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. 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 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 show the benefits of various versions of the bumper standards. Similar results were obtained in a study by the Highway Loss Data Institute in which a different data base was used.

In light of NHTSA's decision to modify the bumper standard from 5 mph to 2.5 mph effective with 1983 model year vehicles, 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 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. 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: sub-compact, 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, the proportion of claims involving the bumper face bar, and (b) the face bar or the bumper fascia.
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

<table>
<thead>
<tr>
<th>Vehicle Size and Involvement Criteria</th>
<th>Claims by Vehicles of Designated Size (% of total)</th>
<th>Total Bumper-Related Accidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subcompact vehicles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Face bar</td>
<td>1980: 21.2 11.5 32.7</td>
<td>34.0 25.0 45.8</td>
</tr>
<tr>
<td></td>
<td>1981: 23.5 13.4 37.7</td>
<td>33.0 28.2 45.0</td>
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<td>32.0 30.4 48.0</td>
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<tr>
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<td>1981: 22.4 17.6 40.0</td>
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<td></td>
<td>1982: 23.0 17.4 40.4</td>
<td>35.5 27.5 47.5</td>
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<tr>
<td>Face bar-fascia damage</td>
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<td>32.0 27.0 45.5</td>
</tr>
<tr>
<td></td>
<td>1982: 24.0 18.5 42.5</td>
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<td>1982: 20.7 17.4 38.0</td>
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<td>1981: 21.4 12.2 33.7</td>
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<td>1982: 19.9 11.2 32.9</td>
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<tr>
<td></td>
<td>1982: 30.0 14.6 45.6</td>
<td>35.0 27.0 47.0</td>
</tr>
</tbody>
</table>

aDifference in claim proportions relative to 1980 claims is significant at a 5 percent confidence level.
bDifference in claim proportions relative to 1981 claims using same involvement criteria is significant at a 5 percent confidence level.

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 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.

**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 a significant increase in average repair costs.
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 im-

### TABLE 2 Sample Sizes for Proportion and Repair Cost Analyses

<table>
<thead>
<tr>
<th>Vehicle Size and Involvement Criteria</th>
<th>Sample Sizes</th>
<th>Total Bumper-Related Accidents</th>
<th>All Claims</th>
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### TABLE 3 Summary of Repair Cost Analyses

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<tr>
<th>Vehicle Size and Involvement Criteria</th>
<th>Average Repair Costs at 9.36% Inflation Rate (1982 dollars)</th>
<th>Average</th>
<th>Bumper-Related Accidents</th>
<th>All</th>
<th>E = (P x C x Ns) / Ns</th>
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<tbody>
<tr>
<td></td>
<td>Model Year</td>
<td>Front</td>
<td>Rear</td>
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<td>1981</td>
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<td>902</td>
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</table>

aDifference 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:

$$ E = \frac{(P \times C \times N_S)}{N_S} $$

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.
measure 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 front and rear impacts; however, a substantial decrease in the value of E for all impacts has increased from 1980 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 increases 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 1980 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-

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

<table>
<thead>
<tr>
<th>Model Year</th>
<th>Proportion</th>
<th>Cost ($)</th>
<th>E = Prop. x Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Face Bar Only (all classes combined)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1980</td>
<td>.3477</td>
<td>1,189</td>
<td>413.42</td>
</tr>
<tr>
<td>1981</td>
<td>.3364</td>
<td>1,234</td>
<td>415.12</td>
</tr>
<tr>
<td>1982</td>
<td>.2675</td>
<td>1,253</td>
<td>335.18</td>
</tr>
<tr>
<td>Face Bar Only (all classes, front)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1980</td>
<td>.2172</td>
<td>1,371</td>
<td>297.78</td>
</tr>
<tr>
<td>1981</td>
<td>.2140</td>
<td>1,413</td>
<td>302.38</td>
</tr>
<tr>
<td>1982</td>
<td>.1791</td>
<td>1,396</td>
<td>250.02</td>
</tr>
<tr>
<td>Face Bar Only (all classes, rear)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1980</td>
<td>.1304</td>
<td>886</td>
<td>115.53</td>
</tr>
<tr>
<td>1981</td>
<td>.1224</td>
<td>923</td>
<td>112.98</td>
</tr>
<tr>
<td>1982</td>
<td>.0884</td>
<td>966</td>
<td>85.39</td>
</tr>
<tr>
<td>Face Bar-Fascia (all classes combined)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1980</td>
<td>.4288</td>
<td>1,193</td>
<td>511.56</td>
</tr>
<tr>
<td>1981</td>
<td>.4599</td>
<td>1,178</td>
<td>537.05</td>
</tr>
<tr>
<td>Face Bar-Fascia (all classes, front)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1980</td>
<td>.2781</td>
<td>1,354</td>
<td>376.55</td>
</tr>
<tr>
<td>1981</td>
<td>.3099</td>
<td>1,309</td>
<td>405.66</td>
</tr>
<tr>
<td>Face Bar-Fascia (all classes, rear)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1980</td>
<td>.1507</td>
<td>898</td>
<td>115.32</td>
</tr>
<tr>
<td>1981</td>
<td>.1460</td>
<td>902</td>
<td>111.69</td>
</tr>
</tbody>
</table>

4Indicates 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 criteria, 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 1980 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.

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

<table>
<thead>
<tr>
<th>Market Class and Model Year</th>
<th>Face Bar Only</th>
<th>Fascia-Face Bar</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Front</td>
<td>Rear</td>
</tr>
<tr>
<td>Subcompact 1980</td>
<td>288.97</td>
<td>100.86</td>
</tr>
<tr>
<td>1981</td>
<td>282.77</td>
<td>94.71</td>
</tr>
<tr>
<td>1982</td>
<td>221.66</td>
<td>68.19</td>
</tr>
<tr>
<td>Compact 1980</td>
<td>289.77</td>
<td>124.66</td>
</tr>
<tr>
<td>1981</td>
<td>307.25</td>
<td>117.51</td>
</tr>
<tr>
<td>1982</td>
<td>318.46</td>
<td>116.33</td>
</tr>
<tr>
<td>Intermediate 1980</td>
<td>329.08</td>
<td>130.79</td>
</tr>
<tr>
<td>1981</td>
<td>350.16</td>
<td>182.16</td>
</tr>
<tr>
<td>1982</td>
<td>313.03</td>
<td>171.59</td>
</tr>
</tbody>
</table>
creases the expected repair cost for compact vehicles by over $100.

Because subcompacts and compacts together 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), be employed in future claim studies.

REFERENCES


