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Impact of Nissan ProPILOT Assist on insurance losses

Summary

This study estimates the unique effect of a Level 2 driving automation technology, Nissan's ProPILOT Assist, as equipped on the 2018 Nissan Rogue, on insurance losses after controlling for various other Advanced Driver Assistance Systems (ADAS) equipped to the same vehicle. ProPILOT Assist combines steering support with Nissan's adaptive cruise control system (called Intelligent Cruise Control) to keep the vehicle in the center of the lane while controlling speed and following distance. Numerous studies by the Highway Loss Data Institute (HLDI) have found that various ADAS significantly reduce claim frequency under different vehicle damage and injury coverage types. But to date, HLDI has not isolated the effect of the technology that automates part of the driving task (driving automation technology) on insurance losses due to the confounding effects of associated ADAS features.

Claim frequency results for the 2017–18 Nissan Rogue are shown in the following table. Statistically significant results are bolded. Consistent with previous HLDI research on ADAS, the ADAS available on the 2017–18 Nissan Rogue were associated with reductions in claim frequency under the different coverage types; many of the reductions were statistically significant.

Intelligent Cruise Control was expected to further reduce insurance losses; however, the system was associated with increases in insurance losses although not statistically significant. After controlling for the effects of Intelligent Cruise Control and other ADAS, ProPILOT Assist was associated with a 1 percent reduction in collision claim frequency, a 12 percent reduction in property damage liability claim frequency, and large reductions in claim frequency for each injury coverage type. Only the reduction observed for personal injury protection was statistically significant.

Change in claim frequencies by collision avoidance feature, results summary					
Vehicle damage coverage type	**Forward Emergency Braking**	**Intelligent Cruise Control**	**ProPILOT Assist**	**Blind Spot Warning / Rear Cross-Traffic Alert**	**Around View Monitor / Moving Object Detection**
Collision	-2.0%	1.9%	-1.1%	**-4.7%**	-1.9%
Property damage liability	**-8.6%**	4.3%	-11.9%	**-11.2%**	**-5.9%**
Injury coverage type					
Bodily injury liability	-5.6%	8.2%	-43.0%	**-16.9%**	**-16.1%**
Medical payment	9.9%	-15.0%	-30.2%	-11.7%	**-16.8%**
Personal injury protection	1.0%	7.8%	**-27.8%**	-2.7%	**-14.9%**

At first glance, the results of this study suggest that the lane-centering function of ProPILOT Assist is responsible for the observed reductions in insurance losses, but this conclusion may be premature. Lane departure warning and lane departure prevention have not been consistently associated with insurance loss reductions in previous HLDI research, so a lane-centering function would not be expected to provide much benefit. Intelligent Cruise Control and Nissan's lane departure prevention system were always paired together, so this feature dependency may have obscured the benefits of Intelligent Cruise Control on insurance losses observed for other Nissan vehicles. Previous IIHS research has shown that Level 2 driving automation technologies are used more than adaptive cruise control systems. Hence, ProPILOT Assist may have bolstered the use of Intelligent Cruise Control to further reduce insurance losses.

Early evidence indicates that Nissan's Level 2 driving automation system, ProPILOT Assist, is preventing crashes and reducing insurance losses, but additional research is necessary to understand the mechanism through which it is reducing insurance losses.

Introduction

Advanced Driver Assistance Systems (ADAS) inform the driver of a potential collision and may apply steering or braking input to mitigate or prevent a crash. Numerous studies by HLDI have found that the presence of different ADAS features is associated with a significant reduction in claim frequency under different vehicle damage and injury coverage types (HLDI, 2018b). ADAS are foundational elements of driving automation technology that continuously support the driver by providing sustained steering, throttle, or braking input. For instance, adaptive cruise control (ACC) maintains a set speed and also modulates vehicle speed to maintain a set following distance to a vehicle ahead; it is a Level 1 driving automation technology based on the definitions established by SAE International (2018). By continuously supporting the driver, driving automation technology like ACC helps maintain or increase safety margins (Kessler et al., 2012) and may prevent safety-critical events from developing into near crashes or crashes that are not addressed by current ADAS.

Previous HLDI research on the real-world benefits of driving automation technology relative to the underlying ADAS features is mixed. A 2009 HLDI study examined an ACC system equipped to 2008 and 2009 model year Mercedes vehicles called Distronic that also included a forward collision warning (FCW) feature (HLDI, 2009). The presence of Distronic was associated with a 5 percent reduction in collision claim frequency and an 8 percent reduction in property damage liability (PDL) claim frequency, but the independent contribution of the ACC and FCW functions of the Distronic system to these reductions could not be determined. Subsequent HLDI research on ADAS (HLDI, 2018b) suggests that FCW contributed to most of the effect observed in this early HLDI study on ADAS.

A 2017 HLDI study examined the effects of various ADAS features on 2012–16 Tesla Model S vehicles that became available through over-the-air software updates. One feature that was added in a software update was Tesla Autopilot, a Level 2 driving automation technology. Autopilot supported the driver with multiple aspects of the driving task by providing sustained steering, throttle, and braking control. The actual software version present on individual Tesla Model S vehicles could not be determined, so this study compared periods where a feature was available with periods where it was not. Collision claim frequency during a period following the introduction of Autopilot and other features via software update (e.g., automated lane change, side-collision avoidance) was significantly reduced by 13 percent relative to an earlier period where Autopilot was not available but other ADAS features were. No other significant changes in claim frequency were observed.

In the 2018 model year, Nissan introduced a Level 2 driving automation technology called ProPILOT Assist as an optional feature on certain Rogue and Leaf vehicles. ProPILOT Assist adds steering support to an available ACC system called Intelligent Cruise Control to keep the vehicle centered in the lane in addition to maintaining a set speed and following distance to the vehicle ahead. Both driving automation technologies are available on Nissan Rogue vehicles that are equipped with other standard or optional ADAS features. The staggered introduction of Intelligent Cruise Control followed by ProPILOT Assist as a stand-alone optional feature on the Nissan Rogue across model years provides a unique opportunity to examine the effects of Level 1 and Level 2 driving automation technology on insurance losses independent of other ADAS features. Both driving automation technologies were expected to strengthen the reductions in insurance losses associated with different ADAS features that have been observed in past HLDI studies, by reducing the severity of crash imminent situations that ADAS features typically act on and by preventing crash imminent situations from developing altogether.

The following Nissan ADAS and driving automation technologies were examined in this study.

Advanced Driver Assistance Systems

Forward Emergency Braking (FEB) uses a front radar sensor to measure the distance to the vehicle ahead. A visual and auditory warning is provided to the driver if a risk of a forward collision is detected. If the driver does not brake following the warning, then the system applies partial braking if a forward collision risk is still detected. The system applies harder braking if a collision is imminent. The system functions at speeds above 3 mph and will not detect stationary vehicles when the vehicle is traveling over 50 mph. Some FEB systems also include pedestrian detection, which provides a visual and auditory warning and automatic braking if a collision risk with a pedestrian is detected. The pedestrian detection function is available between 6 and 37 mph.

Blind Spot Warning (BSW) uses radar sensors mounted near the rear bumper to detect other vehicles in adjacent lanes. An indicator light near the A-pillar is illuminated when a vehicle is detected by the system. An audible warning is provided and the A-pillar light flashes if the turn signal is used in the direction of an adjacent vehicle detected by the system. The system detects vehicles up to 10 feet behind the rear bumper that are within 10 feet of either side of the vehicle. The system is available above 20 mph.

Rear Cross-Traffic Alert (RCTA) uses the same radar sensors as the BSW system to detect vehicles approaching from the side when the vehicle is reversing at less than 5 mph. If the system detects an approaching vehicle, then an indicator light near the A-pillar on the side the vehicle is approaching from flashes and an audible warning is presented. The system can detect approaching vehicles from about 66 feet away.

Around View Monitor (AVM) uses cameras located in the front grille, on the side mirrors, and above the vehicle license plate to display a bird's-eye view of the vehicle, 150-degree-front view, 150-degree-rear view, or a front-passenger-side view. Predicted course lines based on steering wheel position are displayed in the front view and rear view with distance indicators at 1.5, 3, 7, and 10 feet. The different camera views are available when the vehicle transmission is in reverse. The front view is only available at speeds below 6 mph.

Moving Object Detection (MOD) uses image processing technology on the camera images to detect moving objects around the vehicle. A yellow frame is displayed on the camera image and an auditory warning is provided when a moving object is detected.

High-Beam Assist is available at speeds above 25 mph. The system will automatically switch from the high-beam setting to the low-beam setting when the ambient-image sensor near the rearview mirror detects an oncoming vehicle or vehicle ahead.

RearView Monitor uses a camera located above the vehicle's license plate to show an image of the area directly behind the vehicle when it is in reverse. Guidelines showing the approximate distance to objects in the camera image are provided at 1.5, 3, 7, and 10 feet behind the vehicle. Every 2017–18 Nissan Rogue was equipped with this technology.

Intelligent Lane Intervention uses a front-facing camera behind the rearview mirror to monitor the travel lane at speeds above 37 mph. A visual and auditory warning is provided when the vehicle approaches a lane marking. The system applies braking to the left or right wheels to assist the driver in returning the vehicle to the center of the lane.

Driving automation technologies

Intelligent Cruise Control is an ACC system that uses a radar sensor mounted on the front bumper to monitor traffic ahead. The system maintains the driver's selected speed and automatically reduces it to maintain a driver-selected following distance when it detects a slower moving vehicle ahead. The system is available at speeds between 20 and 90 mph and can bring the vehicle to a complete stop. The system can apply up to 40 percent of the vehicle's total braking power when slowing for traffic ahead. Intelligent Cruise Control is an SAE Level 1 driving automation technology (SAE International, 2018).

ProPILOT Assist combines steering assist with ICC and uses a front-facing camera located behind the rearview mirror to provide steering input to assist in keeping the vehicle centered in the lane. Steering assist is only available when lane markings are detected, a vehicle ahead is detected (only necessary when traveling under 37 mph), the driver's hands are detected on the steering wheel and the windshield wiper is not operating at low or high speed. The steering assist is placed into a temporary standby mode when a turn signal is used or lane markings on both sides of the lane are not detected. If the system detects that the steering wheel is not being operated or the driver's hands are off of the steering wheel, then a cascade of warnings will be presented, followed by a quick brake application, and finally, the vehicle will slow to a stop with the hazard flasher turned on. Additionally, the ProPILOT Assist system is not available when the driver seatbelt is unbuckled. ProPILOT Assist is a Level 2 driving automation technology.

Method

Feature dependencies

Many sensor systems enable more than one ADAS or driving automation feature and, consequently, some features are only available with other features. For example, BSW and RCTA both use radar sensors in the rear bumper to detect vehicles approaching from the side either in adjacent lanes (BSW) or approaching the path of a reversing vehicle (RCTA). BSW and RCTA are often bundled together, and the effect cannot be separated. Similarly, multiple features may be available as standard equipment on specific models but optional or not available on others. The insurance data provided to HLDI do not contain information on the type of crash that led to a claim, so it is not possible to separate the effect of individual features in a bundle on insurance losses. Due to these feature dependencies, BSW and RCTA were grouped together for the purposes of statistical analysis and AVM and MOD were grouped together. The presence of additional features related to other feature dependencies are noted in the Results.

Vehicles

Although some features are available as standard equipment for certain model years and trim levels, other features are offered as optional equipment. The presence or absence of these optional features is not discernible from the information encoded in the Vehicle Identification Number (VIN), and must be determined from build information maintained by the manufacturer. Nissan provided HLDI with VINs for 2015–18 model year Nissan Rogue vehicles and information about the presence or absence of the ADAS and driving automation technologies listed previously for each VIN. However, this study only included 2017–18 Nissan Rogues for the following reasons:

- The 2015 Nissan Rogue was excluded from the study because the sensors that enabled certain functions differed from the sensors that enabled the same functions in the 2016–18 Nissan Rogues. Specifically, the BSW system in the 2015 Nissan Rogue used image processing of a rear-facing camera to detect approaching vehicles in adjacent lanes instead of radars mounted in the rear bumper like the 2016–18 Nissan Rogues. Image processing of the rear-facing camera image also was used to support detection of lane markings to enable a lane departure warning system; a similar function was enabled using a front-facing camera in 2017–18 Nissan Rogues.
- The 2016 Nissan Rogue was excluded from the study because the feature dependencies of the optional ADAS were different from subsequent model years and did not permit the effect of AVM with MOD and BSW with RCTA on insurance loss to be computed.

Table 1 lists the model years and total collision exposure in insured vehicle years for the 2017–18 Nissan Rogues included in this study. **Table 2** lists the percentage of collision exposure by feature.

Table 1: Feature exposure by vehicle series

Make	Series	Model year range	Total collision exposure
Nissan	Rogue 4D 2WD	2017–18	187,107
Nissan	Rogue 4D 4WD	2017–18	275,128
Total collision exposure			**462,235**

Table 2: Percent of collision exposure with feature

Feature	Collision exposure with feature
Forward Emergency Braking	43%
Intelligent Cruise Control	15%
ProPILOT Assist	2%
Blind Spot Warning / Rear Cross-Traffic Alert	76%
Around View Monitor / Moving Object Detection	37%

Insurance data

Automobile insurance covers damage to vehicles and property plus injuries to people involved in the 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, PDL, bodily injury (BI) liability, personal injury protection (PIP), and medical payment (MedPay) coverages. Exposure is measured in insured vehicle years. An insured vehicle year is one vehicle insured for one year, two vehicles insured for six months, etc.

Different crash avoidance features may affect insurance coverage types differently. Hence, it is important to understand how coverages vary among the states and how this affects inclusion in the analyses. Collision coverage insures against vehicle damage to an at-fault driver's vehicle sustained in a crash with an object or another vehicle; this coverage is common to all 50 states. PDL coverage insures against vehicle damage that at-fault drivers cause to other people's vehicles and property in crashes. This coverage exists in all states except Michigan, where vehicle damage is covered on a no-fault basis where each insured vehicle pays for its own damage in a crash regardless of who is at fault.

Coverage of injuries is more complex. BI liability coverage insurers against medical, hospital, and other expenses for injuries that at-fault drivers inflict on occupants of other vehicles or other road users. Although motorists in most states may have BI liability coverage, this information is analyzed using information from 33 states with traditional tort insurance systems where the at-fault driver has first obligation to pay for injuries. MedPay coverage also is sold in the 33 states with traditional tort insurance systems and covers injuries to insured drivers and passengers in their vehicles but not injuries to people in other vehicles involved in the crash. Seventeen states employ no-fault injury systems. In these systems, PIP coverage pays up to a specified amount for injuries to occupants of involved-insured vehicles, regardless of who is at fault in a collision. The District of Columbia has a hybrid insurance system for injuries and was excluded from the injury analyses.

Statistical methods

Regression analysis was used to quantify the effect of each vehicle feature or groups of features while controlling for the other features and covariates. The covariates included calendar year, model year, garaging state, the number of registered vehicles per square mile (vehicle density), rated driver age group, rated driver gender, rated driver marital status, deductible range (collision coverage only), and risk. A single variable called SERIESMY was created using the model year and vehicle series to control for the variation caused by vehicle design changes across model years. A binary variable for FEB, Intelligent Cruise Control, ProPILOT Assist, BSW and RCTA, and AVM and MOD was included to indicate when each feature or feature group was present or absent.

Claim frequency was modeled using a Poisson distribution, whereas the average loss payment per claim, or 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. Estimates for frequency, severity, and overall losses are presented for collision and property damage liability coverages. Three frequency estimates are presented for PIP, BI liability, and MedPay. The first is the frequency for all claims including those that already have been paid and for which money has been set aside for possible payment in the future, known as claims with reserves. The other two frequencies include only paid claims separated into low- and high-severity ranges. Note that the percentage of all injury claims that were paid by the date of analysis varies by coverage: 76 percent for PIP, 67 percent for BI liability, and 62 percent for MedPay. The low-severity range was less than $1,000 for PIP and MedPay, and less than $5,000 for BI liability coverage. The high-severity range covered all loss payments that exceeded the low-severity range.

A separate regression was performed for each insurance loss measure for a total of 15 regressions (5 coverages × 3 loss measures each) per feature. For space reasons, only the estimates for the individual ADAS and driving automation technology features are shown on the following pages. The effect associated with the presence of a feature on each insurance loss measure was expressed as a percentage change to simplify the presentation of results. The effect was computed by exponentiating the parameter estimate, subtracting 1, and then multiplying the resultant by 100. For example, the parameter estimate for the effect of FEB on collision claim frequency was −0.0201; thus, vehicles with this feature had 2 percent fewer collision claims than vehicles without the feature ((exp(−0.0201)−1)×100=−2.0). The **Appendix** contains full model results for collision claim frequencies to illustrate the regression analyses.

Results

Results for the various ADAS and driving automation technology features are summarized in **Tables 3–7**. In each table, the lower and upper bounds represent the 95 percent confidence limits for each estimate. Estimates that are statistically significant at the 95 percent confidence level are bolded.

Forward Emergency Braking

The effects of Forward Emergency Braking (FEB) on insurance losses are summarized in **Table 3**. The presence of FEB was associated with a 2 percent reduction in collision claim frequency and a significant 9 percent reduction in PDL claim frequency. Collision claim severity was significantly increased by 5 percent for Rogues with FEB compared with Rogues without the feature. PDL claim severity was increased by 4 percent for vehicles with FEB, but this effect was not statistically significant. Overall losses under collision coverage for vehicles with FEB were increased 3 percent but decreased 5 percent under PDL coverage; neither change was statistically significant.

The effect of FEB on insurance losses under the different injury coverages was mixed. FEB was associated with a 6 percent reduction in BI liability claim frequency, a 10 percent increase in MedPay claim frequency, and a 1 percent increase in PIP claim frequency. None of these changes in claim frequency were statistically significant. The presence of FEB was associated with a significant 46 percent increase in the frequency of low-severity PIP claims (<$1,000). None of the other results were statistically significant.

Table 3: Change in insurance losses for Forward Emergency Braking

Vehicle damage coverage type	Lower bound	FREQUENCY	Upper bound	Lower bound	SEVERITY	Upper bound	Lower bound	OVERALL LOSSES	Upper bound
Collision	-5.7%	-2.0%	1.8%	0.5%	**4.7%**	9.1%	-3.0%	2.6%	8.5%
Property damage liability	-14.0%	**-8.6%**	-2.9%	-2.0%	3.6%	9.6%	-12.8%	-5.3%	2.8%

Injury coverage type	Lower bound	FREQUENCY	Upper bound	Lower bound	LOW-SEVERITY FREQUENCY	Upper bound	Lower bound	HIGH-SEVERITY FREQUENCY	Upper bound
Bodily injury liability	-23.3%	-5.6%	16.1%	-41.8%	-13.2%	29.5%	-25.5%	9.5%	61.0%
Medical payment	-8.6%	9.9%	32.0%	-30.6%	22.9%	117.6%	-8.2%	17.8%	51.2%
Personal injury protection	-10.0%	1.0%	13.3%	10.7%	**46.0%**	92.5%	-17.2%	-3.9%	11.6%

Intelligent Cruise Control

Intelligent Cruise Control was not available as a stand-alone option on the 2017–18 Nissan Rogue. Intelligent Cruise Control on the 2017 Nissan Rogue was packaged with Intelligent Lane Intervention and FEB with pedestrian detection. The system was packaged with AVM and MOD on some 2018 Nissan Rogues and was a standard feature along with other ADAS features (e.g., FEB with pedestrian detection, Intelligent Lane Intervention, High-Beam Assist) on other 2018 Nissan Rogues.

Table 4 summarizes the effects of Intelligent Cruise Control on insurance losses after controlling for other vehicle features and variables included in the model. Intelligent Cruise Control was associated with increased insurance losses under both collision and PDL coverage types, but none of the changes were statistically significant. The presence of Intelligent Cruise Control was associated with a 2 percent increase in collision claim frequency, 3 percent increase in collision claim severity, and almost a 5 percent increase in overall losses under collision coverage. PDL claim frequency increased 4 percent, PDL claim severity increased 3 percent, and overall losses under PDL coverage increased 7 percent for Rogues with Intelligent Cruise Control relative to Rogues without the feature.

The effect of Intelligent Cruise Control on insurance losses under injury coverage types was mixed. The presence of Intelligent Cruise Control was associated with an 8 percent increase in BI liability claim frequency, a 15 percent decrease in MedPay claim frequency, and an 8 percent increase in PIP claim frequency. None of the changes in insurance losses under the different injury coverage types were statistically significant.

Table 4: Change in insurance losses for Intelligent Cruise Control

Vehicle damage coverage type	Lower bound	FREQUENCY	Upper bound	Lower bound	SEVERITY	Upper bound	Lower bound	OVERALL LOSSES	Upper bound
Collision	-2.3%	1.9%	6.3%	-1.8%	2.7%	7.5%	-1.6%	4.7%	11.4%
Property damage liability	-2.4%	4.3%	11.4%	-3.4%	2.7%	9.2%	-2.1%	7.1%	17.2%

Injury coverage type	Lower bound	FREQUENCY	Upper bound	Lower bound	LOW-SEVERITY FREQUENCY	Upper bound	Lower bound	HIGH-SEVERITY FREQUENCY	Upper bound
Bodily injury liability	-14.8%	8.2%	37.4%	-24.1%	19.5%	88.0%	-37.6%	-0.2%	59.6%
Medical payment	-31.5%	-15.0%	5.3%	-39.3%	12.5%	108.8%	-35.2%	-13.1%	16.6%
Personal injury protection	-5.0%	7.8%	22.3%	-24.3%	3.1%	40.4%	-9.4%	6.6%	25.4%

ProPILOT Assist

The effect of ProPILOT Assist on insurance losses under different coverage types after controlling for the effects of Intelligent Cruise Control, other ADAS features, and other variables on insurance losses is summarized in **Table 5**. ProPILOT Assist was associated with a 1 percent reduction in collision claim frequency, a 3 percent increase in collision claim severity, and a 2 percent increase in overall losses under collision coverage; none of these effects were statistically significant. ProPILOT Assist was associated with a 12 percent reduction in PDL claim frequency. PDL claim severity was decreased 2 percent and overall losses were decreased 14 percent for Rogues with ProPILOT Assist relative to Rogues without the feature. The changes in insurance losses under PDL coverage were not statistically significant.

In general, ProPILOT Assist was associated with reductions in insurance losses under each injury coverage type, but many of these effects were not statistically significant. The presence of ProPILOT Assist was associated with a 43 percent reduction in BI liability claim frequency and a 30 percent reduction in MedPay claim frequency; neither effect was statistically significant. The effects of ProPILOT Assist on overall PIP claim frequency and the frequency of high-severity PIP claims were statistically significant. Overall PIP claim frequency was 28 percent lower for vehicles with ProPILOT Assist than vehicles without the feature, and the frequency of high-severity PIP claims was reduced by 33 percent.

Table 5: Change in insurance losses for ProPILOT Assist

Vehicle damage coverage type	Lower bound	FREQUENCY	Upper bound	Lower bound	SEVERITY	Upper bound	Lower bound	OVERALL LOSSES	Upper bound
Collision	-8.9%	-1.1%	7.3%	-5.5%	3.1%	12.5%	-9.5%	2.0%	15.0%
Property damage liability	-23.2%	-11.9%	1.1%	-13.8%	-2.2%	10.9%	-28.5%	-13.9%	3.8%
Injury coverage type	**Lower bound**	**FREQUENCY**	**Upper bound**	**Lower bound**	**LOW-SEVERITY FREQUENCY**	**Upper bound**	**Lower bound**	**HIGH-SEVERITY FREQUENCY**	**Upper bound**
Bodily injury liability	-70.3%	-43.0%	9.5%	-81.9%	-40.1%	98.3%	-95.8%	-68.9%	132.0%
Medical payment	-58.0%	-30.2%	16.0%	-96.1%	-70.4%	123.1%	-46.1%	0.2%	86.1%
Personal injury protection	-46.7%	**-27.8%**	-2.1%	-48.2%	3.8%	108.1%	-54.9%	**-32.9%**	-0.3%

Blind Spot Warning and Rear Cross-Traffic Alert

Blind Spot Warning (BSW) and Rear Cross-Traffic Alert (RCTA) were always present together on the 2017–18 Nissan Rogue. **Table 6** summarizes the results for the combination of BSW and RCTA on the Nissan Rogue. The presence of BSW and RCTA was associated with significant reductions in collision claim frequency (–5 percent) and PDL claim frequency (–11 percent). Collision claim severity was slightly increased by 2 percent for Rogues with BSW and RCTA and PDL claim severity was significantly increased by 6 percent. Despite increased claim severity under vehicle damage coverage types, BSW and RCTA were associated with 3 and 6 percent reductions in overall losses under collision and PDL coverage, respectively.

The presence of BSW and RCTA was associated with a significant 17 percent reduction in BI liability claim frequency. The frequency of high-severity BI liability claims was significantly reduced by 30 percent for Rogues with these features. BSW and RCTA also was associated with reductions in MedPay claim frequency (–12 percent) and PIP claim frequency (–3 percent), but neither reduction was statistically significant.

Table 6: Change in insurance losses for Blind Spot Warning and Rear Cross-Traffic Alert									
Vehicle damage coverage type	**Lower bound**	**FREQUENCY**	**Upper bound**	**Lower bound**	**SEVERITY**	**Upper bound**	**Lower bound**	**OVERALL LOSSES**	**Upper bound**
Collision	-7.5%	**-4.7%**	-1.9%	-1.4%	1.8%	5.0%	-7.1%	-3.1%	1.2%
Property damage liability	-15.0%	**-11.2%**	-7.2%	1.6%	**5.8%**	10.1%	-11.5%	**-6.1%**	-3.0%
Injury coverage type	**Lower bound**	**FREQUENCY**	**Upper bound**	**Lower bound**	**LOW-SEVERITY FREQUENCY**	**Upper bound**	**Lower bound**	**HIGH-SEVERITY FREQUENCY**	**Upper bound**
Bodily injury liability	-27.6%	**-16.9%**	-4.7%	-33.2%	-14.3%	9.9%	-44.7%	**-30.1%**	-11.6%
Medical payment	-23.0%	-11.7%	1.3%	-47.4%	-22.2%	15.1%	-29.5%	-14.3%	4.2%
Personal injury protection	-10.7%	-2.7%	5.9%	-13.1%	8.9%	36.5%	-12.7%	-2.7%	8.4%

Around View Monitor and Moving Object Detection

Around View Monitor (AVM) and Moving Object Detection (MOD) were part of an optional package on the 2017–18 Nissan Rogue; the optional package on the 2018 Nissan Rogue also included Intelligent Cruise Control. The combination of AVM and MOD was associated with a 2 percent reduction in collision claim frequency and a significant 6 percent reduction in PDL claim frequency. The severity of collision claims was unchanged by the presence of AVM and MOD, but PDL claim severity was significantly reduced by 5 percent for Rogues with the feature relative to Rogues without it. Overall, AVM and MOD was associated with a 2 percent reduction in overall losses under collision coverage and a significant 11 percent reduction in overall losses under PDL coverage.

The combination of AVM and MOD was associated with significant reductions in claim frequency under the different injury coverage types. BI liability claim frequency was reduced 16 percent, MedPay claim frequency was reduced 17 percent, and PIP claim frequency was reduced 15 percent for vehicles with AVM and MOD.

Table 7: Change in insurance losses for Around View Monitor and Moving Object Detection									
Vehicle damage coverage type	**Lower bound**	**FREQUENCY**	**Upper bound**	**Lower bound**	**SEVERITY**	**Upper bound**	**Lower bound**	**OVERALL LOSSES**	**Upper bound**
Collision	-5.0%	-1.9%	1.4%	-3.6%	-0.2%	3.3%	-6.6%	-2.1%	2.7%
Property damage liability	-10.5%	**-5.9%**	-1.1%	-9.4%	**-5.2%**	-0.7%	-16.6%	**-10.7%**	-4.5%
Injury coverage type	**Lower bound**	**FREQUENCY**	**Upper bound**	**Lower bound**	**LOW-SEVERITY FREQUENCY**	**Upper bound**	**Lower bound**	**HIGH-SEVERITY FREQUENCY**	**Upper bound**
Bodily injury liability	-29.2%	**-16.1%**	-0.7%	-45.0%	-24.5%	3.6%	-46.3%	-26.4%	0.8%
Medical payment	-29.0%	**-16.8%**	-2.4%	-60.3%	-34.6%	7.6%	-31.6%	-14.6%	6.6%
Personal injury protection	-22.7%	**-14.9%**	-6.4%	-40.7%	**-24.2%**	-3.1%	-25.0%	**-15.3%**	-4.3%

Discussion

This study was the first to estimate the effect of a Level 2 driving automation technology on insurance losses separately from other related ADAS features. Consistent with previous HLDI research (HLDI, 2018b), every ADAS feature on the 2017–18 Nissan Rogue was associated with reductions in collision claim frequency and PDL claim frequency; most of the effects were statistically significant. The driving automation technologies available on the 2017–18 Nissan Rogues were expected to further reduce insurance losses, but results were mixed.

Intelligent Cruise Control, a Level 1 driving automation technology that assisted with speed control and maintained following distance, did not reduce collision claim frequency or PDL claim frequency. In fact, the presence of the feature was associated with a slight, but not statistically significant, increase in collision and PDL claim frequency. On the other hand, ProPILOT Assist, a Level 2 driving automation technology that added sustained steering support to Intelligent Cruise Control, was associated with reductions in collision claim frequency and PDL claim frequency. Neither reduction was statistically significant, but the effect for PDL claim frequency approached statistical significance and indicated that ProPILOT Assist is associated with additional safety benefits beyond those provided by other ADAS features on the Nissan Rogue.

The insurance loss results for Intelligent Cruise Control were unexpected. Previous research has found that using ACC increases following distance (Kessler et al., 2012) which would be expected to reduce front-to-rear crash risk, but the presence of an ACC system on the 2017–18 Nissan Rogue was associated with a slight increase in insurance losses under vehicle damage coverage types. However, the estimate for the Nissan Rogue Intelligent Cruise Control did not reflect the effect of this feature alone, as it was often available in combination with Intelligent Lane Intervention and FEB with pedestrian detection. Pedestrian detection would not be expected to influence collision and PDL claim frequency. On the other hand, lane departure warning and prevention systems like Intelligent Lane Intervention have been shown to reduce relevant police-reported crash rates (Cicchino, 2018) even if the effect of these systems on insurance losses is indiscernible (HLDI, 2018b). A companion HLDI analysis of Intelligent Cruise Control and other ADAS features on the 2016–18 Nissan Sentra, Murano, and Altima better isolated the effects of Intelligent Cruise Control from other ADAS features. This analysis found that the system significantly reduced PDL claim frequency and BI liability claim frequency by 8 percent and 17 percent, respectively (HLDI, 2019). Hence, the dependency between Intelligent Cruise Control and Intelligent Lane Intervention may have obscured the benefits of the Nissan Rogue's Intelligent Cruise Control on insurance losses in the current analysis.

As noted previously, the ProPILOT Assist system added steering support and lane centering to Intelligent Cruise Control and was a stand-alone option on the most expensive 2018 Nissan Rogue model that was already equipped with Intelligent Cruise Control and a host of other ADAS features. A field operational test of vehicles with ACC and Level 2 driving automation technology found that people who drove a 2017 Volvo S90 used the vehicle's Level 2 driving automation technology 3 times more than the ACC system alone (Reagan, Hu, Cicchino, Seppelt, Fridman, & Glazer, 2019). Hence, it is plausible that the estimated benefit of ProPILOT Assist may be due to the increased use of Intelligent Cruise Control and not the lane-centering feature alone. Future HLDI research should examine the point-of-impact distribution of all collision claims alone and with matching PDL claims for Nissan Rogues with and without ProPILOT Assist to help identify the crash types that the feature is preventing and the mechanism through which it is reducing insurance losses.

The average severity of collision claims by claim size is shown in **Table 8** for Rogues with FEB; FEB and Intelligent Cruise Control; FEB, Intelligent Cruise Control, and ProPILOT Assist; or Rogues without any of these technologies. Collision claim severity was similar in each claim size range except for claims of $12,000 or more. The average size of high-severity collision claims of $12,000 or more was 9 percent higher for vehicles with FEB; 17 percent higher for vehicles with FEB and Intelligent Cruise Control; and 25 percent higher for vehicles with FEB, Intelligent Cruise Control, and ProPILOT Assist relative to vehicles without these technologies. The ADAS and driving automation technologies available on the 2017–18 Nissan Rogue were first introduced on the most expensive models before becoming available on less expensive models in a subsequent model year. Consequently, the cost of repairing Nissan Rogues with ADAS or driving automation technology that were either severely damaged in a crash or declared a total loss would be more expensive, on average, due to differences in base price and would be reflected by the increased collision claim severity associated with these features.

Features	Low severity (<$2,000)	Mid-low severity ($2,000–$4,999)	Mid-high severity ($5,000–$11,999)	High severity ($12,000+)	Overall severity
No FEB, Intelligent Cruise Control, or ProPILOT Assist	$1,025	$3,241	$7,535	$18,954	$5,399
FEB only	$1,027	$3,243	$7,580	$20,626	$5,649
FEB and Intelligent Cruise Control	$1,031	$3,226	$7,569	$22,159	$5,653
FEB, Intelligent Cruise Control, and ProPILOT Assist	$1,041	$3,279	$7,553	$23,629	$5,753

Table 8: Average severity by 2017–18 Nissan Rogue collision claims by claim size and features

As found in previous HLDI studies of ADAS, BSW with RCTA and AVM with MOD significantly reduced claim frequency under different coverage types. The 5 percent and 11 percent reductions in collision and PDL claim frequency associated with the Nissan Rogue's BSW and RCTA systems were larger than the 1.5 and 7 percent reductions observed for these coverage types observed in previous HLDI (2018b) studies of ADAS, and so was the 17 percent reduction in BI liability coverage. The 6 percent reduction in PDL claim frequency observed for AVM with MOD was similar to the 7 percent reduction in PDL claim frequency observed for Audi's surround view camera (HLDI, 2018a). AVM with MOD significantly reduced claim frequency under each injury coverage, but the confidence bounds for these effects were large so these effects may change as the data mature.

Limitations

ADAS and driving automation technology can only affect insurance losses if the technology is used by drivers. Many ADAS systems, like FCW and automatic emergency braking, are enabled at ignition or are left on by drivers (Reagan, Cicchino, Kerfoot, & Weast, 2018). In contrast, the use of driving automation technologies like Intelligent Cruise Control and ProPILOT Assist is discretionary, and drivers mostly use Level 1 and Level 2 driving automation technology on limited-access freeways and highways (Reagan et al., 2019). Hence, driving automation technology like the ones examined in this study may only act on a limited population of crashes that result in insurance losses, which suggests that the actual effect of Intelligent Cruise Control and ProPILOT Assist on insurance losses may be much greater than the effect observed in this study.

The data supplied to HLDI do not include detailed crash information. Information on point of impact is limited and information on the vehicle's transmission status and the status of ADAS or driving automation technology at the time of loss is not available. The technologies in this study target specific crash types. For example, FEB is designed to prevent front-to-rear crashes while AVM is designed to prevent low-speed collisions that typically occur during backing. All collisions, regardless of the ability of a feature to mitigate or prevent a crash and a subsequent insurance claim, were included in the analysis and may have obscured the effects that a given feature had on the relevant crash population and associated insurance loss.

Finally, data were relatively sparse for vehicles with Intelligent Cruise Control or ProPILOT Assist. Consequently, the confidence bounds were large for many of the effects (e.g., ProPILOT Assist and BI liability claim frequency). This analysis will be repeated and expanded as the data mature in order to better understand how these systems are affecting insurance losses.

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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	-8.4720		0.0326	-8.5359	-8.4081	67520.70	
Calendar year	2016	1	-1.3889	-75.1%	0.2042	-1.7893	-0.9885	46.23	<0.0001
	2017	1	0.0273	2.8%	0.0140	-0.0001	0.0549	3.79	0.0516
	2019	1	-0.0537	-5.2%	0.0119	-0.0771	-0.0304	20.42	<0.0001
	2018	0							
Vehicle model year and series	2017 ROGUE 4D 2WD	1	0.0297	3.0%	0.0210	-0.0114	0.0708	2.00	0.1571
	2018 ROGUE 4D 2WD	1	-0.0248	-2.4%	0.0303	-0.0843	0.0347	0.67	0.4140
	2018 ROGUE 4D 4WD	1	-0.0319	-3.1%	0.0237	-0.0784	0.0145	1.82	0.1778
	2017 ROGUE 4D 4WD	0							
Rated driver age group	14–24	1	0.1471	15.8%	0.0258	0.0964	0.1977	32.41	<0.0001
	25–29	1	0.0881	9.2%	0.0217	0.0455	0.1307	16.43	0.0001
	30–39	1	0.0200	2.0%	0.0179	-0.0151	0.0552	1.25	0.2632
	50–59	1	-0.0322	-3.2%	0.0181	-0.0678	0.0033	3.15	0.0760
	60–64	1	-0.0403	-3.9%	0.0225	-0.0845	0.0038	3.19	0.0739
	65–69	1	0.0308	3.1%	0.0235	-0.0152	0.0770	1.72	0.1895
	70+	1	0.1210	12.9%	0.0210	0.0798	0.1623	33.08	<0.0001
	Unknown	1	-0.0233	-2.3%	0.0430	-0.1077	0.0611	0.29	0.5885
	40–49	0							
Rated driver gender	Male	1	-0.0315	-3.1%	0.0115	-0.0540	-0.0089	7.49	0.0062
	Unknown	1	-0.1678	-15.4%	0.0509	-0.2677	-0.0678	10.83	0.0010
	Female	0							
Rated driver marital status	Single	1	0.1886	20.8%	0.0116	0.1658	0.2115	262.08	<0.0001
	Unknown	1	0.2218	24.8%	0.0482	0.1272	0.3164	21.13	<0.0001
	Married	0							
Risk	Nonstandard	1	0.2703	31.0%	0.0253	0.2205	0.3200	113.46	<0.0001
	Standard	0							
State	Alabama	1	0.1251	13.3%	0.0509	0.0252	0.2249	6.03	0.0141
	Alaska	1	0.1802	19.7%	0.1817	-0.1759	0.5365	0.98	0.3212
	Arizona	1	0.1911	21.1%	0.0468	0.0992	0.2829	16.64	<0.0001
	Arkansas	1	0.0641	6.6%	0.0758	-0.0845	0.2128	0.71	0.3979
	California	1	0.3319	39.4%	0.0266	0.2797	0.3841	155.54	<0.0001
	Colorado	1	0.2154	24.0%	0.0516	0.1142	0.3166	17.42	<0.0001
	Connecticut	1	0.0063	0.6%	0.0449	-0.0816	0.0944	0.02	0.8868
	Delaware	1	0.0627	6.5%	0.0876	-0.1089	0.2344	0.51	0.4738
	Dist of Columbia	1	0.6607	93.6%	0.1238	0.4180	0.9034	28.47	<0.0001
	Florida	1	-0.0914	-8.7%	0.0258	-0.1421	-0.0406	12.47	0.0004
	Georgia	1	0.0426	4.4%	0.0369	-0.0297	0.1151	1.33	0.2481
	Hawaii	1	0.0877	9.2%	0.0936	-0.0957	0.2712	0.88	0.3486
	Idaho	1	0.0653	6.7%	0.1194	-0.1687	0.2994	0.30	0.5843
	Illinois	1	0.0862	9.0%	0.0368	0.0140	0.1583	5.49	0.0192
	Indiana	1	0.0935	9.8%	0.0590	-0.0221	0.2091	2.51	0.1131

Appendix: Illustrative regression results — collision frequency									
Parameter		**Degrees of freedom**	**Estimate**	**Effect**	**Standard error**	**Wald 95% confidence limits**		**Chi-square**	**P-value**
	Iowa	1	0.0395	4.0%	0.0751	-0.1077	0.1867	0.28	0.5991
	Kansas	1	-0.0354	-3.5%	0.0924	-0.2165	0.1456	0.15	0.7011
	Kentucky	1	-0.1307	-12.3%	0.0654	-0.2589	-0.0025	4.00	0.0455
	Louisiana	1	0.2159	24.1%	0.0468	0.1241	0.3077	21.27	<0.0001
	Maine	1	0.1034	10.9%	0.0789	-0.0513	0.2582	1.72	0.1903
	Maryland	1	0.3432	40.9%	0.0430	0.2589	0.4275	63.66	<0.0001
	Massachusetts	1	0.5908	80.5%	0.0416	0.5091	0.6725	200.98	<0.0001
	Michigan	1	0.3960	48.6%	0.0482	0.3015	0.4905	67.46	<0.0001
	Minnesota	1	0.0466	4.8%	0.0531	-0.0575	0.1507	0.77	0.3803
	Mississippi	1	0.2036	22.6%	0.0700	0.0663	0.3408	8.45	0.0037
	Missouri	1	-0.0178	-1.8%	0.0555	-0.1266	0.0909	0.10	0.7477
	Montana	1	0.0001	0.0%	0.1578	-0.3092	0.3096	0.00	0.9991
	Nebraska	1	-0.0587	-5.7%	0.0846	-0.2246	0.1072	0.48	0.4881
	Nevada	1	0.1854	20.4%	0.0632	0.0615	0.3093	8.60	0.0034
	New Hampshire	1	0.2794	32.2%	0.0631	0.1557	0.4032	19.60	<0.0001
	New Jersey	1	0.0353	3.6%	0.0339	-0.0311	0.1018	1.09	0.2972
	New Mexico	1	0.2134	23.8%	0.0880	0.0409	0.3859	5.88	0.0153
	New York	1	0.2137	23.8%	0.0298	0.1552	0.2722	51.36	<0.0001
	North Carolina	1	-0.1144	-10.8%	0.0427	-0.1983	-0.0306	7.16	0.0074
	North Dakota	1	0.3370	40.1%	0.1408	0.0610	0.6130	5.73	0.0167
	Ohio	1	-0.0611	-5.9%	0.0390	-0.1377	0.0154	2.45	0.1176
	Oklahoma	1	0.0283	2.9%	0.0667	-0.1024	0.1591	0.18	0.6710
	Oregon	1	0.0872	9.1%	0.0692	-0.0485	0.2230	1.59	0.2078
	Pennsylvania	1	0.2334	26.3%	0.0335	0.1677	0.2992	48.45	<0.0001
	Rhode Island	1	0.1114	11.8%	0.0849	-0.0550	0.2779	1.72	0.1894
	South Carolina	1	-0.0165	-1.6%	0.0516	-0.1177	0.0847	0.10	0.7494
	South Dakota	1	0.1016	10.7%	0.1847	-0.2605	0.4637	0.30	0.5824
	Tennessee	1	0.1406	15.1%	0.0389	0.0642	0.2170	13.02	0.0003
	Utah	1	-0.0385	-3.8%	0.0727	-0.1810	0.1039	0.28	0.5957
	Vermont	1	-0.0517	-5.0%	0.1344	-0.3153	0.2118	0.15	0.7004
	Virginia	1	0.1210	12.9%	0.0391	0.0442	0.1978	9.55	0.0020
	Washington	1	0.1272	13.6%	0.0520	0.0253	0.2291	5.99	0.0144
	West Virginia	1	0.0796	8.3%	0.0871	-0.0912	0.2505	0.83	0.3611
	Wisconsin	1	-0.0442	-4.3%	0.0611	-0.1640	0.0755	0.52	0.4691
	Wyoming	1	-0.1731	-15.9%	0.2107	-0.5863	0.2399	0.67	0.4114
	Texas	0							
Deductible range	0–250	1	0.1101	11.6%	0.0140	0.0827	0.1376	61.90	<0.0001
	1001+	1	-0.4834	-38.3%	0.0771	-0.6345	-0.3323	39.31	<0.0001
	501–1000	1	-0.1578	-14.6%	0.0148	-0.1869	-0.1287	113.16	<0.0001
	251–500	0							
Registered vehicle density	0–99	1	-0.2916	-25.3%	0.0193	-0.3296	-0.2537	227.11	<0.0001
	100–499	1	-0.1784	-16.3%	0.0131	-0.2041	-0.1527	185.13	<0.0001
	500+	0							

Appendix: Illustrative regression results — collision frequency								
Parameter	Degrees of freedom	Estimate	Effect	Standard error	Wald 95% confidence limits		Chi-square	P-value
Around View Monitor / Moving Object Detection	1	-0.0189	-1.9%	0.0165	-0.0514	0.0134	1.31	0.2518
Blind Spot Warning / Rear Cross-Traffic Alert	1	-0.0486	-4.7%	0.015	-0.0781	-0.0191	10.44	0.0012
Forward Emergency Braking	1	-0.0201	-2.0%	0.0195	-0.0585	0.0181	1.07	0.3019
Intelligent Cruise Control	1	0.0189	1.9%	0.0215	-0.0232	0.0610	0.77	0.3793
ProPILOT Assist	1	-0.0110	-1.1%	0.0417	-0.0929	0.0707	0.07	0.7907

HLDI
Highway Loss Data Institute

4121 Wilson Boulevard, 6th floor
Arlington, VA 22203
+1 703 247 1500
iihs-hldi.org

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