



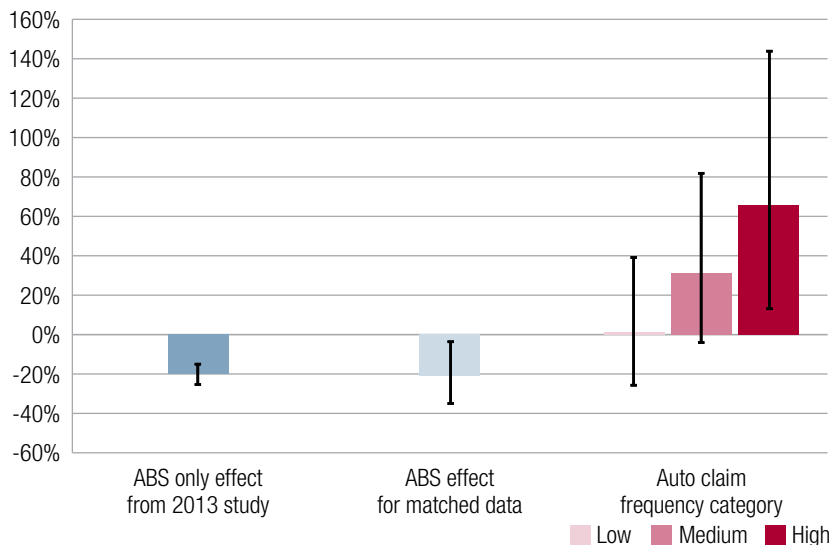
Evaluation of motorcycle antilock braking systems

► Summary

Previous studies have shown that antilock braking systems (ABS) reduce insurance claim rates and fatal crash rates for motorcycles. An unresolved question about the prior research was whether the ABS effect was influenced by self-selection. People who place a greater value on safety may be more likely to purchase an optional safety feature and to ride in a manner that makes them less likely to crash. Previous Highway Loss Data Institute (HLDI) research controlled for rated driver age, gender, marital status, insurance risk profile, and insurance policy deductible. These variables have been shown to be highly correlated with insurance losses, but may not fully control for differences between safety conscious and more risky drivers. The purpose of this study is to evaluate ABS on motorcycles using a motorcycle rider's auto claim frequency as an indicator of the riders' penchant for risk in addition to these other predictive variables. The table below shows the breakdown of motorcycle exposure with and without ABS by auto claim frequency category for motorcycles with optional ABS. Although the amount of the exposure is small, the percentage of exposure with optional ABS increases with auto claim frequency. The figure below shows that after controlling for a rider's auto claim frequency, motorcycles with ABS are associated with a 21 percent reduction in motorcycle collision claim frequency compared with motorcycles without ABS, which is consistent with previous findings.

Distribution of exposure by auto claim frequency category for April 2013 study vehicles			
Auto claim frequency category	Exposure	Percent ABS	Percent no ABS
Zero	33,279	26%	74%
Low	2,590	28%	72%
Medium	1,949	29%	71%
High	1,021	32%	68%

Effect of optional ABS and auto collision claim frequency on motorcycle collision claim frequency, April 2013 study vehicles



► Introduction

According to the National Highway Traffic Safety Administration (NHTSA), motorcycle registrations more than doubled between 1997 and 2010 (NHTSA, 2012). Analysis by the Insurance Institute for Highway Safety of data from the Fatality Analysis Reporting System shows that, during the same time period, fatalities in motorcycle crashes increased by 110 percent. Motorcyclist deaths began to increase in 1998 and continued to increase and peaked in 2008. Motorcyclist deaths decreased by 16 percent in 2009 compared with 2008 and increased only slightly in 2010 and in 2011. It is not known to what extent the overall decrease from 2008 is related to improvements in highway safety or due to the significant drop in new motorcycle sales from more than 1.1 million in 2008 to only 560,000 in 2010 (Motorcycle Industry Council, 2011). Compared with automobiles, motorcycles offer much less occupant protection in the event of a crash. Only 20 percent of automobile crashes result in injury or death, whereas 80 percent of motorcycle crashes do (NHTSA, 2005). Therefore, any countermeasure aimed at reducing the likelihood of motorcycle crashes should significantly reduce the risk of injury or death.

The purpose of this study is to examine the relationship between ABS and insurance losses under collision coverage while controlling for self-selection. People who place a greater value on safety may be more likely to purchase an optional safety feature and to ride in a manner that makes them less likely to crash. If primarily safer riders are the ones purchasing ABS-equipped motorcycles, then it is possible that a portion of the ABS effect observed in prior research was attributable to safer crash risk. This study controls for the safer rider effect by using a motorcycle rider's available auto claim history as a measure of their crash risk. Doing so separates the effect on motorcycle collision claim frequency due to the ABS technology from that attributable to crash risk.

► 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.

Motorcycle and auto loss data

In general, insurance companies who provide HLDI with loss data do not use the same policy ID numbers for a person's auto and motorcycle insurance. Therefore, in order to match motorcycle and auto loss data by rated driver, the following multi-step process was used:

1. Rated rider/driver demographic data was used to create a mapping of a rated motorcycle rider's policy ID with their corresponding auto policy ID. An individual rated rider/driver was identified by their insurance company, gender, marital status, year of birth, date of birth, zip code, and state. Full date of birth data for some companies first became available to HLDI beginning in 2011.
2. In total, 505,864 unique combinations of insurance company, gender, marital status, year of birth, date of birth, zip code and state existed in both auto and motorcycle databases concurrently. Approximately 13 percent of these combinations were associated with multiple auto or multiple motorcycle policy IDs or both and were therefore excluded from the analysis. The remaining 87 percent had a one-to-one mapping of motorcycle and auto policy IDs.
3. Once the mapping of policy IDs was established, the motorcycle and auto loss data associated with the rated rider/driver were linked. Although a rider/driver's full date of birth was initially used to create the policy ID mappings, full date of birth data were only available beginning in 2011. Therefore, after motorcycle and auto policy IDs were mapped, year of birth was used as a substitute to track a rated rider/driver's motorcycle and auto loss data through years preceding 2011.

This procedure resulted in 949,551 years of motorcycle collision exposure and 16,605 motorcycle claims for model years 2003 to 2014, and calendar years 2006 to 2013. This was matched to 1,204,271 years of auto collision exposure and 62,742 auto claims.

The observed auto claim frequency for each rider, based on their total available matched auto history, was calculated as the total number of auto claims divided by the total years insured times 100. For example, a rider with one auto claim over 5 years with auto insurance would have an observed auto claim frequency of $1/5 * 100 = 20$. The total years insured is the number of years the rider/driver had auto insurance. For riders with multiple autos, the years insured was limited to at most one auto over any given time period. The observed auto claim frequencies were then categorized, as shown in [Table 1](#).

Category	Auto Claim Frequency	Description
Zero	0	No auto claims
Low	0 – 20	An average of between 0 and 1 claims per 5 years insured
Medium	20 – 40	An average of between 1 and 2 claims per 5 years insured
High	40 +	An average of more than 2 claims per 5 years insured

Analysis Methods

Regression analysis was used to quantify the effect of ABS and/or auto claim frequency on motorcycle collision claim frequency and severity while controlling for other covariates. Covariates included calendar year, vehicle age, 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. For analysis including only optional ABS vehicles, make and series was included as a covariate. For analysis including vehicles where ABS is standard or not available, motorcycle class and engine displacement were included as covariates.

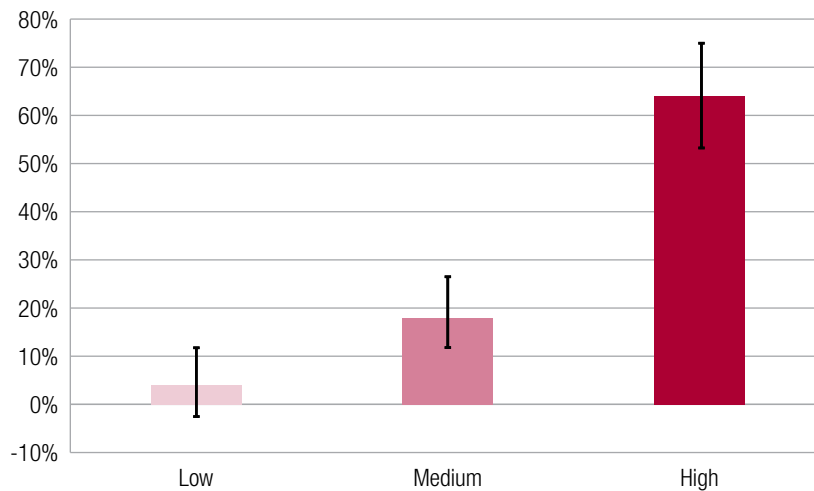
Claim frequency was modeled using a Poisson distribution, whereas claim severity (average loss payment per claim) was modeled using a Gamma distribution. Both models used a logarithmic link function.

For space reasons, full regression results are limited to 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 estimate of the effect for ABS on motorcycle collision claim frequency was (-0.3268); thus, collision claim frequency for motorcycles with optional ABS is expected to be 28 percent lower than for motorcycles without ABS ($(\exp(-0.3268) - 1) * 100 = -28$).

► Results

Before analyzing the effect of ABS, the relationship between auto claim frequency category and motorcycle claim frequency was examined. **Figure 1** shows that riders with higher auto claim frequencies are associated with higher motorcycle claim frequency. The black bars correspond to the 95 percent confidence intervals. Riders categorized with a high auto claim frequency (an average of more than two auto claims per 5 years insured) are associated with a statistically significant 64 percent increase in motorcycle collision claim frequency compared with riders with no history of auto claims. Riders categorized with a medium auto claim frequency were associated with a statistically significant 18 percent increase, while those categorized with a low auto claim frequency were associated with a 4 percent increase.

Figure 1: Motorcycle collision claim frequency by auto claim frequency category relative to rider/drivers with no auto claims



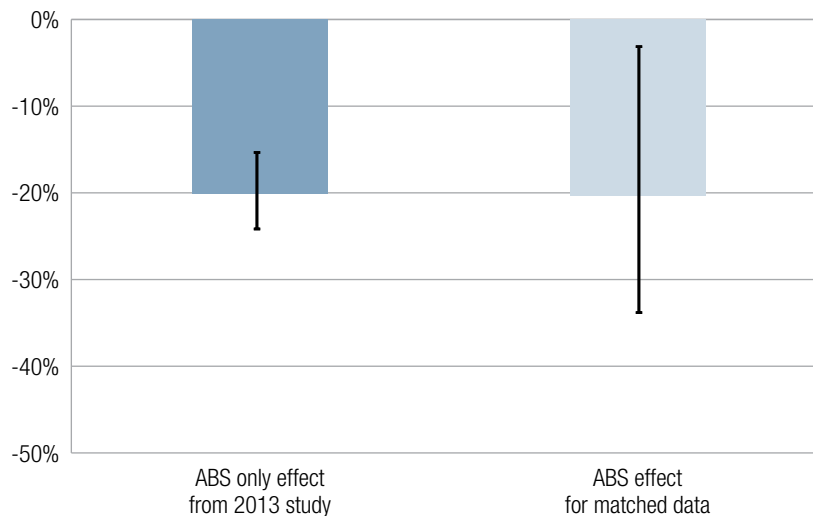
The next step of the analysis was to examine whether auto claim frequencies could explain part of the ABS effect that was observed in prior studies. The most recent HLDI study was in April 2013 (HLDI, 2013). For a motorcycle to be included in that study, their vehicle identification numbers (VINs) had to have an ABS indicator. Only motorcycles with optional ABS and with loss data for both ABS and non-ABS versions were included. It should be noted that some motorcycles in this study population were also equipped with combined control braking systems (CCBS). However, both the ABS and non-ABS motorcycles had CCBS. Since CCBS was present in both the control and study group for those motorcycles the estimated effect was for ABS only.

For comparative purposes, the same study vehicles from the 2013 ABS only study were used in this analysis. The motorcycles from the 2013 ABS/CCBS study were not included. Additionally, only motorcycles with at least one claim for both the ABS version and non-ABS version were included. This resulted in 38,838 years of motorcycle exposure and 622 motorcycle claims, matched with 56,707 years of auto insurance with 2,638 auto claims.

Table 2 shows the exposure for these vehicles after the matching procedure. In order to determine if the previously observed ABS effect is present in this new data set, the same regression model from the April 2013 study was used. Auto claim frequency category was not controlled for in this model so that the only differences between these models are the underlying data sets. **Figure 2** compares the results from the April 2013 study with the results using the matched data. Despite a smaller dataset, motorcycle claim frequency declined by 20 percent, almost identical to the ABS only result from the 2013 study.

Table 2: Distribution of exposure of antilock braking systems for April 2013 study vehicles			
Make/Series	Exposure	Percent ABS	Percent no ABS
Aprilia Scarabeo 500	174	32%	68%
Honda Gold Wing	25,581	23%	77%
Honda Interceptor 800	1,005	29%	71%
Honda Reflex	856	16%	84%
Honda Silver Wing	1,221	20%	80%
Honda ST1300	2,448	31%	69%
Kawasaki Ninja 650	90	36%	64%
Kawasaki Ninja ZX-10R	119	40%	60%
Suzuki Bandit 1250	503	27%	73%
Suzuki Burgman 400	181	42%	58%
Suzuki Burgman 650	1,447	20%	80%
Suzuki V-Strom 650	1,672	30%	70%
Triumph Sprint ST	587	41%	59%
Triumph Thunderbird	477	58%	42%
Triumph Tiger	672	34%	66%
Triumph Tiger 800	310	89%	11%
Yamaha FJR1300	1,496	48%	52%
Total	38,838	26%	74%

Figure 2: Effect of optional ABS on motorcycle collision claim frequency without regard to auto claim frequency, April 2013 study vehicles



Given that the ABS effect is present in the matched data set, the effect of additionally controlling for auto claim frequency was then analyzed. **Table 3** shows the breakdown of motorcycle exposure with and without ABS by auto claim frequency category. Although the amount of the exposure is small, the percentage of exposure with ABS increases with auto claim frequency. 26 percent of the motorcycle exposure with zero auto claim frequency was for motorcycles with ABS compared to 32 percent of the exposure with high auto claim frequency.

Auto claim frequency category	Exposure	Percent ABS	Percent no ABS
Zero	33,279	26%	74%
Low	2,590	28%	72%
Medium	1,949	29%	71%
High	1,021	32%	68%

Figure 3 shows the results when both ABS status and the auto claim frequency categories are added as variables in the regression model. After controlling for auto claim frequency, the reduction in motorcycle collision claim frequency for ABS-equipped motorcycles increases slightly from 20 to 21 percent. The results for auto claim frequency are consistent with **Figure 1**, although the confidence bounds are larger due to the reduced size of the dataset.

Figure 3: Effect of optional ABS and auto collision claim frequency on motorcycle collision claim frequency, April 2013 study vehicles

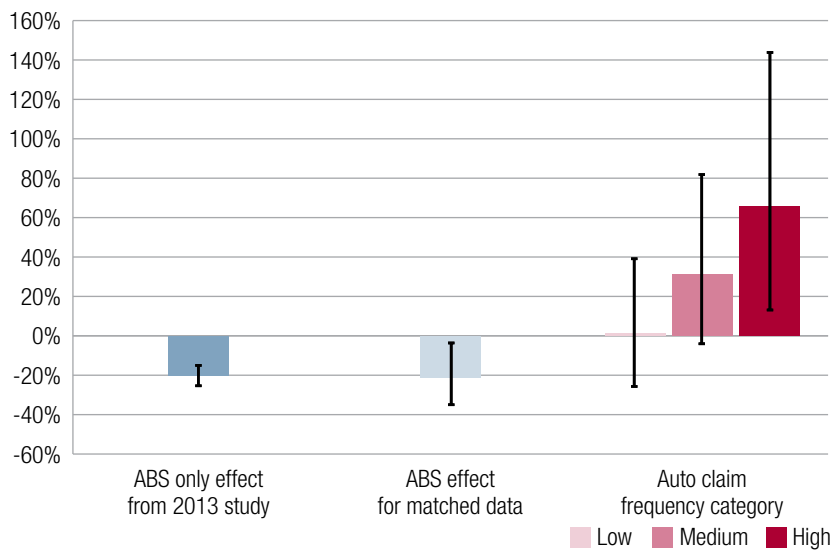


Figure 4 shows that the effects of ABS and auto claim frequency on motorcycle collision severity were not statistically significant. Figure 5 shows that overall losses declined by 17 percent for motorcycles with ABS, although the result was not statistically significant.

Figure 4: Effect of optional ABS and auto collision claim frequency on motorcycle collision severity, April 2013 study vehicles

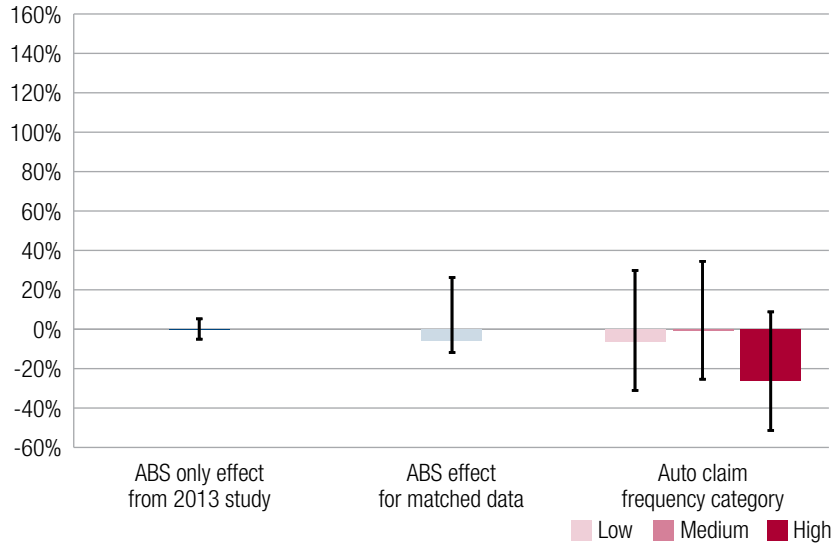
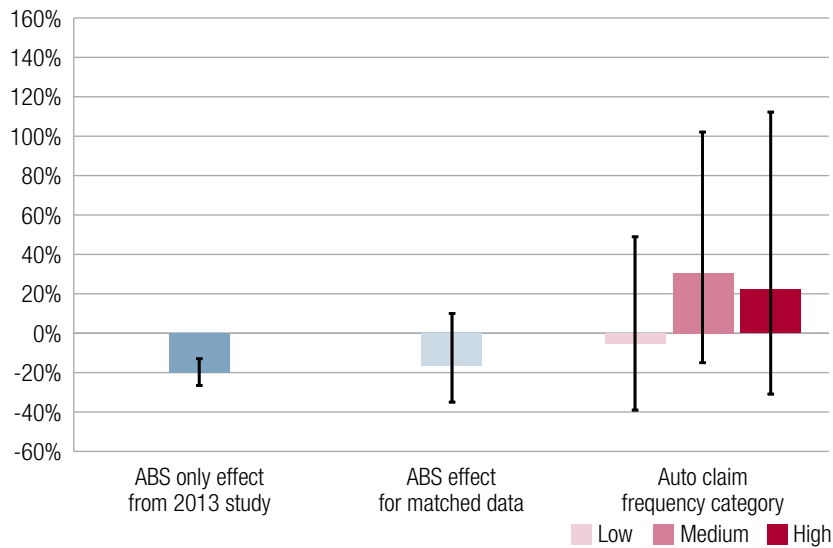


Figure 5: Effect of optional ABS and auto collision claim frequency on motorcycle collision overall losses, April 2013 study vehicles



The above analysis includes only the motorcycle series used in the April 2013 HLDI ABS study. Although these new results are consistent with the prior study, the amount of data available for these motorcycles after the rider/driver matching is limited. In order to further explore the effect of self-selection a supplemental analysis using a larger population of motorcycles was conducted. Both optional ABS motorcycles as well as those with ABS as standard or not available were analyzed. For some motorcycles ABS is available for purchase but the presence of ABS is not included in the VIN. These motorcycles were excluded.

The addition of motorcycles with standard and not available ABS resulted in 842,487 years of motorcycle exposure and 14,311 motorcycle claims matched with 1,093,225 years of auto exposure and 57,193 auto claims. This was an increase of over 21 times the motorcycle exposure of the optional ABS analysis. Since some make/series are only available with ABS standard, or do not have ABS available at all, make/series was removed as a covariate in the regression model due to confounding. Instead, the motorcycle class and engine displacement were used to control for the differences in motorcycle types.

While only motorcycles with known ABS status are included in this analysis, the CCBS status is not always known. For the April 2013 ABS/CCBS study, an extensive review of publically available documentation was conducted on all motorcycles included in the analysis. However, information about the presence of CCBS for some motorcycles is not always available from public sources. This analysis includes over 630 different motorcycle series over 12 model years. As a result, the effect of ABS in this study may be confounded with CCBS since some of the study motorcycles have ABS only while others may have both ABS and CCBS. The purpose of the following analysis is to examine the effect of motorcycles with ABS or ABS/CCBS compared to motorcycles without ABS. The effect of “ABS and ABS/CCBS” is analyzed with and without controlling for auto claim frequency. It should be noted that some of the motorcycles without ABS may have CCBS. However, this analysis assumes that CCBS in non-ABS motorcycles is a small part of the overall exposure.

As with the earlier analysis, the effect of ABS and ABS/CCBS was first examined without controlling for auto claim frequency. **Figure 6** shows that the effect of ABS and ABS/CCBS, without controlling for auto claim frequency, was a statistically significant 28 percent. For comparative purposes the 2013 study results for ABS only and ABS/CCBS are shown. The observed effect of 28 percent for ABS and ABS/CCBS falls between the 2013 studies results of 20 percent for ABS only and 31 percent for ABS/CCBS.

Figure 6: Effect of ABS and ABS/CCBS on motorcycle collision claim frequency, no auto claim frequency

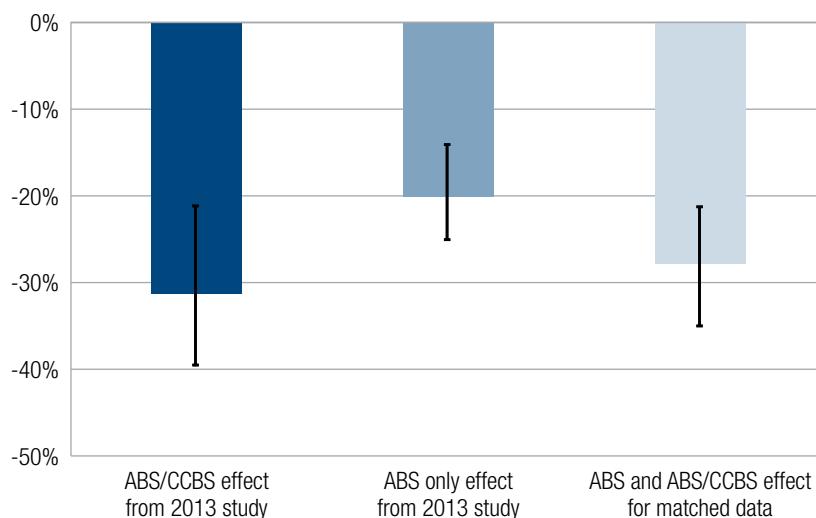
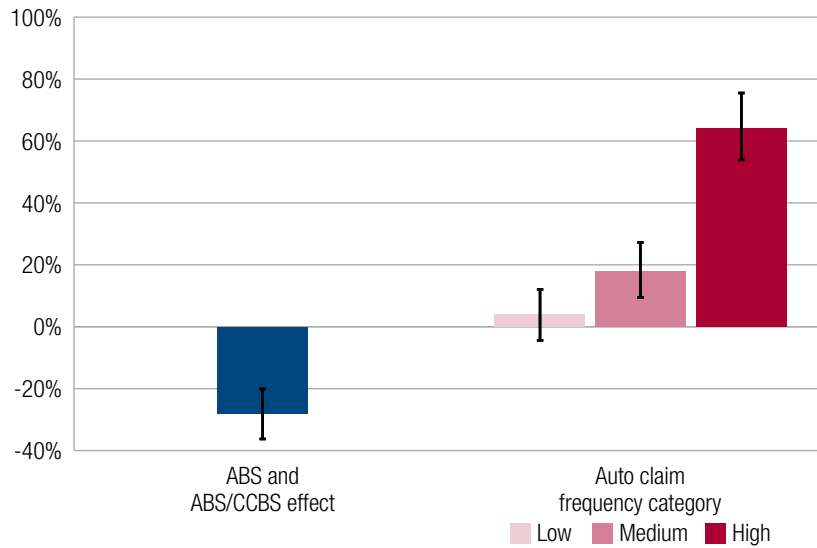


Figure 7 shows that after controlling for auto claim frequency, the effect of ABS and ABS/CCBS was also a statistically significant 28 percent. This affirms the results of the optional ABS analysis that additionally controlling for auto claim frequency does not substantively affect the observed ABS effect.

Figure 7: Effect of ABS and ABS/CCBS and auto collision claim frequency on motorcycle collision claim frequency



The effects of ABS and ABS/CCBS by auto claim frequency on motorcycle collision severity were not statistically significant, as shown in Figure 8. Figure 9 shows that overall losses for motorcycles with ABS and ABS/CCBS declined by a statistically significant 25 percent while controlling for auto claim frequency.

Figure 8: Effect of ABS and ABS/CCBS and auto collision claim frequency on motorcycle collision severity

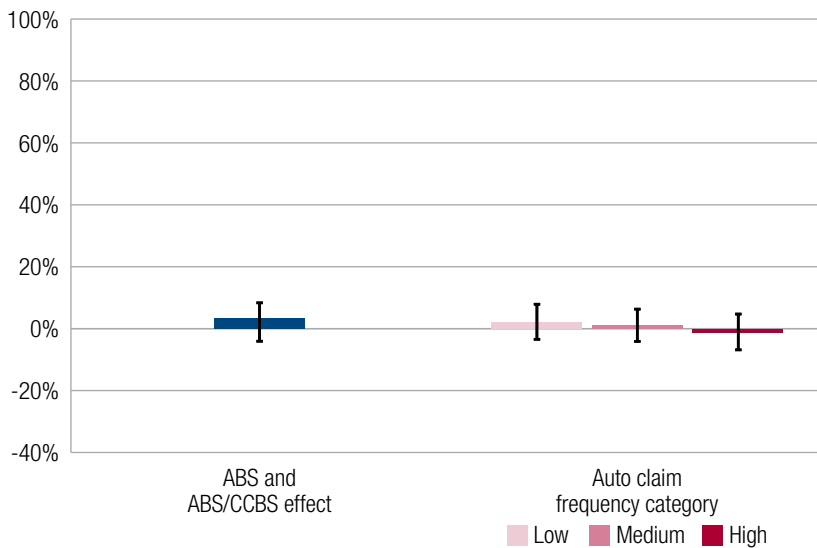


Figure 9: Effect of ABS and ABS/CCBS and auto collision claim frequency on motorcycle collision overall losses

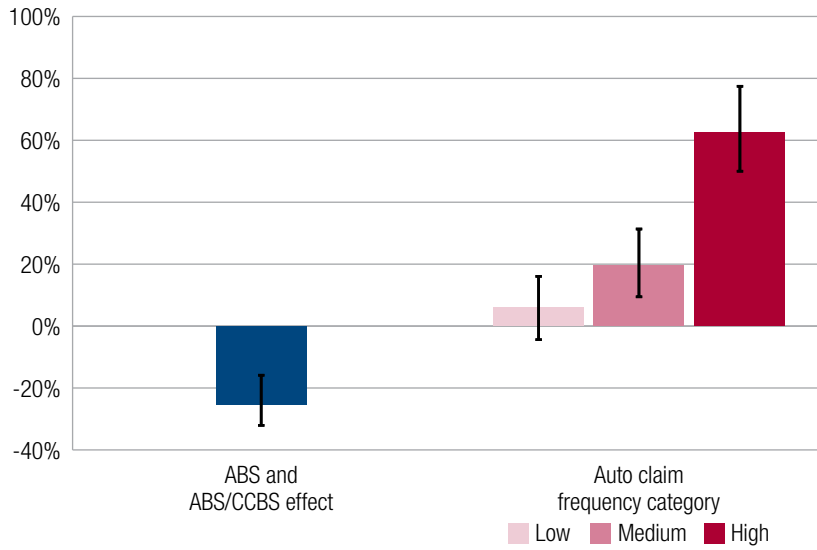
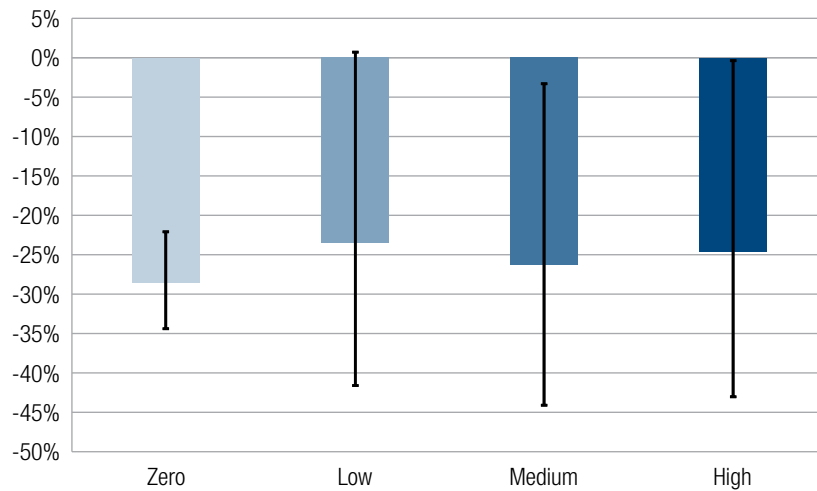


Figure 10 shows the effect of ABS and ABS/CCBS by auto claim frequency category. The effect by auto claim frequency category is fairly consistent. Motorcycles with ABS and ABS/CCBS are associated with a 29 percent reduction in motorcycle claim frequency compared with motorcycles without ABS for riders with no history of auto claims. ABS and ABS/CCBS for riders categorized with a low auto claim frequency was associated with a 24 percent reduction. ABS and ABS/CCBS for riders categorized with medium or high auto claim frequencies was associated with 26 and 25 percent reductions, respectively. The differences between the effects of ABS and ABS/CCBS by rider auto claim frequency was not statistically significant.

Figure 10: Effect of ABS and ABS/CCBS by auto claim frequency category



► Discussion

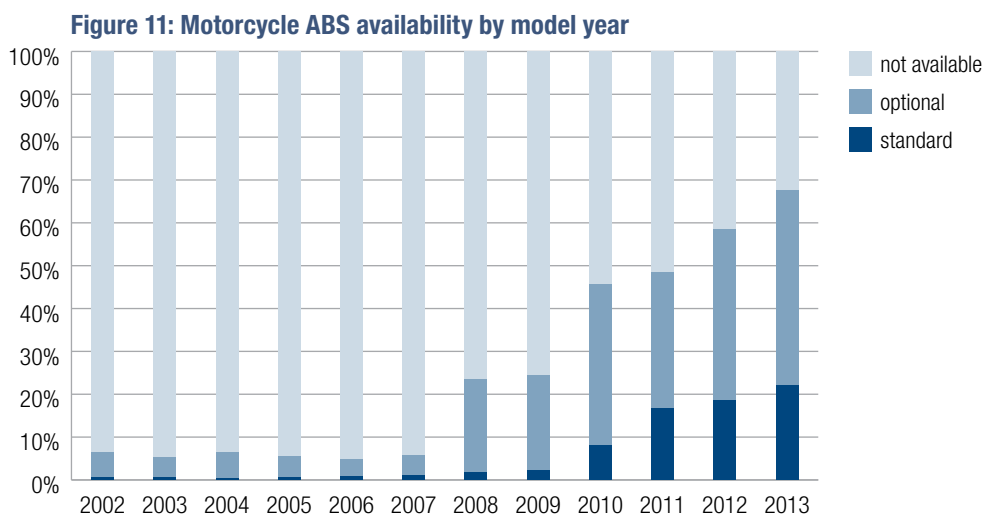
Prior HLDI studies have shown that ABS on motorcycles is effective in reducing collision losses. This study confirms those results while further addressing the issue of self-selection. A rider's auto claim frequency was used as a measure of their crash risk. Regression analysis showed that riders with higher auto claim frequencies were associated with higher motorcycle collision claim frequencies.

Before controlling for a rider's auto claim frequency, motorcycles with optional ABS were associated with a statistically significant 20 percent reduction in motorcycle collision claim frequency. After controlling for auto claim frequency, the reduction in motorcycle collision claim frequency for ABS equipped motorcycles increased slightly from 20 percent to 21 percent. Controlling for a rider's auto claim frequency did not substantively inform the observed ABS effect.

Supplemental analysis on a larger motorcycle population confirmed these results. The estimated ABS and ABS/CCBS effect with and without a control for auto claim frequency was 28 percent. As expected, this falls between the earlier estimate for ABS only (20 percent) and ABS/CCBS (31 percent) (HLDI, 2013). As before, controlling for a rider's auto claim frequency did not impact the observed effect. This benefit also did not vary significantly depending on the auto claim frequency category of the rider. These results indicate that all riders may benefit from ABS technology on their motorcycles.

Although previous studies have shown the benefit of antilock brakes for motorcycles, ABS is not currently required in the United States. Beginning in 2016 in the European Union, it will be mandatory for motorcycles that have an engine displacement greater than 125 cc to be fit with ABS. Manufacturers have taken the initiative to increase the availability of ABS on new motorcycles in the United States over the past few years.

Figure 11 shows the increase in ABS availability by model year. For this figure, the motorcycle series are weighted using HLDI's database of almost 5 million unique motorcycle VINs. This is not the HLDI loss database but rather an accumulation of every VIN in the HLDI loss database and VINs that HLDI has been asked to decode. More than 90 percent of 2002 model year bikes did not have ABS available. This is in stark contrast to the 2013 model year, in which more than two-thirds of new bikes either have standard (22 percent) or optional (46 percent) ABS.



► Limitations

There are limitations on the data used in this analysis. Using auto claim frequency as a covariate in the regression required matching data from two separate databases using demographic data. Although there is no way to be absolutely certain that a matched rider/driver is the same person, using the full date of birth, zip code, gender and marital status limits the likelihood of erroneous matches. It is also possible that a particular person would have their auto and motorcycle policy with different companies. These individuals would be excluded from the analysis. In addition, motorcycle riders who do not have an auto policy would also be excluded from this analysis. It is unknown whether there are significant differences between riders who also have an auto policy and those with just a motorcycle.

References

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Appendix: Illustrative regression results - collision claim frequency for motorcycles with and without ABS or ABS/CCBS

Parameter		Degrees of freedom	Estimate	Effect	Standard Error	Wald 95% Confidence Limits		Chi-Square	P-value
Intercept		1	-9.2916		0.4588	-10.1908	-8.3925	410.22	<0.0001
Calendar Year	2006	1	-0.3742	-31.2%	0.0961	-0.5626	-0.1857	15.15	<0.0001
	2007	1	-0.4147	-33.9%	0.0571	-0.5266	-0.3029	52.83	<0.0001
	2008	1	-0.4572	-36.7%	0.0428	-0.5412	-0.3732	113.87	<0.0001
	2009	1	-0.5816	-44.1%	0.0389	-0.6578	-0.5053	223.49	<0.0001
	2010	1	-0.5634	-43.1%	0.0332	-0.6285	-0.4982	287.54	<0.0001
	2011	1	-0.3190	-27.3%	0.0249	-0.3679	-0.2701	163.45	<0.0001
	2012	1	-0.2549	-22.5%	0.0230	-0.3001	-0.2098	122.37	<0.0001
	2013	0	0	0	0	0	0		
Vehicle age		1	-0.1087	-10.3%	0.0038	-0.1161	-0.1013	825.01	<0.0001
Rated driver age	14–24	1	0.9486	158.2%	0.0545	0.8417	1.0554	302.84	<0.0001
	25–39	1	0.3173	37.3%	0.0383	0.2422	0.3923	68.65	<0.0001
	40–64	1	0.0105	1.1%	0.0347	-0.0575	0.0784	0.09	0.7629
	65+	0	0	0	0	0	0		
Gender	Female	1	-0.1211	-11.4%	0.0266	-0.1732	-0.0691	20.79	<0.0001
	Male	0	0	0	0	0	0		
Marital status	Married	1	-0.1211	-11.4%	0.0978	-0.3128	0.0706	1.53	0.2158
	Single	1	0.0231	2.3%	0.0988	-0.1706	0.2168	0.05	0.8152
	Unknown	0	0	0	0	0	0		
State	Alabama	1	0.3570	42.9%	0.1816	0.0011	0.7130	3.86	0.0493
	Arizona	1	0.4653	59.2%	0.1771	0.1182	0.8125	6.90	0.0086
	Arkansas	1	0.2089	23.2%	0.1995	-0.1820	0.5999	1.10	0.2949
	California	1	0.4862	62.6%	0.1724	0.1484	0.8240	7.96	0.0048
	Colorado	1	0.2029	22.5%	0.1782	-0.1463	0.5521	1.30	0.2548
	Connecticut	1	0.2198	24.6%	0.1846	-0.1420	0.5817	1.42	0.2337
	Delaware	1	0.8593	136.2%	0.3354	0.2018	1.5167	6.56	0.0104
	Dist of Columbia	1	0.6508	91.7%	0.2285	0.2031	1.0986	8.12	0.0044
	Florida	1	0.1984	21.9%	0.1726	-0.1398	0.5366	1.32	0.2502
	Georgia	1	0.3296	39.0%	0.1762	-0.0157	0.6748	3.50	0.0614
	Hawaii	1	0.2810	32.4%	0.2000	-0.1111	0.6730	1.97	0.1601
	Idaho	1	0.1199	12.7%	0.2018	-0.2757	0.5155	0.35	0.5525
	Illinois	1	0.0813	8.5%	0.1768	-0.2653	0.4279	0.21	0.6457
	Indiana	1	0.2783	32.1%	0.1842	-0.0829	0.6394	2.28	0.1310
	Iowa	1	-0.0066	-0.7%	0.1868	-0.3727	0.3594	0.00	0.9717
	Kansas	1	0.1217	12.9%	0.1895	-0.2498	0.4931	0.41	0.5209
	Kentucky	1	0.3797	46.2%	0.1978	-0.0080	0.7674	3.68	0.0549
	Louisiana	1	0.4134	51.2%	0.1817	0.0573	0.7695	5.18	0.0229
	Maine	1	0.3473	41.5%	0.2226	-0.0890	0.7836	2.43	0.1187
	Maryland	1	0.3205	37.8%	0.1769	-0.0262	0.6673	3.28	0.0700
	Michigan	1	0.3058	35.8%	0.1845	-0.0558	0.6674	2.75	0.0974
	Minnesota	1	0.0431	4.4%	0.1875	-0.3243	0.4105	0.05	0.8181
	Mississippi	1	0.2709	31.1%	0.2041	-0.1292	0.6710	1.76	0.1845
	Missouri	1	0.2400	27.1%	0.1890	-0.1304	0.6105	1.61	0.2040
	Montana	1	-0.1582	-14.6%	0.3089	-0.7637	0.4472	0.26	0.6085

Appendix: Illustrative regression results - collision claim frequency for motorcycles with and without ABS or ABS/CCBS

Parameter	Degrees of freedom	Estimate	Effect	Standard Error	Wald	95% Confidence Limits	Chi-Square	P-value
	Nebraska	1	0.0666	6.9%	0.1946	-0.3147 0.4479	0.12	0.7322
	Nevada	1	0.6364	89.0%	0.1901	0.2639 1.0090	11.21	0.0008
	New Hampshire	1	0.2025	22.4%	0.2255	-0.2395 0.6446	0.81	0.3691
	New Jersey	1	0.1643	17.9%	0.1879	-0.2039 0.5325	0.76	0.3818
	New Mexico	1	0.2884	33.4%	0.1846	-0.0735 0.6502	2.44	0.1183
	New York	1	0.3641	43.9%	0.1733	0.0243 0.7038	4.41	0.0357
	North Carolina	1	0.2203	24.6%	0.1785	-0.1295 0.5701	1.52	0.2171
	North Dakota	1	0.1481	16.0%	0.3090	-0.4575 0.7536	0.23	0.6318
	Ohio	1	0.0211	2.1%	0.1763	-0.3245 0.3667	0.01	0.9046
	Oklahoma	1	0.2389	27.0%	0.1851	-0.1238 0.6016	1.67	0.1968
	Oregon	1	0.3714	45.0%	0.1877	0.0035 0.7394	3.92	0.0478
	Pennsylvania	1	0.2132	23.8%	0.1760	-0.1318 0.5582	1.47	0.2258
	Rhode Island	1	0.1529	16.5%	0.2267	-0.2914 0.5973	0.46	0.4999
	South Carolina	1	0.2064	22.9%	0.1838	-0.1538 0.5667	1.26	0.2614
	South Dakota	1	0.0033	0.3%	0.2620	-0.5102 0.5169	0.00	0.9898
	Tennessee	1	0.3529	42.3%	0.1738	0.0122 0.6935	4.12	0.0423
	Texas	1	0.3324	39.4%	0.1729	-0.0064 0.6713	3.70	0.0545
	Utah	1	-0.0321	-3.2%	0.1852	-0.3951 0.3309	0.03	0.8623
	Vermont	1	-0.0052	-0.5%	0.2690	-0.5324 0.5220	0.00	0.9845
	Virginia	1	0.2582	29.5%	0.1750	-0.0847 0.6012	2.18	0.1400
	Washington	1	0.3058	35.8%	0.1786	-0.0443 0.6558	2.93	0.0869
	West Virginia	1	-0.0597	-5.8%	0.2119	-0.4749 0.3556	0.08	0.7781
	Wisconsin	1	0.0623	6.4%	0.1917	-0.3135 0.4380	0.11	0.7453
	Wyoming	1	0.2364	26.7%	0.2433	-0.2404 0.7132	0.94	0.3313
	Alaska	0	0	0	0	0		
Density	< 50	1	-0.4348	-35.3%	0.0380	-0.5092 -0.3603	130.95	<0.0001
	50–99	1	-0.3254	-27.8%	0.0322	-0.3884 -0.2624	102.39	<0.0001
	100–249	1	-0.2349	-20.9%	0.0277	-0.2892 -0.1806	71.87	<0.0001
	250–499	1	-0.2269	-20.3%	0.0274	-0.2806 -0.1732	68.59	<0.0001
	599–999	1	-0.1463	-13.6%	0.0277	-0.2006 -0.0920	27.86	<0.0001
	> 999	0	0	0	0	0		
Risk	Nonstandard	1	0.0509	5.2%	0.0202	0.0112 0.0905	6.32	0.0119
	Standard	0	0	0	0	0		
Deductible range	0	1	-0.2403	-21.4%	0.4516	-1.1254 0.6447	0.28	0.5946
	1–50	1	0.6109	84.2%	0.4142	-0.2009 1.4228	2.18	0.1402
	51–100	1	-0.2555	-22.5%	0.4096	-1.0583 0.5472	0.39	0.5327
	101–200	1	-0.1534	-14.2%	0.4106	-0.9581 0.6513	0.14	0.7087
	201–250	1	-0.0151	-1.5%	0.4090	-0.8167 0.7865	0.00	0.9706
	251–500	1	-0.1875	-17.1%	0.4087	-0.9884 0.6135	0.21	0.6464
	501–1000	1	-0.5987	-45.0%	0.4102	-1.4028 0.2053	2.13	0.1444
	> 1000	0	0	0	0	0		
Motorcycle class	Chopper	1	-0.8309	-56.4%	0.1007	-1.0283 -0.6335	68.07	<0.0001
	Cruiser	1	-0.5776	-43.9%	0.0505	-0.6765 -0.4786	130.85	<0.0001
	Dual Purpose	1	-1.0269	-64.2%	0.0777	-1.1792 -0.8747	174.73	<0.0001

Appendix: Illustrative regression results - collision claim frequency for motorcycles with and without ABS or ABS/CCBS

Parameter	Degrees of freedom	Estimate	Effect	Standard Error	Wald 95% Confidence Limits	Chi-Square	P-value
Scooter	1	-0.2698	-23.6%	0.0674	-0.4018 -0.1377	16.03	<0.0001
Sport	1	0.2885	33.4%	0.0584	0.1740 0.4030	24.39	<0.0001
Sport Touring	1	-0.1931	-17.6%	0.0759	-0.3419 -0.0442	6.46	0.0110
Standard	1	-0.2881	-25.0%	0.0841	-0.4529 -0.1233	11.74	0.0006
Super Sport	1	0.5819	78.9%	0.0535	0.4771 0.6868	118.31	<0.0001
Touring	1	-0.4736	-37.7%	0.0553	-0.5820 -0.3651	73.27	<0.0001
Unclad Sport	0	0	0	0	0	0	
Engine displacement	1	0.0004	0.0%	0.0000	0.0004 0.0005	235.58	<0.0001
Auto claim frequency category							
Low	1	0.0358	3.6%	0.0377	-0.0381 0.1098	0.90	0.3422
Medium	1	0.1661	18.1%	0.0349	0.0976 0.2345	22.63	<0.0001
High	1	0.4975	64.5%	0.0358	0.4272 0.5677	192.65	<0.0001
Zero	0	0	0	0	0	0	
ABS and ABS/CCBS							
Equipped	1	-0.3268	-27.9%	0.0421	-0.4092 -0.2444	60.38	<0.0001
Not Equipped	0	0	0	0	0	0	

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