HLDI
Highway Loss Data Institute

Bulletin | Vol. 35, No. 46 : December 2018

Collision insurance losses for the 2015–16 Ford F-150: an update

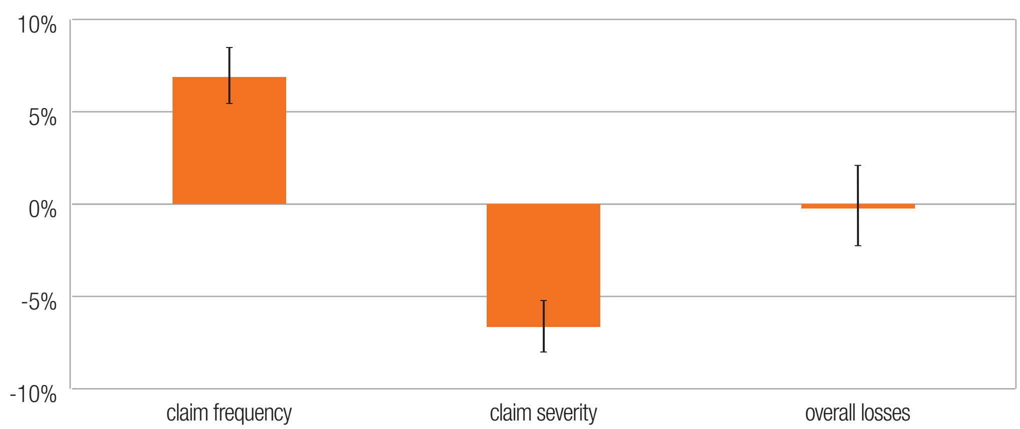
Summary

Prior research by the Highway Loss Data Institute (HLDI, 2014) found that aluminum usage in high-end luxury vehicles was associated with increases in collision severity. When Ford Motor Company announced that their best-selling F-150 would be redesigned with an all-aluminum body beginning with the 2015 model year, there were concerns that collision claim severities would increase. Crash tests by the Insurance Institute for Highway Safety (IIHS, 2015) found that the total repair cost for damage sustained in similar crashes was 26 percent higher for the aluminum 2015 F-150 than for the steel 2014 F-150. However, two HLDI studies (HLDI 2016, 2017a) found no significant increases in collision claim severity for the aluminum F-150s compared with their earlier steel counterparts. The studies did find that claim loss development (i.e., the accumulation of payment information for an insurance claim) took longer for the aluminum F-150s compared with the steel F-150s and other comparable large-sized pickup trucks. Although HLDI does not receive information regarding repair times, it was hypothesized that this may indicate that the aluminum-based F-150s are taking longer to repair.

This report updates the prior analyses with additional loss data, accounts for trends in claim frequency and severity, and provides a longer term look at the loss development trends for the aluminum-based pickups. The figure below compares collision insurance losses for the 2015 and 2016 F-150 with the 2014 F-150 and other large pickups. Results indicate a significant decrease in collision claim severity of 7 percent for the 2015–16 model years compared with the 2014 model year and other large pickups. Collision claim frequencies, however, were higher by 7 percent and significant, resulting in no difference to overall losses.

Further analysis also indicates that the loss development time was higher for the aluminum-based vehicles. This effect was significantly pronounced for the 2015 model year when it was first introduced, but the effect has been diminishing over time. This effect could indicate that initial repairs were taking longer for the aluminum models compared with the steel-based counterparts, but over time this has normalized as repair shops have gained more familiarity and experience with aluminum repairs.

Estimated differences in collision insurance losses for the 2015–16 F-150 compared with 2014 F-150 and other large pickups



Introduction

Beginning with model year 2015, Ford Motor Company redesigned the F-150, the best-selling vehicle in the United States for 35 years (Smith, 2017), with an all-aluminum body. Although most of the frame is comprised of high-strength steel, nearly all the sheet metal used for the F-150 body is aluminum (Markus, 2014). Previously, full-bodied aluminum and aluminum-intensive vehicles had been largely limited to high-end luxury and performance vehicles. The 2015 F-150 marks the first high-volume, mass-market vehicle to be constructed largely from aluminum. The redesigned F-150 variants are up to 700 pounds lighter than their predecessor. For the 2017 model year, Ford switched the F-250, F-350, and F-450 to aluminum. While initial rumors were that other manufacturers had plans to adopt aluminum (Ewing, 2015), they have not followed suit (Autoweek, 2018).

While aluminum traditionally provides weight savings over steel, it is not without its disadvantages. The properties of aluminum are different than steel, and repairing the material can require different techniques and tools. Repairing extreme damage may require a clean room to prevent contamination of the metal. If aluminum is contaminated, it will corrode faster than normal. Aluminum parts are often more expensive than steel parts, and many body shop owners say the repairs take longer, resulting in increased labor and total repair costs (Stoklosa, 2014; Truett, 2014; Wernie, 2014).

A previous study by HLDI (2014) found that in high-end luxury vehicles, aluminum is associated with increases in collision claim severities and that the higher the aluminum content, the greater the increase in claim severity. An IIHS crash test evaluation similarly found that total repair costs for the aluminum 2015 F-150 were 26 percent higher than the steel 2014 F-150 (IIHS, 2015). However, despite indications that loss development was taking longer, HLDI (2016, 2017a) found no evidence of significantly increased collision severities. The current study updates the prior report with additional collision loss data for the 2014–2016 F-150 and provides a longer term analysis of the loss development of the aluminum vehicles.

Methods

Insurance data

Automobile insurance covers damage to vehicles and property as well as injuries to people involved in crashes. Different insurance coverages pay for vehicle damage versus injuries, and different coverages may apply depending on who is at fault. The current study is based on collision coverage. Collision coverage insures against vehicle damage to an at-fault driver's vehicle sustained in a crash with an object or other vehicle; this coverage is common to all 50 states. Data are supplied to HLDI by its member companies.

HLDI creates data warehouses three times a year (April, September, and December) to coincide with the production of our standard reports on the major insurance coverages. For the April data warehouse, insurance records through December of the prior year are processed; for the September data warehouse, insurance records through May are processed; and for the December data warehouse, insurance records through August are processed.

Payments on claims are made over some period of time. This time period is relatively short for claims for vehicle damage while claims for injuries usually have longer payment periods.

Payment information is sent to HLDI on a monthly basis. As a consequence, the total amount of payment for claims can increase over time. The accumulation of payment information is called *loss development*. To mitigate the effect of loss development on severities, the most recent month(s) claims (and exposure) data, based on crash/coverage date, are excluded from the warehouse while payment information from the most current month for claims in prior months are included. If these claims and exposure were not excluded, loss results would drop significantly for later months. For collision, the back-off period is 1 month. Therefore, the current data warehouse at the time of this report includes claims and exposure through July 2018 and payments through August 2018. To investigate the effect of the 2015–16 F-150 redesign on loss development, some of the analyses in this report used alternate cutoff dates from the current data warehouse.

Vehicle data

Insurance loss analyses were based on 2014–16 model years for the Ford F-150, Chevrolet Silverado 1500, GMC Sierra 1500, and Ram 1500 large pickups. The regular cab-size variant has been excluded from the analysis, as data are limited for this cab-size variant on the 2015 model year for the Ford F-150. In addition, the Ford Raptor trim is not available for the 2015–16 model year. Prior HLDI research (HLDI, 2015) has shown that collision losses for the Ford Raptor are significantly higher than those for other F-150 pickups. Since it was not available for the 2015–16 model years, the Raptor trim level has also been excluded from this analysis. Other trim-level differences may exist between the model years. However, only the Raptor trim was VIN-discernible.

A vehicle's age was calculated as the difference between the calendar year and model year. Many manufacturers release new models in the calendar year prior to the vehicle's model year. For example, a vehicle's 2014 model year may be released during the 2013 calendar year. For the purposes of this analysis, such a vehicle is considered to have an age of –1 in calendar year 2013, 0 in calendar year 2014, 1 in calendar year 2015, etc. To maintain a more consistent comparison between the different model years, the insurance loss analysis restricts the 2014 model year to vehicle ages –1 to 3. This resulted in 7.1 million insured vehicle years.

To compare loss development, claims and payment data for the Ford F-150 were also compared with comparably sized pickups. These included the Chevrolet Silverado 1500, GMC Sierra 1500, and Ram 1500. For this portion of the analysis, the 2017 model year was also included. As with the F-150, the regular cab-size variants were excluded. Unlike prior analyses, vehicle age was not restricted to allow for a longer term comparison of loss development across model years and different vehicle ages.

Analysis methods

Regression analysis was used to quantify the differences in collision insurance losses between the 2015–16 and 2014 model years while controlling for other covariates. The covariates included garaging state, vehicle density (number of registered vehicles per square mile), rated driver age group, rated driver gender, rated driver marital status, vehicle age, deductible range, and risk. In addition, the cab size (SuperCab or SuperCrew) and drive type (2WD or 4WD) were also included in the regression model.

Claim frequency was modeled using a Poisson distribution, whereas claim severity (average loss payment per claim) was modeled using a Gamma distribution. Both models used a logarithmic link function. Estimates for overall losses were derived from the claim frequency and claim severity. For space reasons, full regression results are found in the Appendix. To further simplify the presentation here, the exponent of the parameter estimate was calculated, 1 was subtracted, and the result multiplied by 100. The resulting number corresponds to the effect of the feature on that loss measure. For example, the parameter estimate collision claim frequency for the 2015 model year was 0.0508; thus, collision claim frequency for the 2015 model year is expected to be 5 percent higher compared to the 2014 model year ((exp(0.0508) –1)*100 = 5.2).

An additional regression analysis was conducted to compare the overall difference between the 2015–16 F-150 with the 2014 F-150 while accounting for frequency and severity trends over time. A difference-in-difference approach was used to compare the difference in insurance losses between the 2014 F-150 and other 2014 large pickups with the difference in insurance losses between the 2015–16 F-150 and other 2015–16 large pickups.

How the loss development of claims for the aluminum-based F-150s changed over time compared with other comparably sized pickups was also analyzed. Unlike the loss development analysis done in the prior HLDI studies (HLDI 2016, 2017a) vehicle age and loss development were not restricted to allow for this examination of how the loss development changed over time. Since the most recent claims by nature have had less time for loss development, only claims with crash dates through April 2018 were included, with payment information through August 2018.

For the purposes of this analysis, individual payment records are not considered. All payment records are aggregated together by the month in which they are received by HLDI.

Results

Figures 1–3 show the regression estimated differences in collision losses between the 2014 and 2015–16 model years after controlling for other covariates for the Ford F-150, Chevrolet Silverado 1500, GMC Sierra 1500, and Ram 1500. The black bars represent the 95 percent confidence intervals. **Figure 1** shows that collision claim frequency was estimated to be 5 percent higher for the 2015 F-150 and 2 percent higher for the 2016 model year. Both results were statistically significant. Meanwhile, claim frequencies for the other large pickups declined or were not statistically significant.

Figure 1: Estimated differences in collision claim frequency for 2015–16 versus 2014 large pickups

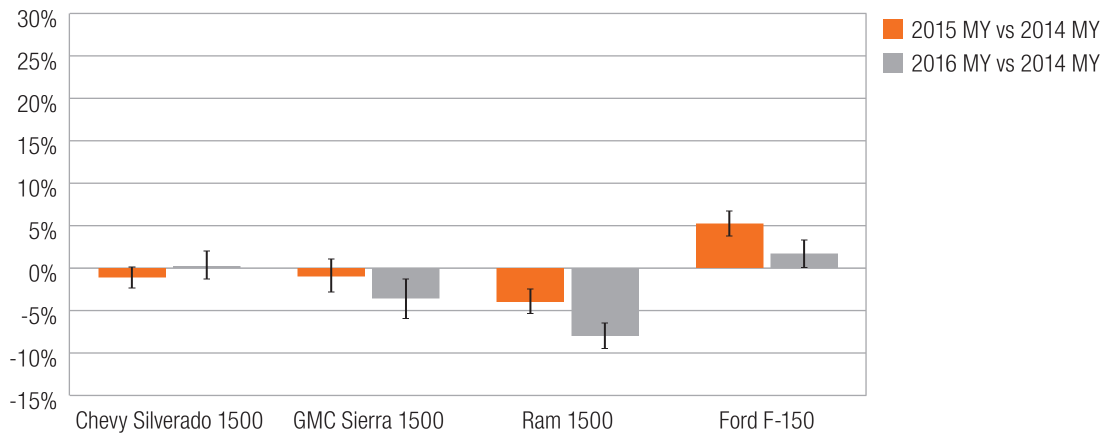
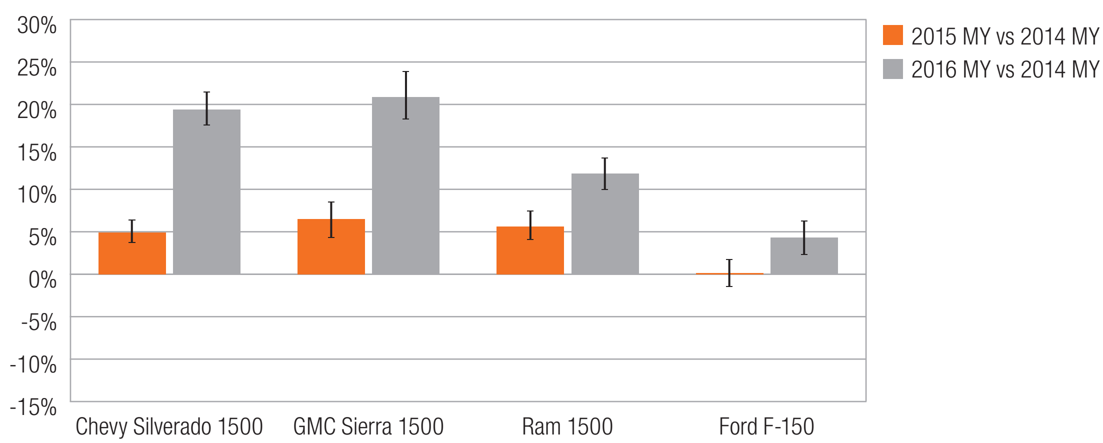


Figure 2 indicates that collision claim severity increased for all four pickups relative to the 2014 model year, with the largest increases for the 2016 model year. However, the magnitude of the increase was the smallest for the F-150 for both the 2015 and 2016 model years. Compared with the 2014 model year, 2015 severities for the other large pickups increased significantly between 5 and 7 percent. The 2015 F-150 severity increased by less than 1 percent and was not significant. Likewise, the severities for the 2016 model years increased between 12 to 21 percent for the other large pickups while the F-150 increased by only 4 percent.

Figure 2: Estimated differences in collision claim severity for 2015–16 versus 2014 large pickups



Consequently, overall losses increased for all pickups for the 2015 and 2016 model years compared with the 2014 model year as shown in **Figure 3**. All results were statistically significant except for the 2015 Ram 1500.

Figure 3: Estimated differences in collision overall losses for 2015–16 versus 2014 large pickups

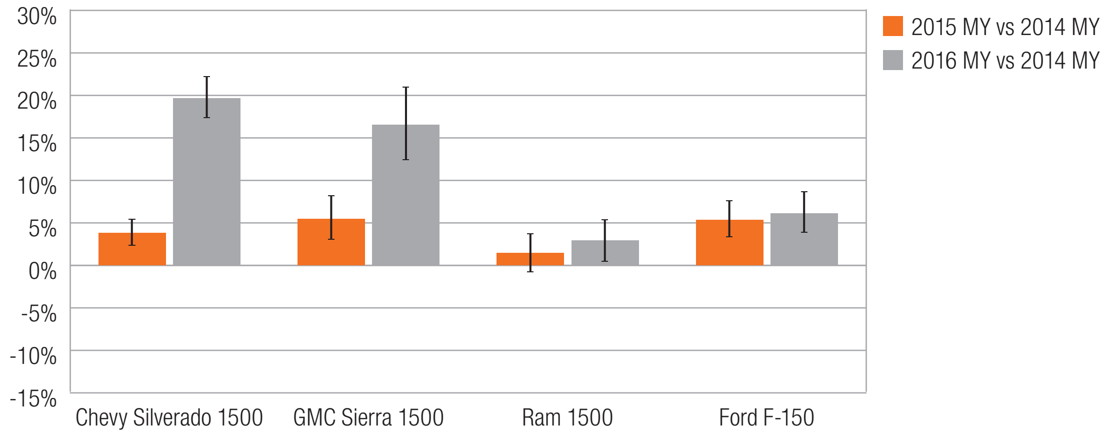
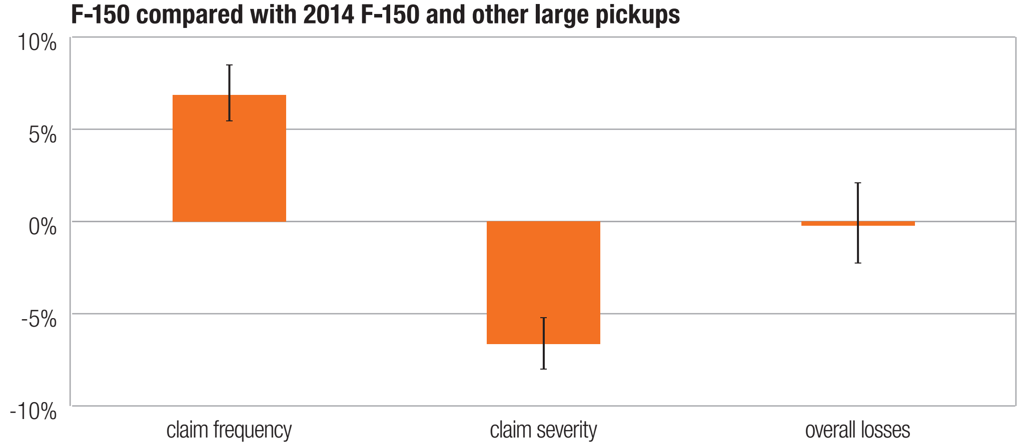


Figure 4 compares the insurance losses of the 2015–16 F-150 with those of the 2014 F-150 and other large pickups. A difference-in-difference approach was used to compare the difference between the 2014 F-150 and other 2014 large pickups with the difference in insurance losses between the 2015–16 F-150 and other 2015–16 large pickups. This approach allows the model to account for the loss trends over time as exhibited by changes in insurance losses for the other large pickups. After accounting for these trends, the 2015–16 F-150 was associated with a significant 7 percent increase in collision claim frequency that was offset by a 7 percent reduction in collision claim severity, resulting in no significant change to overall losses.

Figure 4: Estimated differences in collision insurance losses for the 2015–16 F-150 compared with 2014 F-150 and other large pickups



Figures 5–8 investigate whether the loss development on severity for the 2015–17 F-150 differed from that of the 2014 F-150 and other comparably sized pickups. Unlike the loss development analysis done in the prior HLDI studies (HLDI 2016, 2017a), loss development was not restricted to allow for an examination of how the loss development changed over time. Consequently, although similar, these results are not directly comparable with those of the prior study.

Figure 5 shows the proportion of claims with positive supplemental payment information for new vehicles (ages –1 and 0). For the non-Ford vehicles, there was an upward trend in the number of claims with supplements by model year. For the Ford F-150, there was a sharp increase from 27 percent to 36 percent after aluminum was introduced for the 2015 model year. The proportion dipped slightly to 34 percent for the 2016 model year before increasing to 35 percent for the 2017 model year.

Figure 5: Percentage of claims with positive supplemental payment information by model year, vehicle ages -1 and 0

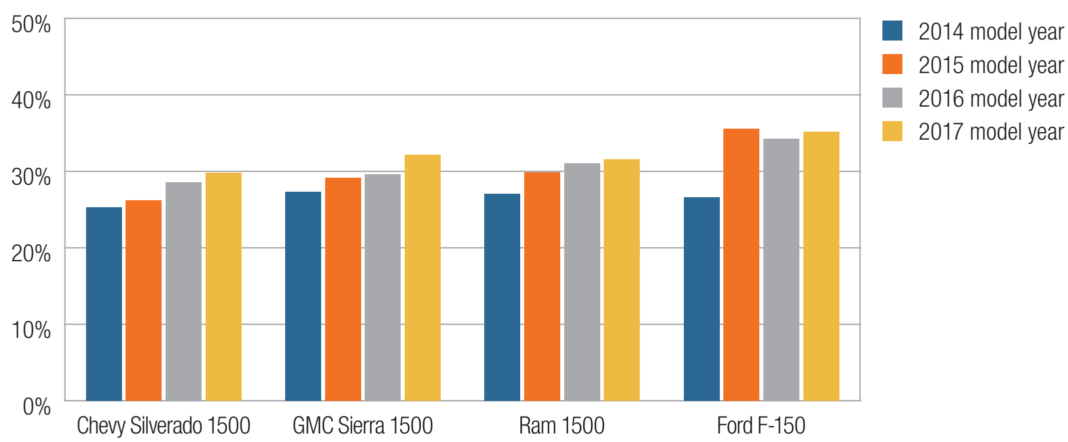
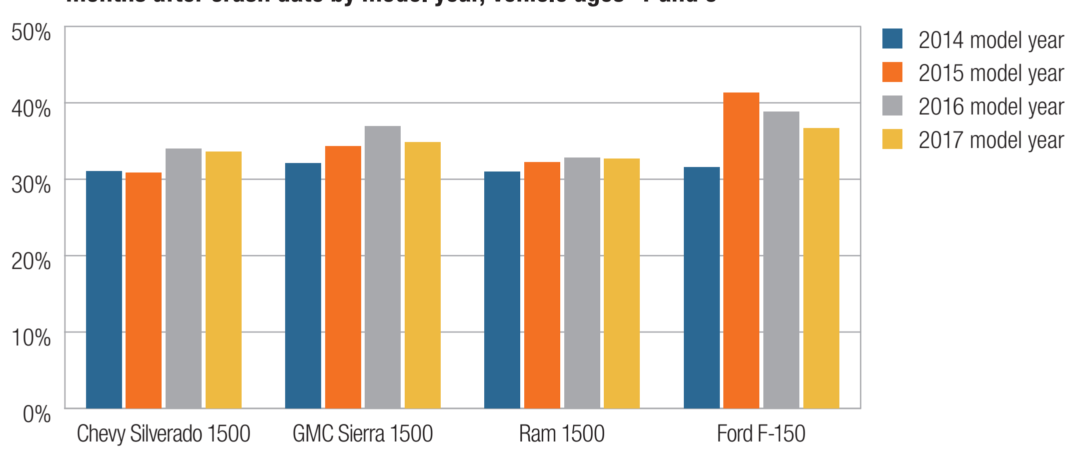


Figure 6 examines the timing of the payment information. This figure compares the last payment information HLDI received for a claim (thus far) with its crash date for new vehicles (age –1 and 0). The pattern is generally similar to that of **Figure 5**. For non-Ford pickups, the proportion of claims with payment information received 2 or more months after the crash date exhibit an upward trend by model year. In contrast, for the F-150, there was a sharp increase from 32 percent for the steel 2014 model to 41 percent for the aluminum 2015 model. The proportion then declined for both the 2016 and 2017 models.

Figure 6: Percentage of claims with payment information received 2 or more months after crash date by model year, vehicle ages -1 and 0



To assess how this loss development has changed over time, the proportions from **Figures 7 and 8** were calculated for all vehicle ages. The ratio of these proportions for the Ford pickups to the other manufacturers' pickups was then compared by model year and vehicle age. **Figure 7** shows the ratio for the proportion of claims with positive supplemental payment information, while **Figure 8** shows the ratio for the proportion of claims with payment information received 2 or more months after the crash date. Both figures indicate that when the aluminum 2015 F-150 first came out, there was a sharp increase in the loss development time. However, over time that effect has diminished, both for the 2015 F-150 as it has aged and for subsequent model years.

Figure 7: Ratio of percentage of claims with positive supplemental payment information by model year and vehicle age, Ford F-150 versus other large pickups

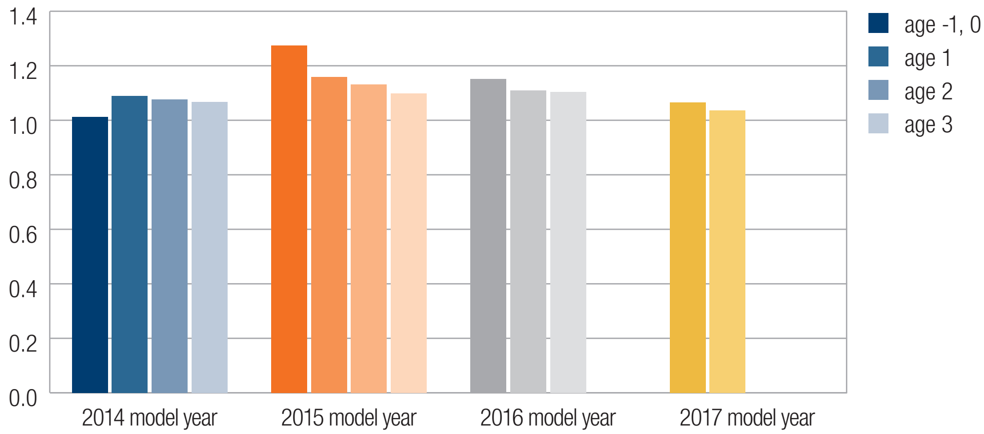
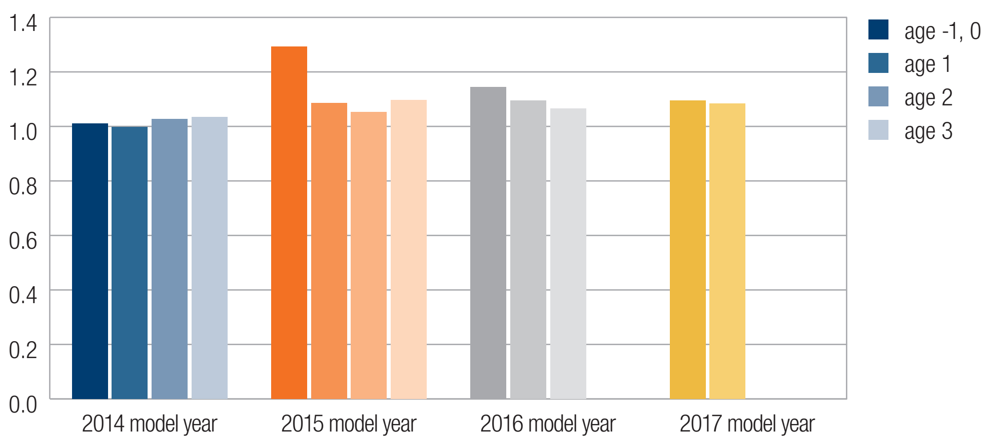


Figure 8: Ratio of percentage of claims with payment information received 2 or more months after crash date by model year and vehicle age, Ford F-150 versus other large pickups



Discussion

This study indicates that loss development for the aluminum-based Ford F-150's initially took longer when they were first introduced. However, over time that effect has been diminishing. Although HLDI does not receive information regarding repair times, this could indicate that the aluminum-based F-150s initially took longer to repair, but over time that has normalized as repair shops have gained more familiarity and experience with aluminum repairs.

Compared with the steel 2014 model, collision claim severity for the aluminum 2016 F-150 was significantly higher by 4 percent, although the 2015 model showed no significant difference. The prior study showed a nearly 10 percent decrease for the 2016 model year. However, at the time, data and loss development were limited for the 2016 model year. The current study has over 6 times the number of claims for the 2016 model year as the prior study. Additionally, this approach does not account for overall trends in severity. HLDI (2018) indicates that across all vehicles, including pickups, claim severity has been increasing in recent years. This finding is corroborated by the results for the other large pickups, all of which exhibited significantly increased collision claim severity for the 2015 model year, and even higher severities for the 2016 model year, compared with the 2014 model year. Although the F-150 followed a similar pattern, the magnitude of the effect was less compared with the other pickups. It is likely then, that the 4 percent increase observed for the 2016 model year is attributable to other, uncontrolled for factors, and is not due to aluminum usage.

After accounting for the trends exhibited by the other large pickups, the 2015–16 F-150 is associated with significantly higher collision claim frequency but reduced claim severity. It is unclear why collision claim frequency is higher for the aluminum-based 2015–16 models. The severity results also run contrary to initial expectations based on prior HLDI research which found that increased aluminum content was associated with increased collision claim severity on large luxury vehicles. Crash tests by IIHS also found that the total repair costs were 26 percent higher for an aluminum 2015 F-150 compared with a steel 2014 F-150.

Anticipating that the cost of repairs would be a concern, Ford used a modular design on the aluminum-intensive F-150 to make repairs easier and less costly. For example, Ford made the front structure that supports the fenders modular and estimated that it can be replaced in 6–7 fewer hours than the front structure on the 2014 model. This component is vulnerable in crashes that account for 15 percent of collisions (Zoia, 2014). In addition to the design changes, Ford also launched a program allowing dealerships with body shops to purchase the tools necessary to work on the 2015 F-150 at a significant discount. Repair shops that are prepared to repair aluminum body panels could spend anywhere from $30,000 to $50,000 on tools, facility upgrades, and training (Rall, 2014).

Ford has also priced many parts for the 2015–16 F-150 lower than comparable parts for the 2014 model. **Table 1** provides a summary example of prices for the current parts compared with prices for the same parts over the past several years (Audatex). The parts chosen were based on the components damaged in the 2015 IIHS test. Green prices indicate that the price dropped while red prices indicate the price increased more than a few dollars compared with the prior year. Based on this sample of parts, with few exceptions the prices for the 2014 model year had been increasing while prices for the 2015–16 model year have been decreasing. Most recently, however, prices have been increasing for the 2015–16 model and decreasing for the 2014 model year. However, except for the rear bumper and bedside, most part prices remain cheaper for the 2014 model. Note that the bumper prices include the cost of bracing and bracketry, and that the 2014 model requires a small top cover that needs to be painted (this adds approximately $150 to the price). The 2015–16 model year is chrome and therefore does not require additional painting.

Table 1: Comparison of parts pricing for 2014 and 2015–16 F-150

	2014 model year				2015–16 model year				2015–16 vs 2014
Part	**Apr-15**	**Mar-16**	**Apr-17**	**Apr-18**	**Apr-15**	**Mar-16**	**Apr-17**	**Apr-18**	**Apr-18**
Hood	$880	$1,021	$1,021	$1,018	$880	$823	$489	$580	-43%
Fender	$268	$272	$307	$308	$268	$264	$205	$263	-15%
Front bumper	$929	$929	$930	$918	$528	$528	$548	$581	-37%
Headlight	$270	$270	$271	$270	$248	$251	$179	$179	-34%
Rear bumper	$584	$584	$592	$579	$794	$794	$816	$916	58%
Exhaust pipe	$689	$689	$612	$728	$522	$522	$488	$434	-40%
Bedside	$654	$654*	$760	$650	$967	$864	$852	$853	31%
Taillight	$123	$115	$115	$116	$144	$108	$79	$66	-43%
Total	**$4,397**	**$4,534**	**$4,608**	**$4,587**	**$4,351**	**$4,154**	**$3,656**	**$3,872**	**-16%**

*Price unavailable so prior year's price used.

Repair costs are primarily based on three factors: repair shop overhead, the cost of labor, and the cost of parts (Torbjornsen, 2011). Ford has taken measures to address all three areas with subsidies for tools and training, modular designs to reduce repair time, and aggressive parts pricing. This approach appears to be having its intended effect and has helped keep the repair costs down for the 2015–16 F-150, offsetting any potential cost increases due to the intensive usage of aluminum. However, given Ford's efforts to keep costs down, these results may not generalize to future aluminum-based vehicles. Still, this is good news for consumers. After accounting for increasing trends in claim severity, severities for the aluminum F-150 are currently lower than the prior model.

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Appendix

Appendix: Illustrative regression results — collision frequency									
Parameter		Degrees of freedom	Estimate	Effect	Standard error	Wald 95% confidence limits		Chi-square	P-value
Intercept		1	-8.8257		0.0137	-8.8527	-8.7988	412182.00	<0.0001
Cab Configuration	SuperCrew 2WD	1	0.0549	5.6%	0.0089	0.0375	0.0723	38.21	<0.0001
	SuperCab 2WD	1	0.0368	3.7%	0.0132	0.0110	0.0626	7.81	0.0052
	SuperCab 4WD	1	-0.0751	-7.2%	0.0096	-0.0939	-0.0563	61.32	<0.0001
	SuperCrew 4WD	0	0	0	0	0	0		
Age	<25	1	0.1614	17.5%	0.0144	0.1333	0.1895	126.50	<0.0001
	66+	1	0.0235	2.4%	0.0088	0.0062	0.0408	7.09	0.0078
	Unknown	1	0.0222	2.2%	0.0206	-0.0181	0.0626	1.16	0.2807
	25–65	0	0	0	0	0	0		
Gender	Male	1	-0.0293	-2.9%	0.0077	-0.0443	-0.0143	14.64	0.0001
	Unknown	1	-0.1439	-13.4%	0.0319	-0.2064	-0.0814	20.36	<0.0001
	Female	0	0	0	0	0	0		
Marital status	Single	1	0.2329	26.2%	0.0073	0.2186	0.2472	1022.76	<0.0001
	Unknown	1	0.0765	8.0%	0.0293	0.019	0.1340	6.80	0.0091
	Married	0	0	0	0	0	0		
Risk	Nonstandard	1	0.2910	33.8%	0.0161	0.2595	0.3225	328.42	<0.0001
	Standard	0	0	0	0	0	0		
State	Alabama	1	0.0117	1.2%	0.0246	-0.0366	0.0600	0.23	0.6352
	Alaska	1	0.2410	27.3%	0.0495	0.1439	0.3381	23.68	<0.0001
	Arizona	1	0.0506	5.2%	0.0240	0.0035	0.0977	4.44	0.0351
	Arkansas	1	0.1438	15.5%	0.0321	0.0809	0.2066	20.10	<0.0001
	California	1	0.2561	29.2%	0.0146	0.2275	0.2847	308.06	<0.0001
	Colorado	1	0.0816	8.5%	0.0233	0.0359	0.1273	12.25	0.0005
	Connecticut	1	-0.0262	-2.6%	0.0480	-0.1203	0.0679	0.30	0.5852
	Delaware	1	0.1028	10.8%	0.0550	-0.0051	0.2107	3.49	0.0618
	Dist of Columbia	1	0.8256	128.3%	0.1295	0.5718	1.0794	40.64	<0.0001
	Florida	1	-0.0479	-4.7%	0.0142	-0.0757	-0.0200	11.37	0.0007
	Georgia	1	-0.0505	-4.9%	0.0184	-0.0865	-0.0144	7.52	0.0061
	Hawaii	1	0.3638	43.9%	0.0480	0.2696	0.4580	57.33	<0.0001
	Idaho	1	-0.0490	-4.8%	0.0410	-0.1294	0.0314	1.43	0.2325
	Illinois	1	-0.0944	-9.0%	0.0215	-0.1366	-0.0523	19.28	<0.0001
	Indiana	1	0.0343	3.5%	0.0265	-0.0176	0.0862	1.67	0.1958
	Iowa	1	-0.1349	-12.6%	0.0317	-0.1970	-0.0728	18.12	<0.0001
	Kansas	1	-0.1113	-10.5%	0.0319	-0.1738	-0.0487	12.16	0.0005
	Kentucky	1	-0.0827	-7.9%	0.0295	-0.1405	-0.0249	7.85	0.0051
	Louisiana	1	0.1838	20.2%	0.0187	0.1471	0.2205	96.30	<0.0001
	Maine	1	0.1410	15.1%	0.0481	0.0467	0.2353	8.59	0.0034
	Maryland	1	0.0579	6.0%	0.0251	0.0087	0.1070	5.33	0.0210
	Massachusetts	1	0.0134	1.3%	0.0329	-0.0511	0.0778	0.17	0.6837
	Michigan	1	0.3801	46.2%	0.0167	0.3474	0.4129	517.59	<0.0001
	Minnesota	1	-0.0883	-8.5%	0.0222	-0.1319	-0.0447	15.77	<0.0001
	Mississippi	1	0.0640	6.6%	0.0308	0.0037	0.1243	4.33	0.0375
	Missouri	1	-0.0692	-6.7%	0.0232	-0.1147	-0.0237	8.89	0.0029

Appendix: Illustrative regression results — collision frequency									
Parameter		Degrees of freedom	Estimate	Effect	Standard error	Wald 95% confidence limits		Chi-square	P-value
	Montana	1	0.1164	12.3%	0.0479	0.0226	0.2101	5.91	0.0150
	Nebraska	1	-0.1338	-12.5%	0.0363	-0.2050	-0.0627	13.59	0.0002
	Nevada	1	0.1123	11.9%	0.0371	0.0396	0.1850	9.17	0.0025
	New Hampshire	1	0.1347	14.4%	0.0439	0.0487	0.2207	9.43	0.0021
	New Jersey	1	-0.0113	-1.1%	0.0263	-0.0628	0.0402	0.18	0.6674
	New Mexico	1	0.0295	3.0%	0.0339	-0.0369	0.0960	0.76	0.3838
	New York	1	0.0355	3.6%	0.0190	-0.0018	0.0728	3.49	0.0619
	North Carolina	1	-0.1052	-10.0%	0.0215	-0.1473	-0.0631	23.96	<0.0001
	North Dakota	1	0.1539	16.6%	0.0451	0.0655	0.2422	11.64	0.0006
	Ohio	1	-0.1144	-10.8%	0.0199	-0.1534	-0.0753	32.94	<0.0001
	Oklahoma	1	-0.0012	-0.1%	0.0260	-0.0522	0.0497	0.00	0.9631
	Oregon	1	0.0260	2.6%	0.0331	-0.0389	0.0910	0.62	0.4324
	Pennsylvania	1	0.0812	8.5%	0.0172	0.0475	0.1150	22.27	<0.0001
	Rhode Island	1	0.3001	35.0%	0.0644	0.1738	0.4264	21.68	<0.0001
	South Carolina	1	-0.0930	-8.9%	0.0271	-0.1461	-0.0400	11.82	0.0006
	South Dakota	1	-0.0345	-3.4%	0.0496	-0.1318	0.0628	0.48	0.4875
	Tennessee	1	0.1056	11.1%	0.0209	0.0647	0.1465	25.61	<0.0001
	Utah	1	-0.0979	-9.3%	0.0367	-0.1699	-0.0260	7.11	0.0077
	Vermont	1	0.0613	6.3%	0.0651	-0.0663	0.1890	0.89	0.3463
	Virginia	1	0.0368	3.7%	0.0213	-0.0050	0.0786	2.98	0.0843
	Washington	1	0.0245	2.5%	0.0254	-0.0253	0.0743	0.93	0.3350
	West Virginia	1	-0.0552	-5.4%	0.0344	-0.1227	0.0122	2.58	0.1082
	Wisconsin	1	-0.0835	-8.0%	0.0246	-0.1317	-0.0352	11.50	0.0007
	Wyoming	1	0.0234	2.4%	0.0576	-0.0896	0.1363	0.16	0.6853
	Texas	0	0	0	0	0	0		
Deductible Range	0	1	-0.2398	-21.3%	0.1668	-0.5667	0.0871	2.07	0.1505
	1–50	1	0.6405	89.7%	0.0455	0.5513	0.7296	198.27	<0.0001
	51–100	1	-0.0208	-2.1%	0.0140	-0.0482	0.0065	2.23	0.1351
	101–200	1	0.2531	28.8%	0.0260	0.2021	0.3041	94.66	<0.0001
	201–250	1	0.2081	23.1%	0.0091	0.1902	0.2260	520.66	<0.0001
	501–1000	1	-0.2908	-25.2%	0.0094	-0.3092	-0.2724	957.55	<0.0001
	1001+	1	-0.6676	-48.7%	0.0502	-0.7660	-0.5692	176.90	<0.0001
	251–500	0	0	0	0	0	0		
Registered Vehicle Density	<50	1	-0.2911	-25.3%	0.0200	-0.3302	-0.2519	212.13	<0.0001
	50–99	1	-0.2878	-25.0%	0.0206	-0.3282	-0.2474	195.21	<0.0001
	100–249	1	-0.2211	-19.8%	0.0174	-0.2552	-0.1869	160.78	<0.0001
	250–499	1	-0.1854	-16.9%	0.0182	-0.2210	-0.1498	104.30	<0.0001
	500–999	1	-0.1288	-12.1%	0.0179	-0.1639	-0.0938	51.85	<0.0001
	1000+	0	0	0	0	0	0		
Vehicle age	-1	1	-1.7852	-83.2%	0.2673	-2.3091	-1.2613	44.60	<0.0001
	0	1	-0.0207	-2.0%	0.0100	-0.0403	-0.0010	4.24	0.0395
	2		-0.0851	-8.2%	0.0074	-0.0997	-0.0705	131.03	<0.0001
	3		-0.1487	-13.8%	0.0093	-0.1669	-0.1306	258.50	<0.0001
	1	0	0	0	0	0	0		

Appendix: Illustrative regression results — collision frequency									
Parameter		Degrees of freedom	Estimate	Effect	Standard error	Wald 95% confidence limits		Chi-square	P-value
Model year	2015	1	0.0508	5.2%	0.0072	0.0366	0.0650	49.20	<0.0001
	2016	1	0.0170	1.7%	0.0083	0.0007	0.0332	4.20	0.0404
	2014	0	0	0	0	0	0		

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