2019

Autonomous Vehicles, Technological Progress, and the Scope Problem in Products Liability

Alexander Lemann
Marquette University Law School, alexander.lemann@marquette.edu

Publication Information
Alexander B. Lemann, Autonomous Vehicles, Technological Progress, and the Scope Problem in Products Liability, 12 J. Tort. L. 157 (2019). https://doi.org/10.1515/jtl-2019-0029

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Abstract: Autonomous vehicles are widely expected to save tens of thousands of lives each year by making car crashes attributable to human error – currently the overwhelming majority of fatal crashes – a thing of the past. How the legal system should attribute responsibility for the (hopefully few) crashes autonomous vehicles cause is an open and hotly debated question.

Most tort scholars approach this question by asking what liability rule is most likely to achieve the desired policy outcome: promoting the adoption of this lifesaving technology without destroying manufacturers' incentives to optimize it. This approach has led to a wide range of proposals, many of which suggest replacing standard rules of products liability with some new system crafted specifically for autonomous vehicles and creating immunity or absolute liability or something in between.

But, I argue, the relative safety of autonomous vehicles should not be relevant in determining whether and in what ways manufacturers are held liable for their crashes. The history of products liability litigation over motor vehicle design shows that the tort system has been hesitant to indulge in such comparisons, as it generally declines both to impose liability on older, more dangerous cars simply because they lack the latest safety features and to grant immunity to newer, safer cars simply because of their superior aggregate performance. These are instances in which products liability law fails to promote efficient outcomes and instead provides redress for those who have been wronged by defective products.

Applying these ideas to the four fatalities that have so far been caused by autonomous vehicles suggests that just as conventional vehicles should not be considered defective in relying on a human driver, autonomous vehicles should not be immune when their defects cause injury.

Keywords: autonomous vehicles, Products Liability, products liability litigation, tort law

***Corresponding author: Alexander B. Lemann,** Assistant Professor of Law, Marquette University Law School, Milwaukee 53201 WI, USA, E-mail: Alexander.Lemann@marquette.edu

Introduction

Car crashes are the leading cause of death for Americans aged 18 to 24, and they kill roughly 40,000 people every year. The vast majority of those deaths – about 94%, by one estimate – are caused by one or another form of human error,[1] a seemingly intractable problem. By either supplanting or complementing human driving with automated features that are capable of controlling various aspects of the driving task, autonomous vehicles will someday eliminate virtually all of these crashes, ushering in a new world of safety and convenience.

Despite the fact that fully autonomous vehicles[2] are not yet commercially available, their development has already attracted enormous attention. To many commentators, automobile accidents caused by autonomous vehicles will raise new problems for our system of tort law. These problems, it is thought, chiefly concern whether, to what degree, and by what standards manufacturers of autonomous vehicles will be liable for car crashes. This is a subject of great import not just for the manufacturers themselves but for society as a whole, given the shared interest in hastening the adoption of such potentially life-saving technology.

Almost all of the scholarly literature on autonomous vehicles adopts as a major premise the idea that autonomous vehicles will be significantly safer than traditional vehicles. This helps frame as a problem the possibility that autonomous vehicle manufacturers will be liable to their customers for whatever crashes they cannot eliminate. A second major premise of the scholarly literature is that the machine learning algorithms[3] that make up the heart (or, perhaps more appropriately, the brain) of autonomous vehicles will exhibit behavior that is inscrutable and thus not possible to describe as defective. For

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1 Santokh Singh, NHTSA, DOT HS 812 115, Critical Reasons for Crashes Investigated in the National Motor Vehicle Crash Causation Survey 1 (2015), *available at*: https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812115.

2 "Fully" or "highly" autonomous vehicles are designed to perform all aspects of the driving task, in contrast to low-level automation features like antilock brakes and cruise control that are only designed to perform discrete tasks in certain situations. *See* U.S. Department of Transportation, *Automated Vehicles 3.0: Preparing for the Future of Transportation* vi (2018), https://www.transportation.gov/sites/dot.gov/files/docs/policy-initiatives/automated-vehicles/320711/preparing-future-transportation-automated-vehicle-30.pdf (last visited June 20, 2019).

3 Machine learning "refers to computer algorithms that are able to automatically 'learn' or improve in performance on some task over time" meaning that "the computer learns the 'rules' to guide its actions on its own, rather than having those rules pre-programmed by human programmers." Harry Surden & Mary-Anne Williams, *Technological Opacity, Predictability, and Self-Driving Cars*, 38 Cardozo L. Rev. 121, 147–48 (2016).

these reasons, many scholars propose wholly new systems for handling autonomous vehicle liability, from immunity to absolute liability in the form of compulsory insurance. There are reasons to be skeptical of both of these premises. As a statistical matter, highly autonomous vehicles will need to log orders of magnitude more miles before their safety record can be meaningfully compared with that of human drivers. It is also not clear that their behavior will be so opaque as to baffle any effort to apply existing tort concepts in evaluating it after it crashes.

More importantly, products liability law has always hesitated to evaluate the defectiveness of products by reference to other products (as opposed to alternative designs of the same product, a distinction that has always been blurry). With each of the incremental improvements that have cumulatively revolutionized automobile safety in the past half century, products liability has frequently declined to impose liability on manufacturers for their failure to include cutting edge safety technology and, conversely, has declined to immunize manufacturers of defective safety technology simply because it may still make cars safer overall than they once were. The way products liability law has defined defect in design cases, its hostility to category liability and requirement of a reasonable alternative design, and its treatment of custom evidence all suggest that autonomous vehicle manufacturers should not be immunized from liability for selling defective products just because they improve upon the frustratingly dismal performance of human drivers. Contrary to the majority of legal scholarship that has so far explored this issue, I argue that the relative safety of autonomous vehicles as compared with conventional ones should be irrelevant in evaluating their liability in tort.

This article begins by surveying the current state of autonomous vehicle development, with particular emphasis on the four fatalities that have so far been caused by cars operating autonomously. Part II.A then draws on the history of products liability cases involving the design of automobiles and argues that the tort system has traditionally evaluated automobile safety technology on its own merits, largely without reference to whether it makes cars safer in the aggregate than those that preceded them. Parts II.B and C then use these doctrinal lessons to argue that in these instances, tort law declines to impose liability in ways that would promote economic efficiency and instead provides redress to those who have been wrongfully injured by defective products. Finally, Part III applies these ideas to the four autonomous vehicle fatalities that have so far occurred, arguing that manufacturers in each case could plausibly be said to have sold defective products whose accidents should raise at least the possibility of liability.

I Factual background

A The current state of autonomous vehicle development

Highly autonomous vehicles have been imagined for decades, but only recently, thanks to advances in artificial intelligence programming, computing power, and sensor technology, have they been seen as anything other than a distant dream. The past decade has seen a wave of optimism and hubris surrounding the development of autonomous vehicles followed by a trough of pessimism and caution that arguably best characterizes the current moment. All along there have been two competing models for the development of autonomous vehicles, a "sea-change" model and a more gradual, "incremental" model.

1 The sea-change model

For the better part of the past decade, autonomous vehicles were thought to be a technology whose arrival could be expected imminently. Executives of companies working on autonomous vehicle development confidently predicted that autonomous vehicles would whisk us around cities by the year 2017[4] and built cars without pedals or steering wheels. In the press, think pieces and books explored the myriad implications of this new technology for urban land use, public transit systems, the energy grid, greenhouse gas emissions, the insurance industry, residential and commercial architecture, and virtually every other aspect of the modern economy and built environment.[5]

The sea-change model envisioned a leap from the traditional, primarily human-operated vehicles we know today to highly autonomous, futuristic vehicles operated chiefly or even exclusively by artificial intelligence. On the Society of Automotive Engineers' 5 level spectrum of autonomy, these vehicles represent Levels 4 and 5 automation, meaning that they are capable of handling the "driving task" without human oversight or attention, freeing human

4 Donna Tam, *Google's Sergey Brin: You'll ride in robot cars within 5 years*, CNET, https://www.cnet.com/news/googles-sergey-brin-youll-ride-in-robot-cars-within-5-years/ (last visited June 20, 2019).

5 *See, e.g.* AnnaLisa Meyboom & Lorinc Vass, Driverless urban futures: a speculative atlas for autonomous vehicles (2019); Samuel I. Schwartz & Karen Kelly, No one at the wheel: driverless cars and the road of the future (2018); Andreas Herrmann, Walter Brenner & Rupert Stadler, Autonomous driving: how the driverless revolution will change the world (2018).

passengers to do other things. (The difference between Level 4 and 5 automation is that Level 5 automation can be expected to work in "all conditions," whereas Level 4 only requires that the vehicle perform all driving functions under "certain conditions.")[6]

Several companies have made substantial bets on the sea-change model. Waymo, which began life in 2009 as a project within Google's X lab and became a standalone subsidiary in 2016, has always pursued this path, and is today widely considered to be the leader in the field. In 2014, Google revealed a fully functioning prototype autonomous vehicle called the Firefly that lacked a steering wheel and pedals, which it announced it would begin testing on public streets. More recently, Waymo has used standard vehicles retrofitted with sensors in a range of environments, from Arizona to Michigan. Most of this testing is overseen by a human driver who is capable of interrupting the computer program if necessary. Waymo also operates an autonomous taxi service in the Phoenix suburb of Chandler, Arizona. When the program was first announced, in November 2017, it was limited to a 100-square mile area and to pre-selected members of Waymo's "Early Rider" program.[7] The program, called Waymo One, now operates as a ride-hailing service in Tempe, Mesa, and Gilbert (in addition to Chandler), but it is still only available to about 1,000 pre-approved customers, although it has a list of "tens of thousands" waiting to join.[8]

Uber, too, has in a sense bet its future on achieving Level 4 or 5 automation within the next few years. After its highly anticipated initial public offering, the company has been under enormous pressure from the investing public to become profitable (it currently loses around a billion dollars a quarter).[9] One of its key strategies in this effort is eliminating the driver, to whom it currently pays a substantial portion of every fare.[10] To that end, Uber has been investing

6 U.S. Department of Transportation, *supra* note 2.

7 Andrew J. Hawkins, *Waymo is first to put fully self-driving cars on US roads without a safety driver*, The Verge (2017), https://www.theverge.com/2017/11/7/16615290/waymo-self-driving-safety-driver-chandler-autonomous (last visited June 20, 2019).

8 Alan Ohnsman, *Hand Gestures And Horses: Waymo's Self-Driving Service Learns To Woo The Public*, Forbes, 2019, https://www.forbes.com/sites/alanohnsman/2019/05/19/waymo-six-month-checkup-headway-on-hand-gestures-and-cops-on-slow-ride-to-self-driving-future/ (last visited June 20, 2019).

9 Eliot Brown, *Wall Street Isn't Buying What Silicon Valley Is Selling*, Wall St J., May 25, 2019, https://www.wsj.com/articles/wall-street-isnt-buying-what-silicon-valley-is-selling-11558756810 (last visited June 20, 2019).

10 Exactly how much of the fare is paid to drivers varies by region and even by individual ride. *See* Kathleen Pender, *How much of your fare goes to Uber and Lyft drivers? You'd be surprised*, S.F. Chron., May 9, 2019, https://www.sfchronicle.com/business/networth/article/For-a-driver-s-pay-what-s-fair-in-an-Uber-13830931.php (last visited August 14, 2019).

heavily in developing autonomous taxis much like those used by Waymo One. Uber suffered a significant setback when one of its autonomous vehicles struck and killed a pedestrian in March 2018, an event that will be discussed in greater detail below.[11]

The sea-change model excites the imagination. Although public opinion surveys routinely report that most of us are afraid to ride in a car driven by a robot,[12] many are eager to imagine the ways highly autonomous vehicles would change the world. Most obviously, autonomous driving would theoretically eliminate the majority of car accidents, saving tens of thousands of lives per year and preventing hundreds of thousands of injuries and their associated economic toll.[13] Without the fear of crashes, cars could be designed without things like crumple zones, seatbelts, and airbags, freeing designers to imagine living rooms (or even bedrooms) on wheels.[14] Time spent commuting by car could be just as productive as time spent at a desk. Driverless cars could also drive in closely packed "platoons," optimizing aerodynamics like Tour de France cyclists to improve fuel economy, reduce emissions, and increase the capacity of highways.[15]

11 *See infra* Part I.A.3.b. In addition to Waymo and Uber, a host of other companies are pursuing autonomous driving under the sea-change model, including Apple and Uber's chief rival, Lyft. Vindu Goel, *Apple Gets Permit to Test Self-Driving Cars in California*, N.Y. TIMES, April 14, 2017, https://www.nytimes.com/2017/04/14/technology/apple-self-driving-car-permit.html?searchResultPosition=1 (last visited September 4, 2019); Mike Isaac, *Playing Catch-Up to Uber on Self-Driving, Lyft Teams Up With Partners*, N.Y. TIMES, June 6, 2017, https://www.nytimes.com/2017/06/06/technology/lyft-self-driving-nutonomy-partnership.html (last visited September 4, 2019).

12 Keith Naughton, *Americans Still Fear Self-Driving Cars*, BLOOMBERG, March 13, 2019, https://www.bloomberg.com/news/articles/2019-03-14/americans-still-fear-self-driving-cars (last visited August 20, 2019).

13 See Jerry Albright et al., KPMG, *Marketplace of Change: Automobile Insurance in the Era of Autonomous Vehicles* 26 (October 2015), available at: https://assets.kpmg/content/dam/kpmg/pdf/2016/06/id-market-place-of-change-automobile-insurance-in-the-era-of-autonomous-vehicles.pdf (predicting 80 % potential reduction in accident frequency per vehicle); Michelle Bertoncello & Dominik Wee, McKinsey & Co., *Ten Ways Autonomous Driving Could Redefine the Automotive World* (June 2015) (predicting that widespread adoption of autonomous vehicles could eliminate up to 90 % of crashes); Bryant Walker Smith, *Automated Driving and Product Liability*, 2017 MICH. ST L. REV. 1, 15 (2017) ("Automated driving systems may avoid many of the errors . . . that contribute to some 94% of crashes.").

14 Vlad Savov, *Volvo's 360c concept car is a fully autonomous bedroom on wheels*, THE VERGE, 2018, https://www.theverge.com/2018/9/5/17822398/volvos-360c-concept-autonomous-car-electric-future (last visited August 20, 2019).

15 HERRMANN, BRENNER, AND STADLER, *supra* note 5, at 163–64.

Advocates imagine cities without parking lots, as the autonomous Uber that drove you to work would not need to wait outside for eight hours until it's time to head home.[16] This great liberation of urban land would help ameliorate the national housing crisis.[17] Even the airline industry is thought to be at risk.[18]

2 The incremental model

The feverish optimism of the sea-change model has more recently given way to a kind of glum practicality.[19] Executives are now more commonly heard expressing caution and asking for patience, and the idea of fully autonomous vehicles operating on a broad scale by 2020 now looks like a fantasy.[20] Indeed, when Elon Musk recently suggested that Tesla's dire financial situation would be ameliorated by the launch of a robo-taxi service in 2020,[21] he was met with ridicule.[22] Many experts now acknowledge that full autonomy could be "the

16 Meyboom and Vass, *supra* note 5, at 126–37.
17 Wolf Richter, *How self-driving cars could completely reshape the housing market*, Business Insider, 2017, https://www.businessinsider.com/self-driving-cars-effect-on-housing-market-2017-9 (last visited August 20, 2019).
18 Stephen Rice & Scott Winter, *Driverless cars are coming for the airlines*, Fast Company, June 10, 2019, https://www.fastcompany.com/90362158/autonomous-cars-are-coming-for-the-airlines (last visited August 14, 2019).
19 Lawrence Ulrich, *Driverless Cars May Be Coming, but Let's Not Get Carried Away*, The New York Times, June 21, 2019, https://www.nytimes.com/2019/06/20/business/self-driving-cars-cadillac-super-cruise.html (last visited June 21, 2019) (quoting director of Toyota Research Institute referring to "the current 'trough of disillusionment' in autonomy").
20 *Id.* ("[W]e've tried to turn down the hype and make people understand how hard this is."); Neal E. Boudette, *Despite High Hopes, Self-Driving Cars Are 'Way in the Future,'* N.Y. Times, July 17, 2019, https://www.nytimes.com/2019/07/17/business/self-driving-autonomous-cars.html (last visited July 17, 2019) ("Several carmakers and technology companies have concluded that making autonomous vehicles is going to be harder, slower and costlier than they thought.").
21 Dalvin Brown, *Elon Musk says Tesla owners could make $30,000 in robotaxi network*, USA Today, April 23, 2019, https://www.usatoday.com/story/tech/2019/04/23/elon-musk-says-tesla-owners-could-make-30-000-robotaxi-network/3549652002/ (last visited June 20, 2019).
22 Emily Stewart, *Tesla's 2020 self-driving car promise sounds too good to be true because it is*, Vox (2019), https://www.vox.com/2019/4/23/18513045/tesla-robotaxi-earnings-elon-musk (last visited June 20, 2019) (quoting experts referring to Musk's claims as "totally off-base" and "half baked"); Christopher Mims, *Self-Driving Cars Have a Problem: Safer Human-Driven Ones*, Wall Street Journal, June 15, 2019, https://www.wsj.com/articles/self-driving-cars-have-a-problem-safer-human-driven-ones-11560571203 (last visited June 15, 2019) (describing Musk's goal as "something few analysts believe is feasible").

hardest engineering problem in our time," one whose solution seems to require more effort the closer it gets.[23] In a lecture at MIT, Waymo's director of engineering said that although driverless cars were "90% done," they "still have 90% to go" because the first "90% of the technology takes 10% of the time."[24] Several recent analyses have predicted that only around 10% of vehicles will be fully autonomous by 2030.[25]

Recognizing these challenges, many companies have pursued a more incremental approach to autonomous driving.[26] Instead of pursuing a Level 4 or 5 autonomous vehicle without human controls, some manufacturers have developed standalone technologies designed to work in tandem with human drivers at Level 1 or 2 automation and often offered as optional features on high-end cars that are already being sold today.[27]

Cars have long included features properly characterized as somewhat autonomous. Anti-lock braking automatically modulates the application of brakes during sudden stops to prevent cars from skidding. Electronic stability control detects loss of traction from abrupt changes in direction and automatically applies brakes to one or more of the wheels as needed to correct the vehicle's course. Incremental development along these lines continues, and has gotten increasingly futuristic. Many cars now feature "automatic emergency braking," which monitors the road in front of the car and applies the brakes without any input from the driver when it detects an imminent collision. The Insurance Institute for Highway Safety estimates that automatic emergency braking reduces rear end crashes by 50% and crashes with injuries by 56%; the

23 John D. Stoll, *Driverless Cars Are 90% Here. Another 90% Is Left to Go.*, WALL STREET JOURNAL, May 24, 2019, https://www.wsj.com/articles/driverless-cars-are-90-here-theres-another-90-left-to-go-11558717322 (last visited June 15, 2019).

24 *Id.*; Stephen Wilmot, *The Long, Shared Road to Driverless Cars*, WALL STREET JOURNAL, March 18, 2019, https://www.wsj.com/articles/the-long-shared-road-to-driverless-cars-11552919131 (last visited June 21, 2019) (noting that "the arrival date of profit-generating self-driving vehicles keeps getting pushed back" and that "[s]elf-driving technology will be a drain on the resources of tech companies and car makers alike for the foreseeable future").

25 Mims, *supra* note 22.

26 Ulrich, *supra* note 19 (describing "growing consensus that driver-free transport will begin with a trickle, not a flood").

27 In Level 1 automation, the driver and the automated system share control of the vehicle. Classic examples include cruise control and lane keeping assistance, both of which are designed to augment rather than replace human driving. In Level 2 automation, the automated system takes full control of the vehicle, but the driver is expected to monitor the system's driving and be prepared to retake control at a moment's notice. U.S. DEPARTMENT OF TRANSPORTATION, *supra* note 2, at vi.

National Transportation Safety Board (NTSB) estimates that it can reduce fatalities and injuries resulting from rear-end crashes by 80%.[28]

Several carmakers are taking aim at distracted driving, which accounted for about 9% of traffic fatalities – 3,166 lives – in 2017.[29] Volvo plans to introduce cameras that monitor drivers' eyes and "send an alert or even limit a car's speed whenever its driver's eyes are averted for too long."[30] Subaru's similar system will beep if drivers' eyelids droop.[31] Cadillac's Super Cruise – available since 2017 on its luxury sedan – is an outlier.[32] Like several other high-end cars, the Cadillac can steer and modulate speed to keep the car in a lane at a safe distance from traffic in front.[33] What sets the Cadillac Super Cruise apart is its awareness of its own limitations. Unlike, notably, Tesla, Cadillac has designed the Super Cruise so that it cannot be activated unless it is on limited-access highways that Cadillac has already mapped at fine detail.[34] It also monitors its driver's eyes and issues warnings if the driver gets distracted.[35] With technologies like these, it is possible that manufacturers will be able to achieve many of the safety gains offered by autonomy without necessarily solving the much harder problem of eliminating the human driver altogether.

3 Autonomous crashes

Much of the early scholarship on autonomous vehicles dealt with the subject on an almost purely hypothetical basis. In addressing who would be liable in the event of an autonomous crash, scholars were forced to imagine how exactly such a crash could occur. There have now been four fatalities in the United States attributable at least in part to autonomous vehicles, all of which have

28 Mims, *supra* note 22. Thanks to a voluntary commitment by twenty auto makers, "nearly all" new cars in the U.S. will have automatic emergency braking by 2020. *Id.*

29 Adrienne Roberts, *Car Companies Sharpen Focus on Curbing Distracted Driving*, WALL STREET JOURNAL, June 15, 2019, https://www.wsj.com/articles/car-companies-sharpen-focus-on-curbing-distracted-driving-11560591000 (last visited June 15, 2019).

30 *Id.*

31 *Id.*

32 Patrick Olsen, *Cadillac Tops Tesla in Consumer Reports' First Ranking of Automated Driving Systems*, CONSUMER REPORTS, October 4, 2018, at 4.

33 *Id.* (describing systems developed by Volvo, Nissan, Cadillac, and Tesla).

34 *Id.*

35 *Id.*; Ulrich, *supra* note 19 (describing Cadillac's "digital disciplinarian that makes drivers sit straight and keep eyes up front").

helped shed light on the ways in which autonomous vehicles can kill and the liability issues that result.[36]

a *Tesla*

Three of the four fatal crashes involving autonomous vehicles have killed drivers of Teslas, all of whom were using a suite of features the company calls "Autopilot." The first of these, widely reported as the first autonomous vehicle fatality, occurred in Willison, Florida in May 2016 and attracted enormous media attention. The driver, Joshua Brown, was travelling along a highway at 74 miles per hour (the speed limit was 65) and was killed instantly when he collided head on with a tractor-trailer that was making a left turn across his path. The NTSB issued a 63-page report about the incident, which cast some blame on virtually every party involved.[37] As for the truck driver, the NTSB found that the Tesla was well within his line of sight when he initiated his left hand turn across the its path, and that he should he should have waited until there was no oncoming traffic.[38]

Untangling the responsibility of Tesla and Brown is substantially trickier, and requires a somewhat detailed understanding of how the Tesla's autonomous features are designed to work. Tesla's "Autopilot" consists of three related systems: "Traffic Aware Cruise Control," "Autosteer," and "Auto Lane Change."[39] Together, these features allow the car to maintain a desired speed, automatically slow down and speed up based on traffic conditions, and steer to maintain its position in its lane.[40] The Tesla also had a "Forward Collision Avoidance" system, which includes a forward collision warning designed to alert the driver to the need to brake, and automatic emergency braking, which is designed to brake without driver input.

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36 Autonomous vehicles have also been involved in a larger number of more minor crashes, most of which have not resulted in injury. I focus here on fatal crashes both because their factual record is more developed (thanks in large part to NTSB investigations) and because the liability issues surrounding fatal crashes are necessarily weightier.

37 National Transportation Safety Board, *Highway Accident Report: Collision Between a Car Operating With Automated Vehicle Control Systems and a Tractor-Semitrailer Truck Near Williston, Florida, May 7, 2016*, at 63 (2017).

38 *Id.* at 30. The Florida Highway Patrol cited the driver for failure to yield. *Id.* The truck driver also tested positive for THC, the active ingredient in marijuana, but the highway patrol noted that he exhibited no signs of impairment after the crash, and the NTSB noted that testing positive does not necessarily indicate intoxication. *Id.* at 31–32.

39 *Id.* at 9.

40 *Id.* The auto lane change feature allows the driver to tell the car to change lanes using the turn indicator, without using the steering wheel or interrupting the autosteer function. *Id.*

The Autopilot system is only supposed to be used in certain circumstances. According to the owner's manual, "autosteer is intended for use on freeways and highways where access is limited by entry and exit ramps" (the Federal Highway Administration refers to such roads as "limited-access roadways").[41] The manual also warned that Autosteer was only to be used "with a fully attentive driver" and insisted that "[y]ou must keep your hands on the steering wheel at all times."[42] The NTSB refers to instructions like these as "soft constraints."

Autopilot also included "hard constraints," programmed-in limits that could not be simply ignored by the driver. First, as a proxy for driver attentiveness, Tesla required that drivers' hands be on the steering wheel, which it detected by measuring torque applied to the wheel. If the car determined that the driver's hands were not on the wheel, it would trigger a series of warnings whose frequency varied depending on a complex set of circumstances including the straightness of the road.[43] First, the car would flash a visual alert. If the driver did not place his hands on the wheel within 15 seconds, a chime would sound, followed by a second chime 10 seconds later and finally, five seconds after that, a "final warning and slowdown."[44]

Another important hard constraint related to the car's determination of the speed limit of the road on which it was traveling. If the car cannot detect a speed limit, the adaptive cruise control cannot be set higher than 45 mph. If the car is on a "non-preferred roadway," it cannot be set to more than 5 mph above the speed limit. (One of the roads Brown used in the minutes before his death was "non-preferred" because it lacked a center divider.) Finally, if the car is on a "preferred roadway," it can be set to cruise at speeds up to 90 mph, regardless of the posted speed limit. The road on which Brown was killed was a preferred roadway because it had a grassy center median, even though it was not a limited-access road, meaning that it intersected with surface streets rather than on-ramps and drivers were sometimes permitted to make left turns across traffic.

Particularly significant is the divergence between the guidance Tesla gave in its owner's manual and the hard constraints it programmed into its system. While Tesla indicated that Autopilot was only to be used on limited-access highways, its system could be activated even on lesser roads with hazards like crossing traffic. The problem with this situation is particularly glaring in light of the NTSB's further evaluation of the automatic emergency braking and forward

41 *Id.* at 12–13. The manual also warned drivers that "Traffic Aware Cruise Control is primarily intended for driving on dry, straight roads, such as highways and freeways." *Id.* at 13.
42 *Id.*
43 *Id.* at 12.
44 *Id.* at 12.

collision warning systems, which a layperson might reasonably expect to be able to detect something as conspicuous as a tractor-trailer completely obstructing the road ahead. To the contrary, the NTSB explained, "Current Level 2 vehicle automation technologies cannot reliably identify and respond to crossing vehicle traffic."[45] Indeed, following the crash, the NTSB's Office of Defects Investigation determined that no car manufacturer at the time had a system that was designed to brake for "crossing path collisions" and that the Tesla system "was not designed to, and did not, identify the truck crossing the car's path or recognize the impending crash."[46] It therefore concluded that "there was no defect in the design of the Tesla crash avoidance and mitigation systems."[47]

On the other hand, the NTSB did not shy away from criticizing Tesla. In its report, the NTSB stressed the importance of the concept of "operational design domain" in autonomous vehicle development. As Tesla's user manual indicates, autonomous vehicles are designed to be able to operate only in certain conditions. Troublingly, while Tesla's "owner's manual stated that Autopilot should only be used in preferred road environments . . . Tesla did not automatically restrict the availability of Autopilot based on road classification," as indicated by the fact that Brown was able to use Autopilot on roads that were not limited-access, to tragic effect.[48] "Simply stated," the NTSB concluded, "the driver could use the Autopilot system on roads for which it was not intended to be used . . . . This situation allows the driver to activate automated systems in situations and circumstances for which their use is not appropriate or safe."[49]

A related problem is Tesla's method of ensuring that the driver is paying attention. Because Autopilot is a Level 2 automation system, it requires the driver to diligently monitor the road and be prepared to intervene at a moment's notice. This is simple but not easy. As the NTSB noted, "human drivers have cognitive limitations that make fulfilling this responsibility difficult because people . . . do not perform well on tasks requiring passive vigilance."[50] Requiring that the driver keep his hands on the steering wheel is a poor method of ensuring that he is paying attention, since what matters is that he is actually watching the road. Indeed, the internet is full of tips and tricks for how to defeat

45 *Id.* at 30.
46 *Id.* The NTSB noted that there was no indication, either on the road or in data from the car's electronic control unit, that either the car or the driver saw the truck and attempted to brake before the crash. *Id.* at 14–15, 28.
47 *Id.* at 31. The NTSB does not use the term "defect" in the same way it would be used by a court evaluating a products liability claim.
48 *Id.* at 33.
49 *Id.* at 33–34.
50 *Id.* at 34.

Tesla's system, the simplest of which is to prop a water bottle in the steering wheel.[51] As a result, the internet is also full of videos of people not paying attention while driving their Teslas.[52] The NTSB noted with approval that Cadillac's Super Cruise system directly monitors the driver's head position.[53]

Of course, Brown's conduct was not flawless. He was clearly not watching the road. The NTSB estimated that both he and the truck driver were visible to each other for about ten seconds before the crash, and yet Brown apparently never saw the truck he was hurtling towards.[54] Data from the car indicated that Brown repeatedly triggered the Autopilot's warning by taking his hands off the wheel in the minutes before the crash, only to silence the alarm by briefly replacing them. In fact, the vehicle's data showed that he had his hands on the wheel for only 25 seconds in the 37 minutes leading up to the crash.[55] The NTSB concluded that Brown "either did not know of or did not heed the guidance in the manual."[56] While the truck driver was widely quoted in the media after the crash as accusing Brown of watching a movie, the NTSB found no evidence to support his claim.[57]

The NTSB has not yet completed its full investigation of the second and third fatalities involving Tesla's Autopilot, but they raise similar issues. The second crash killed Walter Huang, a 38 year old Apple employee who had just dropped his children at school and was on his usual commute to work.[58] Huang was traveling on a limited-access highway with his adaptive cruise control set to 75 mph.[59] Because there was traffic in front of him, his car had slowed to 65 mph.[60] When

51 Rob Stumpf, *People Keep Coming Up With Simple Ways to Fool Tesla's Autopilot*, THE DRIVE, February 1, 2018, https://www.thedrive.com/sheetmetal/18168/people-keep-coming-up-with-ways-to-fool-teslas-autopilot (last visited August 14, 2019).

52 Faiz Siddiqui, *Tesla floats fully self-driving cars as soon as this year. Many are worried about what that will unleash.*, WASHINGTON POST, July 17, 2019, https://www.washingtonpost.com/technology/2019/07/17/tesla-floats-fully-self-driving-cars-soon-this-year-many-are-worried-about-what-that-will-unleash/ (last visited July 17, 2019) ("The Internet is filled with videos of Tesla drivers acting recklessly, in extreme cases taking naps or otherwise driving with their hands off the wheel as they marvel at the system.").

53 NATIONAL TRANSPORTATION SAFETY BOARD, *supra* note 37, at 34.

54 *Id.* at 29.

55 *Id.* at 35.

56 *Id.* at 36.

57 *Id.* at 17, 36.

58 Edvard Pettersson & Diana Hull, *Tesla Sued Over Fatal Crash Blamed on Autopilot Malfunction*, BLOOMBERG, May 1, 2019, https://www.bloomberg.com/news/articles/2019-05-01/tesla-sued-over-fatal-crash-blamed-on-autopilot-navigation-error (last visited June 25, 2019).

59 NATIONAL TRANSPORTATION SAFETY BOARD, *Preliminary Report: Highway HWY18FH011* (2018), https://www.ntsb.gov/investigations/AccidentReports/Reports/HWY18FH011-preliminary.pdf (last visited June 24, 2019).

60 *Id.* at 2.

the car in front moved out of the way, Huang's Tesla accelerated and then veered into a barrier between the main highway and an exit ramp.[61] Like Brown, Huang apparently was not watching the road in the minutes before the crash.[62] The NTSB's investigation is still ongoing; so far there is no indication of why the Tesla veered out of its lane and into the barrier.[63]

The final crash involving Autopilot occurred in March 2019 and killed Jeremy Banner in circumstances eerily similar to the Brown crash three years earlier. Banner was driving with autopilot engaged on a divided (but not limited-access) highway in Florida when his Tesla collided with a tractor-trailer that was turning left across his path.[64] The Tesla was travelling at 68 mph (the speed limit was 55 mph), and neither Banner nor the Autopilot system reacted to the truck in any way.[65] Banner was killed instantly.

b *Uber*

The fourth and – as of this writing – last fatality involving an autonomous vehicle occurred when an Uber that was undergoing testing of its autonomous

61 *Id.* The barrier was a "crash attenuator," a device designed to absorb energy from a collision by crumpling into itself. Unfortunately, it was damaged from a crash that occurred 10 days earlier and thus incapable of absorbing the impact from Huang's car. *Id.* at 3.

62 *Id.* at 2.; Tesla, *An Update on Last Week's Accident* (2018), https://www.tesla.com/blog/update-last-week%E2%80%99s-accident (last visited June 25, 2019) (noting that "[t]he driver had about five seconds and 150 meters of unobstructed view of the concrete divider with the crushed crash attenuator, but the vehicle logs show that no action was taken").

63 Huang's family has filed suit against Tesla. Complaint, Huang v. Tesla, Inc., No. 19CV346663 (Cal. Sup. Ct. April 26, 2019). There have been several other, nonfatal crashes in which Teslas operating in Autopilot have unexpectedly veered off the road. *See, e.g.* Chris Isidore & Gwen Sung, *Driver in Tesla Autopilot accident would buy another Tesla*, CNN Business, July 12, 2016, https://money.cnn.com/2016/07/12/technology/tesla-autopilot-accident/index.html?sr=twCNN071216tesla-autopilot-accident0540PMVODtopLink&linkId=26486092 (last visited June 27, 2019) (describing accident in which car "veered to the right and hit a series of wooden stakes on the side of the road"); Mike Spector, Jack Nicas & Mike Ramsey, *Tesla's Autopilot Vexes Some Drivers, Even Its Fans*, Wall St. J., July 6, 2016, https://www.wsj.com/articles/teslas-autopilot-vexes-some-drivers-even-its-fans-1467827084 (last visited June 27, 2019) (describing several crashes in which Teslas collided with immobile objects). It is perhaps notable that there are numerous videos on YouTube showing Tesla's autopilot engaging in similar behavior, with drivers intervening at the last moment to correct the computer's disastrous course. *See., e.g.* Stan Lettink, *Tesla Autopilot Fails and Crashes (2019)*, https://www.youtube.com/watch?v=cPMvQphJQiE (last visited June 25, 2019).

64 National Transportation Safety Board, *Preliminary Report: Highway HWY19FH008* 1–2 (2019), https://www.ntsb.gov/investigations/AccidentReports/Pages/HWY19FH008-preliminary-report.aspx (last visited June 24, 2019).

65 *Id.* at 2.

system crashed into a pedestrian named Elaine Herzberg in Tempe, Arizona.[66] Although this collision too is still under investigation, it is already clear that there are many parties whose omissions helped cause the accident. Herzberg, for instance, was jaywalking at night across an unlit portion of a four-lane road whose speed limit was 45 mph.[67] She was wearing dark clothing and pushing a bicycle that lacked side reflectors, and she did not react at all as the car approached her.[68] Toxicology tests were positive for methamphetamine and marijuana.[69]

Meanwhile, the autonomous Uber's testing was being overseen by a human safety driver, whose job was to supervise the vehicle's driving and "intervene if the system fails to perform appropriately during testing."[70] The operator was also responsible for monitoring a display in the middle of the car's dashboard.[71] This display showed diagnostic messages and also allowed the operator to tag "events of interest" for follow-up by engineers.[72] The operator was being recorded by inward-facing cameras and can be seen looking down at a screen until the final moment before the crash.[73] She told investigators that she had been monitoring the car's display,[74] but data obtained by the Tempe Police Department from the operator's Hulu account strongly suggests that she was watching an episode of *The Voice* at the time of the crash.[75]

While both of the humans involved failed to notice the impending collision, the autonomous system that was driving the car did at least detect Herzberg crossing the street. The system registered radar and LIDAR observations of Herzberg about six seconds before the crash, while the car was traveling at 43 mph. What happened next is hard to understand. As the car sped towards

66 Fredrick Kunkle, *Fatal crash with self-driving car was a first – like Bridget Driscoll's was 121 years ago with one of the first cars*, WASHINGTON POST, March 22, 2018, https://www.washingtonpost.com/news/tripping/wp/2018/03/22/fatal-crash-with-self-driving-car-was-a-first-like-bridget-driscolls-was-121-years-ago-with-one-of-the-first-cars/ (last visited June 25, 2019); NATIONAL TRANSPORTATION SAFETY BOARD, *Preliminary Report: Highway HWY18MH010* (2018).
67 NATIONAL TRANSPORTATION SAFETY BOARD, *supra*, at 1.
68 *Id.* at 3.
69 *Id.* at 4.
70 *Id.* at 2.
71 *Id.*
72 *Id.*
73 *Id.* at 3. (noting that the vehicle operator intervened by engaging the steering wheel "less than a second" before the crash and did not brake until after impact).
74 *Id.*
75 Kate Conger & Bryan Menegus, *Uber Driver in Fatal Tempe Crash May Have Been Watching The Voice Behind the Wheel*, GIZMODO, June 22, 2018, https://gizmodo.com/uber-driver-in-fatal-tempe-crash-may-have-been-watching-1827039127 (last visited June 26, 2019).

Herzberg, the autonomous system struggled to decide what, exactly, it was seeing. First it classified her as an unknown object, then as a vehicle, and finally as a bicycle.[76] Each of these classifications triggered different expectations of Herzberg's future path.[77] Regardless of what it thought Herzberg was, the system did not see the need to slow down or change lanes, as a human driver naturally would. Only after about five seconds of dithering did the system finally determine that an "emergency braking maneuver" was called for.[78] Unfortunately, emergency braking maneuvers had been disabled during testing "to reduce the potential for erratic vehicle behavior."[79] The system was also not capable of alerting the operator of the need to brake.[80]

4 Are autonomous vehicles safer?

Much of the scholarly and popular writing about autonomous vehicles and the liability issues they raise predicts that they will be substantially safer than conventional, human-driven cars. While autonomous vehicles show enormous promise, they have yet to prove that they are substantially safer than human drivers, and may not be able to do so for many decades.[81] Cars being operated by autonomous systems have killed four people in the United States, a number that pales in comparison to the roughly 40,000 killed in car crashes every year, but of course what matters is the fatality rate per mile traveled, and on that basis the superior safety of autonomous vehicles remains theoretical. Meanwhile, more prosaic low-level automation features that are already available today may achieve many of the safety gains promised by highly autonomous vehicles.

Roughly 94% of roadway fatalities are currently attributable to one or another form of human error. Twenty-nine percent of fatalities involved alcohol impairment, 26% involved speeding, 8.5% involved distracted driving, and 2.1% involved drowsy drivers.[82] Whatever else can be said of autonomous vehicles,

76 National Transportation Safety Board, *supra* note 66, at 2.
77 *Id.*
78 *Id.*
79 *Id.*
80 *Id.*
81 Nidhi Kalra & Susan M. Paddock, *Driving to Safety: How Many Miles of Driving Would It Take To Demonstrate Autonomous Vehicle Reliability* (2016), https://www.rand.org/pubs/research_reports/RR1478.html (last visited June 26, 2019).
82 National Highway Traffic Safety Administration, *Traffic Safety Facts: Research Note* 4, 5 (2018), https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812603 (last visited June 26, 2019). These figures are not necessarily cumulative.

they presumably will never get drunk, text their friends, or fall asleep at the wheel. They also have powers of perception, attention, and reaction that far surpass even the most skilled human driver.[83] This enormous promise has led many to envision a world virtually free of car accidents,[84] in which crumple zones and seatbelts will be a thing of the past.

Nevertheless, as the crashes surveyed above suggest, "[t]he common suggestion that 'driverless cars' are 'already safer' than conventional vehicles remains premature."[85] While Tesla has defended itself against media scrutiny in the wake of fatal crashes by insisting that from the perspective of fatalities per mile travelled, Autopilot is more than three times safer than a human driver,[86] it has not released data sufficient to support that claim.[87] Tesla's cars are significantly heavier, newer, and more expensive than the typical American car, making any comparison of Autopilot crash statistics with countrywide figures inherently fraught.[88] Autopilot is also designed to be operated only on limited-access highways, which even for human drivers are by far the safest type of road on a per-vehicle-mile-traveled basis.[89]

None of the other companies working on fully autonomous, Level 4 and 5 vehicles have yet caused a fatality, making it hard to evaluate their safety relative to traditional cars. This problem is compounded by the fact that companies like Waymo have only very recently (and very gingerly) begun removing

83 Kalra and Paddock, *supra* note 81, at 1.

84 General Motors, *2018 Self-Driving Safety Report* 3, https://www.gm.com/content/dam/company/docs/us/en/gmcom/gmsafetyreport.pdf (last visited June 27, 2019) ("At General Motors, we envision a future with zero crashes, zero emissions, and zero congestion.").

85 Smith, *supra* note 13, at 17.

86 Tesla, *supra* note 62.

87 Tom Simonite, *Tesla's Dubious Claims About Autopilot's Safety Record*, MIT Tech. Rev., Jul. 6, 2016, https://www.technologyreview.com/s/601849/teslas-dubious-claims-about-autopilots-safety-record/ (last visited June 27, 2019) (quoting experts referring to Tesla's claims as "ludicrous" and having "no meaning").

88 Nick Lum & Edward Niedermeyer, *How Tesla and Elon Musk Exaggerated Safety Claims About Autopilot and Cars*, The Daily Beast, July 14, 2016, https://www.thedailybeast.com/how-tesla-and-elon-musk-exaggeraged-safety-claims-about-autopilot-and-cars (last visited June 27, 2019); *see also* Sam Abuelsamid, *Adding Some Statistical Perspective To Tesla Autopilot Safety Claims*, Forbes, 2016, https://www.forbes.com/sites/samabuelsamid/2016/07/05/adding-some-statistical-perspective-to-tesla-autopilot-safety-claims/ (last visited June 27, 2019); Matt Drange, *Studies Don't Support Elon Musk's Autopilot Safety Claims*, The Information, 2019, https://www.theinformation.com/articles/studies-dont-support-elon-musks-autopilot-safety-claims (last visited June 27, 2019).

89 U.S. Department of Transportation, *2015 Status of the Nation's Highways, Bridges, and Transit: Conditions & Performance* 4–8 (2016), https://www.fhwa.dot.gov/policy/2015cpr/pdfs/2015cpr.pdf (last visited June 28, 2019).

human safety operators from the driver's seat of their autonomous vehicles. In some states (most notably California), companies testing autonomous vehicles are required to file periodic reports that list statistics like the number of miles driven and "disengagements," or instances in which human operators intervene to correct the autonomous system's driving. These figures are notoriously resistant to meaningful analysis. While the number of disengagements per mile is widely treated as a yardstick for companies' relative progress in developing a viable fully autonomous vehicle,[90] it can also be highly sensitive to the environment in which the vehicle is being tested: The busy streets of downtown San Francisco pose a far greater challenge to an autonomous vehicle than the predictable, well-groomed suburbs of Phoenix.

Even on the more concrete metric of injuries per mile, there are limits to the autonomous vehicles' ability to demonstrate their own safety. Waymo, the industry leader in terms of miles traveled,[91] had driven around 1.3 million miles on public roads as of 2015.[92] In that time it was involved in 11 crashes, only two of which caused injury.[93] Conventional vehicles, by contrast, cause 77 injuries and 1.09 fatalities per 100 million miles driven.[94] But humans drive about 3 *trillion* miles in the U.S. every single year. Compared with that number, even Waymo's experience is just a blip – far too small for statistical comparison.[95] Indeed, a RAND report concluded that autonomous vehicles would have to drive hundreds of millions or even billions of miles before their safety could be meaningfully compared with that of conventional vehicles.[96]

Meanwhile, as the hope of a widely available highly autonomous vehicle appearing in the near term has faded, automakers have gotten better and better at developing more incremental technology that offers much of the safety benefit of full autonomy with less convenience and world-changing frisson. One study estimated that blind-spot monitoring, lane departure warning, and forward

90 Mark Gurman, *Apple's Autonomous Cars Need Much More Human Help Than Its Rivals*, BLOOMBERG.COM, February 13, 2019, https://www.bloomberg.com/news/articles/2019-02-13/apple-s-autonomous-cars-need-much-more-human-help-than-rivals (last visited August 7, 2019) (interpreting Apple's higher disengagement rate as "an indication the iPhone maker may lag well behind" competitors like Waymo and Cruise).

91 Alan Ohnsman, *Waymo Is Millions Of Miles Ahead In Robot Car Tests; Does It Need A Billion More?*, FORBES, Mar. 2, 2018, https://www.forbes.com/sites/alanohnsman/2018/03/02/waymo-is-millions-of-miles-ahead-in-robot-car-tests-does-it-need-a-billion-more/ (last visited July 2, 2019).

92 WAYMO, *Waymo Safety Report: On the Road to Fully Sefl-Driving* 7, https://storage.googleapis.com/sdc-prod/v1/safety-report/Safety%20Report%202018.pdf (last visited June 27, 2019).

93 KALRA AND PADDOCK, *supra* note 81, at 2.

94 *Id.* at 2.

95 *Id.* at 1–2.

96 *Id.* at 1.

collision warning could prevent 10,100 fatal crashes every year if they were universally adopted.[97] Automatic emergency braking could reduce rear-end crashes (which killed 2,300 people in 2016)[98] by 80%, according to the NTSB.[99] It is worth mentioning that around 10,000 people who were not wearing seat belts are killed in car crashes every year.[100] The technology to ensure seat belt use has existed for decades.[101]

B Scholarly literature on autonomous vehicle liability

Despite being a technology in its infancy that has so far killed only four people, autonomous vehicles have already generated an enormous body of scholarly literature. Law reviews have published dozens of articles exploring the implications of autonomous vehicles for various areas of law,[102] but the problems they pose for tort law in particular have attracted the most sustained and serious attention.[103] If there exists a spectrum of liability, from "absolute" liability on

97 Smith, *supra* note 13, at 16–17.

98 Insurance Information Institute, *Facts + Statistics: Highway safety*, https://www.iii.org/fact-statistic/facts-statistics-highway-safety (last visited July 2, 2019).

99 Mims, *supra* note 22.

100 NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION, *supra* note 82, at 5.

101 See Andrzej Rapaczynski, *Driverless Cars and the Much Delayed Tort Law Revolution*, Colum. L. & Econ. Working Paper No. 540, at 22 (2016) (unpublished manuscript), *available at:* https://www.ssrn.com/abstract=2764686 (last visited June 18, 2019).

102 See, e. g., Mark A. Lemley & Bryan Casey, *Remedies for Robots*, ___ U. CHI. L. REV. ____ (forthcoming 2019), *available at*: https://www.ssrn.com/abstract=3223621 (last visited June 19, 2019) (exploring implications for remedies law); Ryan Calo, *Robotics and the Lessons of Cyberlaw*, 103 CALIF. L. REV. 53 (2015) (cyberlaw); Robert Peterson, *New Technology – Old Law: Autonomous Vehicles and California's Insurance Framework*, 52 SANTA CLARA L. REV. 1341 (2012) (insurance law).

103 See F. Patrick Hubbard, *"Sophisticated Robots": Balancing Liability, Regulation, and Innovation*, 66 FLA. L. REV. 71 (2014); David C Vladeck, *Machines Without Principals: Liability Rules and Artificial Intelligence*, 89 WASH. L. REV. 34 (2014); Rapaczynski, *supra* note 101; Ryan Benjamin Abbott, *The Reasonable Computer: Disrupting the Paradigm of Tort Liability*, 86 GEO. WASH. L. REV. 1 (2016); Mark A Geistfeld, *A Roadmap for Autonomous Vehicles: State Tort Liability, Automobile Insurance, and Federal Safety Regulation*, 105 CALIF. L. REV. 85 (2017); Bryan H. Choi, *Crashworthy Code*, 94 WASH. L. REV. 39 (2019); Kenneth S. Abraham & Robert L. Rabin, *Automated Vehicles and Manufacturer Responsibility for Accidents: A New Legal Regime for a New Era*, 105 VA. L. REV. 127 (2019); Kyle D. Logue, *The Deterrence Case for Comprehensive Automaker Enterprise Liability*, 2019 J. L. & MOB. 1 (2019); Steven Shavell, *On the Redesign of Accident Liability for the World of Autonomous Vehicles*, NBER Working Paper No. 26220 (2019) (unpublished manuscript), *available at*: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3437474 (last visited August 23, 2019).

one end to immunity on the other, legal scholars have recommended that autonomous vehicles be placed at virtually every position on that spectrum.

While this scholarship differs as widely as possible on this important prescriptive question, it often shares a set of factual and normative assumptions that drive its analyses. First, as discussed above, scholars widely assume that autonomous vehicles will be far safer than conventional vehicles. Second, scholars widely assume that the first assumption is of central importance in addressing the issue of autonomous vehicle liability. In other words, the relative safety of autonomous vehicles as compared with conventional vehicles is treated as a fact that is critically important in any analysis of how the tort system should treat autonomous vehicles. I argue that this is not the case, or at least that its truth depends on certain important prior normative commitments that are often unstated. The question of how relevant the safety of one technology is to the design of another is one that tort law has grappled with for decades, with mixed and difficult to explain results.

Among scholars who have addressed the issue of autonomous vehicle liability, the majority take the position that the application of current tort doctrine to accidents involving autonomous vehicles is problematic for some reason. Relatively few, in other words, argue that tort law is capable of handling disputes over autonomous vehicle crashes.[104] The majority position, by contrast, is that applying existing tort principles to autonomous vehicle crashes will be undesirable for several reasons.

First, many scholars, adopting a broadly "realist" utilitarian perspective, express concern that tort liability will slow the adoption of autonomous vehicles. Because autonomous vehicles are taken to be a technology that will transform life in a whole host of ways, including by making car crashes a thing of the past,

104 Hubbard, *supra* note 103, at 1803 (arguing that "the legal system's method of addressing physical injury from robotic machines that interact closely with humans provides an appropriate balance of innovation and liability for personal injury"); Smith, *supra* note 13, at 2–3 (arguing that "the current product liability regime . . . is probably compatible with the adoption of automated driving systems"); Andrew P. Garza, *Note, Look Ma, No Hands: Wrinkles and Wrecks in the Age of Autonomous Vehicles*, 46 New Eng. L. Rev. 581–616, 581 (2012) ("Products liability law is capable of handling the advent of autonomous vehicles just as it handled seat belts, airbags, and cruise control."); Bryan Casey, *Robot Ipsa Loquitur*, ___ Geo. L.J. ____ (forthcoming 2019), *available at:* https://www.ssrn.com/abstract=3327673 (last visited June 17, 2019) (arguing that "the purportedly novel challenges posed by robots are neither unprecedented, unresolvable, nor even unique to emerging technologies"). *See also* Vladeck, *supra* note 103, at 58, 67 (arguing that "the introduction of truly autonomous vehicles is unlikely to present legal issues that tax our current product liability regime" but also that "the law is not necessarily equipped to address the legal issues that will start to arise when . . . there is no 'principal' directing the actions of the machine").

hastening their adoption is thought to be a matter of grave concern. In a way, focusing on fatalities minimizes the overall impact of car crashes in the United States, since the vast majority of crashes do not kill anyone.[105] The NHTSA has calculated a total *annual* economic impact of about $836 billion.[106] Autonomous vehicles are also commonly thought to offer decreased congestion, increased fuel economy, increased productivity, and increased mobility, all of which could lead to substantial economic gains beyond the enormous savings in accident avoidance. While estimates of the total cost of autonomous vehicle development are hard to come by, they appear to be a technology that is clearly, overwhelmingly "efficient," in the sense of satisfying the Hand formula.

Against this backdrop, imposing *any* liability on manufacturers of autonomous vehicles begins to look like a problem. Many commentators, surveying the legal landscape, predict that while autonomous vehicles may decrease the overall "pie" of accident costs, the companies that make them will be responsible for a far larger "slice" of that pie, because they will have taken over from the rest of us responsibility for the driving task.[107] If that bigger slice of a smaller pie is larger than car manufacturers' current responsibility for the costs of accidents, then saddling them with liability threatens to deter them from developing this life-saving, world-changing technology.[108]

105 Smith, *supra* note 13, at 22 (noting roughly 19 million crashes involving property damage only).

106 *Id.* at 21. Roughly one third of that figure represents direct economic costs; the other two thirds is comprised of estimates of the monetary value of loss of life and diminished quality of life. *Id*. The $836 billion figure is based on a "value of a statistical life" of $9 million. Using other popular figures causes the total cost to range from about $500 billion to over $1 trillion. *Id*.

107 *Id.* at 2, 20.

108 Calo, *supra* note 102, at 575 ("[T]he potential for crippling legal liability . . . may lead entrepreneurs and investors to abandon open robots in favor of robots with more limited functionality."); Rapaczynski, *supra* note 101, at 25 (noting that "the question concerning the ability of the present torts system to handle the introduction of self-driving cars without unduly delaying it or making it prohibitively costly seems to be generating some anxiety among the experts and the industry"); Gary E. Marchant & Rachel A. Lindor, *The Coming Collision between Autonomous Vehicles and the Liability System*, 52 SANTA CLARA L. REV. 1321–1340, 1322 (2012) (arguing that "liability has the potential to present a significant deterrent to the development of autonomous vehicles, even though such vehicles would provide an overall safety benefit"). Mark Geistfeld dismisses concerns that lawsuits will "kill the autonomous car" as "sensationalizing," but nevertheless expresses concern that "substantial uncertainty about the potential scope of manufacturer liabilities could . . . impede the widespread deployment of autonomous vehicles." Geistfeld, *supra* note 103, at 1617.

There is reason to be skeptical of the argument that tort liability threatens to deter the development of autonomous vehicles to any meaningful extent. While manufacturers are

Another set of arguments starts from a more conceptualist or interpretivist premise and posits that there is something uniquely new about autonomous vehicles that makes attempting to apply existing tort doctrine to them incoherent. Much of this scholarship draws on technical aspects of artificial intelligence and the various ways in which it will prove hard for the legal system to understand. The key feature here is the concept of "emergent behavior," in which an algorithm is programmed to pursue certain goals while following a set of rules and can then teach itself how to behave by doing some activity over and over.[109] Unlike in a more traditional programming context, explaining why the software did something (like veer off the road) is difficult, because it isn't programmed as a series of "if, then" instructions.[110] Instead, the algorithm makes decisions of its own for reasons that are inscrutable.[111] Many experts have thus concluded that identifying a discrete defect in the algorithm will prove impossible, because there will not be a single line of code or design feature to which responsibility for a crash can be attributed.[112] The concept of a reasonable alternative design is widely thought to be an awkward fit here as well, since the only way an algorithm can be taught to behave differently in a given situation is with more

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frequently quoted in the popular press expressing concern, it is hard to know what effect the fear of liability is having on their behavior, if any. Companies like Google, Uber, Tesla, Apple, and General Motors have for years been investing many billions of dollars in autonomous vehicle development. It seems hard to credit the idea that their investments would be greater if the threat of liability were removed. In California alone, there are currently 61 companies licensed to test autonomous vehicles on public roads. State of California Department of Motor Vehicles, *Permit Holders (Testing with a Driver)* (2019), https://www.dmv.ca.gov/portal/dmv/detail/vr/autonomous/permit (last visited June 28, 2019).

109 Calo, *supra* note 102, at 56; Surden and Williams, *supra* note 3, at 147–48.

110 Geistfeld, *supra* note 103, at 1644–45 (explaining how machine learning differs from "if-then" commands).

111 Hubbard, *supra* note 103, at 120–21 (arguing that emergent behavior "raise[s] virtually insurmountable proof problems concerning such issues as defectiveness and causation"). Sophia H Duffy & Jamie Patrick Hopkins, *Sit, Stay, Drive: The Future of Autonomous Car Liability* 16 SMU SCI. & TECH. L. REV. 453, 479 (2013) (arguing that "[e]xisting laws governing vehicles and computers do not provie the proper means to assess liability for autonomous cars").

112 Abraham and Rabin, *supra* note 103, at 144 (arguing that "esoteric, algorithm-based design differences . . . would impose overwhelming stress on the premises of conventional analysis."); Nora Freeman Engstrom, *When Cars Crash: The Automobile's Tort Law Legacy*, 53 WAKE FOREST L. REV. 293, 297 (2018) ("Our traditional negligence system, designed for the Model T and premised on personal responsibility, will fit this new world awkardly, indicating that fundamental change ought to come."); Choi, *supra* note 103, at 44 ("A fundamental attribute of software–computational complexity–confounds the usual tort calculus refined for ordinary manufactured goods.").

training, and it is impossible to know how much more would be required to avoid any particular crash.[113] This is in sharp contrast to the designer of a physical product like a lathe, whose decision to select a particular type of set screw to hold a piece of wood in place can easily be reevaluated ex post.[114]

These lines of reasoning lead to the conclusion that tort law must be changed in some way to accommodate the advent of the driverless car. Many scholars have proposed entirely new liability regimes for driverless cars that represent dramatic departures from traditional tort principles. Mark Geistfeld, for example, has argued that autonomous vehicles should be considered per se non-defective in any particular crash so long as they can be demonstrated to be at least twice as safe as conventional vehicles in the aggregate (and as long as the manufacturer warns consumers about the level of risk that remains).[115] Kenneth Abraham and Robert Rabin, expressing fear that Geistfeld's twice-as-safe hurdle will be far too easy to clear,[116] have proposed a system called "manufacturer enterprise responsibility," in which bodily injury would be compensated from a fund created by assessments on manufacturers.[117] Steven Shavell has proposed a new system of strict liability in which damages would be paid to the state rather than to victims.[118] Other scholars have put forward a range of creative solutions to the problem of autonomous vehicle liability, from no-fault insurance schemes[119] to doctrinal tweaks like treating autonomous

113 Abraham and Rabin, *supra* note 103, at 144 ("As largely uniform software becomes pervasive, the concept of a reasonable alternative design . . . is likely to become increasingly indeterminate."); Choi, *supra* note 103, at 64 ("[T]he challenge of software liability is that it is seemingly impossible to identify marginal-cost measures that can or should be taken to improve software safety.").

114 See Greenman v. Yuba Power Prods. 377 P.2d 897, 899 (Cal. 1963).

115 Geistfeld, *supra* note 103, at 1651 ("Taking into account the risk-utility trade-off between a conventional vehicle and an imperfect but safer autonomous vehicle, the fully functioning autonomous vehicle will necessarily drive in a reasonably safe manner if prior driving experience shows that the operating system at least halves the incidence of crashes relative to conventional vehicles."). Geistfeld sees continued relevance for the application of traditional tort principles in cases, crashes caused by a malfunction of the operating system due to programming error, or hacking by a third party. *Id.* at 1634, 1663. In a similar vein, Ryan Abbott suggests that autonomous vehicle manufacturers be subject to negligence rather than strict liability as long as their driving is safer than that of a reasonable person. Abbott, *supra* note 103, at 27.

116 Abraham and Rabin, *supra* note 103, at 145.

117 *Id.* at 147. Kyle Logue has proposed a comprehensive automaker enterprise liability system in which manufacturers of vehicles of any kind would be "unconditionally responsible for the economic losses resulting from any crashes of their vehicles." Logue, *supra* note 103, at 5.

118 Shavell, *supra* note 103.

119 Vladeck, *supra* note 103, at 147–49.

driving as an "ultrahazardous activity"[120] or holding that autonomous vehicles are functionally equivalent to animals and thus subject to the same set of strict liability rules.[121]

There are reasons to be skeptical of all of these arguments. Autonomous vehicles arguably pose no greater challenge to the application of traditional tort principles than many other once cutting-edge technologies. Applying those principles leads to insights both about how autonomous vehicle liability should work and about how we should understand the tort system more generally.

II What tort law says about driverless cars, and vice versa

Much of the scholarly literature on autonomous vehicle liability relies explicitly on the premise that autonomous vehicles will be far safer than conventional ones. Indeed, this premise drives much of the utilitarian concern that autonomous vehicle development will be deterred by excessive liability. My quarrel is not with the validity of this premise but rather with its relevance. In determining whether and when autonomous vehicle manufacturers should be liable for car crashes, their overall statistical safety relative to human drivers should be irrelevant, at least from the perspective of tort law.[122] There are several conceptually overlapping tort doctrines that compel this result. They also lead to theoretical insights about how tort law does and does not promote the efficient allocation of resources, and the moral principles that lie at its core.

A Doctrine

Many commentators have based arguments for some sort of modification to tort doctrine for driverless cars on the idea that driverless cars will be much safer than conventional ones. Thus, it is widely thought, it is appropriate to shield them from the intense scrutiny of strict products liability. Notably absent from the discussion,

120 See Hubbard, *supra* note 103, at 131–32 (collecting cites).
121 Duffy & Hopkins, *supra* note 111, at 453.
122 It is worth emphasizing that my argument has no bearing on whether conventional vehicles should be disfavored as a regulatory matter, or even as a personal matter.

however, is the issue of liability for manufacturers of conventional vehicles. In a world with flawless robot drivers, does a human-driven car become defective? If the defectiveness of autonomous vehicles ought to be evaluated by comparing them with conventional vehicles, the opposite would seem to be equally true. Scholars do not, however, argue that a conventional vehicle should be considered defective in relying on a human driver.[123]

The reason is that such a case would appear to be an obvious non-starter. There are a host of doctrinal obstacles that stand in the way of an argument that an outmoded, less-safe technology is therefore defective. These include the various ways of defining design defects (including what constitutes a reasonable alternative design), the widespread rejection of "category liability," and the admissibility of evidence of custom. At various points in the history of motor vehicle safety, plaintiffs have argued that their cars were defective because they lacked the latest safety features. Thanks to these doctrines, they have mostly been unsuccessful. All of this evidence suggests that when evaluating the defectiveness of a particular product, tort law is hesitant to expand the scope of its analysis to include other products that accomplish similar ends.

1 Defect

It has been a commonplace observation for many decades that strict products liability is not truly "strict" in the sense of relieving the plaintiff of the burden of showing fault.[124] Instead of requiring that the plaintiff prove that the defendant failed to exercise reasonable care, products liability requires that the plaintiff show that the product contained a defect (either in manufacturing, design, or warning) that caused injury. Manufacturing defects, which focus on a flaw in the individual product sold to the plaintiff that deviates from the manufacturer's own specifications, have always been relatively straightforward conceptually. Indeed, the first

123 Ryan Abbott argues that autonomous vehicles should be subject to negligence rather than strict liability as long as they are "safer than a reasonable person." He then argues that once autonomous drivers pass this threshold, the "reasonable person" standard for negligent human drivers should be jettisoned in favor of a "reasonable computer" standard, since "we are all 'hasty and awkward' compared to the reasonable computer." Abbott, *supra* note 103, at 1. Abbott does not, however, argue that manufacturers of conventional vehicles should be liable to their customers in products liability when their customers' human errors cause crashes.

124 David G. Owen, *Defectiveness Restated: Exploding the "Strict" Products Liability Myth*, 1996 U. Ill. L. Rev. 743 (1996).

cases holding manufacturers liable for injuries caused by their products regardless of privity of contract involved manufacturing defects.[125]

Design defects, in which the plaintiff identifies some purported flaw with an entire line of products, are the hardest to define with precision, since virtually all products are capable of causing injury even when used reasonably.[126] In no context is this more true than with the automobile. Giving people the power to transport themselves at great speed on all types of roads at all times of day in all weather conditions and burdened by the distractions of everyday life is an inherently dangerous enterprise. Moreover, cars have been designed and produced in almost unimaginable variety, with details large and small[127] contributing in significant ways to vehicle safety.

Although cars attracted ire as bringers of death and destruction almost since their first invention, manufacturers argued for decades that they had no obligation to design cars in such a way as to minimize injury in the event of a collision. Courts routinely accepted this argument, holding that a manufacturer had no duty "to make his car accident-proof or fool-proof."[128] This reasoning was finally rejected in 1968 in the landmark case of *Larsen v. General Motors*, in which the plaintiff argued that his Chevy Corvair was defective in design after a relatively low-speed front end collision caused the steering column to be thrust backwards into his head like a "spear aimed at a vital part of the driver's anatomy."[129] *Larsen* held that a car manufacturer is "under a duty to use reasonable care in

125 James A. Henderson Jr & Aaron Twerski, *Closing the American Products Liability Frontier: The Rejection of Liability Without Defect*, 66 N.Y.U. L. REV. 1263, 1269–70 (1991).

126 David G. Owen, *Design Defects*, 73 MO. L. REV. 291, 291 (2008) (calling the "true meaning" of design defect "[e]lusive as an elf" and noting that it "has largely escaped capture by court or commentator, and the search therefor leads inexorably to consternation and confusion").

127 *See, e. g.*, Mickle v. Blackmon, 166 S.E.2d 173, 187–88 (S.C. 1969) (plaintiff impaled on gear shift whose protective plastic knob had gradually deteriorated when exposed to sunlight because manufacturer used white rather than black plastic).

128 Evans v. General Motors Corp., 359 F.2d 822, 824 (1966). *Evans* involved a car with an "x-frame" that lacked side rails and thus offered significantly less protection to occupants in a side-impact collision than a car with a "perimeter frame." *Id.* at 823. The court held that the car was not "unfit for its intended use" because "[t]he intended purpose of an automobile does not include its participation in collisions with other objects." *Id.* at 825. The court admitted that it might perhaps "be desirable to require manufacturers to construct automobiles in which it would be safe to collide," but insisted that "that would be a legislative function, not an aspect of judicial interpretation of existing law." *Id.* at 824.

129 Larsen v. General Motors Corp., 391 F.2d 495, 497 n.2 (1968). The Corvair attracted the particular ire of Ralph Nader, who called attention to its lack of a steering shaft that would collapse in the event of a front-end impact, in addition to numerous other problems with the car's design. RALPH NADER, UNSAFE AT ANY SPEED: THE DESIGNED-IN DANGERS OF THE AMERICAN AUTOMOBILE (1965).

the design of its vehicle to avoid subjecting the user to an unreasonable risk of injury in the event of a collision," which after all, "with or without fault of the user are clearly foreseeable by the manufacturer and are statistically inevitable."[130] *Larsen*, probably not coincidentally, was decided against a national backdrop of concern over the mounting toll of car crashes and anger at car manufacturers' failure to emphasize safety in their designs that culminated in the passage of the National Traffic and Motor Vehicle Safety Act of 1966, which established the NHTSA and tasked it with regulating the design of motor vehicles.[131]

Larsen and its progeny definitively rejected the argument that manufacturers had no duty to take crashworthiness into account in designing a car. It did not, however, hold that manufacturers would be strictly liable for crashes.[132] Determining just what makes the design of a car defective has proven tricky. The consumer expectations and risk/utility tests emerged as two formulations, initially competing alternatives[133] and then confined to (somewhat) distinct realms,[134] before the Third Restatement endorsed the risk/utility test to the exclusion of the consumer expectations test.

Both tests would initially appear to rely on a kind of cross-product comparison that arguably supports the idea that autonomous vehicle safety should be evaluated by reference to conventional vehicle safety. The consumer expectations test, after all, asks whether the product "failed to perform as safely as an ordinary consumer would expect when used in an intended or reasonably foreseeable manner,"[135] and the reasonable consumer's expectations are presumably shaped to a significant degree by his or her exposure to similar products. For example, consumers do not expect that cars will suddenly lose power on the highway or suddenly accelerate from a dead stop without driver input, because cars do not typically do these things. These are easy cases.[136]

130 Larsen, 391 F.2d at 502.

131 *See generally* NADER, *supra* note 129; JERRY L. MASHAW & DAVID L. HARFST, THE STRUGGLE FOR AUTO SAFETY (1990).

132 Larsen, 391 F.2d at 506.

133 Barker v. Lull Eng'g Co., 573 P.2d 443 (Cal. 1978).

134 *See* Soule v. General Motors Corp., 882 P.2d 298, 311 (Cal. 1994) (holding that use of consumer expectations test is inappropriate in cases involving "technical and mechanical detail" in which "ordinary experience and understanding" are unlikely to create any reasonable expectation in the mind of an ordinary consumer).

135 Barker, 573 P.2d at 443.

136 *See* James A. Henderson, *Judicial Review of Manufacturers' Conscious Design Choices: The Limits of Adjudication*, 73 COLUM. L. REV. 1531, 1571–72 (1973).

And yet the extent to which consumers can look outside the product at issue to establish their expectations is limited. In *Dyson v. General Motors*, for example, the plaintiff was driving a two-door "hardtop" convertible that rolled onto its roof during a crash.[137] Because the car lacked the rigid center posts and door frames of a typical sedan, the roof was not able to support its weight, and it collapsed.[138] The court followed *Larsen* and rejected the argument that the manufacturer had no duty at all, holding that "it is the obligation of an automobile manufacturer to provide more than merely a movable platform capable of transporting passengers from one point to another. The passengers must be provided a reasonably safe container within which to make the journey."[139] On the question of whether the car at issue *was* reasonably safe, however, the court expressed doubt. It noted that "[t]he manufacturer cannot be expected to provide a convertible which is as safe in roll-over accidents as a standard four-door sedan."[140] Rather, it was only obligated to make "a reasonably safe version of such model" that was not "substantially less safe than other hardtop models."[141] The problem is one of scope: in evaluating the defectiveness of a design for purposes of strict products liability, the court noted, it would be wrong to compare the rollover safety of convertibles with standard sedans; it simply didn't matter that the sedan was the inherently safer design.[142]

2 Category liability and reasonable alternative design

Dyson introduces nicely the problem of "category liability": cases in which the plaintiff's success in proving that a product is defective would amount to a

137 298 F. Supp. 1064 (E.D. Pa. 1969); see also *Note, Automobile Design Liability: Larsen v. General Motors and Its Aftermath*, 118 U. Pa. L. Rev. 299 (1969) (discussing Dyson).
138 *Id*. at 1073.
139 *Id*.
140 *Id*.
141 *Id*.
142 *See* Holiday Motor Co. v. Walters,790 S.E.2d 447, 456 (Va. 2016) ("If a person purchases a convertible, he cannot expect – and the Court may not impose on the manufacturer a duty to provide him with – the exact kind of protection in a rollover accident as in the standard American passenger car." (quotations omitted)); Delvaux v. Ford Motor Co., 764 F.2d 469, 474 (7th Cir. 1985) ("Since the most obvious feature of a convertible is its lack of a roof, dangers which the ordinary consumer would associate with that feature will not support a strict product liability cause of action in Wisconsin."); Curtis v. General Motors Corp., 649 F.2d 808, 811 (10th Cir. 1981) ("Plaintiff Curtis made a deliberate choice to purchase a vehicle which, as a reasonable consumer, he should have expected was not as safe as others on the market.").

determination that an entire category of products is defective. In other words, there appeared to be no way in *Dyson* to manufacture a hardtop convertible whose roof would not have collapsed under the weight of the overturned car.[143] Category liability has always been controversial.[144] Apart from a few scattered exceptions, it has never been the law in any state.[145] Henderson and Twerski, the reporters of the Third Restatement of Products Liability, attacked it with particular force, and argued that the consumer expectations test suffered from the "fatal flaw" of exposing the manufacturer to "the real possibility of liability without defect."[146] Henderson and Twerski thus argued that the consumer expectations test was so subjective as to be "almost entirely rhetorical."[147] Even the risk/utility test, they pointed out, threatened to trigger category liability, since it imposed no internal constraint on how drastically defective the defendant's design could be.[148]

The solution to the threat posed by category liability, Henderson and Twerski argued, was the addition of a "reasonable alternative design" requirement to the risk/utility test.[149] This proposal was deeply controversial, and led to a flurry of scholarship debating its merits.[150] Ultimately it became part of the Third Restatement.[151] In addition to requiring that the plaintiff establish defect

143 Another example is *Pietrone v. American Honda Motor Co.*, 235 Cal. Rptr. 137 (1987), in which the plaintiff was riding a motorcycle when a car crashed into her leg. The plaintiff alleged merely that the design of the motorcycle caused her injury, without specifying a way in which it could have been designed differently so as to prevent it. *Id.* at 139; Henderson and Twerski, *supra* note 125, at 1293.

144 Harvey M. Grossman, *Categorical Liability: Why the Gates Should Be Kept Closed*, 36 S. TEX. L. REV. 385, 386 (1995) (noting "widespread hostility on the part of courts and commentators").

145 Henderson and Twerski, *supra* note 125, at 1292; Grossman, *supra* note 144, at 386 (noting that "[t]he cases in which it was urged have rejected it with virtual unanimity" and that "[a] few abberational cases that embraced the doctrine were eviscerated by subsequent litigation"). See also RESTATEMENT (SECOND) OF TORTS § 402A cmt. i (1965) ("Good tobacco is not unreasonably dangerous merely because the effects of smoking may be harmful.").

146 Henderson and Twerski, *supra* note 125, at 1295; REST. 3D OF TORTS: PRODUCTS LIABILITY § 2 cmt. e Part IV.D.

147 *Id.* at 1295.

148 *Id.* at 1316–19.

149 James A. Henderson, Jr. & Aaron D. Twerski, *A Proposed Revision of Section 402A of the Restatement (Second) of Torts*, 77 CORNELL L. REV. 1512, 1514, 1520–21 (1992).

150 Richard L. Cupp, Jr., *Defining the Boundaries of Alternative Design under the Restatement (Third) of Torts: The Nature and Role of Substitute Products in Design Defect Analysis*, 63 TENN L REV 329, 332–333 & n.19 (1996) (collecting cites).

151 RESTATEMENT (THIRD) OF TORTS: PRODUCTS LIABILITY § 2(b).

by reference to an alternative design, the Restatement offered a list of factors to be used in considering "whether an alternative design is reasonable and whether its omission renders a product not reasonably safe."[152] These include, among others, the relative advantages and disadvantages of the alternative design, including how it would impact the product's cost, "longevity, maintenance, repair, and esthetics."[153]

In an illustration, the Restatement hypothesizes a case in which a plaintiff is injured in a car accident he alleges would have been less severe if he had been driving a full-size rather than a compact car.[154] Such a plaintiff, the Restatement says, has not shown that the car is defective, because the alternative design (a heavier, larger car) would involve trade-offs in cost and fuel efficiency, and "eliminating smaller automobiles from the market would unduly restrict the range of consumer choice among automobile designs."[155] The problem need not be expressed in the Restatement's terminology of reasonable alternative design; one could just as easily say that a compact car's safety must be evaluated by reference to other compact cars rather than to larger full-size cars.

Several of the leading cases relied on by the Third Restatement grappled with this problem in the automotive context. In *Driesonstok v. Volkswagenwerk, A.G.*, for example, the plaintiff was riding in the front seat of a Volkswagen microbus that crashed into a telephone pole at about 40 miles per hour.[156] The microbus, an iconic design of the 1960s, had no forward crumple zone at all, since engine was in the rear and the front seats were just behind the bumper.[157] The plaintiff argued that this constituted a design defect, as it rendered the passengers vulnerable in relatively low-speed front end collisions, and suggested as an alternative design the "standard American made vehicle . . . with an engine in front and with a long hood."[158] The court, relying on *Dyson*, held that comparing the microbus with a standard sedan would be just as wrong as comparing a standard sedan with a convertible.[159] In each case, customers sacrificed safety in exchange for some

152 *Id.* at § 2 cmt. f.
153 *Id.*
154 *Id.* at Ill. 9.
155 *Id.*
156 489 F.2d 1066, 1068 (4th Cir. 1974). *See also* Cupp, Jr., *supra* note 150, at 347 (discussing *Driesonstok*); Aaron D. Twerski, *Seizing the Middle Ground between Rules and Standards in Design Defect Litigation: Advancing Directed Verdict Practice in the Law of Torts*, 57 N.Y.U. L. Rev. 521, 578–85 (1982) (same).
157 489 F.2d at 1073–74.
158 *Id.* at 1074.
159 *Id.*

other feature, either “openness” or “additional cargo and passenger space” in a relatively cheap, compact, maneuverable car.[160] A sedan, the court noted, has “a different nature and utility,” making it an improper basis for a conclusion that the microbus was defectively designed.[161]

And if category liability is doctrinally impermissible, then surely category immunity would be as well. In other words, it has never been open to a defendant to argue that although their product may have had a defect, it should nonetheless be immune from liability because the product is much safer overall than some other category of product that achieves the same purpose.[162] To perhaps belabor the point, a defective airbag does not enjoy immunity from liability simply because a car equipped with airbags is statistically much safer than a car without them. For the same reason, it is hard to see why autonomous vehicles should enjoy any degree of immunity from liability simply because they may be safer in the aggregate than conventional vehicles.

Of course, not every product is in a “category” of its own. A convertible feels like a category, while a car that lacks a shoulder belt in its rear middle seat does not.[163] Alcoholic beverages, handguns, cigarettes, and above-ground pools have all been called categories.[164] Just where the line is drawn is not entirely clear, in large part because the idea of category liability is not something the parties raise as an issue in the vast majority of products liability cases. It is, rather, lurking in the idea of defect, as several commentators have observed.[165] In general, plaintiffs are more successful alleging a defect and a reasonable alternative design (and therefore avoiding the problem of category liability) when the challenged aspect of the design is not visible or salient and when its elimination does not significantly change the product’s cost or functionality. So, for example, the placement of a gas tank, the use of a particular combustible gas to inflate an airbag, and the design of an ignition switch could all be defects without the doctrines of category liability or reasonable alternative design presenting any

160 *Id.*

161 *Id.* Like *Larsen*, the case was decided under negligence principles, but the court noted that the outcome would have been the same under products liability. *Id.* at 1068 n.2.

162 Abraham and Rabin, *supra* note 103, at 145–46 (“[P]roducts liability law has never gauged the reasonableness of a design by comparison to designs that have been rendered obsolete. A chainsaw’s trigger guard may be defectively designed even if the design is twice as safe as a saw without any guard at all; and depending on its side effects, an MRI machine may be defectively designed even if it is twice as safe as the X-ray machine that it supersedes.”).

163 Williamson v. Mazda Motor of America, Inc., 131 S.Ct. 1131 (2011).

164 Grossman, *supra* note 144, at 392–93.

165 *Id.*; Henderson and Twerski, *supra* note 125.

obstacle; nobody argues that an airbag inflated by ammonium nitrate is a distinct category of product.

Against this backdrop, the gap between a conventional vehicle like those that surround us today and Waymo's "firefly," which lacks a steering wheel or pedals and operates by computer alone,[166] feels like the gap between two product categories. Or, to put it another way, the "defect" of relying on a human driver feels so big that it is arguably no defect at all, merely an inherent feature of what we have always known as an automobile.

3 Custom evidence

Another doctrine that limits the extent to which parties can rely on cross-product arguments on defect is tort law's treatment of custom evidence. Because the history of automobile safety has been one of incremental improvements that have led to exponential increases in the safety of motor vehicle travel, older cars are generally less safe than newer ones.[167] When safety technologies are introduced, they are rarely made standard equipment on all models at once. More commonly, a manufacturer will release a new safety feature on higher-end models, as is happening now with advanced low-level automation like automatic emergency braking and lane departure warning. With most technological advancements, there is thus a class of people who are injured in crashes that would not have occurred (or whose severity would have been greatly reduced) if they had bought cars with the latest safety features available. When these plaintiffs sue car manufacturers, they argue that the absence of the safety feature in question rendered their car defective. These suits typically fail.

Electronic stability control (ESC) was an early form of low-level automation that represented a significant breakthrough in preventing accidents rather than mitigating their effects. ESC senses when a car is losing control in a turn and automatically, selectively applies the brakes to one or more wheels to prevent the car from skidding off the road.[168] ESC was first offered in 1997 by Mercedes-Benz.[169] By 2000, it was standard on most BMW and Mercedes cars, the Cadillac

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166 Waymo Team, *From post-it note to prototype: The journey of our Firefly* (June 12, 2017), https://medium.com/waymo/from-post-it-note-to-prototype-the-journey-of-our-firefly-30569ac8fd5e (last visited July 25, 2019).

167 See Charles J. Kahane, NHTSA, *Lives Saved by Vehicle Safety Technologies and Associated Federal Motor Vehicle Safety Standards, 1960 to 2012*, DOT HS 812 069, at x–xi (Jan. 2015).

168 *Id.* at 48–49.

169 *Id.* at 48.

Seville, and a few luxury cars made by GM.[170] During this period the NHTSA issued several reports assessing the effectiveness of the technology;[171] in 2004 the agency reported that it could save around 10,000 lives annually if it was included on every car.[172] Based on this data, NHTSA decided in 2007 to require that all passenger cars include ESC as standard equipment by 2012, with a gradual phase-in applying in the interim.[173]

Meanwhile, people were dying in crashes that could have been prevented by ESC. I have been able to find seven published opinions resolving cases in which plaintiffs alleged that their cars were defective by virtue of not including ESC.[174] In each case, the plaintiff lost.[175] Six of these cases were tried to a jury, all of whom returned verdicts for the defense on plaintiffs' design defect claims relating to ESC.[176]

Jae Kim v. Toyota Motor Corp., which reached the California Supreme Court, illustrates the problem of custom evidence particularly nicely. The plaintiff in *Jae Kim* was paralyzed in an accident he argued would have been prevented if

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170 *Id.* at 48.

171 *Id.* at 49 n.151 (collecting cites).

172 Jennifer N. Dang, NHTSA, *Preliminary Results Analyzing the Effectiveness of Electronic Stability Control (ESC) Systems*, DOT HS 809 790 (Sept. 2004), http://www.nhtsa.gov/cars/rules/regrev/evaluate/809790.html [https:// perma.cc/PBS6-DKCQ].

173 Federal Motor Vehicle Safety Standards; Electronic Stability Control Systems; Controls and Displays, 72 Fed. Reg. 17236 (April 6, 2007) (to be codified at 49 C.F.R. pts. 571 & 585).

174 There are certainly many more cases that have been filed and settled. *See, e.g.* Order Approving Settlement and Final Judgment, Benavides v. Chrysler Group LLC, No. 2:14-CV-00465, Dkt. #39 (S.D. Tex. November 20, 2015); Agreed Final Judgment, Garcia v. Nissan Motor Co., No. 7:05CV00059, Dkt. #48 (S.D. Tex. September 7, 2006).

175 *See* Jae Kim v. Toyota Corp., 424 P.3d 290, 293 (Cal. 2018) (affirming jury verdict for defense); Hinkle v. Ford Motor Co., No. 3:11-24-DCR, 2013 WL 2285447, at *3 (E.D. Ky. May 23, 2013) (noting jury's verdict in favor of defendant on design defect claim); May v. Ford Motor Co., No. 09-165-GFVT, 2010 WL 5391605, at *2 (E.D. Ky. December 22, 2010); (granting summary judgment for defendant on plaintiff's design defect claim); Cambron v. Ford Motor Co., No. B225122, 2012 WL 34233, at *3 (Cal. Ct. App. January 9, 2012) (noting jury's rejection of plaintiff's design defect theory); Fleurime v. Ford Motor Co., No. 14 FJVR 6–2, 2013 WL 8642137 (Fla. Cir. Ct. September 25, 2013) (jury verdict in favor of defense on design defect claim); Gallagher v. DaimlerChrysler Corp., 238 S.W.3d 157, 160 (Mo. Ct. App. 2007) (affirming jury verdict in favor of defendant and denial of plaintiff's motion for new trial); Hamid v. Lexus, 369 S.W.3d 291, 300–01 (Tex. App. 2011) (affirming jury verdict in favor of defendant and trial court's instruction that jury could presume that car was not defective because it complied with applicable safety regulations).

176 Only May v. Ford Motor Co. was resolved differently. In that case, the court granted summary judgment for the defendant due to inadequacies in the plaintiff's proposed expert testimony. May v. Ford Motor Co., No. 09-165-GFVT, 2010 WL 5391605, at *2 (E.D. Ky. December 22, 2010).

his 2005 Toyota Tundra had been equipped with ESC. (It was available as an optional add-on but he did not purchase it).[177] Kim's argument on defect was straightforward: ESC would have cost Toyota about $300 to $350 per vehicle and its benefits outweighed its cost.[178] Toyota, on the other hand, elicited testimony that no other manufacturer offered ESC as a standard feature on a pickup truck in 2005, and in fact the Toyota Tundra was the first pickup truck to offer ESC as an option.[179] The jury was instructed to apply the risk-benefit test, and it concluded that the car did not have a design defect.[180]

On appeal, Kim argued that the trial court had erred in admitting Toyota's evidence of industry custom, which he argued should be irrelevant in evaluating the defectiveness of a design under the risk-benefit test. After all, if a design is defective in that it "creates preventable danger that is excessive in relation to [its] advantages,"[181] what difference does it make whether every other manufacturer has the same design? As the court noted, it is possible that "the entire industry has 'unduly lagged' in adopting feasible safety technologies."[182] Indeed, a line of California appellate court cases had held that evidence of industry custom was irrelevant and thus inadmissible in products liability cases.[183]

The court affirmed, holding that the challenged evidence was admissible, not as dispositive evidence that the product was not defective, but because "competing manufacturers' independent design decisions may reflect their own research or experience in balancing safety, cost, and functionality, and thus shed some light on the appropriate balance of safety risks and benefits."[184]

177 Jae Kim v. Toyota Motor Corp., 424 P.3d 290, 293 (2018).
178 *Id.* at 294.
179 *Id.* In what must have been a risky strategic decision, Kim elected to call Toyota's product planning manager as an adverse witness. The manager admitted that the company had by 2005 decided to include ESC on all SUVs, and that an engineer had recommended they do the same with pickups, due to their similar rollover risks. But he also testified that pickup truck buyers were "price sensitive and uninterested in [ESC], and that none of Toyota's competitors were offering [ESC] as either standard or optional equipment on their 2005 pickup truck models." *Id.*
180 *Id.* at 295.
181 *Id.* at 294.
182 *Id.* at 300 (quoting The T.J. Hooper, 60 F.2d 737, 740 (2d Cir. 1932)).
183 *Id.* at 295–97. The same issue comes up in negligence cases and was the subject of intense debate and disagreement among courts until the rule of *The T.J. Hooper*, which treats custom evidence as relevant but not dispositive, gradually became the majority position. *See* Richard A. Epstein, *The Path to "The T. J. Hooper": The Theory and History of Custom in the Law of Tort*, 21 J. Legal Stud. 1, 16–38 (1992) (tracing this history).
184 *Id.* at 299.

This holding, the court noted, aligned it with the majority of states that have considered the issue, as well as the Third Restatement.[185]

The connection between this doctrine and the idea of category liability was made explicit by defense counsel, who argued in closing that "the Kims' theory that the 2005 Toyota Tundra contained a design defect 'meant that every 2005 pickup was defective.'"[186] The court of appeals criticized this argument sharply, calling it "'a prime example' of when industry custom and practice would not be relevant" because "[a]ll manufacturers may be producing an unsafe product."[187] The Supreme Court was less concerned. The "premise is correct," it argued, "but the conclusion is somewhat overstated." "Evidence of industry custom and practice," the court concluded, "may in some cases illuminate whether the product embodies excess preventable danger, given the trade-offs between competing design choices."[188]

Ultimately, the jury was not of course required to explain *why* it concluded that Kim's car was not defective by virtue of not including ESC. But the ability to introduce evidence that no pickup truck on the market included it must at least represent a thumb on the scale in favor of the defense. Thus while the court paid lip service to Learned Hand's insistence in *The T.J. Hooper* that "a whole calling may have unduly lagged in the adoption of new and available devices,"[189] it was perfectly comfortable with the jury being told to compare the car at issue with *other pickup trucks* and not with the more advanced, higher-end sedans and SUVs that already included ESC. It was not unusual in reaching this conclusion.[190]

Two of the California appellate cases discussed in *Kim* shed further light on the problem of custom evidence. In *Grimshaw v. Ford Motor Co.*, the plaintiff's Ford Pinto was rear-ended at low speed and burst into flames, killing her and severely injuring her son.[191] Facing a litany of bad facts and a host of ways it could have fixed the Pinto's alleged defects at extremely low cost,[192] Ford tried

185 *Id.* at 299 n.5 (collecting cites).
186 *Id.* at 302.
187 *Id.*
188 *Id.*
189 60 F.2d at 740.
190 Gideon Parchomovsky & Alex Stein, *Torts and Innovation*, 107 MICH. L. REV. 285, 299 (2008) ("Under the prevalent product-liability regime, a manufacturer's conformity with the relevant industrial custom is admissible as evidence tending to prove that its product was safe and not defectively designed."); David G. Owen, *Proof of Product Defect*, 93 KY. L.J. 1, 8–9 (2004) ("A great majority of jurisdictions maintain that a manufacturer's compliance or noncompliance with industry custom is some evidence that the product was or was not defective.").
191 Grimshaw v. Ford Motor Co., 119 Cal. App. 3d 757, 772 (1981).
192 *Id.* at 774–776. (noting various design changes that "would have enhanced the integrity of the fuel tank system at relatively little cost per car").

to defend itself by arguing, among other things, that the Pinto's "design and manufacture matched the average quality of other automobiles" and did not substantially deviate from the industry custom.[193] In *Buell-Wilson v. Ford Motor Co.*, the plaintiff was severely injured when her Ford Explorer rolled over and the roof collapsed.[194] The plaintiff's allegations of defect focused on the Explorer's high rollover risk and the various low-cost modifications Ford could have made to ameliorate it.[195] Ford sought to present expert testimony on how the Explorer's rollover rate compared with that of other, similar cars, with the aim of showing that the Explorer was "a reasonably safe vehicle that is not unusually prone to roll over in comparison to other vehicles."[196]

Both cases held that the defendant's proposed custom arguments were irrelevant, and both were overruled by *Jae Kim*.[197] The upshot is that today, California courts hold that it is it appropriate for juries to consider a car's safety relative to other comparable cars, and not just how safe it could have been had it been designed differently. Against this backdrop, it would seem hard to make the argument that a conventional vehicle is defective by virtue of not including optional, advanced safety features like automatic emergency braking, lane keeping assist, or even drowsiness alerts that help correct human foibles.[198]

B Efficiency

From a purely utilitarian perspective, tort law's relentless focus on defect is troublingly myopic. Who cares if Tesla's Autopilot could have been improved in some incremental way that would have prevented three fatalities if it can save

193 *Id.* at 803.

194 Buell-Wilson v. Ford Motor Co., 141 Cal. App. 4th 525, 531 (2006).

195 As in *Grimshaw*, Buell-Wilson unearthed a host of bad facts for Ford. In particular, Ford knew the Explorer had stability problems, and ignored pleas from its own engineers to make changes to its design. *Id.* at 536–38.

196 *Id.* at 544.

197 Jae Kim, *supra* note 177, at 301 n.6.

198 I have been able to find one case in which a plaintiff made this argument. In *Dashi v. Nissan North America, Inc.*, the plaintiff was struck head on by another car while making an illegal u-turn. 445 P.3d 13, 14–15 (Az. Ct. App. June 13, 2019). She argued that the other car was defective by virtue of not including features like automatic emergency braking and forward collision warning, which she argued would have prevented the crash. *Id.* at 15. The Arizona court of appeals dismissed the case as preempted by the NHTSA's 2017 decision, in response to a petition for rulemaking, not to mandate the inclusion of such features in all cars. *Id.* at 20–21; *see also* NHTSA, Denial of Petition for Rulemaking, Federal Motor Vehicle Safety Standards: Automatic Emergency Braking, 82 Fed. Reg. 8391–01 (January 25, 2017).

tens of thousands every year? To the welfare economist, the appropriate question is not whether Autopilot was "defective," but rather whether imposing liability will help encourage an efficient allocation of resources. With this concern in mind, one should ask how society might most efficiently accomplish the task of personal transportation.[199] Just as the NHTSA was able to conclude that requiring ESC would lead to a net gain in social welfare, an omniscient regulator might well conclude that replacing human drivers with autonomous ones would do the same. To many commentators, that conclusion seems inescapable, even though autonomous cars do not yet exist. These are important questions. But they are not the questions with which tort law concerns itself.

The degree to which tort law generally and products liability law in particular are capable of promoting the efficient allocation of resources has long been a source of controversy.[200] For some, tort law's various failures to promote efficiency are reasons to abandon the idea that tort law should be understood or evaluated instrumentally.[201] For others, these shortcomings become reasons to reform tort law in some way so that it can be made to promote efficient deterrence.[202] These arguments take many forms and take aim at various aspects of tort law, from the institutional competency of courts generally to determine what constitutes an efficient precaution,[203] to the justifiability of particular doctrines large and small. For those who are committed to the idea that the tort system should be understood and evaluated as a system that promotes efficiency, the chief problem with tort law's treatment of innovation has

199 Shavell, *supra* note 103, at 2 ("The social objective . . . is assumed to be the usual utilitarian goal associated with economic analysis of accidents, namely the maximization of the benefits parties obtain from their activities, here traveling in their vehicles, less the costs of achieving safety together with those of accidents themselves.").

200 *See* John C.P. Goldberg, *Twentieth Century Tort Theory*, 91 GEO. L.J. 513, 544–60 (2003) (surveying the debate).

201 *See, e.g.* Richard W. Wright, *The New Old Efficiency Theories of Causation and Liability*, 7 J. TORT L. 65 (2014).

202 A. Mitchell Polinsky & Steven Shavell, *The Uneasy Case for Product Liability*, HARV. L. REV. 1437, 1492 (2010) (proposing the contemplation of "[l]egislative change . . . that would limit or eliminate product liability in certain industries or for certain widely sold products"); *see also* Goldberg, supra note 200, at 546–53 (distinguishing between interpretive and prescriptive versions of economic deterrence theory).

203 Polinsky and Shavell, *supra* note 202, at 1440 (arguing that the "beneficial effects of product liability . . . are, for many products, likely to be outweighed by the litigation and related costs of product liability"); Henderson, *supra* note 136, at 1534 (arguing that courts "are not suited to the task of establishing specific product safety standards in the course of applying general reasonableness tests to determine the adequacy of allegedly defective products brought before them").

traditionally been that it is too quick to impose liability on new technologies. In other words, to most efficiency theorists, tort law functions as an excessively burdensome tax on innovation, in that it is too eager to punish new technologies for breaking from the status quo.[204]

My focus here is on a less frequently noticed tendency of tort law that has the same effect: it imposes *too low* a tax on established technologies. If, for example, it is efficient to equip every car with ESC, then tort law should (if it were to promote efficiency) treat every car without ESC as defective.[205] Such cars are, after all, just like the tugboats without radios in *The T.J. Hooper*: unduly lagging. And yet for the doctrinal reasons canvassed above, tort law often declines to impose liability in these circumstances.

As to ESC, regulatory analyses have always supported the idea that mandating its inclusion is clearly cost-justified.[206] For instance, the NHTSA estimated the cost of the rule requiring ESC as ranging from $180,000 to $450,000 per life saved.[207] The agency also estimated that ESC would prevent between 46,000 and 65,000 non-fatal injuries and prevent between $376 million and $535 million in property damage and travel delays.[208] On the other side of the ledger, the technology was calculated to increase the cost of each new passenger car by $90.30 (on average) and to require the use of an additional 2.6 gallons of fuel over the entire lifetime of the car.[209] The rule requiring ESC, the agency concluded, "is extremely cost-effective," so much so that its cost-effectiveness compared favorably with the rules requiring advanced airbags and center seat shoulder belts.[210]

204 George L. Priest, *The Effects of Modern Tort Law on Innovation and Economic Growth*, *in* Rules for Growth: Promoting Innovation and Growth Through Legal Reform 273, 273 (2011) (arguing that tort liability "has operated as a tax . . . without commensurate benefit to consumers" and that "[t]he effect of expanded tort liability has been to suppress innovation and reduce U.S. economic growth"); Peter Huber, *Safety and the Second Best: The Hazards of Public Risk Management in the Courts*, 85 Colum. L. Rev. 277–337, 278 (1985) (arguing that tort law is "imprudently biased against many progressive, risk-reducing . . . technologies" and that "[t]his bias significantly hinders our progress towards a healthier, safer environment").

205 Ellen Wertheimer, *Unavoidably Unsafe Products: A Modest Proposal*, 72 Chi-Kent L. Rev. 189, 195, 199 (1996) (arguing that manufacturers should bear the costs of injuries caused by unavoidably unsafe products because "[a]ny calculation which fails to take such costs into account allows the manufacturer to reap the benefits of the product without having to confront its costs").

206 NHTSA, *supra* note 173, 72 Fed. Reg. at 17297. *See also* NHTSA, FMVSS No. 126: Electronic Stability Control Systems, Final Regulatory Impact Analysis (Mar. 2007).

207 *Id*. (The range results in part from different rates used to discount figures to present value).

208 *Id*.

209 *Id*. at 17298.

210 *Id*. at 17297.

And yet, as discussed above, plaintiffs did not generally succeed in holding manufacturers liable for declining to equip their cars with ESC.[211]

The history of litigation over airbags provides another telling example. The development and adoption of airbags is a much more complex story than that of ESC; it spans many decades and involves technological development, Congressional intervention, public pressure, and a complicated series of administrative rules.[212] In its broadest strokes, though, it fits a similar pattern: a cost-justified technology[213] is developed and gradually incorporated into passenger vehicles, during which time people who buy cars without the technology are killed. As with ESC, this situation triggered a spate of "no airbag" cases, in which plaintiffs argued that their cars were defective in design by virtue of not including technology whose adoption would seem to be compelled by the risk/utility test.

Many of these cases were decided on preemption grounds, and ultimately the Supreme Court held in *Geier v. American Honda Motor Corp*. that state common law suits that sought to impose a duty on manufacturers to include airbags were preempted by Federal Motor Vehicle Safety Standard 208, which at the time expressly gave manufacturers a choice of which type of "passive restraint" to adopt, with airbags being one of several options.[214] Cases that predated *Geier* were often resolved on preemption grounds without mention of the substantive merits of the plaintiffs' claims.[215] In some cases, however, courts also addressed the idea of a "no airbag" claim from a products liability

211 *See supra* notes 174–190 and accompanying text.

212 *See generally* Mashaw and Harfst, *supra* note 131; see also Geier v. American Honda Motor Co., 529 U.S. 861, 875–81 (2000); Kahane, *supra* note 167, at 121–22.

213 The cost-effectiveness of airbags has been a subject of controversy since at least the 1970s. More recent work supports the idea that airbags are clearly cost-justified, even if perhaps less so than the NHTSA's initial estimates predicted. According to one analysis, driver's side airbags cost $24,000 per "quality adjusted life year" saved. John D. Graham et al., *The Cost-effectiveness of Air Bags by Seating Position*, 278 Journal of the American Medical Assoc. 1418 (1997); *see also* Kimberly M. Thompson, Maria Segui-Gomez & John D. Graham, *Validating Benefit and Cost Estimates: The Case of Airbag Regulation*, 22 Risk Analysis 803, 808 (2002). This figure compares favorably with other public health interventions, like regular pap smears, radon testing, and the 55-mph speed limit. *Id*. at 808.

214 529 U.S. at 886.

215 This is so even in cases where state courts held that plaintiffs' claims were not preempted. *See* Drattel v. Toyota Motor Corp., 699 N.E.2d 376 (N.Y. 1998); Minton v. Honda of Am. Mfg., Inc., 684 N.E.2d 648 (Ohio 1997); Munroe v. Galati, 938 P.2d 1114 (Ariz. 1997); Wilson v. Pleasant, 660 N.E.2d 327 (Ind. 1995); Tebbetts v. Ford Motor Co., 665 A.2d 345 (N.H. 1995).

perspective, typically holding that cars sold without airbags were not defective as a matter of law.[216]

In *Cooper v. General Motors*, the Mississippi Supreme Court rejected the idea that the absence of airbags could render a car defective in particularly forceful terms. The court first noted that under the consumer expectations test, plaintiffs "cannot expect an air bag to pop out knowing it did not exist."[217] Plaintiffs relied instead on the then-recently-adopted risk/utility test. The court vehemently rejected this argument. Rather than addressing the actual costs and benefits of airbags, the court insisted that imposing liability for a manufacturer's failure to install an "additional safety device" would be bad public policy, because it would subject manufacturers to a wide range of design standards in different states and thus make cars "prohibitively expensive."[218] Of course the presence of federal regulations makes it hard to draw strong conclusions from courts' treatment of "no airbag" cases. But there is precious little evidence that courts stood willing to impose liability on manufacturers for their failure to adopt this now-universal efficient precaution.

Category liability is another barrier to the imposition of liability on older, more dangerous technology. The rejection of category liability, after all, amounts to an exception to the idea expressed long before *The T.J. Hooper* that courts must in some cases stand willing to declare the practice of an entire industry to be inadequate.[219] That may be true as to minor details or alternative designs of the same product, but the rejection of category liability tells us that, paradoxically, the more significant the problem with the design of a product, the more likely it is to be beyond the scrutiny of tort law.[220] Several scholars committed to the idea that tort doctrine should be made to promote efficiency

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216 *See* Cooper v. General Motors, 702 So.2d 428 (Miss. 1997); Honda Motor Co. v. Kimbrel, 376 S. E.2d 379, 384 (Ga. Ct. App. 1988) ("Safety belts rather than airbags would not be a defect . . . ."); Hughes v. Ford Motor Co., 677 F. Supp. 76, 85 (D. Conn. 1987) (applying consumer expectations test and holding that car without airbags was not defective because "the ordinary consumer who purchased the 1974 Pinto, with the ordinary knowledge common to the community, could not possibly have contemplated the presence of airbags."); *but see* Taylor v. General Motors Corp., 875 F.2d 816 (11th Cir. 1989) (holding that claim is preempted but also reversing district court's grant of summary judgment on the ground that airbags did not offer a safety benefit when seatbelts were used); Wood v. General Motors Corp., 673 F. Supp. 1108 (D. Mass. 1987) (holding that no airbag claim was not preempted and could go to the jury on the issue of defect).

217 702 So.2d at 443.

218 *Id.* at 443–44 & n.5.

219 Epstein, *supra* note 183, at 25–32.

220 Richard A. Epstein, *The Risks of Risk/Utility*, 48 OHIO ST L.J. 469, 475 (1987) ("If [the risk/utility test] can be used to decide whether certain features of a machine tool should be replaced, why cannot it be used to answer the question of whether entire classes of products, from handguns to convertible automobiles to alcohol should be marketed at all?").

have thus argued that products that are inefficiently dangerous should be exposed to liability, regardless of whether such liability would amount to a prohibition on an entire product category.[221]

The consideration of custom evidence is also problematic from an efficiency perspective. If what matters is creating liability rules that penalize the failure to take precautions that cost less than the injuries they prevent, it is hard to see why evidence that other cars don't include ESC should be relevant. Indeed, this has been the view of several efficiency theorists, who favor a categorical exclusion of custom evidence.[222] Others argue, to the contrary (and less defensibly), that custom should be exclusive evidence of due care, since to defer to industry custom is to create a "market-based standard of liability," and the market should be presumed to have arrived at the efficient allocation of resources whenever the parties have a preexisting relationship, like that of manufacturer and consumer.[223] It is harder to find efficiency theorists defending the

221 Steven Croley & Jon Hanson, *What Liability Crisis? An Alternative Explanation for Recent Events in Products Liability*, 8 YALE J. ON REG. 1, 8, 84–90 (1991) (arguing that "courts should complete the shift towards enterprise liability" because doing so leads to the removal from the market of inefficiently unsafe products); Marc Z. Edell, *Risk Utility Analysis of Unavoidably Unsafe Products*, 17 SETON HALL L. REV. 623–655, 655 (1987) (arguing that courts should hold manufacturers liable under the risk/utility test when their products are unavoidably unsafe and do "more harm than good"); John L. Diamond, *Eliminating the Defect in Design Strict Products Liability Theory*, 34 HASTINGS L.J. 529–552, 531 (1983) (arguing that courts should impose strict liability regardless of defect because doing so would "encourage safety measures"); see also Gary T. Schwartz, *Foreword: Understanding Products Liability*, 67 CALIF. L. REV. 435, 443 (1979) (noting argument that imposing liability without defect would create "a powerful and unremitting incentive . . . to adopt all appropriate safety devices").

222 Gideon Parchomovsky & Alex Stein, *Torts, Innovation, and Growth*, *in* RULES FOR GROWTH: PROMOTING INNOVATION AND GROWTH THROUGH LEGAL REFORM 257, 528 (2011) ("These rules deviate from the straightforward 'result criterion' that rejects custom-driven proxies and calls for a direct assessment of the technologies'' risks and benefits. Under this criterion, the technology's compliance or failure to comply with custom should play no role in determining its users' liability for tort damages. That is, defendants who comply with custom should receive no preferential treatment from the torts system.")."

223 Epstein, *supra* note 183, at 4, 37. Jason M. Solomon expresses a similar skepticism of the appropriateness of tort law (and particularly juries) passing judgment on industry custom, but his argument in favor of greater deference to custom is addressed to tort litigation only, and relies less on faith in the efficiency of custom itself. Jason M. Solomon, *Juries, Social Norms, and Civil Justice*, 65 ALA. L. REV. 1125, 1192 (2014) ("[C]ourts, in deciding wrongfulness in tort cases, are not the ones to make the determination that companies ought to behave differently: that is for legislatures or administrative agencies to do."). Epstein extends this argument even to the safety (or lack thereof) of nineteenth century mining operations, whose customs he says should be assumed to be efficient, since there is a "tendency of consensual arrangements to optimize longstanding middle ground, under which custom is relevant but not dispositive evidence of due care.

Efficiency theorists have made several defenses of these doctrines. One defense of the protection afforded to product categories is that they usually do not involve hidden risks and so might rationally be preferred by some consumers.[224] Buyers of motorcycles or convertibles might, for example, place a particularly high subjective value on the feeling of the wind in their hair. On the other hand, people have a tendency to underestimate product risks and undervalue uncertain future harms.[225] Consumers also ignore costs to third parties and may discount even first party costs to the extent they are socialized.[226]

Another response is that when there is no precaution the manufacturer could be induced to take, providing compensation to the customer in the event of a crash would artificially decrease the cost of driving a motorcycle and thus lead to inefficiently high levels of activity (motorcycle driving). Landes and Posner made this argument in the context of design defect claims against automobile manufacturers specifically.[227] They argued that in many cases, the more efficient precaution is not to make the car safer but rather to drive more cautiously, and that having manufacturers compensate injured drivers would only destroy the drivers' incentive to slow down.[228] Indeed, Shavell has made this very point in connection with autonomous vehicles, arguing that having manufacturers pay damages to their customers is undesirable because those damages would artificially reduce the cost of driving and lead to overconsumption (in the form of driving too much).[229]

the joint welfare of the parties." Epstein, *supra* note 183, at 18–19 (discussing Mayhew v. Sullivan Mining Co., 76 Me. 100 (1884)).

224 Henderson and Twerski, *supra* note 125, at 1317.

225 Michael G. Faure, *Economic Analysis of Product Liability*, *in* EUROPEAN PRODUCT LIABILITY: AN ANALYSIS OF THE STATE OF THE ART IN THE ERA OF NEW TECHNOLOGIES 619, 654–55 (2016); Richard J. Pierce Jr., *Encouraging Safety: The Limits of Tort Law and Government Regulation*, 33 VAND. L. REV. 1281, 1284 (1980) (listing "externalities, transaction costs, limited cognitive ability of participants, and the relationship of market choices to preexisting patterns of wealth distribution" as "factors that impair the ability of the market to channel safety spending into patterns deemed optimal by all"). Pierce also noted that people assign different values to their own lives depending on whether the risk they are exposed to is large or small, voluntary or involuntary, or "associated with a particularly vivid or emotive event." *Id.* at 1313.

226 Faure, *supra,* at 639–40; Henderson and Twerski, *supra* note 125, at 1275–76.

227 William M. Landes & Richard A. Posner, *A Positive Economic Analysis of Products Liability Critical Issues in Tort Law Reform: A Search for Principles*, 14 J. LEGAL STUD. 535, 554 (1985).

228 *Id.*

229 Shavell, *supra* note 103, at 3–4. Shavell's solution is to have manufacturers pay damages to the state instead. *Id.* at 4.

This is not a persuasive account of how people decide when and how to drive.[230] It would, for example, be more efficient if people would simply stop driving while drunk, an activity that kills around 10,000 people per year. That the cost of drunk driving is not shifted onto car manufacturers does not seem to be having any effect on drivers' willingness to keep doing it. Meanwhile, devices that can prevent a car from turning on if the driver is drunk were first developed in 1969[231] and even though they could be installed at relatively modest cost,[232] no court has ever held a manufacturer liable for failing to include one in a vehicle.[233]

To be clear, my argument is not that products liability creates no incentive on the part of manufacturers to develop safer products,[234] or that manufacturers

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230 Indeed, the need to regulate activity levels is frequently cited by efficiency theorists as a reason to prefer strict liability, on the theory that manufacturers would pass the cost on to their customers, and that higher prices of things like motorcycles would do more to suppress motorcycle riding than the vague sense that one might someday crash. *See, e.g.* Faure, *supra* note 225, at 639–40; Henderson, *supra* note 136, at 1273–74 (noting argument that "[u]nder a defect-free strict liability rule, the full costs of product-related injuries would be reflected in the purchase prices of products, leading to more appropriate levels of consumption").

231 Rapaczynski, *supra* note 101, at 22 n.53.

232 Patrick M. Carter et al., *Modeling the Injury Prevention Impact of Mandatory Alcohol Ignition Interlock Installation in All New US Vehicles*, 105 AM J PUBLIC HEALTH 1028, 1031 (2015) (noting that interlock devices cost about $400 per vehicle and estimating that they could save about $343 billion in accident costs over 15 years, resulting in net economic benefits per equipped vehicle after just 3 years); see also Rapaczynski, *supra* note 101, at 23 ("[T]he cost of the device is low enough to make its absence into a self-evident violation of the Learned Hand formula defining reasonable care.").

233 Rapaczynski, *supra* note 101, at 23.

234 Indeed, in one study, researchers interviewed the heads of corporate safety offices at nine "large manufacturing concerns" and found that, with a few exceptions, "product liability is the most significant influence on product safety efforts." GEORGE C. EADS & PETER REUTER, RAND INSTITUTE FOR CIVIL JUSTICE, DESIGNING SAFER PRODUCTS: CORPORATE RESPONSES TO PRODUCT LIABILITY LAW AND REGULATION vii (1983). The study also found, however, that the signal conveyed by products liability is "indistinct" and muffled by "long lags between the design decision and the final judgment, . . . the inconsistent behavior of juries, and the rapid change in judicial doctrine in the area." *Id.* Ultimately, the authors concluded, "firms learned little from the results of particular litigation about either specific design decisions or the process of design decisionmaking." *Id.* at vii-viii.

Another study of early improvements in motor vehicle safety concluded that products liability law "is one of several forces that induce manufacturers to consider making pro-safety decisions in the marketplace" and can sometimes "cause safety improvements to occur more quickly than they would have occurred in the absence of liability." John D. Graham, *Product Liability and Motor Vehicle Safety*, *in* THE LIABILITY MAZE: THE IMPACT OF LIABILITY LAW ON SAFETY AND INNOVATION 120 (Peter W. Huber & Robert E. Litan eds. ed. 1991).

are never held liable for things like omitted or insufficient safety devices in automobiles.[235] Automobiles, given their cost and complexity, are arguably an area where tort law is relatively loath to intervene on the side of efficiency, as opposed to say, chainsaws or lawnmowers. It is also certainly true that judges often speak in broadly utilitarian terms in explaining their decisions. Nor is it fair to treat the tort system and the regulatory state as entirely distinct.[236] My claim is a more modest one: products liability's defect requirement, refusal to impose category liability, and insistence on evaluating the defectiveness of products by reference to custom are hard to square with the goal of efficient deterrence.[237] That a car with a human driver would not be considered defective is a prime example.[238] Understanding why tort doctrine responds to technological advancement in this way requires looking beyond efficiency.

C Morality

Products liability's tunnel vision in evaluating the defectiveness of a design is hard to justify on efficiency grounds. Explaining it requires a turn to morality. Why does tort law treat selling a Corvair but not a convertible as a wrong? Part of the answer lies in the idea of consent, which is foundational to torts generally, from intentional torts to negligence to products liability.[239] The buyer of a convertible has necessarily consented to rollover risks in a way that the buyer of a Corvair has not.[240] Another part of the answer lies in the traditional idea that torts are wrongs, and the sense in which selling a defective product that causes injury is a wrong. Together these ideas suggest that manufacturers of autonomous vehicles should face the threat of liability when their products contain

235 See, e. g. Owen, *supra* note 126, at 294 n.13 (citing cases).

236 *See* John C. P. Goldberg & Benjamin C. Zipursky, *The Easy Case for Products Liability: A Response to Professors Polinsky and Shavell*, 123 HARV. L. REV. 1919, 1931 (2010).

237 *See* John C.P. Goldberg and Benjamin C. Zipursky, *Tort Law and Responsibility*, in PHILOSOPHICAL FOUNDATIONS OF THE LAW OF TORTS 17, 22 (John Oberdiek, ed., 2014) (arguing that "products liability law contains fundamental limitations on liability that are difficult to justify by reference to . . . instrumental considerations" like efficient deterrence).

238 See Logue, *supra* note 103, at 6, 24–25 (proposing that manufacturers of vehicles of all types be strictly liable for all car accidents because such a system would hasten the transition from conventional vehicles to autonomous ones).

239 Mark A Geistfeld, *The Value of Consumer Choice in Products Liability*, 74 BROOK. L. REV. 781, 781 (2009).

240 NADER, *supra* note 129, at 2–32 (describing stabilty problems arising from various aspects of the Corvair's design).

defects that cause injury, regardless of whether they may be safer, in the aggregate, than conventional vehicles.

As Geistfeld has shown, the value of consumer choice was at the core of early justifications for imposing products liability, which was seen as a necessary corrective to modern manufacturing and market processes' tendency to obscure products' flaws and risks from consumer scrutiny.[241] The consumer expectations test of defectiveness gave consumer choice an explicit role in products cases, as it treated products as defective when they were dangerous to an extent beyond that which would be contemplated by the ordinary consumer.[242]

Today the role of consumer choice (and thus consent) in design defect cases is considerably murkier. Controversially, the Third Restatement strongly repudiated the consumer expectations test in favor of the risk/utility test, which has no obvious connection to consumer choice. Moreover, the defense of assumption of risk, which instantiates consent in negligence cases, does not apply in products liability cases.[243] Geistfeld has argued that the risk/utilty test, properly understood, vindicates consumer choice by giving effect to the choices consumers would make if they had access to the same information as manufacturers. The risk/utility test therefore contemplates liability for manufacturers' failure to install safety devices like ESC or airbags even though consumers plainly did not choose them because, Geistfeld argues, consumers would have chosen them if they had better access to information.[244]

One problem with this argument is that, as we have seen, products liability has a spotty record when it comes to forcing automobile manufacturers to invest in cost-justified safety technology; while the risk/utility test might seem to compel the addition of features like airbags and ESC, doctrines like category liability, reasonable alternative design, and custom evidence hinder the imposition of liability. A more profound problem is that there are instances in which consumer choice and the rational, efficient risk/utility test diverge. Consumers do not always choose efficient precautions, even when they have access to all the information necessary to do so. A convertible is hard to justify on efficiency grounds. So is a motorcycle.[245] One solution is to assign some large value in the

241 Geistfeld, *supra* note 239, at 784–87.
242 *Id.* at 788. (citing REST. 2D OF TORTS § 402A).
243 *Id.* at 783.
244 *Id.* at 786–87, 790–91.
245 *See* Daniel J. Fagnant, Brice G. Nichols, and Kara M. Kockelman, *Who Rides and Who Pays: Comprehensive Assessment of Motorcycling Costs and Benefits in the United States*, 2388 TRANSPORTATION RESEARCH RECORD 37, 44–45 (2013) ("[T]he various benefits of motorcycles

cost/benefit analysis to subjective goods, but this move risks a kind of free market agnosticism, in which any product whose risk is known moves beyond the reach of products liability.

Products liability law is arguably best seen as giving effect to the value of consent not in the risk/utility test itself but in the various instances highlighted above in which defendants escape liability despite failing to invest in cost-justified precautions. When the value of consumer choice diverges from the value of efficient precaution, products liability law errs on the side of giving effect to consumer choice. Part of the explanation for the contours of reasonable alternative design and category liability is this impulse. When an aspect of a design like the inherently weaker retractable roof of a convertible is extremely salient and is obviously part of the consumer's individual calculus in selecting the product, it is likely to be beyond the scrutiny of products liability.[246] Complex, hidden design details that are not part of why anyone chooses a car, like the inability of the Corvair's steering column to absorb the force of a head-on collision without impaling the driver, enjoy no such protection.[247] In part this can be seen as the *de facto* survival of the rule, repudiated in most jurisdictions, that treated patent or "open and obvious" dangers as not actionable.[248] The more significant a feature, like the retractable top of a convertible, the more clearly it appears that consumers have chosen to expose themselves to its risks.

This view of the role of consent in design defect cases supports tort law's rejection of category liability. Just as car manufacturers are not liable for all crashes simply because train travel is safer, so manufacturers of conventional vehicles should not be liable just because, in a hypothetical future world, autonomous vehicles are safer. We consent to the risks that we will fall asleep

appear to be severely negated by added crash costs, which never return benefit-cost ratios greater than 1, even for the skilled and helmeted riders . . . .").

246 *See* Walters, *supra* note 142, at 458 ("The absence of this structural component is not only obvious but chosen by consumers who desire the flexibility of a soft top that can be easily detached, folded, and stowed for an open-air driving experience . . . ."); Curtis, *supra* note 142, at 811 ("[I]f the vehicle was to be marketed at all . . . a compromise was necessary. If there be no compromise and only the very safest can be marketed, there obviously would be no choice for the buyer as the less safe options would be eliminated.").

247 *See, e.g.*, Larsen v. General Motors, 391 F.2d 495 (8th Cir. 1968); *see also* Keith N. Hylton, *The Law and Economics of Products Liability*, 88 NOTRE DAME L. REV. 2457, 2458 (2013) (noting that "[p]roducts liability law operates largely on products that have observable utility and hidden risks," and that "[t]his combination of features is unlikely to be regulated well by the market").

248 Epstein, *supra* note 220, at 474–76; REST. 3D OF TORTS: PRODUCTS LIABILITY § 2 cmt. d. Part IV.C.

or get distracted or drive drunk every time we get behind the wheel, even if manufacturers have the means to eliminate these risks technologically.[249]

But if these observations are correct, why shouldn't autonomous vehicle manufacturers be immune from liability, as Geistfeld suggests, as long as their products are significantly safer and they disclose whatever risk remains to consumers in a transparent and understandable manner?[250] Haven't users of Tesla's Autopilot consented to the risk of being chauffeured around by an inexperienced and erratic algorithm?

Not if Tesla's autopilot is defective. To corrective justice and civil recourse theorists, tort law is a law of wrongs.[251] Products liability law "allows victims who have been wrongfully injured by the seller of a defective product to invoke the legal system to hold the seller accountable."[252] Somewhat ironically, the concept of a design defect is easier to square with notions of fault that predated the creation of products liability law than the older, conceptually simpler, idea of a manufacturing defect.[253] It is hard to see how the Coca-Cola bottler who exercised due care has wronged the waitress who falls victim to the inevitable one-in-a-million exploding Coke bottle.[254] It is much easier to see how the designers of the Shopsmith wronged Mr. Greenman when they selected for their lathe an inadequate set screw.[255] Indeed, plaintiffs include negligence claims in many products liability cases, partly to ensure the relevance of evidence of the defendant's bad behavior. Many landmark design defect cases involving automobiles fit this pattern.[256]

249 *See supra* notes 231–233 and accompanying text.

250 Geistfeld, *supra* note 103, at 1654–60.

251 *See, e.g.* Goldberg, *supra* note 200, at 570 (describing views of corrective justice theorists); John C.P. Goldberg & Benjamin C. Zipursky, *Torts as Wrongs*, 88 TEX. L. REV. 917 (2010).

252 Goldberg and Zipursky, *supra* note 236, at 1944.

253 G. Edward White, *The Unexpected Persistence of Negligence, 1980–2000*, 54 VAND. L. REV. 1337, 1348 (2001) (arguing that criteria for determining defectiveness in design cases are "virtually identical to the criteria for determining 'reasonable conduct' in negligence cases").

254 The majority opinion in *Escola* relied on an expansive interpretation of the idea of res ipsa loquitur to reach this conclusion. 150 P.2d at 439–40.

255 377 P.2d at 899.

256 *See, e.g.* Hiroko Tabuchi & Neal E. Boudette, *Automakers Knew of Takata Airbag Hazard for Years, Suit Says*, THE NEW YORK TIMES, February 27, 2017, https://www.nytimes.com/2017/02/27/business/takata-airbags-automakers-class-action.html (last visited August 19, 2019); Engstrom, *supra* note 112, at 328–31 (recounting key facts of GM ignition switch litigation, which revealed that GM knew for years that certain ignition switches were prone to failure, disabling the car's power steering, brakes, and airbags, but took no action to fix the problem and attempted to cover it up instead); Buell-Wilson, 141 Cal. App. 4th at 535–36 ("Long before the Wilsons purchased their Explorer, Ford's engineers knew that the vehicle's design was

Focusing on the wrongfulness of the challenged design helps explain products liability's treatment of custom evidence. Custom evidence contains strong whiffs of fault. A defendant's compliance with custom tends to suggest the exercise of ordinary care. So while custom evidence should technically be irrelevant in asking whether a design is defective, courts have admitted it on the arguably tenuous understanding that it helps "shed light . . . on the adequacy of the design itself" by helping juries "consider whether a design is safe enough, given the relative complexity of design decisions and the trade-offs that are frequently required in the adoption of alternative designs."[257] These legal niceties notwithstanding, it is hard to conclude that a design is defective after being told that it is universal or nearly so. The jury in *Jae Kim* thus decided that Kim's Toyota Tundra was not defective by virtue of lacking ESC, after being told that when Kim bought his car no pickup truck on the market included ESC. The lack of ESC was no secret, of course, but as Geistfeld points out, consumer choice alone does not absolve Toyota, since consumers often do not have the information or ability to make informed decisions about complex safety features like ESC or airbags.[258] To treat custom as dispositive of due care, on the other hand, would be problematic as well, as it would eviscerate the legal obligations tort law imposes on industries and return us to the pre-*Larsen* (or even pre-*MacPherson*) days in which the free market status quo was the beginning and end of a manufacturer's responsibility to its customers.

It is admittedly not self-evident that morality requires a system built on fault. It was once common to hear scholars making arguments from morality in favor of enterprise liability, which eschews fault in favor of compensating injured consumers.[259] Consumers after all are innocent of any role in designing or selling the products that injure them and thus arguably should not be made

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unstable and prone to rollover . . . . Ford's design engineers repeatedly requested Ford to widen the track width and lower the center of gravity on the Explorer to increase its stability. However, management declined to do so."); Grimshaw, 119 Cal. App. 3d at 775–77 ("[T]he highest level of Ford's management made the decision to go forward with the production of the Pinto, knowing that the gas tank was vulnerable to puncture and rupture at low rear impact speeds creating a significant risk of death or injury from fire and knowing that 'fixes' were feasible at nominal cost.").

257 Jae Kim, 424 P.3d at 298.

258 Geistfeld, *supra* note 239, at 794.

259 *See, e. g.* White, *supra* note 253, at 1345–46, 1360; Wertheimer, *supra* note 205, at 194–95 (arguing that "fairness requires that manufacturers stand behind their products" by compensating those who are injured, regardless of whether the product is defective). Are we morally responsible for the effects of our actions, even when those actions are in no way wrongful? Intuitively, it seems easy to say no, even when the actions in question are ones that bring us profit. See Goldberg & Zipursky, supra note 237, at 22–23 (arguing that "[a] seller can cogently to bear their losses just because they aren't traceable to defects in the products that hurt them. To corrective justice theorists, though, tort law has always been a system that concerns itself with *wrongful* losses, rather than losses – or need – per se. This is what distinguishes it from distributive justice.[260] Imposing liability on product categories without any showing of defect thus feels unfair; why should a manufacturer be liable for a plaintiff's fall off a well-built ladder?[261]

These observations suggest that manufacturers of autonomous vehicles should not be immune from liability if their products are defective, regardless of whether they are nevertheless safer than conventional vehicles. Focusing on the wrongfulness of selling a defective product helps highlight, too, instances in which manufacturers of autonomous vehicles should *not* be liable. Strict liability has never been truly "strict" in the sense that plaintiffs are absolved of any obligation to show defect and have only to prove that the defendant's product caused their injury. Selling a product that is unavoidably dangerous, tort law has always recognized, is simply not wrong. An autonomous vehicle that crashes should thus be liable only if the plaintiff can trace the crash to some defect.[262]

III Application

What do these observations about the nature of products liability tell us about how cases against autonomous vehicle manufacturers should be resolved? It is worth recalling for a moment the incredible diversity of proposals for addressing autonomous vehicle liability, which range from blanket immunity to strict liability to repudiations of the tort system in favor of new compensation schemes.[263] One theme that is common to virtually all of this scholarship is

be deemed morally responsible for its product having caused an injury when the injury was an avoidable consequence of selling the product").

260 Peter Benson, *The Basis of Corrective Justice and Its Relation to Distributive Justice*, IOWA L. REV. 515–624, 538 (1991).

261 Schwartz, *supra* note 221, at 444.

262 It is entirely possible that an insurance-like system of manufacturer enterprise liability like that proposed by Abraham and Rabin would do a better job of providing both compensation and efficient deterrence. *See supra* note 117. I am willing to admit that such a system might be a desirable replacement for tort law from a normative perspective. It would be important to understand and acknowledge, however, that in abandoning tort law we would be largely jettisoning its valuable moral content. *See* Alexander B. Lemann, *Coercive Insurance and the Soul of Tort Law*, 105 Geo. L.J. 55, 94–96 (2016).

263 See supra notes 115–121 and accompanying text.

that our sense of how autonomous vehicle liability is to be handled should turn on whether and to what degree autonomous vehicles are safer than conventional ones.

To begin, some thoughts will be applicable to any case involving an autonomous vehicle. The doctrines of defect, category liability, reasonable alternative design, and custom evidence suggest that autonomous vehicles should be evaluated on their own merits, without regard to how much safer they are than conventional vehicles. Just as a manufacturer cannot defend an allegation of design defect by pointing out that its car is safer than a horse, so an autonomous vehicle manufacturer should not be able to point to a conventional vehicle in defending itself. Defective airbags, antilock brakes, ignition systems, and seatbelts have all been evaluated by reference to their intended purposes and the limits of current technology, not to older vehicles that lack such features altogether.

The suggestion that autonomous vehicles should be evaluated on their own merits is likely to be divisive, since it ignores broader utilitarian reasons for preferring autonomous vehicles over conventional ones. These reasons may be excellent. They may, some day in the not too distant future, form the basis for a new Federal Motor Vehicle Safety Standard requiring that all passenger cars include features like automatic emergency braking or forward collision warnings.[264] That would, indeed, be a desirable function of the NHTSA. But tort law is a law of wrongs, and it is entirely possible that an autonomous vehicle could be defective, despite its being safer in the aggregate than a conventional one. Similarly, a conventional vehicle does not become defective just because an autonomous vehicle is safer.

The principle of consumer choice, which is given effect widely in tort law, helps support this result. Consumers who choose to purchase and drive a car are well aware of their own foibles. We fall asleep, get distracted, get drunk. Those weaknesses have never triggered liability on the part of manufacturers, even when technology to correct them has existed for decades.[265] The flaws of an algorithm, on the other hand, are to a meaningful extent hidden from view.

264 In response to a petition for rulemaking, the NHTSA in 2017 declined to propose regulations mandating the inclusion of these technologies, but noted that its denial was based on its belief that pressure from various other organizations (including the Insurance Institute for Highway Safety) would lead to the inclusion of these technologies in "substantially all light vehicles." The agency also noted that it would continue assessing whether a new standard "might be needed in the future." NHTSA, Denial of Petition for Rulemaking, Federal Motor Vehicle Safety Standards: Automatic Emergency Braking, 82 Fed. Reg. 8391–01 (January 25, 2017).

265 *See supra* notes 231–233 and accompanying text.

Indeed, understanding whether and how an algorithm is likely to fail in performing the driving task has proved to be a vexing problem for the top minds in computer science. The very complexity of the problem has supported calls for taking responsibility for it away from our civil justice system, which is seen to be poorly equipped to even attempt to understand emergent behavior on the part of the algorithms that will drive us around. If this is true, it is hard to see why consumers should be said to have accepted the risks involved, even if they are provided with some sense of the statistical danger that remains when they are relieved of the burden of driving. After all, one of the enduring lessons of *Larsen* and its progeny is that manufacturers are not relieved of liability for design defects simply because crash statistics are widely available and known to consumers.

Just because an autonomous vehicle is involved in a crash, on the other hand, doesn't mean it is defective. Injuries caused by unavoidable errors in an otherwise safe technology, like the failure of a tire to maintain its grip on icy pavement, do not qualify as wrongs. Many scholars take the view that autonomous vehicle crashes will have this quality.[266] It is, after all, possible that autonomous vehicles will have a known, irreducible error rate and that it will be impossible to trace the crashes that continue to occur to a discrete programming error or design decision.

It helps to consider this argument against the backdrop of the four fatalities autonomous vehicles have so far caused. The fatal crashes involving Tesla's Autopilot, in particular, raise these issues most clearly, both because Tesla's customers were the ones killed and because Tesla has been very vocal in defending itself by arguing that its Autopilot features are safer overall than human drivers. Of those who have been killed by Tesla's Autopilot, only Walter Huang has so far filed suit. Joshua Brown's family was reported to have hired a lawyer to explore the possibility of suing Tesla in 2016.[267] A year later, the family released a statement that seemed to absolve Tesla of any blame for the accident.[268]

266 *See supra* note 112.

267 Stephen Gandel, *Tesla Autopilot Crash Victim's Family Hired a Personal Injury Lawyer*, FORTUNE, Jul. 11, 2016, https://fortune.com/2016/07/11/tesla-autopilot-joshua-brown/ (last visited July 23, 2019).

268 Ryan Felton, *Feds To Partially Blame Tesla's Autopilot In Fatal Crash: Report*, JALOPNIK, Sept. 11, 2017, https://jalopnik.com/the-ntsb-to-partially-blame-teslas-autopilot-in-fatal-c-1803136365 (last visited July 23, 2019) ("We heard numerous times that the car killed our son. That is simply not the case . . . . People die every day in car accidents . . . . Joshua believed, and our family continues to believe, that the new technology going into cars and the move to

Many scholars have focused on the seeming difficulty of identifying the defect in a machine learning algorithm that displays emergent behavior. If proving a design defect requires this level of specificity, this will indeed prove difficult. This is, after all, a way in which litigating the defectiveness of an autonomous vehicle differs qualitatively from litigating the defectiveness of a lathe, for example. It is easy for anyone to see that a different set screw should have been used in the Shopsmith, but far harder for anyone to identify a particular line of code or programming decision made by Tesla engineers that killed Brown, Huang, or Banner.

More recently, there have been suggestions for how to avoid this seemingly intractable problem, one familiar and doctrinal and the other more exotic and technological. First is the doctrine of res ipsa loquitur. Products liability has ever since *Escola* had to struggle with seemingly inexplicable accidents, product failures that cannot be traced to a defect post hoc. At least, we were able to say of the exploding Coke bottle that lacerated the waitress's hand, such a thing simply should not happen in the absence of some sort of defect, and the fact that we aren't able to reconstruct exactly what sort shouldn't doom her case.[269]

Bryan Casey has persuasively argued that we should see res ipsa loquitur as a valuable tool to fill gaps in our understanding of why machines malfunction.[270] The case for res ipsa loquitur would appear to be the strongest for Walter Huang, whose Tesla suddenly veered off the highway and into a crash attenuator at 71 mph.[271] While his family has only recently filed suit and the NTSB's investigation of the crash is ongoing, it seems safe to assume, following many of the experts in the field, that investigators will not be able to identify a discrete error in the code of the Autopilot system that led to the crash. Should that matter? As Casey points out, if a *human* driver suddenly veered off the road and there was nothing physically wrong with his car, we would not have trouble concluding that he had breached the relevant standard of conduct, even if we could not scrutinize a line-by-line transcript of his thought processes to identify

autonomous driving has already saved many lives. Change always comes with risks, and zero tolerance for deaths would totally stop innovation and improvements.").

269 Escola v. Coca-Cola Bottling Company, 150 P.2d 436 (Cal. 1944).

270 Casey, *supra* note 104; see also Vladeck, *supra* note 103, at 142 (arguing that "an inference of defect is reasonably drawn when a product fails, even when a defect cannot be determined by engineers, when the failure occurs with some frequency and the failure follows a common pattern. In those circumstances, courts routinely apply principles of res ipsa loquitur and conclude that the car, not the driver, is at fault").

271 NTSB, *supra* note 59.

exactly why his behavior deviated so badly from expectation.[272] We judge people based on what they do, even when we can't figure out why they did it.[273]

Such an argument might appear to rely on the autonomous vehicle/human comparison that I have made it my goal in this paper to resist. One of the elements of res ipsa loquitur, after all, requires the plaintiff to show that the event that caused her injury is something that would not normally happen without negligence. And how is our sense of what "normally" happens in an autonomous vehicle informed except by reference to a conventional vehicle? This is a tricky problem, and it does seem hard to instruct a jury to draw inferences based on their sense of what's normal in a case involving one of the first ever fatalities caused by a machine learning algorithm.

On the other hand, this problem too dates back to *Escola*, when the court struggled to explain why the plaintiff should be entitled to a res ipsa loquitur instruction despite seemingly uncontroverted testimony about the care exercised by the glassmakers who produced the Coke bottle at issue.[274] The concept of defect was supposed to solve this problem, and cases of manufacturing defect address it in a straightforward way. Manufacturing defects have always been thought to be categorically inapposite to autonomous vehicle liability, since the algorithms that drive the cars are uniform. But maybe the idea of a manufacturing defect isn't completely inapposite after all. The idea of holding manufacturers responsible for the product failures resulting from an irreducible error rate, in which some tiny subset of a line of products fails to perform according to expectations, feels conceptually analogous. The problem may not have been that the code in Walter Huang's car was any different from that of any other Tesla, but rather that it inexplicably swerved into a barrier, just like the Coke bottle inexplicably exploded. We believe there must have been some physical deformity in that particular Coke bottle (unlike the code in Huang's Tesla), but

272 Casey, *supra* note 104, at 34 ("[T]he law doesn't need to understand how the algorithms in our brains work to make sense of our behavior . . . . Indeed, there seems as much reason to fear that the law will be confounded by tomorrow's 'neural networks' as it is today by the neuronal firing of human brains–which is to say, none at all.").

273 Casey and David Vladeck both analogize inexplicable autonomous crashes to the recent litigation against Toyota and Lexus in which plaintiffs argued that their vehicles experienced sudden, uncontrollable acceleration. Despite exhaustive inquiry, engineers were unable to find a defect that caused the problem. A jury, however, applied res ipsa loquitur and held the manufacturers liable. This example leads Casey and Vladeck to conclude that "existing products liability law is well-positioned to address cases where the evidence strongly suggests a defect, but technology cannot isolate the cause." Vladeck, *supra* note 103, at 142–43; see also Casey, *supra* note 104, at 35–36.

274 150 P.2d at 440.

ultimately it may not matter. If a plaintiff is wronged when a seemingly innocuous bottle of Coke inexplicably explodes in her hand, isn't a plaintiff also wronged when a seemingly functional Tesla inexplicably veers off the road at high speed?

These observations highlight why Huang's case may be stronger than those of Brown and Banner, both of whose cars collided with tractor-trailers making left turns across their paths. The NTSB noted in its final report on the Brown crash that no manufacturer had at that time been able to develop an automatic emergency braking system capable of identifying and responding to crossing traffic. This is presumably why Tesla instructed customers to use Autopilot only on divided, limited-access highways. Calling such a flaw a defect may be stretching the concept too far.[275]

On the other hand, Tesla knew the limits of its own system and arguably should have programmed those limits into Autopilot as hard constraints. This would include making it impossible to use Autopilot on anything less than a limited-access highway, which after all is the only environment in which it is supposed to be used. It is possible that this is a design defect. Such a change would presumably not have been expensive (Cadillac's Super Cruise system already works this way),[276] although it arguably would reduce Autopilot's utility for the many people who, ignoring the warnings in the manual, use it on other types of roads. Another arguable defect is Autopilot's way of ensuring that drivers are paying attention, which is easily tricked and only a rough proxy for attentiveness. Tesla allowed drivers to remove their hands from the wheel for long periods of time and to silence any warnings that sounded by replacing their hands only briefly. Again, these are design decisions that can easily be evaluated ex post.

It is also certainly true that Tesla would have strong defenses available in all of these cases. Tesla would presumably rely on product misuse, comparative fault, or assumption of risk in arguing that each driver ignored instructions in the manual clearly indicating that Autopilot is designed to be used by an attentive driver and, in Brown and Banner's cases, only on certain types of roads.[277] It could also seek contribution from other parties who helped cause

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275 *See* REST. 3D OF TORTS: PRODUCTS LIABILITY § 2 cmt. d (noting that a reasonable alternative design must be one that "could have been practically adopted at time of sale" and that "it may be difficult for the plaintiff" to make this showing "[w]hen a defendant demonstrates that its product design was the safest in use at the time of sale").

276 *See supra* notes 32–35 and accompanying text.

277 See REST. 3D OF TORTS: PRODUCTS LIABILITY § 17. On the other hand, manufacturers' duty is based on the foreseeable uses of their products rather than the warnings and restrictions they put in their instructions; a manufacturer "has a duty to prevent an injury caused by the certain of the crashes. The NTSB concluded that the driver of the truck in the Brown accident should have yielded to Brown, and the Florida Highway Patrol issued him a citation for his failure to do so.[278] Huang's car, moreover, collided with a crash attenuator that had already been compressed by an unrelated collision eleven days before.[279] Huang presumably would have survived if the attenuator had been replaced.[280]

Arguably, these cases are relatively easy in that they involve Level 2 automation, which relies on human oversight and so includes design features that are inherently susceptible to evaluation by laypeople. On this score, the crash that killed Elaine Herzberg, which involved a more highly autonomous Uber that was being tested by a human operator, presents more of a challenge. Setting aside for a moment the problems with the way the human oversight was structured and performed (and Herzberg's own arguably negligent behavior), is it possible to identify a defect in the performance of the autonomous system itself?

Following the Uber crash, investigators were able to review the algorithm's "thought process" after its sensors detected Herzberg pushing a bicycle across the street. It struggled to decide what exactly it was seeing but, crucially, did not slow down at all as it spent five seconds thinking about what to do.[281] We would have no problem concluding that a human driver was negligent in such circumstances. Isn't it possible to conclude that an algorithm that drives so poorly is defective? It may not be the case that programmers *instructed* the algorithm to maintain speed when it could not identify a large object in the road, but if that is in fact what it did then we (or a jury) should be able to conclude that it is defective. As a reasonable alternative, the product's designers could instruct it (by whatever means they use) to slow down when it detects an object it thinks might be a vehicle or a bicycle in its path. At the very least, it is hard to see why existing tort concepts are so wholly inadequate to the task of post hoc evaluation that they need to be scrapped. It is also hard to see why we should not stand ready to entertain the argument that Herzberg, Brown, Huang, or Banner were wronged and deserve some form of redress.

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foreseeable misuse of its product." Id. § 2 cmt. p. (quoting Jurado v. Western Gear Works, 619 A.2d 1312, 1318 (N.J. 1993)).

278 See supra note 38.

279 NTSB, *supra* note 59, at 3.

280 Complaint, Huang v. Tesla, Inc., *supra* note 63, at 13–15 (naming State of California as a defendant and alleging that the damaged attenuator was a "substantial factor" in Huang's death).

281 See supra notes 76–80 and accompanying text.

Conclusion

At some point in the future, highly autonomous vehicles will take responsibility for most of our driving, delivering significant gains in safety and convenience. Such a transformational shift in the way we get around is often taken to necessitate an equally transformational shift in products liability law, which many think will need to change if we are to encourage efficient investments in autonomous vehicle adoption and development. But products liability law can be understood and evaluated on moral as well as instrumental grounds, and on that score, the four fatalities that have so far been caused by autonomous vehicles help show that there is a strong case to be made for applying traditional products liability concepts to this new technology, and for giving those who have been and will be injured some way to hold manufacturers to account.

Acknowledgements: I would like to thank Amanda Cook, Heidi Li Feldman, Michelle Layser, and workshop participants at Marquette for helpful and insightful comments. Thanks also to Michelle Mersberger and Josh Bernstein for outstanding research assistance.