

Highway Loss Data Institute Bulletin

Motorcycle Antilock Braking System (ABS)

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Antilock braking systems (ABS) on motorcycles are designed to allow riders to make urgent, yet controlled stops. Motorcycles are fundamentally unbalanced; they are kept stable at very low speeds by a rider holding the handlebar and maintaining balance. At higher speeds, stability comes almost exclusively from the gyroscopic effect of the wheels. While at speed, if one of the wheels stops rotating for a fraction of a second, the result is immediate instability. The effect is more pronounced if it happens to the front wheel, where a fall is almost inevitable — especially while cornering or leaning the motorcycle. ABS has independent braking sensors for each wheel. If the system detects a locked wheel, it releases the brake to allow that tire to retain grip before reapplying the brake. ABS then modulates braking pressure to achieve optimum braking.

This Highway Loss Data Institute (HLDI) bulletin compared the collision losses of 12 motorcycle models available with optional ABS. Model years of the motorcycles studied ranged from 2003 to 2007. Significant reductions in collision claim frequencies and overall losses were found for motorcycles equipped with ABS. No significant reductions were found for claim severity.

For motorcycles to be included in the study, their vehicle identification numbers (VINs) had to have an ABS indicator. This allowed for very tight control over the study population. Twelve motorcycles met this criterion. It should be noted that there were motorcycles available with ABS that were not included in the study because their VINs did not have an ABS indicator. Data were collected by make and series, rated driver age and gender, and vehicle age and density. Vehicle age was defined as the difference between calendar year and model year measured in years. Previous HLDI studies have shown that all of these factors have a significant impact on insurance losses. For insurance purposes, a rated driver is assigned to each vehicle on a policy. Information on the actual driver at the time of a loss is not available in the HLDI database. For the present study data were stratified by rated driver age group (<25, 25-39, 40-64, 65+, or unknown) and gender (male, female, or unknown). The dataset also was stratified by make/series and vehicle density (<100, 100-499, and 500+ vehicles per square mile). For example, a 1-year-old Honda Gold Wing, ABS equipped, with a 40-64 year old male as the rated driver, and garaged in an area with a vehicle density of 100-499 vehicles per square mile constituted one unit of observation. The distribution of motorcycle collision exposure for the six independent variables is listed in Appendix A. It is important to note that rated driver factors and vehicle density were included to control for their potential impact on losses and not to produce estimates for

those variables. The estimated parameters for those variables may not generalize from this subset to the much larger motorcycle population.

Regression analysis was used to quantify the effect of ABS on motorcycle collision losses while controlling for other covariates. Claim frequency was modeled using a Poisson distribution, whereas claim severity was modeled using a Gamma distribution. Both models used a logarithmic link function. Estimates for collision overall losses were derived from the claim frequency and severity models. Reference categories for the categorical independent variables were assigned to the values with the highest exposure. The reference categories were as follows: make/series = Honda Gold Wing, ABS = without ABS, rated driver age range = 25-39, vehicle density = 100-499 vehicles per square mile, and rated driver gender = male. Losses for each unit of observation were weighted by the exposure in the linear regression. The key independent variable in the model, ABS, was treated as categorical. Models were constructed that examined the interaction of the rated driver factors and vehicle density with the presences or absence of ABS. None of those interactions were found to be significant.

Summary results of the regression analysis of motorcycle collision claim frequencies using the Poisson distribution are listed in Table 1. Results for all independent variables in the model, including ABS, had p-values less than 0.05, indicating their effects on claim frequencies were statistically significant.

Detailed results of the regression analysis using claim frequency as the dependent variable are listed in Table 2. The table shows estimates and significance levels for the individual values of the categorical variables. To make results more illustrative, a column was added that contains the exponents of the estimates. The exponent of the intercept equals 0.0000826 claims per day, or about 3 claims per 100 insured vehicle years. The intercept outlines losses for the reference (baseline) categories: the estimate corresponds to the claim frequency for a new Honda Gold Wing without ABS, garaged in a medium vehicle density area, and driven by a male age 25-39. The remaining estimates are in the form of multiples, or ratios relative to the reference categories. For example, the estimate corresponding to female gender equals 0.81, so female rated drivers had estimated claim frequencies 19 percent lower than those for male rated drivers.

The estimate corresponding to motorcycle ABS (-0.22) was highly significant ($p=0.002$). The estimate corresponded to a 19 percent reduction in claim frequencies for motorcycles equipped with ABS.

TABLE 1 SUMMARY RESULTS OF LINEAR REGRESSION ANALYSIS OF COLLISION CLAIM FREQUENCIES

	DEGREES OF FREEDOM	CHI-SQUARE	P-VALUE
Vehicle Age	1	196.270	< 0.0001
Rated Driver Age	4	57.040	< 0.0001
Vehicle Density	2	18.150	0.0001
Vehicle Make/Series	11	292.300	< 0.0001
Rated Driver Gender	2	8.060	0.0178
ABS	1	9.580	0.0020

TABLE 2 DETAILED RESULTS OF LINEAR REGRESSION ANALYSIS OF COLLISION CLAIM FREQUENCIES

PARAMETER	ESTIMATE	EXPONENT (ESTIMATE)	STANDARD ERROR	CHI-SQUARE	P-VALUE
INTERCEPT	-9.4014	3.015	0.0826	12948.8	<0.0001
VEHICLE AGE	-0.2628	0.769	0.0192	187.54	<0.0001
RATED DRIVER AGE					
Unknown	0.1791	1.196	0.0925	3.75	0.0529
14-24	0.5839	1.793	0.094	38.58	<0.0001
25-39	0	1.000	0		
40-64	-0.1433	0.866	0.0649	4.88	0.0272
65+	-0.0747	0.928	0.1026	0.53	0.4663
VEHICLE DENSITY					
0-99	-0.1332	0.875	0.0582	5.23	0.0222
100-499	0	1.000	0		
500+	0.122	1.130	0.0514	5.62	0.0177
RATED DRIVER GENDER					
Female	-0.205	0.815	0.0845	5.88	0.0153
Male	0	1.000	0		
Unknown	0.0431	1.044	0.0527	0.67	0.4135
VEHICLE MAKE/SERIES					
Honda Gold Wing	0	1.000	0		
Honda Interceptor 800	0.8988	2.457	0.1077	69.6	<0.0001
Honda Reflex	0.5596	1.750	0.1093	26.2	<0.0001
Honda Silver Wing	0.7658	2.151	0.1025	55.81	<0.0001
Honda ST1300	0.1745	1.191	0.1128	2.39	0.1218
Suzuki Bandit 1250	1.4525	4.274	0.2295	40.06	<0.0001
Suzuki Burgman 650	0.7284	2.072	0.0954	58.29	<0.0001
Suzuki SV650	1.0251	2.787	0.0747	188.54	<0.0001
Suzuki V-Strom 650	-0.084	0.919	0.1352	0.39	0.5345
Triumph Sprint ST	1.077	2.936	0.1357	63	<0.0001
Triumph Tiger	0.3632	1.438	0.2177	2.78	0.0953
Yamaha FJR1300	0.3276	1.388	0.0949	11.92	0.0006
ABS					
ABS Model	-0.2151	0.806	0.0709	9.19	0.0024
Non-ABS Model	0	1.000	0		

Motorcycle collision claim frequencies increased with increases in vehicle density. Claim frequencies in high vehicle density areas were estimated to be 13 percent higher ($p=0.02$) than those in medium vehicle density areas, whereas claim frequencies in low vehicle density areas were estimated to be 13 percent lower ($p=0.02$). Claim frequencies were estimated to decrease 23 percent ($p<0.0001$) for each 1-year increase in vehicle age.

Individual make/series motorcycles were included in the model, and estimates of their effect on collision claim frequencies were found to be significant. As previously mentioned, the reference category for the make/series variable was the Honda Gold Wing. Significant predictions for make/series ranged from 1.39 for the Yamaha FJR 1300 to 4.27 for the Suzuki Bandit 1250. All make/series estimates were significant at the $p=0.001$ level except for the Honda ST1300, Suzuki V-Strom 650, and Triumph Tiger. The lack of significance for these individual values of the make/series variable indicate that estimated claim frequencies for these motorcycles were similar to the Honda Gold Wing (reference category).

Driver age was highly significant in predicting motorcycle collision claim frequency. Estimated claim frequencies for rated drivers 24 and younger were 79 percent higher ($p<0.0001$) than those for rated drivers ages 25-39 (reference category), whereas estimated claim frequencies for rated drivers ages 40-64 were 13 percent lower ($p=0.03$). The estimated 7 percent decrease in claim frequency for rated drivers 65 and older was not significant. Driver gender also significantly predicted collision claim frequencies. Estimated claim frequencies for female rated riders were 19 percent lower ($p=0.02$) than those for male rated riders.

Summary results of the regression analysis of motorcycle collision claim severities using the Gamma distribution are listed in Table 3. Of the six variables included in the analysis, only vehicle age and make/series had p -values less than 0.05. Neither the rated driver nor the driving environment affects the claim size.

TABLE 3 SUMMARY RESULTS OF LINEAR REGRESSION ANALYSIS OF COLLISION CLAIM SEVERITIES			
	DEGREES OF FREEDOM	CHI-SQUARE	P-VALUE
Vehicle Age	1	12.400	0.0004
Rated Driver Age	4	3.420	0.4907
Vehicle Density	2	2.490	0.2880
Vehicle Make/Series	11	316.960	< 0.0001
Rated Driver Gender	2	0.190	0.9075
ABS	1	0.070	0.7953

Detailed results of the regression analysis using motorcycle collision claim severity as the dependent variable are listed in Table 4. The structure of the table, as well as the variables and reference categories, are the same as those used for claim frequency in Table 2. The variables and reference categories that were used for claim frequency were used for claim severity. The exponent of the intercept equals \$9,089. The intercept outlines losses for the reference (baseline) categories: the estimate corresponds to the claim severity for a new Honda Gold Wing without ABS, garaged in a medium vehicle density area, and driven by a male age 25-39.

The estimate corresponding to the ABS effect, a 2 percent decrease in claim severity, was highly nonsignificant (p=0.8), indicating ABS does not affect claim severity. As previously mentioned, vehicle age and make/series were significant predictors of claim severity. Not surprisingly, as motorcycles age their claim severities decrease. The model estimated a 6 percent decrease (p=0.0004) in claim severity per 1-year increase in vehicle age. Estimated claim severities for the 11 make/series motorcycles, compared with those for the Honda Gold Wing (reference category), ranged from 21 percent lower for the Honda ST1300 to 75 percent lower for the Honda Reflex. All of the make/series estimates were significant at the p<0.05 level.

TABLE 4 DETAILED RESULTS OF LINEAR REGRESSION ANALYSIS OF COLLISION CLAIM SEVERITIES					
PARAMETER	ESTIMATE	EXPONENT (ESTIMATE)	STANDARD ERROR	CHI-SQUARE	P-VALUE
INTERCEPT	9.1148	9088.817	0.0849	11515.1	<0.0001
VEHICLE AGE	-0.0608	0.941	0.0172	12.57	0.0004
RATED DRIVER AGE					
Unknown	0.0819	1.085	0.0838	0.95	0.3286
14-24	0.1743	1.190	0.1029	2.87	0.0905
25-39	0	1.000	0		
40-64	0.0624	1.064	0.0586	1.14	0.2866
65+	0.0415	1.042	0.0866	0.23	0.6317
VEHICLE DENSITY					
0-99	-0.0342	0.966	0.0563	0.37	0.5432
100-499	0	1.000	0		
500+	0.0553	1.057	0.0514	1.16	0.2822
RATED DRIVER GENDER					
Female	0.0319	1.032	0.0728	0.19	0.6613
Male	0	1.000	0		
Unknown	0.0078	1.008	0.0501	0.02	0.8766
VEHICLE MAKE/SERIES					
Honda Gold Wing	0	1.000	0		
Honda Interceptor 800	-0.5373	0.584	0.0928	33.54	<0.0001
Honda Reflex	-1.3808	0.251	0.0916	227.27	<0.0001
Honda Silver Wing	-1.1479	0.317	0.0922	154.93	<0.0001
Honda ST1300	-0.2339	0.791	0.0989	5.59	0.018
Suzuki Bandit 1250	-0.8037	0.448	0.1774	20.53	<0.0001
Suzuki Burgman 650	-0.9265	0.396	0.0908	104.19	<0.0001
Suzuki SV650	-0.9031	0.405	0.0801	127.02	<0.0001
Suzuki V-Strom 650	-0.989	0.372	0.1179	70.33	<0.0001
Triumph Sprint ST	-0.5166	0.597	0.1154	20.03	<0.0001
Triumph Tiger	-0.5712	0.565	0.1755	10.59	0.0011
Yamaha FJR1300	-0.4631	0.629	0.0863	28.81	<0.0001
ABS					
ABS Model	-0.0155	0.985	0.0597	0.07	0.795
Non-ABS Model	0	1.000	0		

Table 5 summarizes the effects of the independent variables on motorcycle collision overall losses, derived from the claim frequency and severity models. Overall losses can be calculated by simple multiplication because the estimates for the effect of ABS on claim frequency and severity were in the form of ratios relative to the reference (baseline) categories. The standard error for overall losses can be calculated by taking the square root of the sum of the squared standard errors for claim frequency and severity. Based on the value of the estimate and the associated standard error, the level of statistical significance (p-value) can be obtained from a probability distribution table.

The estimated effect of ABS was a 21 percent decrease in collision overall losses that was significant (p=0.01). This is a strong indication that ABS is effective in reducing collision overall losses for motorcycles.

Motorcycle collision overall losses were predicted to increase with increased vehicle density. Estimated overall losses in high vehicle density areas were 19 percent higher (p=0.01) than those medium vehicle density in areas (reference category), whereas estimated overall losses in low vehicle density areas were 15 percent lower (p=0.04). Estimated overall losses for the 11 make/series motorcycles, compared with those for the Honda Gold Wing (reference category), ranged from 66 percent lower for the Suzuki V-Strom 650 to 91 percent higher for the Suzuki Bandit 1250. Only about half of the make/series estimates were statistically different from the reference category.

Driver age was a significant predictor of motorcycle collision overall losses. Estimated overall losses for rated drivers 24 and younger were 113 percent higher (p<0.0001) than those for rated drivers ages 25-39 (reference category). Rated drivers ages 40-64 and 65 and older had slightly lower estimated overall losses, but these estimates did not reach statistical significance. Vehicle age also was significantly predictive of collision overall losses. Overall losses decreased by an estimated 28 percent (p<0.0001) for each 1-year increase in vehicle age.

TABLE 5 RESULTS FOR COLLISION OVERALL LOSSES DERIVED FROM CLAIM FREQUENCY AND SEVERITY MODELS

PARAMETER	FREQUENCY		SEVERITY		OVERALL LOSSES			P-VALUE
	ESTIMATE	STANDARD ERROR	ESTIMATE	STANDARD ERROR	ESTIMATE	STANDARD ERROR	EXPONENT (ESTIMATE)	
INTERCEPT	-9.4014	0.0826	9.1148	0.0849	-0.2866	0.1185	0.7508	0.0155
VEHICLE AGE	-0.2628	0.0192	-0.0608	0.0172	-0.3236	0.0258	0.7235	<0.0001
RATED DRIVER AGE								
Unknown	0.1791	0.0925	0.0819	0.0838	0.2610	0.1248	1.2982	0.0365
1. 14-24	0.5839	0.094	0.1743	0.1029	0.7582	0.1394	2.1344	<0.0001
25-39	0	0	0	0	0	0	1.0000	
40-64	-0.1433	0.0649	0.0624	0.0586	-0.0809	0.0874	0.9223	0.3549
65+	-0.0747	0.1026	0.0415	0.0866	-0.0332	0.1343	0.9673	0.8047
DENSITY								
0-99	-0.1332	0.0582	-0.0342	0.0563	-0.1674	0.0810	0.8459	0.0387
100-499	0	0	0	0	0	0	1.0000	
500+	0.122	0.0514	0.0553	0.0514	0.1773	0.0727	1.1940	0.0147
RATED DRIVER GENDER								
Female	-0.205	0.0845	0.0319	0.0728	-0.1731	0.1115	0.8411	0.1207
Male	0	0	0	0	0	0	1.0000	
Unknown	0.0431	0.0527	0.0078	0.0501	0.0509	0.0727	1.0522	0.4839
VEHICLE MAKE/SERIES								
Honda Gold Wing	0	0	0	0	0	0	1.0000	
Honda Interceptor 800	0.8988	0.1077	-0.5373	0.0928	0.3615	0.1422	1.4355	0.0110
Honda Reflex	0.5596	0.1093	-1.3808	0.0916	-0.8212	0.1426	0.4399	<0.0001
Honda Silver Wing	0.7658	0.1025	-1.1479	0.0922	-0.3821	0.1379	0.6824	0.0056
Honda ST1300	0.1745	0.1128	-0.2339	0.0989	-0.0594	0.1500	0.9423	0.6921
Suzuki Bandit 1250	1.4525	0.2295	-0.8037	0.1774	0.6488	0.2901	1.9132	0.0253
Suzuki Burgman 650	0.7284	0.0954	-0.9265	0.0908	-0.1981	0.1317	0.8203	0.1325
Suzuki SV650	1.0251	0.0747	-0.9031	0.0801	0.1220	0.1095	1.1298	0.2653
Suzuki V-Strom 650	-0.084	0.1352	-0.989	0.1179	-1.0730	0.1794	0.3420	<0.0001
Triumph Sprint ST	1.077	0.1357	-0.5166	0.1154	0.5604	0.1781	1.7514	0.0017
Triumph Tiger	0.3632	0.2177	-0.5712	0.1755	-0.2080	0.2796	0.8122	0.4570
Yamaha FJR1300	0.3276	0.0949	-0.4631	0.0863	-0.1355	0.1283	0.8733	0.2908
ABS								
ABS Model	-0.2151	0.0709	-0.0155	0.0597	-0.2306	0.0927	0.7941	0.0128
Non-ABS Model	0	0	0	0	0	0	1.0000	

APPENDIX A DISTRIBUTION OF EXPOSURE FOR INDEPENDENT VARIABLES

	EXPOSURE	PERCENT OF TOTAL		
VEHICLE AGE				
0	291	0%		
1	12,177	17%		
2	20,388	28%		
3	18,147	25%		
4	12,748	18%		
5	8,724	12%		
RATED DRIVER AGE				
Unknown	4,886	7%		
14-24	1,696	2%		
25-39	11,274	16%		
40-64	47,687	66%		
65+	6,933	10%		
VEHICLE DENSITY				
0-99	21,281	29%		
100-499	29,331	40%		
500+	21,863	30%		
RATED DRIVER GENDER				
Female	7,034	10%		
Male	43,147	59%		
Unknown	22,294	31%		
VEHICLE MAKE/SERIES	EXPOSURE WITHOUT ABS	PERCENT OF SERIES	EXPOSURE WITH ABS	PERCENT OF SERIES
Honda Gold Wing (Touring)	28,904	82%	6,366	18%
Honda Interceptor 800 (Sport)	1,925	76%	623	24%
Honda Reflex (Scooter)	3,036	87%	443	13%
Honda Silver Wing (Scooter)	2,882	85%	506	15%
Honda ST1300 (Sport)	3,118	68%	1,468	32%
Suzuki Bandit 1250 (Standard)	136	80%	33	20%
Suzuki Burgman 650 (Scooter)	3,219	92%	288	8%
Suzuki SV650 (Unclad Sport)	8,468	100%	11	0%
Suzuki V-Strom 650 (Dual Purpose)	2,986	97%	90	3%
Triumph Sprint ST (Sport)	908	82%	198	18%
Triumph Tiger (Dual Purpose)	695	94%	42	6%
Yamaha FJR1300 (Sport)	3,610	59%	2,520	41%
Total	59,886	83%	12,589	17%

The Highway Loss Data Institute is a nonprofit public service organization that gathers, processes, and publishes insurance data on the human and economic losses associated with owning and operating motor vehicles.

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