Highway Loss Data Institute

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Noncrash fire losses for turbo/supercharged engines

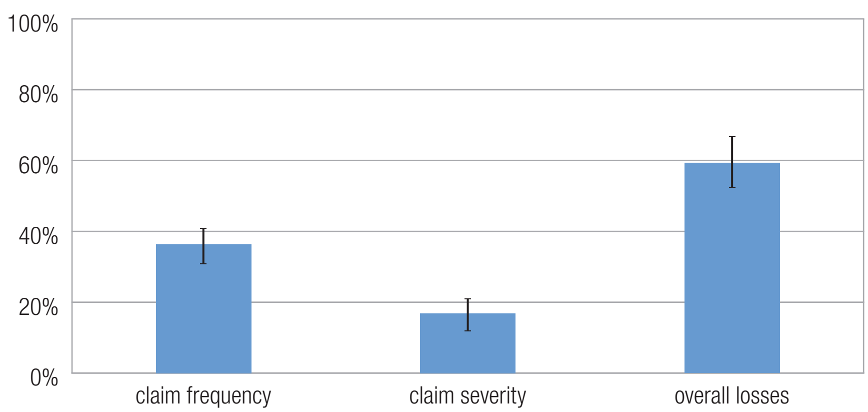
Summary

Noncrash fires are rare events, accounting for only half a percent of the total comprehensive claims in calendar year 2016. However, these events are typically very expensive with an average claim severity of $8,110 (HLDI, 2017b). These fire events can sometimes cause damage to other vehicles and homes, and in some tragic instances, loss of life. Often these fires are caused by a defect or design flaw with the vehicle.

Recent studies by the Highway Loss Data Institute (HLDI, 2018a, 2018b) investigating the high incidence of noncrash fires on certain Hyundai and Kia vehicles found that the vehicles with a turbocharged engine had the highest noncrash fire risk. It was unclear whether the elevated noncrash fire risk was due to the engine being turbocharged or some other unknown factor. This study examines a larger population of vehicles to determine if turbo/supercharged engines are associated with higher noncrash fire claim frequencies.

As shown in the figure below, vehicles with turbo/supercharged engines were associated with significantly higher noncrash fire insurance losses compared with vehicles with nonturbo/supercharged engines. Noncrash fire claim frequency was 36 percent higher for turbo/supercharged engines while claim severity was 17 percent higher, resulting in an increase of 59 percent to overall losses.

Estimated differences in noncrash fire insurance losses for turbocharged and supercharged engines compared with nonturbocharged engines



Introduction

Recent research by the Highway Loss Data Institute (HLDI, 2018a) found that several model years of the Kia Optima, Kia Sorento, Hyundai Sonata, and Hyundai Santa Fe were associated with significantly higher noncrash fire claim frequencies compared with similar size and class control vehicles. A follow-up study (HLDI, 2018b) found that noncrash fire claim frequencies for Hyundai/Kia vehicles equipped with the turbocharged engine were generally higher compared with the same vehicle equipped with nonturbo engine variants as well as a population of control vehicles. It was unclear if this was due to an engine-related defect, some other defect exacerbated by the turbocharged engine, or that turbocharged engines in general have a higher incidence of noncrash fires. The purpose of this study is to examine if noncrash fire claim frequencies differ for turbo/supercharged engines.

Method

Vehicles

The vehicles in this study include only those vehicle series that have both a turbo/supercharged (turbo) and nonturbo/supercharged (nonturbo) engine variant for model years 2005–18. Furthermore, only pairs with at least one noncrash fire claim for both the turbo and nonturbo variants were included to allow for estimation of the model year and vehicle series effect. This encompasses 646 different model year and vehicle series combinations.

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 comprehensive coverage. Comprehensive coverage insures against theft or physical damage to insured people's own vehicles that occurs for reasons other than crashes. Losses due to noncrash fires are covered under comprehensive coverage.

Exposure is measured in insured vehicle years. An insured vehicle year is one vehicle insured for one year, two vehicles for six months, etc. Insurance data in this report are based on over 88 million years of exposure during calendar years 2004–18. Approximately 39 percent of the insured vehicle years were for vehicles with a turbo engine.

Statistical methods

Regression analysis was used to quantify the effect of the turbo engines while controlling for other covariates. Covariates included garaging state, vehicle density (number of registered vehicles per square mile), rated driver age group, rated driver gender, rated driver marital status, deductible range, and risk. Based on the model year, make, and series, a single variable called SERIESMY was created for inclusion in the regression model. Statistically, including such a variable is equivalent to including the interaction of model year, make, and series. This variable effectively restricted the estimation of the effect of the turbo/supercharged engines within model year, make, and series, preventing the confounding of the turbo/supercharged engine effect with other vehicle design changes that could occur from model year to model year. Vehicle age was also included as a covariate, as noncrash fire frequency tends to increase as vehicles get older and the failure rate of parts increases. Vehicle age is calculated as the difference between the calendar year and model year.

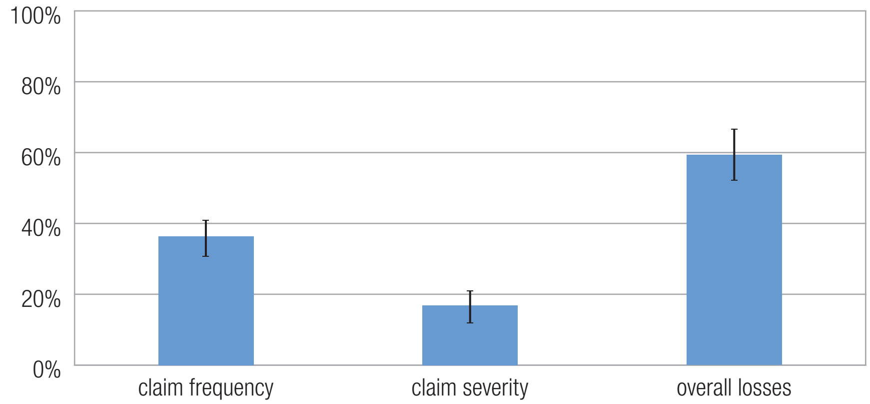
Claim frequency was modeled using a Poisson distribution, whereas claim severity (average loss payment per claim) was modeled using a Gamma distribution. Both models used a logarithmic link function. Estimates for overall losses were derived from the claim frequency and claim severity models.

For space reasons, illustrative full regression results on noncrash fire claim frequency are shown 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 covariate on that loss measure. For example, the estimate of the effect of a turbo/supercharged engine on noncrash fire claim frequency was 0.3102; thus, vehicles with turbo/supercharged engines had 36 percent higher noncrash fire claim frequency than nonturbo vehicles ((exp(0.3102)–1)*100 = 36).

Results

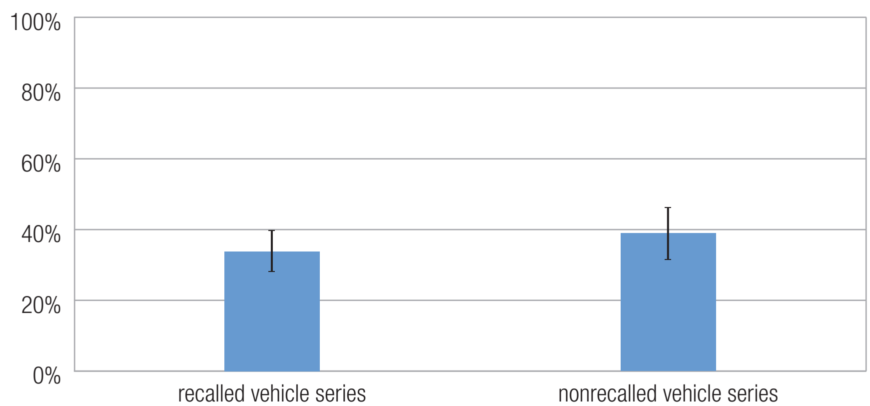
Figure 1 shows the overall estimated difference in noncrash fire insurance losses for vehicles with a turbo engine compared with those without. Here, and in subsequent figures, the vertical I-bars represent the 95 percent confidence limits for the estimates. Noncrash fire claim frequency was a significant 36 percent higher for vehicles with turbo engines. Similarly, the average noncrash fire claim severity was 17 percent higher for turbo engines. This is consistent with prior HLDI research that found that turbo and supercharged engines are associated with higher collision severities (HLDI, 2017a). Consequently, turbo engines were associated with a 59 percent increase to noncrash fire-related overall losses.

Figure 1: Estimated differences in noncrash fire insurance losses for turbocharged and supercharged engines compared with nonturbocharged engines



Some noncrash fires may be caused by manufacturing defects. When these defects are discovered, the vehicle may be recalled. **Figure 2** compares the frequency results for vehicles with and without a noncrash fire recall. The estimated increase in claim frequency associated with turbo engines was higher for vehicles without a noncrash fire recall (39 percent) compared with vehicles with a recall (34 percent). However, these results are within the confidence bounds of each other. Consequently, subsequent analyses include both recalled and nonrecalled vehicle series.

Figure 2: Estimated differences in noncrash fire claim frequency for turbocharged and supercharged engines compared with nonturbocharged engines for recalled and nonrecalled vehicle series



Prior research has shown that the incidence of noncrash fires increases as vehicles age (HLDI, 2017b). **Figure 3** examines the effect of turbo engines by vehicle age. As vehicles get older, the effect of turbo engines increases. For newer vehicles (ages -1 to 1), noncrash fire claim frequencies for turbo engines were 20 percent higher than their nonturbo counterparts. The difference increased to 33 percent for vehicles aged 2 to 4 and 45 percent for vehicles aged 5 to 7. It dropped slightly to 39 percent for vehicles aged 8 to 10 before peaking at 65 percent for vehicles over 10 years old.

Figure 3: Estimated differences in noncrash fire claim frequency for turbocharged and supercharged engines compared with nonturbocharged engines by vehicle age

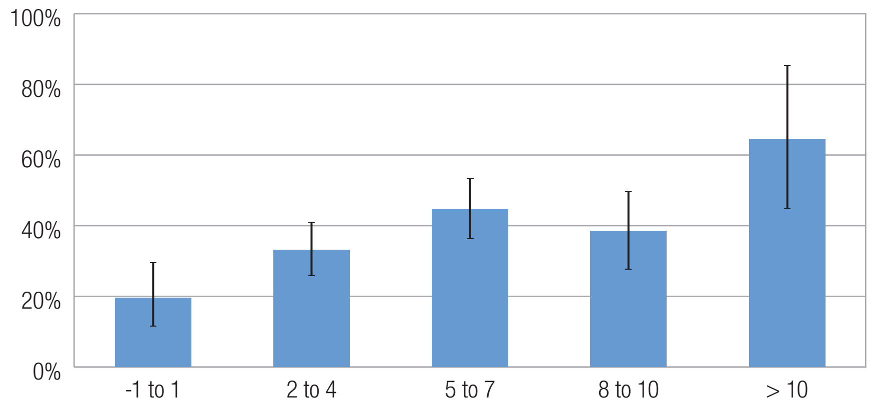


Figure 4 compares the results for passenger cars, SUVs, pickups, and vans. Turbo engines were associated with significantly higher noncrash fire claim frequencies for all vehicle classes, although the effect varies by class. Pickups had the lowest increase in claim frequency at 20 percent. The effect on cars was 46 percent and the effect on SUVs was 52 percent. The largest effect was for vans at nearly 150 percent.

Figure 4: Estimated differences in noncrash fire claim frequency for turbocharged and supercharged engines compared with nonturbocharged engines by vehicle class

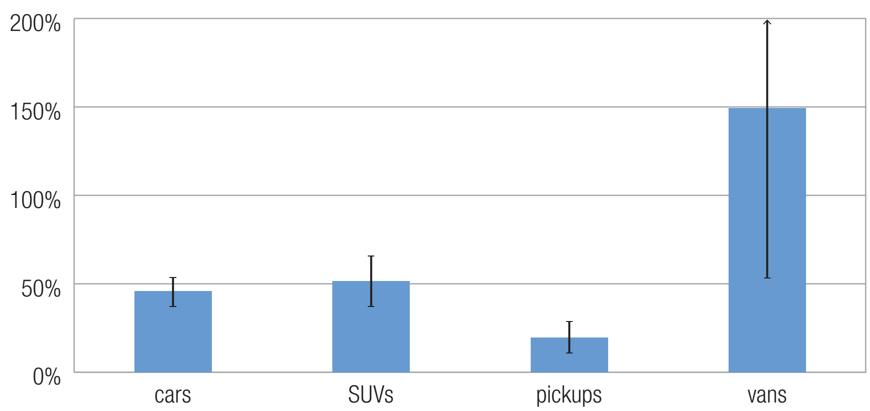
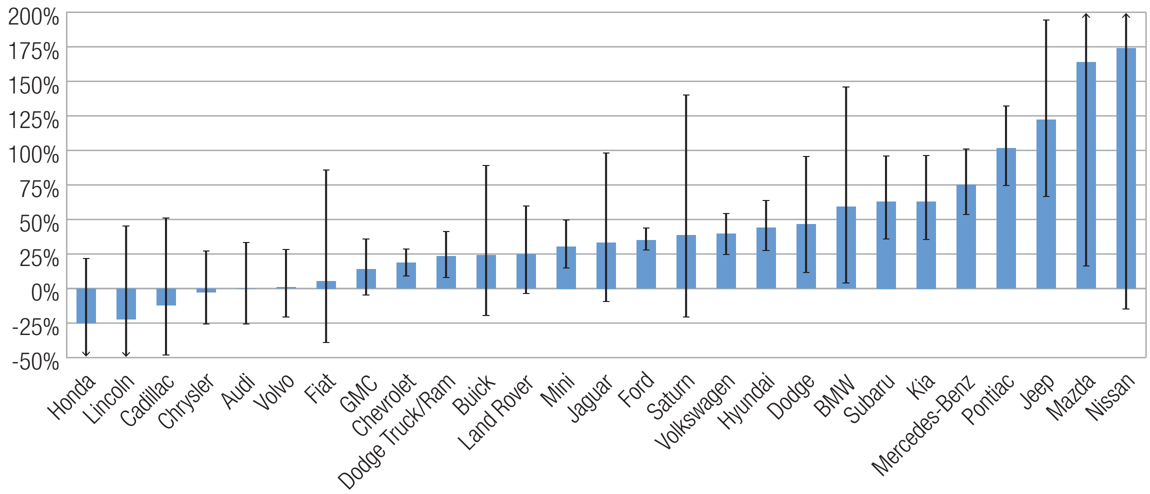


Figure 5 shows the results across manufacturers. When analyzed separately, 14 of the 27 manufacturers are associated with statistically significant increases in noncrash fire claim frequencies for turbo engines. Increases ranged from a 19 percent increase for Chevrolet to a 164 percent increase for Mazda. Results for the remaining 13 manufacturers were not statistically significant. Of those, turbo engines for 8 manufacturers were associated with increases while only five (Honda, Lincoln, Cadillac, Chrysler, and Audi) were associated with decreases in noncrash fire claim frequency. It should be noted that the largest overall increase was for Nissan (174 percent), although this result was not statistically significant, with large confidence bounds.

Figure 5: Estimated differences in noncrash fire claim frequency for turbocharged and supercharged engines compared with nonturbocharged engines by manufacturer



Discussion

Although there is some variation in results by manufacturer and vehicle class, turbo engines are consistently associated with significantly higher noncrash fire claim frequencies compared with nonturbo engines. The effect also appears to increase as vehicles age.

It is unclear exactly why turbocharged engines would be associated with increased noncrash fire risk. Turbo engines add complexity which can increase the potential areas in which a failure can occur. Turbo engines also typically require additional cooling components to manage the different distribution of heat within the engine compartment compared to normally aspirated engines. This results in a tighter engine compartment, with more components occupying the same space compared with a nonturbo engine. Failure of these components can result in a fire. Failure rates typically increase with age, which may explain why the turbo effect increases with vehicle age.

Noncrash fire claim severity was also higher for turbo engines compared with nonturbo engines. Prior HLDI studies have shown increased collision severity for turbo engines (HLDI, 2017a). Although directionally consistent, the magnitude of the severity effect for noncrash fires is far greater than for collision (17 versus 4 percent), so this result was somewhat surprising. It was hypothesized that due to the additional complexity of turbo engines, that they would be more expensive to repair in the event of a crash than a nonturbo engine. Presumably the same would hold true if the engine were damaged by a fire instead of a crash. Noncrash fire claims are also much more likely to be total losses compared with collision claims (HLDI, 2017b). Typically, the turbo variant of a vehicle costs more than the nonturbo variant which may account for some of the severity increase. It is also possible that turbo noncrash fires are more likely to result in a total loss compared with nonturbos. Although the focus of this study was on claim frequency, future research is planned to further investigate the observed severity increase.

Regression analysis was used to quantify the difference between the turbo and nonturbo engines while controlling for other covariates. Most HLDI studies typically control for model year, calendar year, garaging state, vehicle density (number of registered vehicles per square mile), rated driver age group, rated driver gender, rated driver marital status, deductible range, and risk. These covariates are highly correlated with collision claim frequency. However, unlike collision claims, noncrash fire claims do not result from a crash and can occur without a driver in the vehicle. Therefore, it is not expected that all the covariates typically used would be relevant to the noncrash fire claims. In similar studies on noncrash fire losses for different vehicles, HLDI conducted several analyses with and without different covariates, but the inclusion or exclusion of certain covariates did not significantly impact the results.

HLDI will continue to evaluate the effect of these covariates on noncrash fire insurance losses in future studies. For consistency with other studies, the results presented in this bulletin include the usual covariates except for calendar year, as vehicle age was used instead.

References

Highway Loss Data Institute. (2017a). Collision losses for turbo/supercharged engines. *Loss Bulletin*, *34*(12). Arlington, VA.

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Highway Loss Data Institute. (2018a). Noncrash fire insurance losses for Kia and Hyundai midsize four-door cars and SUVs. *Loss Bulletin*, *35*(32). Arlington, VA.

Highway Loss Data Institute. (2018b). Noncrash fire claim frequencies for Kia and Hyundai midsize four-door cars and SUVs by engine type. *Loss Bulletin*, *35*(40). Arlington, VA.

Appendix: Illustrative regression results — noncrash fire claim frequency

Parameter		Degrees of freedom	Estimate	Effect	Standard error	Wald 95% confidence limits		Chi-square	P-value
Intercept		1	-15.2441		0.0778	-15.3966	-15.0915	38358.1	<0.0001
For consideration of space, only a sample of the 646 model year, make, series combinations are listed.									
Model year, make and series	2005 Volkswagen Golf 4dr	1	0.2713	31.2%	0.2460	-0.2109	0.7535	1.22	0.2702
	2005 Volkswagen Jetta 4dr	1	0.2283	25.6%	0.1281	-0.0227	0.4794	3.18	0.0747
	2005 Volkswagen Jetta SW	1	0.0725	7.5%	0.2972	-0.5099	0.6550	0.06	0.8072
	2005 Volkswagen Beetle 2dr	1	0.3098	36.3%	0.1832	-0.0492	0.6688	2.86	0.0908
	…								
	2012 Chevrolet Cruze 4dr	0	0	0	0	0	0		
Vehicle age	-1	1	-0.3108	-26.7%	0.1001	-0.5070	-0.1146	9.64	0.0019
	0	1	-0.1219	-11.5%	0.0328	-0.1862	-0.0577	13.83	0.0002
	2	1	0.0499	5.1%	0.0279	-0.0047	0.1046	3.20	0.0735
	3	1	0.2324	26.2%	0.0282	0.1771	0.2877	67.80	<0.0001
	4	1	0.4205	52.3%	0.0285	0.3646	0.4765	217.07	<0.0001
	5	1	0.5529	73.8%	0.0296	0.4948	0.6110	347.93	<0.0001
	6	1	0.7005	101.5%	0.0311	0.6395	0.7616	505.85	<0.0001
	7	1	0.8013	122.8%	0.0327	0.7372	0.8653	601.74	<0.0001
	8	1	0.8403	131.7%	0.0346	0.7726	0.9081	590.93	<0.0001
	9	1	0.9813	166.8%	0.0348	0.9132	1.0495	797.17	<0.0001
	10	1	1.0817	195.0%	0.0360	1.0111	1.1523	901.97	<0.0001

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Parameter		Degrees of freedom	Estimate	Effect	Standard error	Wald 95% confidence limits		Chi-square	P-value
	11	1	1.0816	194.9%	0.0399	1.0033	1.1598	734.08	<0.0001
	12	1	1.1366	211.6%	0.0460	1.0464	1.2268	610.21	<0.0001
	13	1	1.1251	208.1%	0.0705	0.9869	1.2632	254.80	<0.0001
	1	0	0	0	0	0	0		
Rated driver age	<25	1	0.1414	15.2%	0.0235	0.0954	0.1874	36.31	<0.0001
	>65	1	-0.3631	-30.4%	0.0219	-0.4061	-0.3201	274.19	<0.0001
	Unknown	1	0.0067	0.7%	0.0375	-0.0667	0.0802	0.03	0.8571
	25–65	0	0	0	0	0	0		
Rated driver gender	Male	1	0.0776	8.1%	0.0150	0.0483	0.1070	26.94	<0.0001
	Unknown	1	0.0427	4.4%	0.0479	-0.0512	0.1365	0.79	0.3730
	Female	0	0	0	0	0	0		
Rated driver marital status	Single	1	0.2637	30.2%	0.0153	0.2337	0.2938	296.51	<0.0001
	Unknown	1	-0.0251	-2.5%	0.0461	-0.1154	0.0652	0.30	0.5854
	Married	0	0	0	0	0	0		
Risk	Nonstandard	1	0.2844	32.9%	0.0225	0.2403	0.3285	159.98	<0.0001
	Standard	0	0	0	0	0	0		
State	Alabama	1	0.4035	49.7%	0.0478	0.3098	0.4972	71.23	<0.0001
	Alaska	1	-0.1942	-17.7%	0.0982	-0.3867	-0.0018	3.91	0.0479
	Arizona	1	-0.3780	-31.5%	0.0512	-0.4784	-0.2776	54.48	<0.0001
	Arkansas	1	0.6520	91.9%	0.0548	0.5445	0.7594	141.33	<0.0001
	California	1	0.0315	3.2%	0.0295	-0.0262	0.0892	1.15	0.2845
	Colorado	1	-0.5754	-43.8%	0.0551	-0.6834	-0.4675	109.21	<0.0001
	Connecticut	1	-0.1740	-16.0%	0.0674	-0.3060	-0.0419	6.67	0.0098
	Delaware	1	0.1293	13.8%	0.1059	-0.0782	0.3367	1.49	0.2221
	Dist of Columbia	1	0.1951	21.5%	0.1512	-0.1011	0.4914	1.67	0.1967
	Florida	1	0.0217	2.2%	0.0323	-0.0416	0.0850	0.45	0.5015
	Georgia	1	0.1560	16.9%	0.0400	0.0777	0.2343	15.24	<0.0001
	Hawaii	1	-0.4572	-36.7%	0.1475	-0.7463	-0.1681	9.61	0.0019
	Idaho	1	-0.4898	-38.7%	0.0878	-0.6619	-0.3176	31.10	<0.0001
	Illinois	1	0.0363	3.7%	0.0382	-0.0385	0.1111	0.91	0.3411
	Indiana	1	-0.1171	-11.1%	0.0558	-0.2265	-0.0078	4.41	0.0358
	Iowa	1	-0.2102	-19.0%	0.0652	-0.3379	-0.0825	10.41	0.0013
	Kansas	1	-0.2326	-20.8%	0.0671	-0.3641	-0.1011	12.02	0.0005
	Kentucky	1	0.2306	25.9%	0.0501	0.1324	0.3289	21.18	<0.0001
	Louisiana	1	0.4134	51.2%	0.0440	0.3271	0.4997	88.18	<0.0001
	Maine	1	0.1999	22.1%	0.0823	0.0386	0.3612	5.90	0.0151
	Maryland	1	0.2196	24.6%	0.0451	0.1312	0.3079	23.73	<0.0001
	Massachusetts	1	0.0644	6.7%	0.0525	-0.0385	0.1672	1.51	0.2199
	Michigan	1	0.1134	12.0%	0.0442	0.0266	0.2001	6.57	0.0104
	Minnesota	1	-0.4252	-34.6%	0.0561	-0.5352	-0.3152	57.39	<0.0001
	Mississippi	1	0.5169	67.7%	0.0579	0.4035	0.6303	79.83	<0.0001
	Missouri	1	0.0639	6.6%	0.0454	-0.0251	0.1528	1.98	0.1593
	Montana	1	-0.5785	-43.9%	0.0950	-0.7648	-0.3922	37.04	<0.0001
	Nebraska	1	-0.5880	-44.5%	0.0961	-0.7765	-0.3996	37.41	<0.0001
	Nevada	1	-0.3525	-29.7%	0.0700	-0.4897	-0.2152	25.33	<0.0001

Appendix: Illustrative regression results — noncrash fire claim frequency

Parameter		Degrees of freedom	Estimate	Effect	Standard error	Wald 95% confidence limits		Chi-square	P-value
	New Hampshire	1	-0.0964	-9.2%	0.0924	-0.2775	0.0847	1.09	0.2967
	New Jersey	1	-0.1850	-16.9%	0.0496	-0.2823	-0.0877	13.88	0.0002
	New Mexico	1	-0.4236	-34.5%	0.0718	-0.5643	-0.2830	34.86	<0.0001
	New York	1	-0.0262	-2.6%	0.0358	-0.0964	0.0441	0.53	0.4656
	North Carolina	1	-0.1439	-13.4%	0.0478	-0.2376	-0.0501	9.05	0.0026
	North Dakota	1	-0.3297	-28.1%	0.1165	-0.5580	-0.1015	8.02	0.0046
	Ohio	1	-0.0599	-5.8%	0.0420	-0.1422	0.0223	2.04	0.1531
	Oklahoma	1	0.3207	37.8%	0.0474	0.2278	0.4136	45.81	<0.0001
	Oregon	1	-0.4459	-36.0%	0.0609	-0.5652	-0.3266	53.64	<0.0001
	Pennsylvania	1	-0.0392	-3.8%	0.0377	-0.1132	0.0347	1.08	0.2985
	Rhode Island	1	-0.0501	-4.9%	0.1234	-0.2920	0.1918	0.16	0.6848
	South Carolina	1	0.2491	28.3%	0.0508	0.1496	0.3486	24.07	<0.0001
	South Dakota	1	-0.5541	-42.5%	0.1179	-0.7852	-0.3230	22.08	<0.0001
	Tennessee	1	0.3351	39.8%	0.0433	0.2502	0.4199	59.84	<0.0001
	Utah	1	-0.5732	-43.6%	0.0746	-0.7195	-0.4270	59.05	<0.0001
	Vermont	1	0.0362	3.7%	0.1120	-0.1833	0.2556	0.10	0.7466
	Virginia	1	-0.2102	-19.0%	0.0470	-0.3022	-0.1181	20.03	<0.0001
	Washington	1	-0.3540	-29.8%	0.0501	-0.4523	-0.2557	49.83	<0.0001
	West Virginia	1	0.3101	36.4%	0.0598	0.1930	0.4273	26.94	<0.0001
	Wisconsin	1	-0.5016	-39.4%	0.0611	-0.6214	-0.3818	67.37	<0.0001
	Wyoming	1	-0.7772	-54.0%	0.1140	-1.0006	-0.5538	46.50	<0.0001
	Texas	0	0	0	0	0	0		
Registered vehicle density	<50	1	0.5025	65.3%	0.0234	0.4566	0.5484	459.88	<0.0001
	50–99	1	0.2540	28.9%	0.0238	0.2072	0.3007	113.47	<0.0001
	100–249	1	0.1576	17.1%	0.0214	0.1156	0.1995	54.26	<0.0001
	250–499	1	-0.0042	-0.4%	0.0226	-0.0484	0.0401	0.03	0.8536
	500–999	1	-0.0562	-5.5%	0.0224	-0.1000	-0.0123	6.30	0.0120
	≥1,000	0	0	0	0	0	0		
Deductible range	0	1	-0.0850	-8.1%	0.0289	-0.1416	-0.0283	8.65	0.0033
	1–50	1	-0.2010	-18.2%	0.0451	-0.2894	-0.1126	19.86	<0.0001
	51–100	1	-0.1609	-14.9%	0.0200	-0.2001	-0.1217	64.71	<0.0001
	101–200	1	-0.1547	-14.3%	0.0445	-0.2419	-0.0676	12.11	0.0005
	201–250	1	-0.1249	-11.7%	0.0206	-0.1652	-0.0846	36.92	<0.0001
	501–1,000	1	-0.0086	-0.9%	0.0197	-0.0471	0.0299	0.19	0.6619
	>1,000	1	-0.0234	-2.3%	0.0714	-0.1633	0.1166	0.11	0.7436
	251–500	0	0	0	0	0	0		
Turbo/supercharged engine		1	0.3102	36.4%	0.0163	0.2783	0.3421	363.39	<0.0001

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