

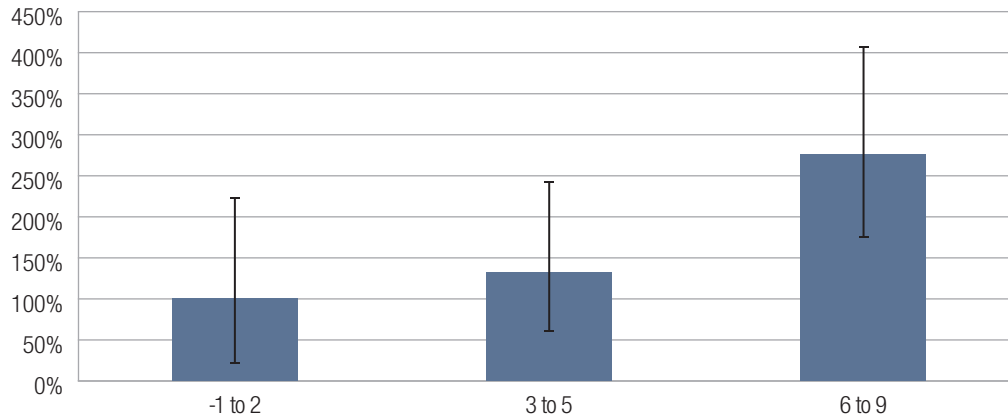


## Noncrash fire insurance losses for the 2008–09 Smart ForTwo

### ► Summary

The 2008–09 Smart ForTwo microcar had a frequency of noncrash fire claims 179 percent higher than other comparable 2008–09 vehicles. Overall losses for these Smart ForTwo vehicles were 209 percent higher than other comparable 2008–09 vehicles. As seen in the figure below, when examining the impact of vehicle age, the frequency of noncrash fire claims for 2008–09 Smart ForTwo vehicles was higher than other comparable 2008–09 vehicles and increased with vehicle age.

**Estimated differences in noncrash fire claim frequency for 2008-09 Smart ForTwo versus 2008-09 control vehicles by vehicle age**



### ► Introduction

Reports of noncrash fires in the Smart ForTwo have been on the rise, the National Highway Traffic Safety Administration (NHTSA) reports. Owners can file vehicle complaints with NHTSA on the agency’s safecar.gov website. A November 12, 2015, complaint filed with NHTSA states that after a 10–15 minute drive, smoke was seen coming out of the rear of the car, and flames were visible once the engine compartment was opened (NHTSA, 2015). NHTSA is currently investigating to evaluate the cause, scope, and frequency of the fires (Edelstein, 2016). This investigation may result in a recall of the Smart ForTwo. This Highway Loss Data Institute (HLDI) report evaluates noncrash fire insurance losses for the 2008–09 Smart ForTwo.

## ► Method

### 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 non-crash fires are covered under comprehensive coverage.

### Insurance measures

Noncrash fire claim frequency is defined as the number of noncrash fire claims divided by comprehensive exposure, expressed as claims per 10,000 insured vehicle years. Typically under comprehensive insurance coverage, claim frequency is expressed as claims per 1,000 insured vehicle years. This distinction is made since noncrash fire claims are filed infrequently. Exposure is the length of time a vehicle is insured under a given coverage type and is measured in insured vehicle years. An insured vehicle year is one vehicle insured for one year, two for six months, etc. Claim severity is the total of all loss payments made for the claims divided by the number of claims paid. Claim severity is measured in dollars paid to settle a claim. It is not a measure of vehicle speed in a crash or injury severity. Overall losses is the product of claim frequency and claim severity, expressed as dollars per insured vehicle year.

### Subject vehicles

**Table 1** shows comprehensive exposure and noncrash fire claims for the Smart ForTwo by model year, starting with its introduction in 2008. The 2008 and 2009 model years comprise 71 percent of the total exposure and 84 percent of the noncrash fire claims. Noncrash fires may or may not persist in later model years, but given how infrequently noncrash fire claims are filed for these vehicles, there are not sufficient data for model years 2010–17 to be reliably analyzed. Thus, this analysis is limited to model years 2008–09.

Model year	Exposure	Claims	Claim frequency
2008	133,888	66	4.9
2009	110,369	39	3.5
2010	12,007	2	1.7
2011	11,759	5	4.3
2012	14,920	1	0.7
2013	35,869	8	2.2
2014	11,265	3	2.7
2015	9,558	1	1.0
2016	3,977	—	—
2017	169	—	—
<b>Total</b>	<b>343,781</b>	<b>125</b>	<b>3.6</b>

A control group was constructed to accurately measure insurance losses relative to the Smart ForTwo (**Table 2**). No other microcars were produced in model years 2008 and 2009; thus, mini two-door and four-door cars and station wagons along with small two-door cars were included. Vehicles with a documented recall due to a defect related to a noncrash fire were excluded from the vehicle population. The studied Smart ForTwo and control vehicles totaled 3,921,705 years of exposure and 717 noncrash fire claims. The 2008–09 Smart vehicles consisted of 244,257 total years of exposure with 105 noncrash fire claims.

**Table 2: Noncrash fire control vehicle population**

Make	Series	Vehicle size	Model years	Exposure	Claims
Chevrolet	Aveo 4dr	Mini	2009	140,227	29
Chevrolet	Aveo station wagon	Mini	2009	128,851	30
Chrysler	PT Cruiser convertible	Small	2008	11,037	2
Ford	Focus 2dr	Small	2008–09	239,696	31
Honda	Civic 2dr	Small	2008–09	796,205	106
Honda	Civic SI 2dr	Small	2008–09	91,865	24
Honda	Fit station wagon	Mini	2009	519,281	32
Hyundai	Accent 2dr	Mini	2008–09	295,877	35
Hyundai	Accent 4dr	Mini	2008–09	298,729	41
Hyundai	Tiburon 2dr	Small	2008	97,094	29
Kia	Rio 4dr	Mini	2008–09	313,188	54
Kia	Rio station wagon	Mini	2008–09	72,220	11
Mini	Cooper convertible	Mini	2008	37,980	10
Pontiac	G3 station wagon	Mini	2009	32,025	7
Saturn	Astra 2dr	Small	2008	29,225	11
Scion	TC 2dr	Small	2008–09	488,685	135
Volkswagen	GTI 2dr	Small	2008–09	85,263	25
<b>Total</b>				<b>3,677,448</b>	<b>612</b>

### Analysis methods

Regression analysis was used to quantify the insurance loss difference between the 2008–09 Smart ForTwo vehicles and other 2008–09 mini and small vehicles while controlling for other covariates. The other covariates included 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.

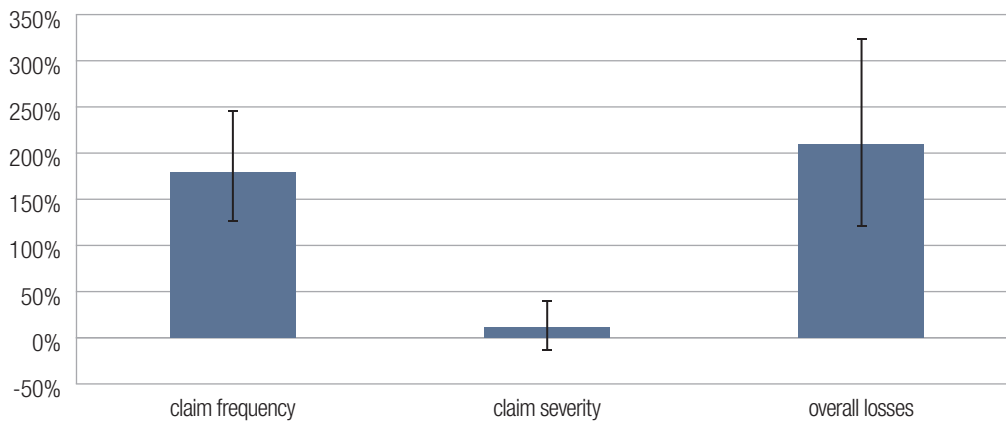
Claim frequency was modeled using a Poisson distribution, and claim severity was modeled using a Gamma distribution. Both models used a logarithmic link function. Estimates for overall losses were derived from the claim frequency and claim severity models. The standard error for overall losses was calculated by taking the square root of the sum of the squared standard errors from the claim frequency and severity estimates. Based on the value of the estimate and the associated standard error, the corresponding two-sided p-value was derived from a standard normal distribution approximation.

Vehicle age was hypothesized to be an important factor in determining the degree of the loss results. Vehicle age can be calculated by subtracting the model year from the calendar year of the claim. Vehicle ages in this analysis were combined into three categories: -1–2, 3–5, and 6–9 years. Model years studied for the Smart ForTwo were 2008–09 in calendar years 2007–17. To investigate the influence of vehicle age, regressions for each age group were run for each of the three loss results for a total of nine regressions. 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 difference between the 2008–09 Smart ForTwo and the 2008–09 control vehicles. For example, the estimate of the regression parameter of the 2008–09 Smart ForTwo indicator on noncrash fire claim frequency was 1.0254; thus, these vehicles had a claim frequency that was 179 percent higher than the 2008–09 control vehicles  $((\exp(1.0254)-1)*100=178.8)$ .

## ► Results

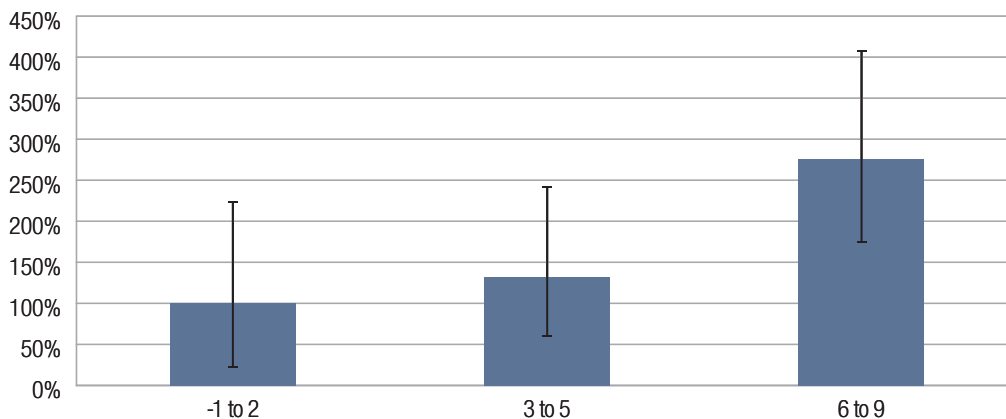
**Figure 1** shows the 2008–09 Smart ForTwo had a noncrash fire claim frequency 179 percent higher and noncrash fire overall losses 209 percent higher than the 2008–09 control vehicles. Both results were statistically significant. Noncrash fire claim severity was 11 percent higher for the 2008–09 Smart ForTwo than for the 2008–09 control vehicles; however, this result was not statistically significant. Here, and in subsequent figures, the vertical I-bars represent the 95 percent confidence limits for the estimates.

**Figure 1: Estimated differences in noncrash insurance losses for 2008–09 Smart ForTwo versus 2008–09 control vehicles**



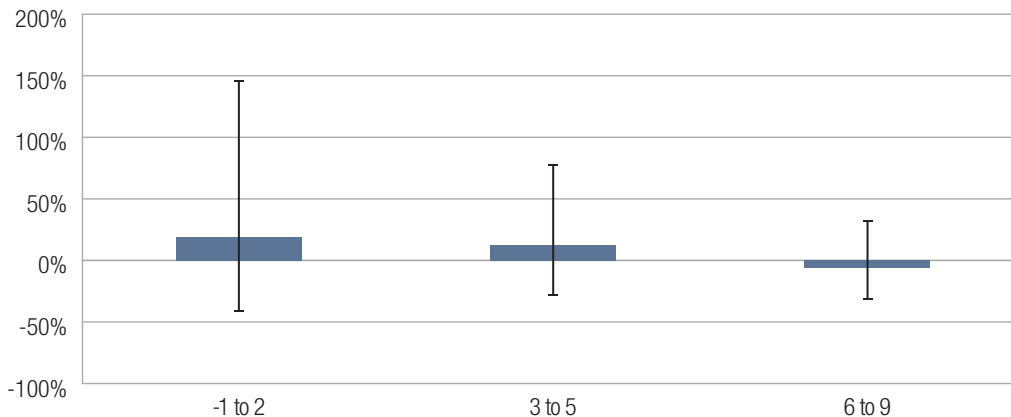
In order to assess the impact of vehicle age on Smart ForTwo noncrash fire losses, the vehicle age measure was grouped into three categories: -1–2, 3–5, and 6–9 ages. **Figure 2** compares the noncrash fire claim frequency for the 2008–09 Smart vehicles relative to the 2008–09 control vehicles by vehicle age. Noncrash fire claim frequency grows with age for the Smart ForTwo. Among vehicles aged 6 to 9, the 2008–09 Smart ForTwo had a claim frequency 275 percent higher than the 2008–09 control vehicles. This result was nearly triple the vehicle age range of -1–2. All results were statistically significant.

**Figure 2: Estimated differences in noncrash fire claim frequency for 2008–09 Smart ForTwo versus 2008–09 control vehicles by vehicle age**



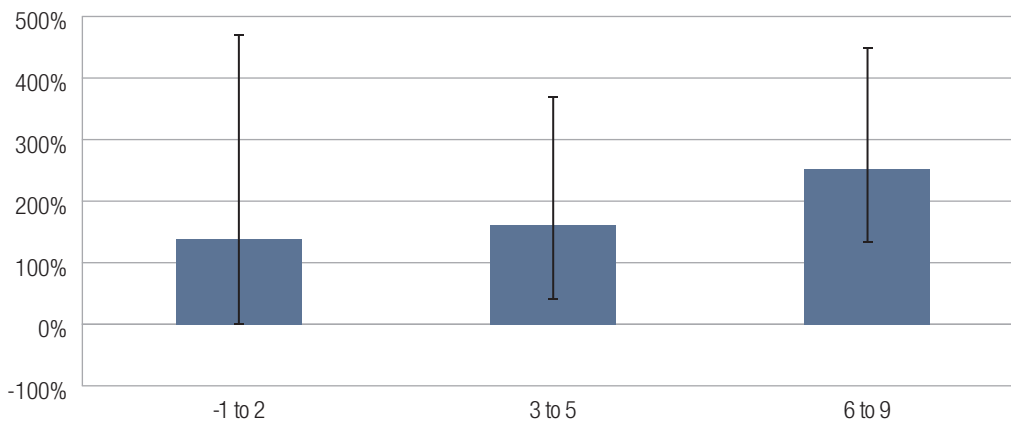
**Figure 3** shows the Smart ForTwo with vehicle ages between -1 and 5 had higher noncrash fire claim severities than the 2008–09 control vehicles, while 6–9-year-old Smart ForTwo vehicles had lower claim severities. None of these results were statistically significant. Noncrash fires typically result in total losses, thus statistically significant differences in claim severity would not be expected unless the estimated total loss value of the Smart ForTwo was significantly different relative to the control vehicles.

**Figure 3: Estimated differences in noncrash fire claim severity for 2008-09 Smart ForTwo versus 2008-09 control vehicles by vehicle age**



Noncrash fire overall losses for the 2008–09 Smart ForTwo in **Figure 4** follow a similar pattern to claim frequencies. The 2008–09 Smart ForTwo with vehicle ages between 6 and 9 years had overall losses 253 percent higher than the 2008–09 control vehicles. This result was about double the overall losses for those of vehicles with ages of -1 to 2. Only the results for the newest vehicles were not statistically significant.

**Figure 4: Estimated differences in noncrash fire overall losses for 2008-09 Smart ForTwo versus 2008-09 control vehicles by vehicle age**



## ► Discussion

Noncrash fire claim frequency and overall losses for the 2008–09 Smart ForTwo were significantly higher than comparable 2008–09 vehicles. When examining the effects by vehicle age, the frequency of claims and overall losses for the 2008–09 Smart ForTwo increased with age. While noncrash fire claim severity decreased with vehicle age, none of the results were statistically significant. Noncrash fires often result in a total loss for a vehicle, thus statistically significant claim severities would not be expected. HLDI did not have sufficient data to examine later model years (2010+) to determine if the high incidence of noncrash fires in the 2008–09 Smart ForTwo persists in later model years. Future HLDI reports could provide a more detailed examination of these model years.

Regression analysis was used to quantify the difference between the 2008-09 Smart ForTwo vehicles and other 2008-09 mini and small vehicles 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. All of these measures have been shown to be highly correlated with collision claim frequency. However, unlike collision claims, non-crash fire claims do not result from a crash and can even occur without a driver in the vehicle. Therefore it is not expected that all the covariates typically used would be relevant to noncrash fire claims. Several analyses were conducted with and without covariates such as the rated driver demographics, but their inclusion or exclusion did not significantly impact results. Therefore, for consistency with other studies, the results presented in this bulletin include all of the above covariates.

## References

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Edelstein, Stephen. 2016. Probe into Smart ForTwo engine fires started by NHTSA. Retrieved from [http://www.greencarreports.com/news/1108003\\_probe-into-smart-fortwo-engine-fires-started-by-nhtsa](http://www.greencarreports.com/news/1108003_probe-into-smart-fortwo-engine-fires-started-by-nhtsa).

## ► Appendix

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	-14.3154		0.1877	-14.6834	-13.9475	5815.85	<0.0001
Model year	2009	1	-0.3401	-28.8%	0.0775	-0.4920	-0.1883	19.28	<0.0001
	2008	0	0	0	0	0	0		
Calendar year	2007	1	-0.4997	-39.3%	0.7157	-1.9025	0.9032	0.49	0.4851
	2008	1	-0.4815	-38.2%	0.2117	-0.8965	-0.0665	5.17	0.0230
	2009	1	-0.6028	-45.3%	0.1686	-0.9333	-0.2722	12.77	0.0004
	2010	1	-0.5973	-45.0%	0.1578	-0.9065	-0.2881	14.33	0.0002
	2011	1	-0.5816	-44.1%	0.1545	-0.8845	-0.2787	14.16	0.0002
	2012	1	-0.4359	-35.3%	0.1483	-0.7265	-0.1452	8.64	0.0033
	2013	1	-0.5665	-43.2%	0.1552	-0.8707	-0.2624	13.33	0.0003
	2014	1	-0.2138	-19.2%	0.1426	-0.4933	0.0658	2.25	0.1340
	2015	1	-0.1836	-16.8%	0.1430	-0.4639	0.0967	1.65	0.1992
	2017	1	0.0620	6.4%	0.2000	-0.3301	0.4540	0.10	0.7568
	2016	0	0	0	0	0	0		
Deductible range	0	1	-0.0443	-4.3%	0.1861	-0.4089	0.3204	0.06	0.8118
	1–50	1	0.2130	23.7%	0.2449	-0.2670	0.6931	0.76	0.3844
	1,001+	1	0.0697	7.2%	0.4510	-0.8142	0.9536	0.02	0.8772
	101–200	1	-0.1743	-16.0%	0.2857	-0.7343	0.3856	0.37	0.5418
	201–250	1	-0.0036	-0.4%	0.1225	-0.2436	0.2365	0.00	0.9768
	501–1,000	1	0.0011	0.1%	0.1208	-0.2357	0.2379	0.00	0.9926
	51–100	1	0.1598	17.3%	0.1141	-0.0638	0.3835	1.96	0.1614
	251–500	0	0	0	0	0	0		

Appendix: Illustrative regression results — noncrash fire claim frequency

Parameter	Degrees of freedom	Estimate	Effect	Standard error	Wald 95% confidence limits		Chi-square	P-value	
Registered vehicle density	<50	1	0.4987	64.7%	0.1519	0.2010	0.7964	10.78	0.0010
	50–99	1	0.2740	31.5%	0.1412	-0.0027	0.5507	3.77	0.0523
	100–249	1	0.0885	9.3%	0.1227	-0.1519	0.3289	0.52	0.4707
	250–499	1	-0.1182	-11.1%	0.1269	-0.3670	0.1306	0.87	0.3519
	500–999	1	-0.1099	-10.4%	0.1199	-0.3450	0.1252	0.84	0.3595
	≥1,000	0	0	0	0	0	0		
State	Alabama	1	-0.0063	-0.6%	0.3581	-0.7081	0.6955	0.00	0.9859
	Alaska	1	0.5326	70.3%	0.5958	-0.6352	1.7003	0.80	0.3714
	Arizona	1	0.0588	6.1%	0.2692	-0.4689	0.5864	0.05	0.8272
	Arkansas	1	0.4068	50.2%	0.3782	-0.3344	1.1479	1.16	0.2821
	California	1	-0.0299	-2.9%	0.1692	-0.3615	0.3017	0.03	0.8597
	Colorado	1	-0.8734	-58.2%	0.4649	-1.7845	0.0377	3.53	0.0603
	Connecticut	1	0.0824	8.6%	0.3402	-0.5843	0.7491	0.06	0.8085
	Delaware	1	0.0732	7.6%	0.5936	-1.0903	1.2367	0.02	0.9018
	Dist of Columbia	1	0.1813	19.9%	0.7205	-1.2308	1.5935	0.06	0.8013
	Florida	1	-0.1729	-15.9%	0.1891	-0.5436	0.1977	0.84	0.3605
	Georgia	1	0.0928	9.7%	0.2466	-0.3905	0.5762	0.14	0.7066
	Hawaii	1	-1.2124	-70.3%	1.0082	-3.1884	0.7636	1.45	0.2291
	Idaho	1	0.2328	26.2%	0.5195	-0.7855	1.2511	0.20	0.6541
	Illinois	1	0.3148	37.0%	0.2026	-0.0823	0.7119	2.41	0.1203
	Indiana	1	-0.4103	-33.7%	0.3766	-1.1485	0.3279	1.19	0.2760
	Iowa	1	0.4661	59.4%	0.3775	-0.2738	1.2060	1.52	0.2169
	Kansas	1	-0.2762	-24.1%	0.4653	-1.1881	0.6358	0.35	0.5528
	Kentucky	1	0.0675	7.0%	0.3271	-0.5736	0.7086	0.04	0.8366
	Louisiana	1	0.5353	70.8%	0.2960	-0.0449	1.1154	3.27	0.0706
	Maine	1	0.1009	10.6%	0.5184	-0.9152	1.1169	0.04	0.8457
	Maryland	1	-0.1464	-13.6%	0.2689	-0.6733	0.3806	0.30	0.5861
	Massachusetts	1	0.3925	48.1%	0.2637	-0.1243	0.9093	2.22	0.1366
	Michigan	1	0.0792	8.2%	0.3054	-0.5193	0.6777	0.07	0.7953
	Minnesota	1	0.0745	7.7%	0.3145	-0.5418	0.6909	0.06	0.8126
	Mississippi	1	0.1844	20.2%	0.5176	-0.8301	1.1990	0.13	0.7216
	Missouri	1	-0.0417	-4.1%	0.3145	-0.6582	0.5748	0.02	0.8945
	Montana	1	0.1322	14.1%	0.7261	-1.2910	1.5555	0.03	0.8555
	Nebraska	1	0.3039	35.5%	0.4644	-0.6063	1.2140	0.43	0.5129
	Nevada	1	-0.3665	-30.7%	0.4323	-1.2137	0.4807	0.72	0.3965
	New Hampshire	1	0.1526	16.5%	0.4690	-0.7667	1.0719	0.11	0.7449
	New Jersey	1	-0.0423	-4.1%	0.2571	-0.5461	0.4616	0.03	0.8694
	New Mexico	1	-0.8937	-59.1%	0.5955	-2.0610	0.2735	2.25	0.1334
New York	1	-0.1564	-14.5%	0.2123	-0.5725	0.2597	0.54	0.4613	
North Carolina	1	-0.1117	-10.6%	0.2596	-0.6204	0.3970	0.19	0.6670	
North Dakota	1	-6.2858	-99.8%	21.9471	-49.3013	36.7297	0.08	0.7746	
Ohio	1	-0.3203	-27.4%	0.2440	-0.7985	0.1580	1.72	0.1894	
Oklahoma	1	0.2240	25.1%	0.3172	-0.3978	0.8457	0.50	0.4802	

Appendix: Illustrative regression results — noncrash fire claim frequency

Parameter	Degrees of freedom	Estimate	Effect	Standard error	Wald 95% confidence limits		Chi-square	P-value
Oregon	1	-0.9392	-60.9%	0.4652	-1.8511	-0.0274	4.08	0.0435
Pennsylvania	1	-0.1260	-11.8%	0.2185	-0.5542	0.3022	0.33	0.5641
Rhode Island	1	-0.1558	-14.4%	0.7186	-1.5642	1.2526	0.05	0.8284
South Carolina	1	0.5275	69.5%	0.2766	-0.0147	1.0696	3.64	0.0566
South Dakota	1	-0.2480	-22.0%	1.0114	-2.2304	1.7343	0.06	0.8063
Tennessee	1	0.1341	14.4%	0.2821	-0.4188	0.6869	0.23	0.6346
Utah	1	-0.7097	-50.8%	0.5908	-1.8676	0.4481	1.44	0.2296
Vermont	1	-0.6878	-49.7%	1.0101	-2.6675	1.2920	0.46	0.4959
Virginia	1	-0.0830	-8.0%	0.2301	-0.5341	0.3680	0.13	0.7183
Washington	1	-0.2159	-19.4%	0.2696	-0.7443	0.3125	0.64	0.4233
West Virginia	1	0.2382	26.9%	0.4025	-0.5507	1.0272	0.35	0.5540
Wisconsin	1	-0.8622	-57.8%	0.4657	-1.7748	0.0505	3.43	0.0641
Wyoming	1	-0.1638	-15.1%	1.0148	-2.1529	1.8252	0.03	0.8718
Texas	0	0	0	0	0	0		
<b>Rated driver age</b>								
<25	1	0.3927	48.1%	0.1066	0.1837	0.6017	13.57	0.0002
>=66	1	-0.1665	-15.3%	0.1308	-0.4227	0.0898	1.62	0.2030
Unknown	1	-0.1817	-16.6%	0.2598	-0.6910	0.3276	0.49	0.4844
25-65	0	0	0	0	0	0		
<b>Rated driver gender</b>								
Male	1	0.1904	21.0%	0.0856	0.0227	0.3582	4.95	0.0261
Unknown	1	0.2057	22.8%	0.2700	-0.3235	0.7348	0.58	0.4462
Female	0	0	0	0	0	0		
<b>Rated driver marital status</b>								
Single	1	0.0975	10.2%	0.0955	-0.0898	0.2847	1.04	0.3077
Unknown	1	-0.1120	-10.6%	0.2687	-0.6385	0.4146	0.17	0.6768
Married	0	0	0	0	0	0		
<b>Risk</b>								
Nonstandard	1	0.2703	31.0%	0.1164	0.0422	0.4985	5.39	0.0202
Standard	0	0	0	0	0	0		
<b>Smart ForTwo indicator</b>								
2008–09 Smart ForTwo	1	1.0254	178.8%	0.1085	0.8127	1.2381	89.29	<0.0001
Other 2008–09 vehicles	0	0	0	0	0	0		



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