

TRANSPORT FINDINGS

Advanced Driver Assistance Systems in Top-Selling Vehicles in the United States: Cost, Vehicle Type, and Trim Level Disparities

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Keywords: ADAS, blind spot detection, automatic emergency braking, forward collision warning, automakers, driver assistance

<https://doi.org/10.32866/001c.38291>

Findings

How are driver assistance technologies available and priced across different vehicle models and trim levels? This study examines the availability of blind spot detection, automatic emergency braking, and forward collision warning on the top-selling passenger vehicles in the United States. We found that these technologies are not uniformly available and safety features are less likely to occur on base models or less-expensive trim packages, particularly of larger vehicles and among US versus international automakers. This represents a cause for concern due to the greater dangers posed by SUVs and light duty trucks and their popularity in the United States.

1. Questions

Automated vehicle technologies vary from simple alerts to partially automated driving tasks that are increasingly available in today's vehicles. Advanced driver assistance systems (ADAS) seek to alert a driver to critical events (e.g., forward collision warning) or even intervene (e.g., emergency braking, lane-keeping steering) to prevent crashes (NHTSA n.d.); however, they are not available equally across the passenger vehicle fleet (Voelk 2020). Forward collision warning systems and blind spot detection are highly effective when used properly and can reduce crashes by 20-30 percent for forward collision warning and as much as 50 percent with automatic emergency braking (Cicchino 2017). These systems also increase safety for pedestrians and bicyclists (Combs et al. 2019), who are at particular risk from larger vehicles like SUVs, vans, and pickup trucks (Hu and Cicchino 2018).

Despite evidence for significant safety gains from assistance technologies (Furlan et al. 2020; Wang et al. 2020), only automatic emergency braking (AEB) has recently received regulatory attention as a mandated technology (LaForest 2022). So far, however, AEB remains a voluntary technology that is rated but not required in New Car Assessment Programs (NCAP) in the US, Europe, and Asia (Euro NCAP n.d.; Japan NCAP n.d.; NHTSA n.d.). ADAS features are named, packaged, and offered differently by each manufacturer (NHTSA 2021) and not necessarily emphasized for safety. For example, Ford's description of their Co-Pilot 360 Ford Driver Assist Technologies: "In an increasingly crowded and distracted world, we can all use more confidence on the road. Introducing a suite of features to help keep you in command, from the driveway to the highway" (Ford Motor Company n.d.)

Several journalists have drawn attention to the issue of ADAS pricing or disparate availability (Atiyeh 2016; Preston 2020; Zipper 2020), but this study directly examines how ADAS availability varies by model and trim on the most popular vehicles. We conducted an inventory of the top selling models in the United States to determine the presence of blind spot detection (BSD), automatic emergency braking (AEB), and forward collision warning (FCW) by vehicle type, model, and trim package.

2. Methods

We collected data for the ten of the largest US, Asian, and European automakers and their top five selling models in the United States, including each major body type and their trim levels for model year 2021 ([Table 1](#)). Two of the three US manufacturers did not have a car in their top five selling models, while six of the seven largest international automakers either do not have a truck in their top-selling models or do not offer a truck.

We created an inventory of the following variables: body type (car, SUV, truck, van); trim level (e.g., base model, upgraded trims); cost (manufacturer's suggested retail price), and three common advanced driver assistance systems: blind spot detection (BSD), automatic emergency braking (AEB), and forward collision warning (FCW). Each model is available with different "trims," which refers to the different versions of a model, where "higher" trim levels include additional convenience, aesthetic, safety, and functional equipment in a variety of bundled packages. The final sample resulted in 290 combinations of make, model, vehicle type, and trim ([Table 2](#)).

3. Findings

Costs of ADAS by vehicle type and automaker

For every body type, the availability of each of the three safety-related features significantly increased the Manufacturer's Suggested Retail Price (MSRP) ([Figure 1](#)).

Table 1. Make, model, and vehicle types in study sample

Make	Car	SUV	Truck
US Manufacturers			
Ford	Fusion	Escape; Explorer	F-150; Transit Connect (van)
Jeep	---	Compass; Cherokee; Grand Cherokee; Wrangler	Gladiator
Chevrolet	---	Equinox; Traverse; Blazer; Trax	Silverado
International (Japanese, South Korean, and German manufacturers)			
Honda	Civic; Accord	CR-V; Pilot; HR-V	---
Hyundai	Elantra; Sonata	Palisade; Tucson; Santa Fe	---
Kia	Soul; Forte	Sorento; Telluride; Sportage	---
Mercedes	CLS-Class; C-Class	GLC-Class; GLE-Class; GLA-Class	---
Nissan	Altima; Sentra	Rogue; Kicks; Murano	---
Subaru	Impreza	Outback; Crosstrek; Ascent	---
Toyota	Corolla; Camry	RAV4; Highlander	Tacoma

*Data collected directly from automaker websites, Edmunds, and Car & Driver's "Makes & Models" database.

Table 2. Sample characteristics by vehicle type

	Car	SUV	Truck	Van	Total
Percent of sample (n)	26.9% (78)	54.5% (158)	16.9% (49)	1.7% (5)	100% (290)
Model/trim combinations with BSD	76.9% (60)	87.3% (138)	53.1% (26)	60% (3)	78.3% (227)
Model/trim combinations with AEB	70.5% (55)	65.8% (104)	77.6% (38)	100% (5)	69.7% (202)
Model/trim combinations with FCW	79.5% (62)	74.1% (117)	81.6% (40)	100% (5)	77.2% (224)
US automaker	4.3% (4)	59.1% (55)	31.2% (29)	5.4% (5)	32.1% (93)
International automaker	37.6% (74)	52.3% (103)	10.2% (20)	0% (0)	67.9% (197)

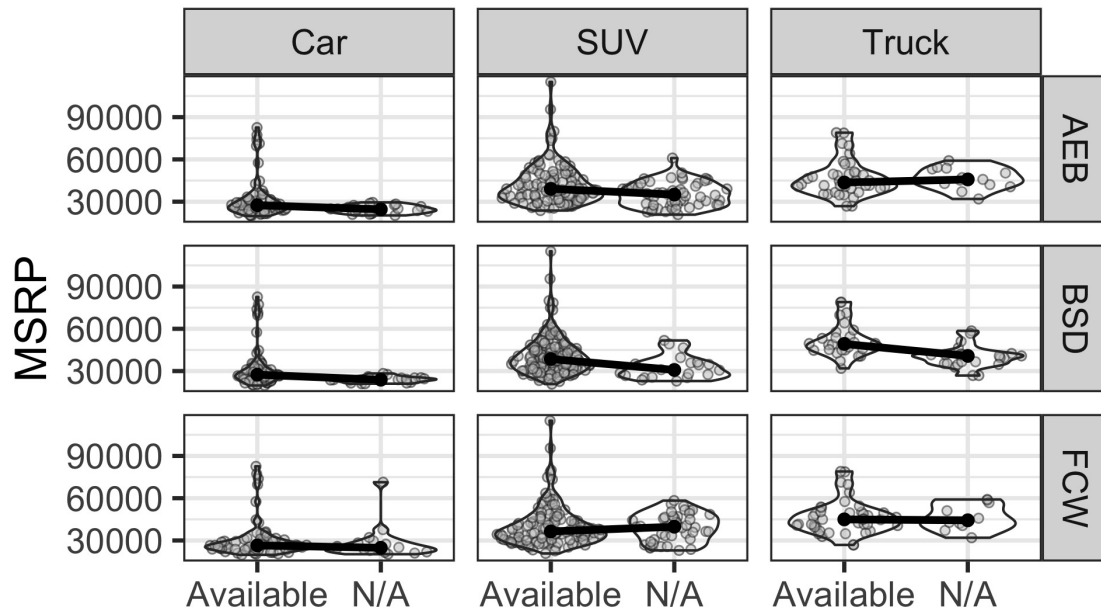


Figure 1. Violin and sinaplots of MSRP by vehicle body type and availability of ADAS technologies (Automated Emergency Braking (AEB), Blind Spot Detection (BSD), and Forward Collision Warning (FCW)).

The grey circles show the MSRP for each model/trim combination. The black lines show median price differences between vehicles with/without the tech.

Cost differences were also correlated with automaker. The MSRP of the top-selling international vehicles ($M=\$35,560$, $SD=\$13,470$) were significantly lower than US vehicles ($M=\$44,260$, $SD=\$13,460$), ($F(1,296)=27.7$, $p<.001$). This corresponds to the top selling US models being more likely to be larger, more expensive vehicle types than the international models ($X^2(3)=53.66$, $p<.001$).

ADAS by body type, trim level, and US versus international automaker

One-fifth to one-quarter of the top-selling model/trim combinations of all body types did not have forward collision warning or automatic emergency braking equipped. Although the difference was not statistically significant between body types, SUVs were less likely than cars or trucks to have either crash-avoidance feature ([Figure 2](#)).

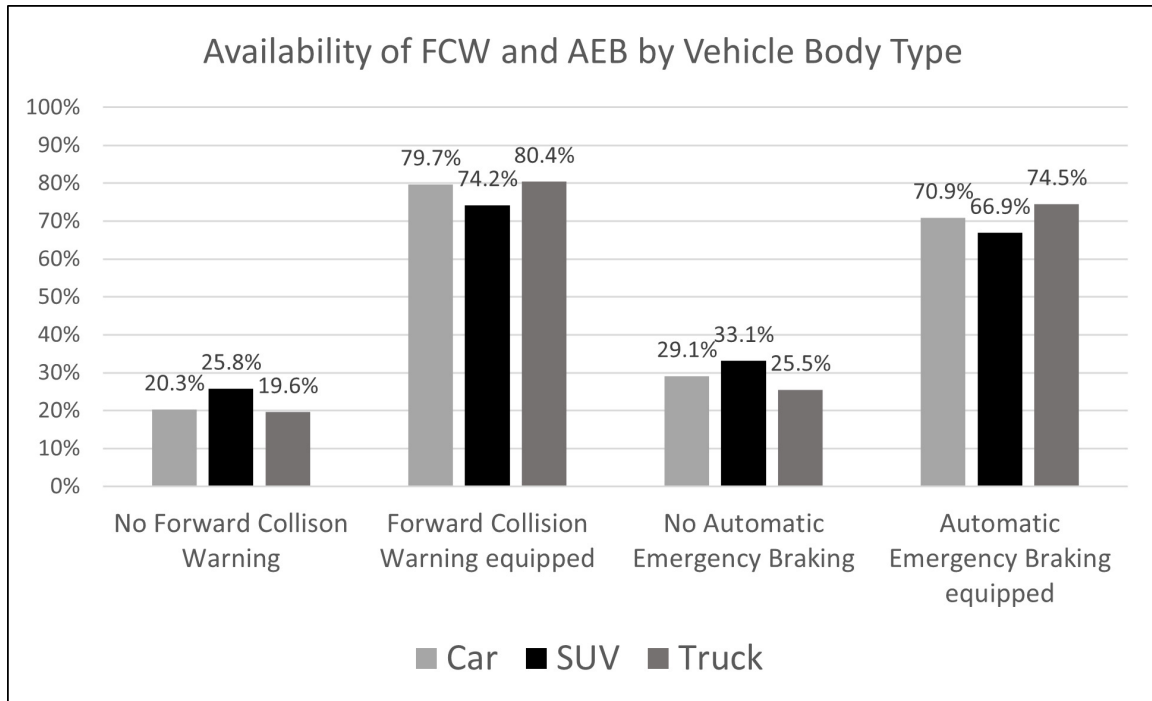


Figure 2. Availability of Forward Collision Warning (FCW) and Automatic Emergency Braking (AEB) by Vehicle Body Type

The top-selling vehicles from international automakers were significantly more likely than vehicles from the US automaker companies to have forward collision warning ([Figure 3](#)). This was largely driven by the difference in SUVs, where 80 percent of international models had FCW available, while only 65 percent of top-selling US SUVs had that feature. One hundred percent of the international truck model/trim combinations ($n=20$) had AEB and FCW, versus US trucks in the sample ($n=31$), of which only 58 percent had AEB, and 68 percent had FCW.

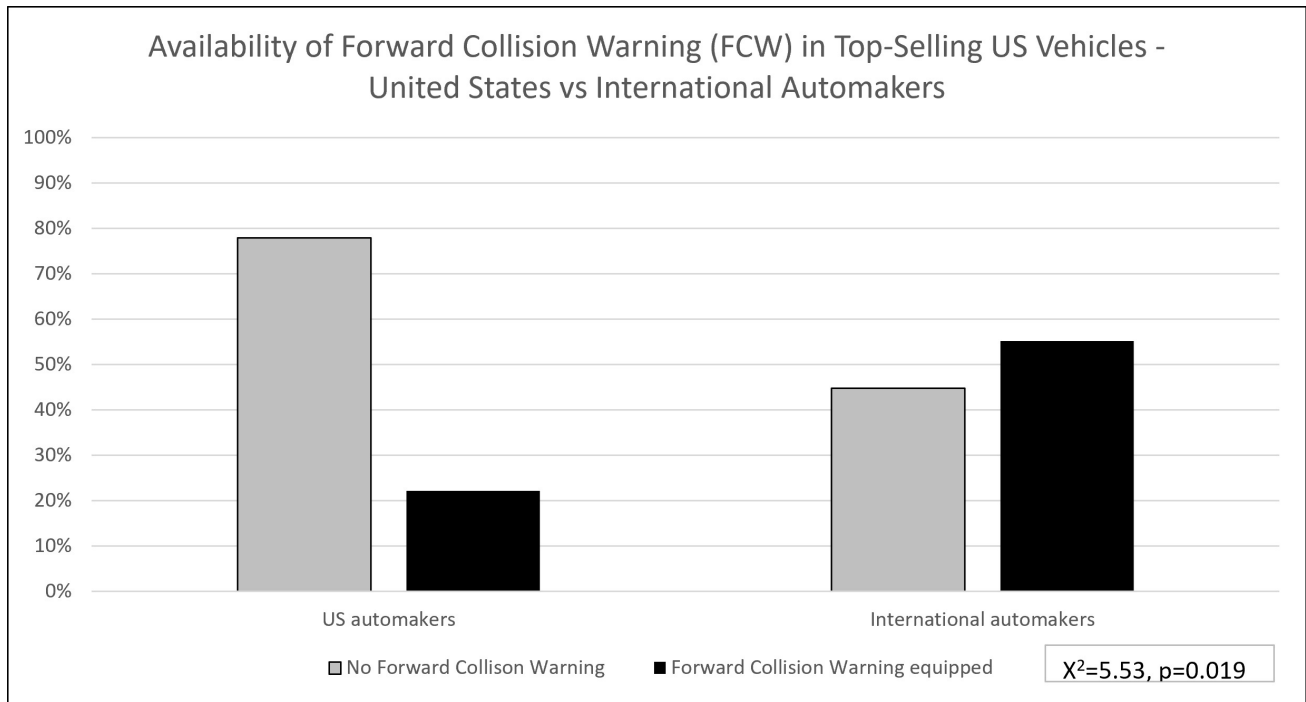


Figure 3. Availability of Forward Collision Warning (FCW) on US and International Automakers' Top-Selling US Models

As trim level is an ordinal variable, we used a Kruskal-Wallis H test (i.e., ANOVA on ranks), which showed each ADAS feature was significantly more likely on a higher trim level (BSD $X^2(1) = 40.98, p < .001$; AEB $X^2(1) = 5.36, p = .021$; FCW $X^2(1) = 4.97, p = .026$). It was not possible to find reliable, uniform data on the precise price differences between trim levels for each model; for the models in this study, trim packages that included one or more ADAS ranged from \$750-\$2295 USD. Because MSRP increases with trim level and ADAS are more likely to occur on higher trims, these safety technologies add to the cost of a vehicle for the consumer.

Because ADAS is more likely to be present on more expensive trim packages of new cars, consumers may be literally priced out of safety-related assistance technologies and their potential life-saving benefits. Even consumers who might be able to afford the additional expense to opt into these technologies may not choose to, if those technologies are seen as a luxury rather than a necessity or are packaged with unwanted upgrades, thus limiting their widespread consumer use and potential for wide-reaching safety improvements. The continuing popularity and increased danger posed by larger vehicles like SUVs warrants particular attention to increase the presence of these crash-avoidance technologies.

Acknowledgements

Support for this research was provided in part by a grant from the U.S. Department of Transportation, University Transportation Centers Program to the Safety through Disruption University Transportation Center

(69A3551747115). CRediT author statement: Tara Goddard: Conceptualization, Methodology, Formal analysis, Writing-original draft preparation, Writing - Review & Editing, Supervision, Project administration, Funding acquisition. Anthony McDonald: Methodology, Formal analysis, Writing - Review & Editing, Supervision. Ran Wei: Investigation/Data collection, Supervision. Divij Batra: Investigation/Data collection, Formal analysis.

Submitted: July 15, 2022 AEST, Accepted: September 13, 2022 AEST



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REFERENCES

- Atiyeh, C. 2016. "Safety For Some: Are Electronic Driver Assists Really for Everyone?" *Car and Driver*, May 20, 2016. <https://www.caranddriver.com/news/a15347301/safety-for-some-are-electronic-driver-assists-really-for-everyone>.
- Car and Driver Magazine. n.d. "Makes & Models." Car and Driver. Accessed July 13, 2022. <https://www.caranddriver.com/>.
- Cicchino, Jessica B. 2017. "Effectiveness of Forward Collision Warning and Autonomous Emergency Braking Systems in Reducing Front-to-Rear Crash Rates." *Accident Analysis & Prevention* 99: 142–52. <https://doi.org/10.1016/j.aap.2016.11.009>.
- Combs, Tabitha S., Laura S. Sandt, Michael P. Clamann, and Noreen C. McDonald. 2019. "Automated Vehicles and Pedestrian Safety: Exploring the Promise and Limits of Pedestrian Detection." *American Journal of Preventive Medicine* 56 (1): 1–7. <https://doi.org/10.1016/j.amepre.2018.06.024>.
- Edmunds. n.d. "New Cars, Used Cars, Car Reviews and Pricing." Edmunds. Accessed July 13, 2022. <https://www.edmunds.com>.
- Euro NCAP. n.d. "The Ratings Explained | Euro NCAP." Accessed September 3, 2022. <https://www.euroncap.com:443/en/vehicle-safety/the-ratings-explained/>.
- Ford Motor Company. n.d. "Ford® Driver Assist Technologies | Ford Co-Pilot 360™." Ford Motor Company. Accessed July 13, 2022. <https://www.ford.com/technology/driver-assist-technology/>.
- Furlan, Andrea D., Tara Kajaks, Margaret Tiong, Martin Lavallière, Jennifer L. Campos, Jessica Babineau, Shabnam Haghzare, Tracey Ma, and Brenda Vrkljan. 2020. "Advanced Vehicle Technologies and Road Safety: A Scoping Review of the Evidence." *Accident Analysis & Prevention* 147 (November): 105741. <https://doi.org/10.1016/j.aap.2020.105741>.
- Hu, W., and J.B. Cicchino. 2018. *An Examination of the Increases in Pedestrian Motor Vehicle Crash Fatalities during 2009-16*. Insurance Institute for Highway Safety.
- Japan NCAP. n.d. "Information of Japan New Car Assessment Program | National Agency for Automotive Safety & Victim's Aid." Accessed September 3, 2022. <https://www.nasva.go.jp/mamoru/en/about/about.html#01>.
- LaForest, A. 2022. "NHTSA Chief: Rule on Braking Tech Could Have 'Huge Benefit.'" *Automotive News*. July 8, 2022. <https://www.autonews.com/executives/nhtsa-chief-steven-cliff-rule-braking-tech-could-have-huge-benefit>.
- NHTSA. 2021. "Driver Assistance Technologies." May 16, 2021. <https://www.nhtsa.gov/equipment/driver-assistance-technologies>.
- . n.d. "Automated Vehicles for Safety | NHTSA." Text. Accessed July 13, 2022a. <https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety>.
- . n.d. "Ratings | NHTSA." Text. Accessed September 3, 2022b. <https://www.nhtsa.gov/ratings>.
- Preston, B. 2020. "The Hidden Cost of Car Safety Features." *Consumer Reports*. January 30, 2020. <https://www.consumerreports.org/car-repair/the-hidden-cost-of-car-safety-features/>.
- Voelk, Tom. 2020. "New Safety Features in Cars (or Just New to You)." *The New York Times*, October 2, 2020. <https://www.nytimes.com/2020/10/08/business/new-car-safety-features.html>.
- Wang, Ling, Hao Zhong, Wanjing Ma, Mohamed Abdel-Aty, and Juneyoung Park. 2020. "How Many Crashes Can Connected Vehicle and Automated Vehicle Technologies Prevent: A Meta-Analysis." *Accident Analysis & Prevention* 136 (March): 105299. <https://doi.org/10.1016/j.aap.2019.105299>.

Zipper, D. 2020. "The Life-Saving Car Technology No One Wants." Bloomberg.Com. August 12, 2020. <https://www.bloomberg.com/news/features/2020-08-12/why-are-cars-still-so-dangerous-to-pedestrians>.