the owner of a vehicle of type S assumes in terms of the anticipated expense of repairing the vehicle in the first year of ownership due to a low-speed accident. Equivalently, E can be considered a figure of merit for the cost-effectiveness of the automobile bumper for a given stratification.

Table 4 gives the claim proportions, average cost values, and computed cost-proportion product E for the All Classes aggregate for 1980, 1981, and 1982. These tables stratify results for both the face bar damage and face bar-fascia damage criteria. The tables further stratify results for front impacts, rear impacts, and the combination of front and rear impacts.

TABLE 4 Comparison of 1980, 1981, and 1982 Data Using Cost-Proportion Product E for All Classes

Model Year	Proportion	Cost ($)	E = Prop. x Cost
Face Bar Only (all classes combined)			
1980	.3477	1,189	413.42
1981	.3364	1,234	415.12
1982	.2675[a]	1,253	335.18
Face Bar Only (all classes, front)			
1980	.2172	1,371	297.78
1981	.2140	1,413	302.38
1982	.1791[a]	1,396	250.02
Face Bar Only (all classes, rear)			
1980	.1304	886	115.53
1981	.1224	923	112.98
1982	.0884	966	85.39
Face Bar-Fascia (all classes combined)			
1981	.4288	1,193	511.56
1982	.4599[a]	1,178	537.05
Face Bar-Fascia (all classes, front)			
1981	.2781	1,354	376.55
1982	.3099[a]	1,309	405.66
Face Bar-Fascia (all classes, rear)			
1981	.1507	898	135.32
1982	.1460	902	131.69

[a]Indicates significant figure.

From the first half of Table 4, which contains data on face bar damage only, the measure E indicates that no substantial change in effectiveness occurred between 1980 and 1981 in either front or rear impacts; however, a substantial decrease in E of approximately $80 occurs in 1982 for the combined front and rear cases. Most of this decrease, $50, is due to a decrease in E for front impacts with the remaining $30 decrease due to a decrease in E for rear impacts. Considering only face bar damage, the measure E suggests that the 1982 bumpers are more cost effective than those in either 1980 or 1981. It was also suggested earlier that the face bar damage criteria may underestimate 1982 claim involvement. This is borne out by comparing face bar-only results for E against face bar-fascia damage results. The value of E for the latter is increased by approximately $100 (front and rear impacts combined) for 1981, and by approximately $200 for 1982. Thus, when fascia damage is included in the criterion, more costly accidents are included in the sample, that is, fascia damage introduces accidents that result in costly damage, even though the face bar itself does not require repair or replacement.

Table 4 (d,e,f) gives data indicating that the value of E for all impacts has increased from 1981 to 1982 by approximately $25 entirely because of an increase in E for front impacts. Thus, this definition of bumper involvement leads to the conclusion that the 1982 bumpers are, overall, less cost effective than those in 1981.

Two important conclusions can be drawn from this analysis. First, considering only face bar damage to identify bumper-involved accidents appears to result in a substantial underestimation of the repair cost effectiveness of the bumper. Furthermore, this underestimation becomes more pronounced with the changes in design occurring from 1981 to 1982. Thus, it is apparent that the face bar-fascia damage definition is the appropriate one to use to properly assess bumper effectiveness in the future.

Based on this first conclusion, it appears that the 1982 bumpers are less cost effective than the 1981 bumpers. The observed increase of $25 in E from 1981 to 1982 for all impacts represents a 5 percent increase over 1981. It should be pointed out that these results are based on the observed values and have not been tested for statistical significance.

Table 5 contains data on the computed value of E by market class and year for both the face bar and face bar-fascia damage definitions. In general, the value of E increases with vehicle size. Also, as noted previously, E is greater when considering face bar or fascia damage, than only face bar damage.

Subcompacts, constituting a major portion of the total mix, exhibit the same results as shown in the previous section for the year-to-year comparison using the vehicle aggregate. Thus, the face bar criteria indicate a decrease taking place from 1981 to 1982, however, the fascia-face bar data show an increase from 1981 and 1982. In each case, the change in E primarily reflects changes for front impacts.

For compacts, however, both involvement criteria show an increase in E from 1980 to 1982. The face bar data show a $10 increase in E from 1981 to 1982 ($424 to $434) for all impacts combined, whereas, the face bar-fascia damage comparison shows an increase of approximately $50 ($519 to $566) from 1981 to 1982. Thus, the inclusion of fascia damage in-

TABLE 5 Value of Cost-Proportion Measure E by Market Class and Year

Market Class and Model Year	Bumper Involvement Definition					
	Face Bar Only			Fascia-Face Bar		
	Front	Rear	Combined	Front	Rear	Combined
Subcompact						
1980	288.97	100.86	389.58	–	–	–
1981	282.77	94.71	377.55	371.48	120.92	492.43
1982	221.66	68.19	289.94	403.86	123.80	527.79
Compact						
1980	289.77	124.66	414.59	–	–	–
1981	307.25	117.51	424.82	382.06	137.51	519.38
1982	318.46	116.33	434.64	423.86	142.57	566.38
Intermediate						
1980	329.08	130.79	459.82	–	–	–
1981	350.16	182.16	531.87	359.45	193.52	552.58
1982	313.03	171.59	484.64	330.07	183.41	513.10
Full size						
1980	457.62	272.00	729.59	–	–	–
1981	581.91	188.33	764.66	581.91	195.75	771.88
1982	392.75	219.78	612.50	392.75	219.78	612.50

creases the expected repair cost for compact vehicles by over $100.

Because subcompacts and compacts together now account for the major portion of the sample mix, the increased value of E in 1982 indicates that bumpers are generally less cost effective. The limited data for intermediate and full-size cars indicate a decrease in the value of E from 1981 to 1982 for both bumper-involvement definitions. There was no difference in full-size vehicles for 1982 when the definition for bumper involvement changed. This probably is due to the small sample size involved, and the fact that full-size cars often have exposed face bars with no fascia.

STUDY RESULTS AND CONCLUSIONS

The analysis of insurance claim data has been an important technique used to assess the effectiveness of federal standards for automotive bumpers. Studies assessing each version of these standards since their inception in 1972 (1-4) have involved the use of this technique. In performing these insurance claim studies, the identification of bumper-involved claims is an essential requirement. Recent changes in automotive design have complicated the process of identifying bumper involvement. This study examined several different criteria that are currently applicable to identify bumper-involved insurance claims. The implications of each of these criteria in influencing the results of claim analyses were considered.

The primary findings of this study were as follows:

1. As a result of newer designs, the face bar damage criteria used in previous bumper claim analyses are no longer as useful as criteria that consider both face bar and fascia damage.
2. If only face bar damage is considered, claims for bumpers using newer, hard-plastic fascia are not included. In the case of soft face designs, considering just face bar damage would eliminate claims in which only the fascia was damaged.
3. A criteria that classifies a claim as bumper-involved if the face bar and/or fascia is damaged will generally cover the widest spectrum of bumper involvement.
4. Due to new soft-face designs, either the face bar or the face bar-fascia damage criteria may overstate bumper involvement relative to the bumper protection standards. The bumper standards are expressed in terms of exterior damage. In some cases where a gap exists between face bar and fascia, it is possible for an impact to damage a covered face bar, yet the outer fascia rebounds and appears undamaged. Such impacts would pass the bumper standards but constitute bumper involvement by either the face bar or face bar-fascia damage criteria used in this study. However, these criteria are considered appropriate for an analysis of the factors influencing bumper performance.
5. A cost-effectiveness measure was developed to quantify the risk or expected expense of repairing a vehicle in the first-year ownership resulting from a low-speed accident. The usefulness of this measure in interpreting insurance claim results was demonstrated in that (a) it showed that the face bar damage criteria underestimated 1982 claim involvement, (b) changes in cost-effectiveness are due primarily to changes occurring in front impacts, and (c) cost-effectiveness generally decreases with increased vehicle size.

This study strongly suggests that damage to either bumper face bar or fascia is currently the most appropriate criterion to be used in evaluating bumper performance on the basis of insurance data. Future studies of relative bumper performance should consider the effect of bumper design changes in the choice of damage criteria used.

It is also recommended that the cost-effectiveness measure E, (described in this paper), should be employed in future claim studies.

REFERENCES

1. P. Abramson and M. Yedlin. Analysis of 1981 and 1982 Insurance Claims to Determine Effect of 1981 and 1982 Bumpers on Crash Damage, Final Report. KLD Associates, Inc., Huntington Station, N.Y., March 1984.
2. P. Abramson and M. Yedlin. Analysis of 1980 Insurance Claims to Determine Effect of 1980 Bumpers on Crash Damage, Final Report. KLD Associates, Inc., Huntington Station, N.Y., March 1982.
3. P. Abramson, J. Cohen, and H. Stein. Analysis of Insurance Claims to Determine Bumper Effect of Crash Damage, Final Report. Report TR-103. KLD Associates, Inc., Huntington Station, N.Y., March 1980.
4. P. Abramson, J. Cohen, and H. Stein. Analysis of Insurance Claims to Determine Bumper Effect on Crash Damage--1979 Model Year, Report TR-103A. KLD Associates, Inc., Huntington Station, N.Y., Oct. 1980.
5. W.G. LaHeist and K.D. Ichter. Evaluation of the Bumper Standard. Report DOT-HS-805-866. NHTSA, U.S. Department of Transportation, April 1981.
6. An Assessment of the Effects of the Federal Safety Bumper Standard on the Losses for 1972 through 1978 Models. Report HLDIA12, Highway Loss Data Institute, Washington, D.C., June 1980.
7. Final Regulatory Impact Analysis Part 581 Bumper Standard. Office of Program and Rulemaking Analysis, NHTSA, U.S. Department of Transportation, May 1982.

Publication of this paper sponsored by Committee on Motor Vehicle Technology.