REGULATING ROBOTAXIS

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ABSTRACT

In several sunbelt cities, commercial robotaxi service has arrived. The leading robotaxi company is providing over 400,000 trips per week. The industry claims that robotaxis will save lives and provide convenient and affordable mobility. Critics counter that they will increase congestion, undermine transit, and subject the public to ubiquitous surveillance. We argue that the social impact of robotaxis depends on how they are regulated. We emphasize two points missing from the debate. First, some of the benefits of robotaxis may be political rather than technological—some longstanding public policy goals may become viable in a robotaxi world. Second, letting one private company dominate the transportation system risks monopoly abuse—and regulators can act now to prevent it.

In this Article, we offer a plan to regulate robotaxis. Carefully crafted externality regulation can address pollution, congestion, wear-and-tear on infrastructure, and privacy risks while minimizing distortions in choices between travel modes. Regulators can promote competition by permitting open entry, banning lock-in contracts, and enabling one-stop access to competing networks. And they can protect riders even if competition fails by mandating that fares be transparent and rider-neutral and requiring that robotaxi companies maintain a fleet sufficient for emergencies. Policymakers should take advantage of robotaxi deployment to reimagine the transportation system—liberate land from the tyranny of parking, refocus mass transit investments on high-throughput routes, and expand mobility for people with low incomes and people with disabilities.

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INTRODUCTION

This Article is about "robotaxis"—motor vehicles without human drivers that are available on demand to paying customers. For nearly a century, the personal motor vehicle has dominated the American conception of travel. Given this, it is easy to forget that we humans have always transported ourselves, our goods, and our messages using a mix of travel modes. Even motorists, after all, become pedestrians after they park. And since the average household vehicle has an occupancy of only 1.5 persons,[1] it is also easy to overlook that many of these other modes were and are shared services—carriages, steamboats, trains, streetcars, buses, and taxis—in which the user is not the operator.[2]

Today, however, "automated vehicle" has become nearly synonymous with "robotaxi." This is largely because of automated driving's market leader in the United States, Waymo, as well as its competitors in China. Waymo currently deploys its automated vehicles only in fleets. In Atlanta, Austin, San Francisco, Phoenix, Los Angeles, and Miami, anyone with a smartphone can hail a ride in a robotaxi—and the company promises more cities are coming soon.[3] In parts of these cities, Waymo's vehicles are ubiquitous: recently, the Waymo carrying one of us was unable to change lanes because the Waymo next to it refused to let it in—and there were even more Waymos ahead and behind.

Will the robotaxi come to supplant the personal motor vehicle as the twenty-first century's defining local travel mode? Maybe.

Automated driving has potential advantages. Automated driving might be safer than conventional driving.[4] People who are unable to drive may be able to ride. Passengers in automated vehicles could use their time more productively than drivers of conventional vehicles.[5] But these potential advantages apply when comparing many kinds of automated vehicles with conventional vehicles. When comparing robotaxis with personal automated vehicles,[6] they are less relevant. The case for robotaxis isn't just that they are automated.

1. Vehicle Technologies Office, *FOTW #1333, March 11, 2024: In 2022, the Average Number of Occupants Per Trip for Household Vehicle in the United States Was 1.5*, U.S. DEP'T OF ENERGY (Mar. 11, 2024), https://www.energy.gov/eere/vehicles/articles/fotw-1333-march-11-2024-2022-average-number-occupants-trip-household [perma.cc/MX3A-XAEW].

2. Indeed, there is even ample precedent for "driverless" transport: clever horses and other animals that return home on their own (with or without a rider), rivers of logs floating from forests to mills, carrier pigeons delivering messages in war, elevators that outgrew their attendants, Morgantown's people mover that just turned fifty years old, and automated metro lines that soon followed.

3. *See* WAYMO, https://waymo.com/waymo-one [perma.cc/4HLW-LF9F] (listing cities where Waymo services are currently available and announcing where services will be coming next).

4. *See infra* Section I.A.

5. Bryant Walker Smith, *Managing Autonomous Transportation Demand*, 52 SANTA CLARA L. REV. 1401, 1409–10 (2012) (discussing the value of automated driving given the value drivers place on their time).

6. It is also important to consider the possibility of aftermarket kits that allow owners of existing vehicles to convert them to automated operation. This could dramatically change the economics and timescales for AV adoption.

Should the robotaxi eclipse the personal car's dominance? We answer this question with a qualified yes. There are compelling reasons to welcome robotaxis.

First, robotaxis could improve road safety even more than personal automated vehicles. This is because robotaxi fleets are likely to be and remain significantly newer than motor vehicles generally. The mean age of vehicles in the United States today is over twelve years—and growing.[7] Simply shifting trips to newer conventional vehicles could have a significant safety benefit.[8] Shifting them to automated vehicles that are carefully maintained and regularly replaced could have an even greater benefit.

Second, robotaxis could improve accessibility—at least in some senses of the term. They could compete on time and cost, for both riders and system operators, with suburban and rural mass transit that has low ridership and long headways. They could better serve some people who are unable to drive because of income[9] or disability.[10] They might be more reliable than an old car in frequent need of repair.

Third, careful integration of robotaxis might unlock smarter uses of streets and city centers. Robotaxis might obviate the demand for much on-street parking, and that space might in turn be used not only for the much greater queuing zones that pickup and drop-off would require but also for sidewalks, bicycle lanes, and parklets. Robotaxis might also reduce demand for much off-street parking, and that space might in turn be used not only for robotaxi queues and depots but also for more parks, homes, and businesses.

Nonetheless, there are also reasons for caution—and therefore for careful and proactive regulation.

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7. Nishant Parekh & Todd Campau, *Average Age of Vehicles Hits New Record in 2024*, S&P GLOBAL (May 29, 2024), https://www.spglobal.com/mobility/en/research-analysis/average-age-vehicles-united-states-2024.html [https://perma.cc/DM3P-UTMP].

8. *See* NAT'L HIGHWAY TRAFFIC SAFETY ADMIN., LEARN THE FACTS ABOUT NEW CARS: WHY NEWER CARS ARE SAFER THAN EVER BEFORE 1 (2020).

9. This is mixed. For a while it may be cheaper to buy an older used car and drive it than to pay for the same amount of travel in a robotaxi—and once one owns that car, the marginal cost of a trip is even cheaper. At the same time, not everyone can afford even that older car. Analogously, even though buying a monthly bus pass tends to be much cheaper than buying single rides, some public transit users buy single tickets because they cannot afford the upfront cost of a monthly pass.

10. To date, though, humans have tended to outperform robots in managing the wide range of human mobility needs and limitations. *See* Douglas Weber & Amos Matsiko, *Assistive Robotics Should Seamlessly Integrate Humans and Robots*, 8 SCI. ROBOTICS 1 (2023), https://www.science.org/doi/10.1126/scirobotics.adl0014 [https://doi.org/10.1126/scirobotics.adl0014]; Linda Sørensen, Dag Thomas Johannesen & Hege Mari Johnsen, *Humanoid Robots for Assisting People with Physical Disabilities in Activities of Daily Living: A Scoping Review*, 37 ASSISTIVE TECH. 203 (2024), https://www.tandfonline.com/doi/full/10.1080/10400435.2024.2337194 [https://doi.org/10.1080/10400435.2024.2337194].

First, robotaxis are likely to compete not only with personal automobiles but also with walking, biking, and communal transit. The history of Uber and Lyft—which are often called Transportation Network Companies ("TNCs")—is illustrative. As we discuss below, one of the biggest policy challenges is approaching automated driving in a way that appropriately reflects both any advantages it ultimately offers vis-à-vis conventional driving and any disadvantages it presents vis-à-vis more active and communal modes of travel.

Second, reducing the costs of travel, in money and time, may encourage more sprawl and more automotive travel. These could, in turn, create even more local, regional, and global pollution. It is important to remember that there is no such thing as a "zero-emission vehicle." Even electric vehicles need to get their power from somewhere. And, although it is true that electric vehicles with no tailpipe have no "tailpipe emissions," they are sources of other pollution. Tires, for example, wear out through contact with the road surface, and this wear is a major source of microplastics.[11]

Third, these and other externalities are likely to be borne by people other than robotaxi developers, operators, and users. A disabled person who needs assistance boarding a conventional vehicle could be harmed if private robotaxi service replaces mass transit that is subject to more stringent accessibility requirements. People around the world could see their food become more expensive if even greater sprawl further reduces arable land. People who are conducting their lives in public may be subject to greater public and private surveillance if automated driving companies use or share their sensor data for purposes other than driving.[12] Secluded door-to-door trips may also reduce the random social interactions that are important to individual and community vitality.

What we have said about robotaxis so far should be familiar. In this Article, we emphasize two points that are new—one an underappreciated reason to welcome robotaxis, the other an underappreciated reason for concern.

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11. *See* Virginia Gewin, *Tracking Tire Plastics—and Chemicals—From Road to Plate*, CIV. EATS (July 16, 2024), https://civileats.com/2024/07/16/tracking-tire-plastics-and-chemicals-from-road-to-plate (citing David Mennekes & Bernd Nowack, *Tire Wear Particle Emissions: Measurement Data Where Are You?*, SCI. OF TOTAL ENV'T, July 15, 2022, at 1, 2 (indicating that tire particles make up between twenty-four and thirty percent of microplastics in Germany, fifty-four percent in China, sixty-one to seventy-nine percent in Sweden, and ninety-four percent in Switzerland)).

12. *See* Bryant Walker Smith, Jeffrey Michael & Johnathon Ehsani, *Ideal Enforcement: How Do We Achieve Optimal Enforcement of Traffic Law as Ubiquitous Enforcement Becomes Technologically Conceivable?*, 30 MICH. TECH. L. REV. 1, 7 (2024).

Robotaxis, at least at this moment, could be a political expedient for implementing policies that are otherwise viewed as politically challenging.[13] The problems of America's reliance on the personal motor vehicle are well-known: crash deaths and injuries, pollution, and sprawl, among others. Policy solutions are also well-known: consistent automated enforcement of safety-relevant traffic rules, insurance minimums that reflect the true cost of injury, taxes on fueling and charging that capture the externalities of energy consumption, parking rates that account for the value of the land used, and so forth. But implementing these policies for conventional vehicles, drivers, and driving may not sit well with the ninety-two percent of American households that have a motor vehicle.[14]

In contrast, automated driving is not yet politically entrenched.[15] Automated vehicles have so far been deployed only in fleets, which facilitates regulation. Fleet owners are better able to comply with complex rules than individual vehicle owners, and regulators may face less (or at least a different kind of) political resistance when they impose burdens on fleet owners than when they impose similar burdens on tens of millions of individual vehicle owners. This partly explains why the U.S. Department of Transportation and states such as California have demanded much more from automated driving developers than they have from ordinary noncommercial vehicle owners and drivers, such as expanded incident reporting at the federal and state levels and higher insurance minimums at the state level.[16]

But this moment is fleeting: if robotaxis and automated driving features become more widespread and popular, imposing new requirements will become correspondingly more difficult. This is a lesson that many cities still remember from the early and ultimately successful efforts of Uber to change

13. Our discussion of this point is based on Bryant Walker Smith, *Ethics of Artificial Intelligence in Transport*, *in* THE OXFORD HANDBOOK OF ETHICS OF AI 670, 672–75 (Markus D. Dubber, Frank Pasquale & Sunit Das eds., 2020); *see also* TRANSFORMING TRANSP. ADVISORY COMM., FORMAL RECOMMENDATIONS OF THE TRANSFORMING TRANSPORTATION ADVISORY COMMITTEE TO THE US DEPARTMENT OF TRANSPORTATION ON ARTIFICIAL INTELLIGENCE, AUTOMATED DRIVING, PROJECT DELIVERY, AND INNOVATION FOR SAFETY 91–92 (2024) (arguing that conventional driving should be held to the same standards of safety, health, equity, sustainability, financial responsibility, and incident recording as automated driving, but recognizing that this may not be politically viable).

14. *Physical Housing Characteristics for Occupied Housing Units*, U.S. Census Bureau, https://data.census.gov/table?q=car%20ownership [perma.cc/9JNT-MF4L] (indicating that 8.5% of households do not have a vehicle).

15. *See generally* DAVID COLLINGRIDGE, THE SOCIAL CONTROL OF TECHNOLOGY (1980) (introducing what has become known as the Collingridge dilemma); Matthew T. Wansley, *Regulation of Emerging Risks*, 69 VAND. L. REV. 401, 412–15 (2016) (arguing that there is often a narrow political window for regulating emerging technologies before a fledgling industry becomes entrenched in the political process).

16. *See infra* Sections I.D.1–2.

the facts on the ground before governments could enforce existing rules or devise new ones.[17]

And that observation brings us to our new reason for concern. If robotaxis take off, a small number of corporations may come to control large parts of the transportation system. Robotaxi companies benefit from economies of scale and network effects, so the robotaxi market may be highly concentrated. That's what we've seen in the TNC market.[18] In most U.S. cities, Uber and Lyft have formed a duopoly.[19] They cannot abuse their market power too much because they face competition from other travel modes. If they jack up their fares, many travelers can take a taxi or transit or just drive their own vehicle. But if robotaxis put other modes of transportation out of business, the risk of monopoly abuse will rise. In the absence of regulation, these companies' interests may not be aligned with the public good.

In this Article, we propose a plan to regulate robotaxis that takes advantage of the opportunity they present to redesign mobility while protecting the public from concentrated private power.

17. Anticipatory governance is more philosophically and pragmatically attractive to European governments than to the U.S. government. To cite three examples: First, it is easier for the U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA) to use its investigatory and recall authority than to use its rulemaking authority. *See* NAT'L HIGHWAY TRAFFIC SAFETY ADMIN., UNDERSTANDING NHTSA'S REGULATORY TOOLS 3 (2017) (noting that, out of regulatory tools available to the agency, rulemaking "generally takes the longest time to complete"). Second, Europe applies its vehicle safety standards through premarket approval, whereas the United States applies its through self-certification; although often overstated, there are real differences between the two. *Contrast id.* at 2 (describing "self-certification system of compliance, in which vehicle and equipment manufacturers certify that their products meet applicable standards"), *with Questions and Answers: New EU Type-Approval Rules for Safety and Cleaner Cars*, EUR. COMM'N (Aug. 30, 2020), https://ec.europa.eu/commission/presscorner/detail/en/qanda_20_1534 [https://perma.cc/Q6HX-5ME9] (discussing focus on "pre-market compliance checks of vehicles that come off the manufacturing assembly line"). Third, Europe tends to embrace the "precautionary principle," which the United States deliberately downgrades to the "precautionary approach." This striking difference in philosophy is evident in one sentence of a 2022 resolution by the United Nations's Global Forum for Road Traffic Safety, "[n]oting that when introducing new technologies impacting road traffic, there is a need to take into account the relevant scientific evidence in order to continue to improve road traffic safety." GLOB. F. FOR RD. TRAFFIC SAFETY, U.N. ECON. COMM'N FOR EUR., RESOLUTION ON SAFETY CONSIDERATIONS FOR ACTIVITIES OTHER THAN DRIVING UNDERTAKEN BY DRIVERS WHEN AUTOMATED DRIVING SYSTEMS ISSUING TRANSITION DEMANDS EXERCISE DYNAMIC CONTROL 1 (2022), https://unece.org/sites/default/files/2022-11/Road%20Safety%20Brochure_EN.pdf. This preambular statement was embraced by U.S. and European delegations—but only because the former interprets it to mean that regulation should come after real-world data and the latter interprets it to mean that regulation should regulation should come before real-world data.

18. *See* Karina M. Wyman, *Taxi Regulation in the Age of Uber*, 20 N.Y.U. J. LEGIS. & PUB. POL'Y 1, 15 (2017).

19. *See* Michal Kaczmarski, *Uber vs. Lyft: Who's Tops in the Battle of U.S. Rideshare Companies*, BLOOMBERG SECOND MEASURE (Apr. 15, 2024), https://secondmeasure.com/datapoints/rideshare-industry-overview [https://perma.cc/FKF5-QFT9].

There is a robust literature on the law of automated driving, but most of it focuses on tort liability[20] and safety regulation.[21] There has been little discussion of the other regulatory issues that policymakers must confront.[22] But some states are already acting. California has developed and implemented robotaxi-specific regulations, and Arizona has applied its pre-existing ridehailing regulations to robotaxis.[23] We consider both of these approaches to illuminate the choices these states have made and to propose reforms relevant to our analysis.

Our argument proceeds in four Parts.

In Part I, we explain what we know about robotaxis so far—the technologies, the economics, the prospects for wider adoption, and some of the layers of regulation that already apply to robotaxi service.

In Part II, we discuss externality regulation. The deployment of robotaxis could contribute to emissions, wear-and-tear on infrastructure, congestion, and privacy loss. But robotaxis could also *reduce* the social costs of transportation relative to personal motor vehicles. And it may be easier—both practically and politically—to regulate a few robotaxi companies than to regulate many drivers. Policymakers should take advantage of the ease of regulating robotaxis but take care not to create distortions that push riders to other modes of travel. We consider an electric vehicle mandate, a vehicle miles traveled ("VMT") tax, congestion pricing, and restrictions on the use of robotaxi sensor data.

In Part III, we turn to rider protection. We start with the premise that the best way to protect riders is to encourage competition. If robotaxi companies compete in a carefully regulated market, riders could get lower fares, better service, and the fruits of more innovation. We also emphasize a

20. *See* 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, 145–71 (2019); Mark A. Geistfeld, *A Roadmap for Autonomous Vehicles: State Tort Liability, Automobile Insurance, and Federal Safety Regulation*, 105 CALIF. L. REV. 1611, 1632–60 (2017). *See also* David C. Vladeck, *Machines Without Principals: Liability Rules and Artificial Intelligence*, 89 WASH L. REV. 117 (2014); Bryant Walker Smith, *Automated Driving and Product Liability*, 2017 MICH. ST. L. REV. 1 (2017); Matthew Wansley, *The End of Accidents*, 55 U.C. DAVIS L. REV. 269 (2021).

21. *See, e.g.,* Mark A. Geistfeld, *The Regulatory Sweet Spot for Autonomous Vehicles*, 53 WAKE FOREST L. REV. 101 (2018); Bryant Walker Smith, *Automated Vehicles Are Probably Legal in the United States*, 1 TEX. A&M L. REV. 411 (2014) [hereinafter *Probably Legal*]; Bryant Walker Smith, *Regulation and the Risk of Inaction*, *in* AUTONOMES FAHREN 593 (Markus Maurer et al. eds. 2015); Matthew T. Wansley, *Regulating Driving Automation Safety*, 73 EMORY L.J. 505 (2024).

22. There is some helpful work on robotaxi regulation from an urban policy perspective. *See* MANUEL ALCALÁ KOVALSKI, YONAH FREEMARK, CHRISTINA STACY & ALENA STERN, STEERING AUTONOMOUS VEHICLES TOWARD EQUITY (2023); N.Y.U. RUDIN CTR. TRANSP., PRINCIPLES FOR AUTONOMOUS URBANISM (2023); Bryant Walker Smith, *How Governments Can Promote Automated Driving*, 47 N.M. L. REV. 99 (2017).

23. *See infra* Section I.D.

less widely appreciated benefit of competition in robotaxis: more independent development of automated driving technologies could ultimately lead to the integration of redundant systems that are safer than systems developed by just one company. We argue that policymakers should promote competition by permitting open entry, banning lock-in contracts, and enabling one-stop access to competing networks.

We recognize, though, that even these policies may not prevent one company from dominating the market because the economies of scale and network effects favor concentration. And that dominance will take on additional social importance if robotaxis start to replace other modes of travel. We therefore propose a different set of policies to preserve rider autonomy even in a concentrated market. Regulators should mandate that robotaxi fares be transparent and rider-neutral. They should also require that, at some point, robotaxi companies individually or collectively are able to serve transportation demand in an emergency. We hope that by ensuring the public will be protected even in a concentrated robotaxi market policymakers can reduce the need for—and the attendant individual and social costs of—personal motor vehicle ownership.

Wide adoption of robotaxis could create the opportunity to redesign the transportation system. In Part IV, we offer some tentative suggestions on what this might look like. We envision a world where cities can reclaim space currently used for parking, giving more space to cyclists and pedestrians and liberating land for housing or other development. Cities can also refocus their investments in mass transit, replacing low-throughput routes and spending scarce dollars on high-throughput routes. The deployment of robotaxis should also create the opportunity to expand access. We think that carefully crafted subsidies can improve mobility for people with low incomes. And we explain how the National Highway Traffic Safety Administration ("NHTSA") can use its authority over vehicle safety standards to encourage the development of automated vehicles that are accessible for people with disabilities. But we take a more skeptical approach to place-based subsidies. We don't want robotaxis to usher in a new era of sprawl.

I. ROBOTAXIS TODAY

Robotaxis are moving from R&D projects to commercial service. In this Part, we explain what is currently known about robotaxis. First, we introduce some of the technologies that make robotaxis possible. Second, we describe the structure of the robotaxi market and the economics of operating a robotaxi service. Third, we consider the prospects for wider adoption. Fourth, we explain some of the layers of regulation that already apply to robotaxis.

A. TECHNOLOGIES

Robotaxis are automated vehicles deployed for commercial passenger service.[24] A robotaxi is equipped with an automated driving system ("ADS")—a combination of sensors, computers, and software that can together perform the dynamic driving task.[25] To oversimplify: every robotaxi in a company's fleet is equipped with a copy of the same ADS—the same kind of sensors, the same kind of computers, and the same software.[26] So in a sense, every robotaxi deployed by one company has the same driver.[27]

Each ADS has a unique operational design domain ("ODD")—a set of specific environmental, geographic, and roadway conditions in which it is intended to operate.[28] Most ADSs on the road in the United States today function only in geofenced regions in a small number of warm-weather cities, though Chinese cities such as Beijing have both snow and robotaxis.[29] Even within those geofenced regions, ADSs may be restricted from driving

24. We recognize that SAE J3016 "deprecate[s]" the term "automated vehicle." *See* SAE INT'L, J3016: TAXONOMY AND DEFINITIONS FOR TERMS RELATED TO DRIVING AUTOMATION SYSTEMS FOR ON-ROAD MOTOR VEHICLES 34 (2021) [hereinafter SAE J3016]. Nonetheless, we use it in a general sense to encompass a wide variety of automated driving applications. *See* UNIF. AUTOMATED OPERATION OF VEHICLES ACT 1 (NAT'L CONF. COMM'RS UNIF. STATE L. 2019); Walker Smith, *supra* note 22, at 106–13. So does the U.S. Department of Transportation. *See generally* U.S. DEP'T OF TRANSP. & NAT'L SCI. & TECH. COUNCIL, ENSURING AMERICAN LEADERSHIP IN AUTOMATED VEHICLE TECHNOLOGIES (2020) (referring to "automated vehicles").

25. *See* SAE J3016, *supra* note 24, at 6, 9 (defining "automated driving system" and "dynamic driving task"). SAE International is currently updating J3016.

26. This is an oversimplification because companies may have a variety of vehicle platforms (i.e., models) that require somewhat different ADS implementations, they may have different ADS hardware packages that require somewhat different ADS software calibrations, and they may have different versions of their ADS software.

27. This is *not* an oversimplification insofar as the ADS *developer* is the vehicle's driver. *Cf.* UNIF. AUTOMATED OPERATION OF MOTOR VEHICLES ACT, *supra* note 24, at 2 ("Under the act, a qualified entity declares to the state that it will be the legal driver for certain automated vehicles. Provided that it meets certain qualifications, this 'automated driving provider' might be an automated driving system developer, a vehicle manufacturer, a component supplier, a data provider, a fleet operator, an insurer, an affiliated firm, or another kind of market participant that has yet to emerge.").

28. SAE J3016, *supra* note 24, at 17 (defining "operational design domain").

29. *See Robotaxis Ready for Hire in Beijing*, STRAITS TIMES (Nov. 22, 2024, 2:59 PM) https://www.straitstimes.com/asia/east-asia/robotaxis-ready-for-hire-in-beijing [https://perma.cc/92TW-VZHZ]; Bryant Walker Smith & Sven Beiker, *We Rode in Dozens of Driverless Robotaxis in China. Here's What We Saw — and our Advice for Other Curious Travelers*, BUS. INSIDER (Jan. 31, 2026, 2:11 AM PT), https://www.businessinsider.com/the-ultimate-guide-for-taking-a-robotaxi-in-china-2026-2 [https://perma.cc/QH6G-DN72].

on specific roads. Waymo's robotaxis, for example, aren't taking many paying passengers on freeways.[30]

Unusual traffic situations—referred to as edge or corner cases—continue to challenge ADSs.[31] Robotaxis have fallen into a construction pit,[32] gotten stuck in a flooded road,[33] parked in prohibited areas,[34] and made an illegal U-turn at a sobriety checkpoint.[35]

The companies developing automated driving technologies are designing their systems in different ways. Some companies use a suite of sensors that includes lidar, radar, and cameras.[36] Others purport to rely on cameras alone.[37] Some companies create high-definition digital maps to help their systems understand the data they receive from the vehicle's sensors.[38] Others have designed their system to learn about their environment largely from the data they receive in real time with only a comparatively basic map.[39]

30. *See, e.g.*, Ricardo Cano, *Waymo Robotaxis Are Now Driving on S.F. Freeways. What It Means for Company's Bar Area Expansion*, S.F. CHRON. (Aug. 12, 2024), https://www.sfchronicle.com/sf/article/waymo-sf-freeways-19651970.php [https://perma.cc/92TW-VZHZ]; Waymo, *Taking Riders Further, Safely with Freeways* (Nov. 12, 2025), https://waymo.com/blog/2025/11/taking-riders-further-safely-with-freeways [https://perma.cc/K7DG-T867]; Press Release, Cal. Dep't Motor Vehicles, California DMV Approves Mercedes-Benz Automated Driving System for Certain Highways and Conditions (June 8, 2023), https://www.dmv.ca.gov/portal/news-and-media/california-dmv-approves-mercedes-benz-automated-driving-system-for-certain-highways-and-conditions [https://perma.cc/VV94-VMEH]. In China, Baidu operates automated vehicles on freeways by integrating remote driving as needed. *See* Bryant Walker Smith, *Comparing Robotaxis: Baidu's Apollo and Alphabet's Waymo*, STAN. CTR. FOR INTERNET & SOC'Y: BLOG (May 13, 2025), https://cyberlaw.stanford.edu/comparing-robotaxis-baidus-apollo-and-alphabets-waymo [https://perma.cc/D4QV-7BNM].

31. For a review of technical challenges in automated driving, see PHILIP KOOPMAN, HOW SAFE IS SAFE ENOUGH? 35–52 (2022).

32. *Baidu Robotaxi Falls into Construction Pit in China, Raising Safety Concerns*, REUTERS (Aug. 8, 2025), https://www.reuters.com/business/media-telecom/baidu-robotaxi-falls-into-construction-pit-china-raising-safety-concerns-2025-08-08 [https://perma.cc/KV7B-R6XK].

33. Brad Templeton, *Waymos Get Stuck in Phoenix Flood, How Could They Do Better?*, FORBES (Sep 29, 2025, 08:00 AM), https://www.forbes.com/sites/bradtempleton/2025/09/29/waymos-get-stuck-in-phoenix-flood-how-could-they-do-better [https://perma.cc/QT3N-UXJF].

34. *See* Pamela Parker, *Expert Details Ways to Tackle Waymo's Parking Problem*, ABC 7 NEWS (Mar. 14, 2025), https://abc7news.com/post/waymos-parking-ticket-problem-expert-details-ways-tackle-bad-robotaxi-san-francisco/16023950 [https://perma.cc/5CUA-XDHM] (describing Waymo's parking violations).

35. Michael Levenson & Laurel Rosenhall, *When a Driverless Car Makes an Illegal U-Turn, Who Gets the Ticket?*, N.Y. TIMES (Oct. 1, 2025), https://www.nytimes.com/2025/10/01/us/waymo-tickets-san-bruno.html [https://perma.cc/RRH2-MXMZ].

36. Ekim Yurtsever, Jacob Lambert, Alexander Carballo & Kazuya Takeda, *A Survey of Autonomous Driving: Common Practices and Emerging Technologies*, 8 IEEE ACCESS 58443, 58447 (2020); WAYMO, WAYMO SAFETY REPORT 14 (2021).

37. TESLA, 2025+ MODEL Y OWNER'S MANUAL 102 (July 27, 2025) (describing how Autopilot relies on cameras to monitor the surrounding area and detect other vehicles, pedestrians, road markings, and obstacles such as barriers and curbs).

38. *See, e.g.*, WAYMO, *supra* note 36, at 8.

39. *See Pioneering a New Way to Solve Self-Driving with Embodied AI*, WAYVE, https://wayve.ai/technology (last visited Sep. 26, 2025) (describing how Wayve's embodied AI system allows it to apply "'learned' driving skills to unexpected scenarios, even without prior training

Companies also differ in how they structure their software. Some ADSs are modular, with different subsystems performing discrete tasks. For example, a modular ADS might include subsystems for localization, perception, behavior prediction, planning, and actuation.[40] Each of these subsystems may or may not incorporate machine learning. Other ADSs, by contrast, have a "pure end-to-end" architecture. In these systems, a machine learning model takes in sensor data and puts out actuation commands.[41] Some companies are combining these approaches.[42] Many deployments are likely to involve bounded flexibility—like putting a soft duffle bag inside a hardshell suitcase.

An ADS can create a digital record of its driving.[43] This record can show the people, animals, and objects detected by the ADS's sensors and the commands sent by its software, and the movement of nearby people and objects.[44] Most robotaxis are also equipped with interior and exterior video cameras, which can record both passengers and the vehicle's surroundings.[45] An ADS generates and processes an immense amount of data, and retaining all these data in their raw form may be impractical. Companies generally decide which data to collect, transmit, and retain. In the absence of a legal requirement, they may make pragmatic or strategic decisions about data retention, especially as they scale their operations.

The data that an ADS collects can feed back into development. When a robotaxi encounters a scenario of concern, the ADS can be tweaked to handle it better next time.[46] The developer can test this update in computer simulations, on closed-course tracks, and then on public roads.[47] Progress

exposure").

40. *See* Yurtsever et al., *supra* note 36, at 58445–46.

41. *Id.* at 58446.

42. Timothy B. Lee, Waymo and Tesla's Self-Driving Systems Are More Similar Than People Think, UNDERSTANDING AI (Dec 17, 2025), https://www.understandingai.org/p/waymo-and-teslas-self-driving-systems [https://perma.cc/M36V-VREL].

43. *See, e.g.,* WAYMO, *supra* note 36, at 18 (describing Waymo's "system for collecting and analyzing data" from road encounters).

44. *See* Yurtsever et al., *supra* note 36, at 58461.

45. *See id.* at 58447–48, 58461 (describing use of external sensing cameras and internal driver-facing cameras).

46. WAYMO, *supra* note 36, at 18 ("Following a collision, we're able to analyze all available data, including video and other sensor data, to evaluate factors that may have contributed to the incident, and we're able to make appropriate software changes and update every vehicle in our fleet accordingly.").

47. *See* Yurtsever et al., *supra* note 36, at 58462 (describing use of simulations for developing algorithms before road tests).

isn't always linear.[48] Tweaks can introduce new errors.[49] But over time, a system's performance should improve, and its ODD should expand.

In the 2010s, the industry was focused on R&D.[50] When companies tested automated vehicles on public roads, they kept a "safety driver" behind the wheel.[51] Near the end of the decade, some companies moved to testing without these safety drivers.[52] And in the past few years, some companies have started to operate commercial services.[53]

These deployments generally rely on support from human agents located in remote centers.[54] Developers take a variety of approaches to remote facilitation, ranging from mere remote assistance to actual remote driving.[55] Remote agents might communicate with passengers, suggest a path for the ADS when the robotaxi gets stuck, call for assistance in an emergency, or interact with first responders.[56] In practice, remote facilitation is frequent. For example, in late 2023, one company's robotaxis required assistance every four to five miles.[57]

Automated driving has the potential to improve road safety. Waymo's researchers published a study in a peer-reviewed journal finding that its

48. This can be fraught. If an ADS developer discovers a danger in its software, does it (a) immediately update the software (at the risk of introducing a new issue), (b) suspend or limit the operation of its vehicles (at the risk of depriving people of vital mobility), (c) put its vehicles into a degraded operation mode (same), or (d) do nothing (at risk of the danger manifesting as harm)?

49. *See* KOOPMAN, *supra* note 31, at 82–83.

50. For a short history of automated driving development, *see* Matthew T. Wansley, *Moonshots*, 2022 COLUM. BUS. L. REV. 859, 899–913 (2023).

51. *See* Andrew J. Hawkins, *Waymo Is First to Put Fully Self-Driving Cars on US Roads Without a Safety Driver: Going Level 4 in Arizona*, VERGE (Nov. 7, 2017), https://www.theverge.com/2017/11/7/16615290/waymo-self-driving-safety-driver-chandler-autonomous [https://perma.cc/E5GL-CN6F].

52. *See id.*

53. *See infra* Section I.B.1 (describing companies deploying robotaxis in the United States). Freight operations are beyond the scope of this Article.

54. Cade Metz, *When Self-Driving Cars Don't Actually Drive Themselves*, N.Y. TIMES (Sep. 21, 2024), https://www.nytimes.com/2024/09/11/insider/when-self-driving-cars-dont-actually-drive-themselves.html [https://web.archive.org/web/20251001094224/https://www.nytimes.com/2024/09/11/insider/when-self-driving-cars-dont-actually-drive-themselves.html].

55. *See* Bryant Walker Smith, *On Remote Driving*, STAN. CTR. FOR INTERNET & SOC'Y: BLOG (May 16, 2022), https://cyberlaw.stanford.edu/blog/2022/05/remote-driving [https://perma.cc/85PS-MCXE]; Walker Smith, *supra* note 30.

56. *See* Brad Templeton, *Cruise Reports Lots of Human Oversight of Robotaxis, Is That Bad?*, FORBES (Nov. 7, 2023), https://www.forbes.com/sites/bradtempleton/2023/11/07/cruise-reports-lots-of-human-oversight-of-robotaxis-is-that-bad [https://perma.cc/ST49-BZ9M]. These roles might be assigned to a single agent or distributed across agents.

57. Tripp Mickle, Cade Metz & Yiwen Lu, *G.M.'s Cruise Moved Fast in the Driverless Race. It Got Ugly.*, N.Y. TIMES (Nov. 3, 2023), https://www.nytimes.com/2023/11/03/technology/cruise-general-motors-self-driving-cars.html [https://web.archive.org/web/20251011182132/https://www.nytimes.com/2023/11/03/technology/cruise-general-motors-self-driving-cars.html]; Lora Kolodny, *Cruise Confirms Robotaxis Rely on Human Assistance Every Four to Five Miles*, CNBC (Nov. 6, 2025), https://www.cnbc.com/2023/11/06/cruise-confirms-robotaxis-rely-on-human-assistance-every-4-to-5-miles.html [https://perma.cc/FRR4-D29A].

vehicles are involved in significantly fewer crashes that involve an injury or an airbag deployment than conventional vehicles in comparable ODDs.[58] The study is based on publicly available crash reports that Waymo submitted to NHTSA.[59] Although the data are self-reported and the conventional vehicle crash rate baselines are contestable, we don't doubt the direction of the results with respect to routine driving.

An earlier study by independent researchers found that Waymo's crash rate in San Francisco was comparable to the reported crash rates of TNC drivers in the city.[60] This is also an encouraging result because the crashes involving automated vehicles had to be reported by law while crashes involving only conventional vehicles are often not reported.[61] It is too early to draw conclusions about fatal crashes, though. In the United States, there are about 1.33 fatal collisions for about every 100 million vehicle miles traveled.[62] Waymo has only traveled about 200 million miles.[63]

B. ECONOMICS

We are beginning to see the structure of the nascent automated driving market generally and the nascent robotaxi market specifically. And we can make educated guesses about the basic economics of a robotaxi service.

1. Market Structure

There are companies developing automated driving technologies in many parts of the world. These companies include automakers such as Mercedes, Tesla, and Volkswagen; automotive suppliers such as Bosch, Mobileye, and Qualcomm; informational technology companies such as Alphabet, Amazon, Baidu, and Huawei; and a variety of automated-driving-specific firms such as May Mobility, Pony.AI, Wayve, and WeRide. It is important not to discount efforts abroad, particularly from companies in

58. Kristofer D. Kusano, John M. Scanlon, Yin-Hsiu Chen, Timothy L. McMurry, Tilia Gode & Trent Victor, *Comparison of Waymo Rider-Only Crash Rates by Crash Type to Human Benchmarks at 56.7 Million Miles*, 28 TRAFFIC INJURY PREVENTION S8, S14 (2025).

59. *Id.* at S10.

60. Jiayu Joyce Chen & Steven E. Shladover, Initial Indications of Safety of Driverless Automated Driving Systems 14 (Jan. 2, 2024) (unpublished manuscript) (on file with arXiv), https://arxiv.org/pdf/2403.14648 [https://perma.cc/39X3-HCZ9] (showing 15.5 crashes per million miles for Uber trips and 14.1 for Waymo).

61. *See* NAT'L HIGHWAY TRAFFIC SAFETY ADMIN., DOT HS 812 013, THE ECONOMIC AND SOCIETAL IMPACT OF MOTOR VEHICLE CRASHES, 2010 (REVISED) 121–43 (2015) (discussing reporting problems in non-fatal crash data).

62. NAT'L HIGHWAY TRAFFIC SAFETY ADMIN., DOT HS 813 560, OVERVIEW OF MOTOR VEHICLE TRAFFIC CRASHES IN 2022 2 (2024).

63. *See* Waymo (@waymo), THREADS (Feb 23, 2026), https://www.threads.com/@waymo/post/DVG6_u0CQ0c.

China that are active at home and could soon be competing with U.S. companies in other parts of the world.[64]

"[A]utomated driving encompasses a wide range of technologies, applications of those technologies, business models for those applications, and participants in those business models."[65] Robotaxis are just one application. Some companies are developing ADSs for personal motor vehicles or for use in low-speed shuttles. Other companies are aiming to automate trucking, delivery, mining, farming, and military vehicles.

We focus on three U.S.-based companies—Waymo, Zoox, and Tesla—that are developing robotaxis and are backed by three of the most valuable corporations in the world. Waymo is a subsidiary of Alphabet, the parent company of Google. Zoox is a subsidiary of Amazon. Tesla we expect you've heard of.

For now, Waymo dominates the robotaxi industry. It is providing commercial robotaxi service in Atlanta, Austin, Los Angeles, Phoenix, San Francisco, and Miami (as of February 2026).[66] And it is planning to provide commercial service in other major U.S. metropolitan areas.[67] Waymo's robotaxis are already competing with Uber and Lyft. In late 2025, Waymo had a twenty-two percent share of the TNC market for trips with an origin and destination within the city limits of San Francisco.[68]

Zoox is testing robotaxis in San Francisco, Las Vegas, and Miami.[69] The company recently started a commercial service in Las Vegas.[70]

64. Bryant Walker Smith & Sven Beiker, *The Ultimate Guide for Taking a Robotaxi in China*, BUS. INSIDER (Feb. 2, 2026), https://www.businessinsider.com/the-ultimate-guide-for-taking-a-robotaxi-in-china-2026-2 [https://perma.cc/93E3-F5DB].

65. UNIF. AUTOMATED OPERATION OF VEHICLES ACT, *supra* note 24, at 1 (citing Walker Smith, *supra* note 22). "For example, a vehicle capable of automated operation may or may not be designed for all roads, communities, and travel conditions; be capable of automated operation for an entire trip; include a traditional steering wheel, throttle, and brake pedal; need a human who can resume driving when requested to do so; need this human to be physically present in the vehicle; rely on a human located far from the vehicle to provide instructions and information; use specific sensor technologies, including camera, radar, lidar, sonar, inertial motion, and GPS; use highly detailed maps that are created in advance; communicate electronically with other vehicles; be originally manufactured as an automated vehicle; be retrofitted by a developer other than the vehicle manufacturer; be modified by third parties without the involvement of that developer; be sold to individual consumers; be deployed only as part of a fleet; carry passengers, deliver goods, provide services, or perform novel functions; and so on." *Id.*; *see also* TRANSFORMING TRANSP. ADVISORY COMM., *supra* note 13, at 45 (same).

66. *See* WAYMO, *supra* note 3.

67. *Id.* (announcing service in Miami and Washington, D.C.).

68. Preetika Rana, *How Uber and Lyft Are Gearing Up for the Robotaxi Revolution*, WALL ST. J. (Jan. 6, 2025), https://www.wsj.com/tech/uber-lyft-self-driving-taxis-a3659c9c [https://perma.cc/Y4AG-ASV3].

69. Metz, *supra* note 54.

70. In September 2025, Zoox began offering free rides from a few select locations on the Las Vegas strip. Salvador Rodriguez & Annie Palmer, *Amazon's Zoox Jumps into the U.S. Robotaxi Race*

Tesla claims it is developing robotaxis.[71] But all Tesla has produced is a system that it dizzyingly calls "Full Self-Driving (Supervised),"[72] which needs a driver to keep their hands on the wheel and their eyes on the road at all times.[73] It is an ADS in aspiration but not in function.[74] In communications with regulators, Tesla continues to take the position that "Full Self-Driving" is just a driver assistance system.[75] In May 2025, Tesla announced the "launch" of a "robotaxi" service in Austin, Texas.[76] But each of the vehicles generally has a Tesla employee who is seated in the driver's seat or passenger seat, monitoring the roadway and able to intervene.[77]

It is important to recognize that, although each of these companies has primarily emphasized robotaxi services, their underlying technologies could be adapted for a variety of other applications, including motor vehicles that are exclusively used by their owners.

The robotaxi companies are taking different approaches to vertical integration. Each company is developing its own ADS software. But they aren't all building vehicles. Waymo has purchased its base vehicles from third parties—Chrysler minivans, Jaguar SUVs, Zeekr minivans, and Hyundai SUVs—and then modified them extensively in its own facilities.[78] Zoox built its own distinctive, bidirectional vehicle in which passengers face

with Las Vegas Launch, CNBC (Sep. 10, 2025), https://www.cnbc.com/2025/09/10/amazons-zoox-jumps-into-us-robotaxi-race-with-las-vegas-launch-.html [https://perma.cc/NZT5-4RMA]; *see also Where to Ride*, ZOOX, https://zoox.com/where-to-ride [https://perma.cc/CZ6V-8DWX] (last visited Mar. 18, 2026) (inviting website visitors to "ride now" in Las Vegas and to "learn more" about San Francisco, Austin, and Miami).

71. Jack Ewing & Peter Eavis, *Elon Musk Says Robotaxis Are Tesla's Future. Experts Have Doubts.*, N.Y. TIMES (July 30, 2024), https://www.nytimes.com/2024/07/29/business/elon-musk-tesla-robotaxi.html [https://web.archive.org/web/20250925195230/https://www.nytimes.com/2024/07/29/business/elon-musk-tesla-robotaxi.html].

72. *See* Bryant Walker Smith, *"Self-Driving" Means Self-Driving*, DRAKE L. REV. (forthcoming).

73. *See* TESLA, *supra* note 37, at 120–23.

74. Bryant Walker Smith, *How Reporters Can Evaluate Automated Driving Announcements*, 2020 J.L. & MOBILITY 1, 10 (2020).

75. E-mail from Eric C. Williams, Associate General Counsel, Regulatory, Tesla, to Miguel Acosta, Chief, Autonomous Vehicles Branch, California Department of Motor Vehicles (Nov. 20, 2020) (on file with author).

76. Edward Ludlow, *Tesla Targets June 12 Launch of Robotaxi Service in Austin*, BLOOMBERG (May 29, 2025), https://www.bloomberg.com/news/articles/2025-05-28/tesla-targets-june-12-launch-of-robotaxi-service-in-austin [https://perma.cc/W3EU-SL46].

77. Aarian Marshall, *This Is Why Tesla's Robotaxi Launch Needed Human Babysitters*, WIRED (July 4, 2025), https://www.wired.com/story/this-is-why-teslas-robotaxi-launch-needed-human-babysitters [https://perma.cc/7Z9D-ZQJ5]; Matt Binder, *Tesla Now Puts Their Robotaxi Safety Monitors in the Driver's Seat*, MASHABLE (Sep. 5, 2025), https://mashable.com/article/tesla-robotaxi-human-safety-monitor-drivers-seat [https://perma.cc/CD7T-WN2V].

78. *See* Jonathan M. Gitlin, *The Hyundai Ioniq 5 Will Be the Next Waymo Robotaxi*, ARS TECHNICA (Oct. 4, 2024), https://arstechnica.com/cars/2024/10/the-hyundai-ioniq-5-will-be-the-next-waymo-robotaxi [https://web.archive.org/web/20241127234511/https://arstechnica.com/cars/2024/10/the-hyundai-ioniq-5-will-be-the-next-waymo-robotaxi].

each other.[79] Tesla has unveiled a more conventionally designed prototype called the Cybercab, but in Austin it uses slightly modified versions of its production vehicles.[80]

The companies are also experimenting with different models for service delivery.[81] In Los Angeles, San Francisco, and Miami, Waymo's robotaxis can be hailed only on the Waymo app.[82] In Phoenix, they can be hailed on the Waymo app or the Uber app.[83] And in Atlanta and Austin, they can be hailed only on the Uber app.[84] In those cities, Uber manages "vehicle cleaning, repair, and other general depot operations" while Waymo manages roadside assistance.[85] Waymo has also suggested it might license its ADS to third parties.[86]

79. *See* ZOOX, https://zoox.com/vehicle [https://perma.cc/FP6S-2R2Y].

80. Andrew J. Hawkins, *Tesla Cybercab Announced: Elon Musk's Robotaxi Is Finally Here*, VERGE (Oct. 10, 2024), https://www.theverge.com/2024/10/10/24265530/tesla-robotaxi-elon-musk-features-range-price-release-date [https://perma.cc/X69K-UXWH]; Scotty Reiss, *Tesla Robotaxi Is Now Open to All in Austin. Here's What It's Like*, FORBES (Sep. 4, 2025), https://www.forbes.com/sites/scottyreiss/2025/09/04/tesla-robotaxi-is-now-open-to-all-in-austin-heres-what-its-like [https://perma.cc/A4TR-M9AC].

81. It is notable that automakers have likewise experimented with a variety of models over the last century. Hertz was owned by GM and later by Ford. *See 100 Years of Hertz History*, HERTZ (June 17, 2022), https://www.hertz.com/us/en/blog/automotive/100-years-of-hertz-history [https://perma.cc/Y6DR-PHFH]; Robert E. Dallos, *Hertz Team, Ford Agree to Buy Car Rental Firm from Allegis in $1.3-Billion Deal*, L.A. TIMES (Oct. 3, 1987), https://www.latimes.com/archives/la-xpm-1987-10-03-fi-3020-story.html [https://perma.cc/PRF8-5VKA]. Volvo offers car insurance. *See* Truman Lewis, *Volvo Launches Insurance Agency in U.S.*, CONSUMER AFFS. (Aug. 26, 2025), https://www.consumeraffairs.com/news/volvo-launches-insurance-agency-in-us-082625.html [https://perma.cc/ZCX7-UYCF]. The automotive supplier now known as Aptiv was spun out by GM. *See* Kurt Nagl, *Detroit 3 Auto Supplier to Spin Off Key Unit in Bid to Grow, Diversify*, CRAIN'S DETROIT BUS., (Jan. 22, 2025), https://www.crainsdetroit.com/manufacturing/auto-supplier-aptiv-spin-key-unit-grow-diversify [https://web.archive.org/web/20250402151055/https://www.crainsdetroit.com/manufacturing/auto-supplier-aptiv-spin-key-unit-grow-diversify].

82. *See Ride with Us in the City of Angels*, WAYMO, https://waymo.com/rides/los-angeles [https://perma.cc/9DA7-UL2D]; *Redefine How You Move Around San Francisco*, WAYMO, https://waymo.com/rides/san-francisco [https://perma.cc/MFS3-RK4J].

83. *The Waymo Driver: Now Available on Uber in Phoenix*, WAYMO (Oct. 26, 2023), https://waymo.com/blog/2023/10/the-waymo-driver-now-available-on-uber-in-phoenix [https://perma.cc/T9SB-T6UQ].

84. *Waymo and Uber Expand Partnership to Bring Autonomous Ride-Hailing to Austin and Atlanta*, WAYMO (Sep. 13, 2024), https://waymo.com/blog/2024/09/waymo-and-uber-expand-partnership [https://perma.cc/7QRK-VTVW].

85. *Id.*

86. *See* Ricardo Cano, *Waymo Eyes S.F. Robotaxi Expansion, Personal Vehicles After First-Year 'Success'*, S.F. CHRON. (Aug. 29, 2024), https://www.sfchronicle.com/bayarea/article/waymo-driverless-robotaxi-expansion-19657064.php [https://web.archive.org/web/20250330184957/https://www.sfchronicle.com/bayarea/article/waymo-driverless-robotaxi-expansion-19657064.php]; Aarian Marshall, *Waymo's New Agreement with Hyundai Raises Questions About China*, WIRED (Oct. 4, 2024), https://www.wired.com/story/waymo-new-agreement-hyundai-raises-questions-china [https://perma.cc/5KYQ-A9MH] (describing partnership with Hyundai to explore installing Waymo's ADS on personal motor vehicles).

Tesla has floated the idea of selling automated vehicles to individuals who would then make them available as robotaxis on a network managed by Tesla.[87] (If those vehicles were as automated as Tesla has promised, then those individuals could presumably make them available on other networks as well.) This business model has some precedent. Uber lets personal motor vehicle owners use their vehicles to provide rides to passengers.[88] Turo lets personal motor vehicle owners rent their vehicles to drivers.[89] And Zipcar lets members have short-term use of fleet vehicles.[90]

A startup recently announced that it would sell automated vehicles to individuals[91]—though of course it is not the first company to make this claim.[92]

2. Cost Structure

The most important cost of operating a robotaxi service is the fixed, upfront cost of developing a safe and functional ADS. Each of the major robotaxi companies has already spent billions on engineering and testing over the last decade.[93] As an ADS stabilizes, engineering costs may decline. But a mature ADS will still need to be updated and refined.[94] The built environment and road user behavior will continue to change, and robotaxis will continue to encounter novel edge cases.

The variable costs of a robotaxi service can be divided into market, vehicle, and mile costs. For each new market a company enters, it must map

87. Abhirup Roy & Akash Sriram, *Tesla CEO Elon Musk Unveils 'Cybercab' Robotaxi*, REUTERS (Oct. 11, 2024), https://www.reuters.com/technology/teslas-musk-unveil-robotaxis-amid-fanfare-skepticism-2024-10-10 [https://perma.cc/XN2R-TGCJ].

88. *See Drive*, UBER, https://www.uber.com/us/en/drive [https://web.archive.org/web/20250426081719/https://www.uber.com/us/en/drive]; TURO, https://turo.com (last visited Sep. 21, 2025).

89. TURO, https://turo.com [https://web.archive.org/web/20250929114143/https://turo.com].

90. *How Zipcar Works*, ZIPCAR, https://www.zipcar.com/how-it-works [https://perma.cc/JE8R-EYW8].

91. Andrew J. Hawkins, *Tensor Wants to Be the First Company to Sell You A 'Robocar' — But Who Are They?*, VERGE (Aug 13, 2025), https://www.theverge.com/news/758605/tensor-autox-autonomous-vehicle-robocar-personal-own-china [https://perma.cc/8K9Q-EXEC].

92. *See, e.g.*, *Hands-Free Driving for $10,000*, NBC NEWS (June 23, 2014), http://www.nbcnews.com/nightly-news/hands-free-driving-10-000-n138876 (last visited Nov. 26, 2025) [https://perma.cc/DH9U-PE3Z] (Cruise); TESLA, *Full Self-Driving Hardware on all Teslas*, (Vimeo, Oct. 20, 2016), https://vimeo.com/188105076 (Tesla); *see also* Bryant Walker Smith, *"Self-Driving" Means Self-Driving*, DRAKE L. REV. (forthcoming).

93. Cade Metz, *The Costly Pursuit of Self-Driving Cars Continues On. And On. And On.* N.Y. TIMES (Sep. 15, 2021), https://www.nytimes.com/2021/05/24/technology/self-driving-cars-wait.html [https://web.archive.org/web/20251012022738/https://www.nytimes.com/2021/05/24/technology/self-driving-cars-wait.html].

94. Brad Templeton, *So You've Built a Robotaxi, Now Where's Your Infrastructure*, FORBES (Aug. 5, 2024), https://www.forbes.com/sites/bradtempleton/2024/08/05/so-youve-built-a-robotaxi-now-wheres-your-infrastructure [https://perma.cc/BST7-GETT] (noting that maps and systems must be updated to adapt to local conditions and "dynamic changes, including construction").

the new territory, ensure sufficient remote assistance capacity, and arrange facilities for storing, charging, cleaning, and maintaining its vehicles.[95] For each new vehicle it assembles, it needs to buy the vehicle platform, the sensors, and the computers. For each new mile its robotaxis drive, it spends more on remote labor, fuel or electricity, cleaning, maintenance, and (indirectly) insurance.

Compared to traditional TNCs, one potential cost advantage of a robotaxi is labor. Much of the cost of an Uber ride is driver pay.[96] Taking the driver out of a taxi could make transportation radically cheaper. But robotaxis will compete against Uber and Lyft drivers who, at least in the United States, might earn less than minimum wage to drive and maintain rather ordinary vehicles (and, notably, to load and unload luggage that their customers may not want or be able to lift).[97]

So, for now, this labor cost saving is hypothetical.[98] The robotaxi companies need humans to help with charging, cleaning, and maintenance. And they rely critically on humans who provide remote assistance to their vehicles, to their passengers, or to law enforcement—and, occasionally, to physically retrieve vehicles when they get stuck.[99] As of November 2023, one robotaxi company was employing 1.5 operations workers per vehicle.[100]

One cost disadvantage of a robotaxi is the robotaxi itself: the vehicle platform, its sensors, and its computers. Waymo's co-CEO has said that the equipment on its robotaxis can cost as much as $100,000.[101] But Baidu, one of Waymo's Chinese competitors has said that its robotaxis cost less than

95. *Id.* It is possible, however, that one remote operation command center may be able to serve fleets in multiple metropolitan areas. *Id.* (noting that a remote ops center can cover multiple service areas).

96. According to data published by the NYC TLC, about seventy-five to eighty percent of an Uber or Lyft base fare (excluding tips and taxes) goes to the driver. *See* Todd W. Schneider, *Taxi and Ridehailing Usage in New York City*, TODD W. SCHNEIDER, https://toddwschneider.com/dashboards/nyc-taxi-ridehailing-uber-lyft-data [https://perma.cc/CJ6V-MR5P]. But it is important to consider that TNC driver pay must cover vehicle purchase, cleaning, maintenance, and (some) insurance costs.

97. *See* Ken Jacobs, Michael Reich, Tynan Challenor & Aida Farmand, *Gig Passenger and Delivery Driver Pay in Five Metro Areas*, U.C. BERKELEY LAB. CTR. (May 20, 2024), https://laborcenter.berkeley.edu/gig-passenger-and-delivery-driver-pay-in-five-metro-areas [https://perma.cc/YB23-R3DP].

98. *See* Leah Kaplan, Lola Nurullaeva & John Paul Helveston, *Modeling the Operational and Labor Costs of Autonomous Robotaxi Services*, 159 TRANSP. POL'Y 108, 117 (2024) (finding that, after accounting for "frontline labor roles involved in existing robotaxi services . . . labor costs for robotaxis are far higher than previously estimated").

99. Metz, *supra* note 54.

100. Mickle et al., *supra* note 57.

101. Eli Tan, *Waymo's Robot Taxis Are Almost Mainstream. Can They Now Turn a Profit?*, N.Y. TIMES (Sep. 4, 2024), https://www.nytimes.com/2024/09/04/technology/waymo-expansion-alphabet.html [https://perma.cc/8FZV-ZF2E].

$30,000 to manufacture—including both the vehicle platform and the ADS.[102]

Another cost disadvantage is real estate. A robotaxi company internalizes the cost of its vehicles driving to and from its depots and service facilities, so it may want to locate them close to the center of travel demand. That's usually a place where land isn't cheap. In contrast, a traditional TNC's drivers or vehicle owners bear these costs—including when they involve significant commutes at the beginning and end of a workday.

In theory, robotaxis can benefit from powerful economies of scale. Once an ADS is acceptably safe and functional, it can be deployed in similar ODDs in metropolitan areas around the country with some adaptations for local driving conditions. However, the significant costs of standing up a new market—the depots, service facilities, and local coordination—may limit early deployments to metropolitan areas with large populations.[103]

The path to profitability will require changes to the cost structure. The cost of components—sensors, computers, and vehicle hardware—needs to fall. Waymo already is moving to replace its Jaguars with Zeekrs.[104] The ratio of operations staff to revenue-generating vehicles needs to fall too. That will mean improving the ADS's performance to reduce the frequency of incidents where remote assistants need to intervene. And it will likely mean automating parts of robotaxi servicing—charging, cleaning, and maintenance.[105] How much costs can fall is an open question.

102. Andrew J. Hawkins, *Baidu's Supercheap Robotaxis Should Scare the Hell Out of the US*, VERGE (Nov. 22, 2024), https://www.theverge.com/2024/11/22/24303299/baidu-apollo-go-rt6-robotaxi-unit-economics-waymo [https://perma.cc/ZPG4-HQPQ]; Walker Smith, *supra* note 30.

103. *See* Brad Templeton, *Some Say Self-Driving Robotaxi Isn't A Business; Billions Are Betting That It Is*, FORBES (Oct. 25, 2021), https://www.forbes.com/sites/bradtempleton/2021/10/25/some-say-self-driving-robotaxi-isnt-a-business--billions-are-being-bet-that-it-is [https://web.archive.org/web/20251102070223/https://www.forbes.com/sites/bradtempleton/2021/10/25/some-say-self-driving-robotaxi-isnt-a-business--billions-are-being-bet-that-it-is/?sh=6954c3565b07] (noting that it is "unlikely robotaxi service will arrive in rural locations for a long time" because efforts may be harder to justify for fewer customers).

104. Brad Templeton, *Waymo's 6th Generation Robotaxi Is Cheaper. How Cheap Can They Go?*, FORBES (Aug. 20, 2024), https://www.forbes.com/sites/bradtempleton/2024/08/20/waymos-6th-generation-robotaxi-is-cheaper--how-cheap-can-they-go [https://web.archive.org/web/20250514224156/https://www.forbes.com/sites/bradtempleton/2024/08/20/waymos-6th-generation-robotaxi-is-cheaper--how-cheap-can-they-go]; Satish Jeyachandran, *Beginning Fully Autonomous Operations with the 6th-Generation Waymo Driver*, WAYMO (Feb. 12, 2026), https://waymo.com/blog/2026/02/ro-on-6th-gen-waymo-driver [https://perma.cc/M6SJ-WHZC].

105. *See, e.g.*, Amanda Silberling, *Waymo Is Asking DoorDash Drivers to Shut the Doors of Its Self-Driving Cars*, TECHCRUNCH (Feb. 12, 2026), https://techcrunch.com/2026/02/12/waymo-is-asking-doordash-drivers-to-shut-the-doors-of-its-self-driving-cars [https://perma.cc/2552-HYUC].

3. Deployment

A profit-maximizing robotaxi company will follow two principles for deployment. First, maximize revenue-generating opportunities (for which miles is an imperfect proxy). Second, minimize non-revenue-generating—or "deadheading"—miles. All else equal, a robotaxi company makes more money when a robotaxi is carrying passengers than when it is parked in a depot. And the company probably loses less money when a robotaxi is parked in a depot than when it is deadheading. A parked robotaxi takes up space in the depot. But a deadheading robotaxi increases charging, cleaning, maintenance, and insurance costs.[106]

These two principles explain why robotaxis (and taxis and TNCs) are deployed in areas with high travel demand. In a high demand area, when one trip ends, the next rider is nearby. There is less deadheading between rides. Robotaxis benefit from network effects. A network with a higher volume of trip requests means fewer deadheading miles between rides. Network effects explain why robotaxis are deployed in large metropolitan areas.[107] And they explain why downtowns are generally more appealing markets than outlying areas.[108] Even in San Francisco—one of the densest cities in the country—Waymo's robotaxis are still deadheading over 40% of the time.[109]

There are other factors beyond travel demand that affect where robotaxis will be deployed. Robotaxis are limited by their ADS's ODD. If an ADS isn't capable of functioning at higher speeds, the robotaxis that use it might not serve neighborhoods where many trips require highway driving. Robotaxi companies may also prefer to deploy in wealthy neighborhoods simply because their wealthy residents have a higher willingness to pay. But again, the analysis is complicated. If wealthy residents are more likely to own a car, they may be less interested in a robotaxi ride. Families with young children (or simply with a lot to carry or store in a vehicle) present another potential challenge to—or possibly opportunity for—robotaxis.

The same principles that explain where robotaxis will be deployed also explain *when* they will be deployed. In most cities, travel demand peaks on

106. Some robotaxi companies may be large enough that they choose to self-insure.

107. *See* Templeton, *supra* note 103 (noting that rural areas are not suited to robotaxi service due to lower density and long distances).

108. There are other factors beyond population density that might affect robotaxi travel demand. For example, a neighborhood with frequent, reliable public transit might have less demand for robotaxis. But that kind of neighborhood might also have a lower vehicle ownership rate and therefore higher demand for both transit and robotaxis. It's hard to predict the net effect on demand without data.

109. Harry Campbell, *What CPUC Data Reveals About Waymo's Deadheading and Utilization*, DRIVERLESS DIGEST (Nov 19, 2025), https://www.thedriverlessdigest.com/p/what-cpuc-data-reveals-about-waymos [https://perma.cc/M36V-VREL] (discussing deadheading data collected from the CPUC databased by Matthew Raifman).

weekdays in the morning and evening rush hours. A fleet of vehicles that can serve peak rush hour demand will leave some vehicles sitting idle in the midday hours and most vehicles sitting idle overnight. Robotaxi companies will likely try to smooth out travel demand by charging more in rush hour, as Uber and Lyft do with surge pricing.[110] They might also use their vehicles for package delivery or other tasks in periods of low demand.[111] But a profit-maximizing company's optimal fleet size is likely lower than a fleet that would completely serve peak demand—a point that influences our analysis below.[112]

Robotaxis might be able to serve more of a city's transportation demand with a smaller fleet than traditional taxis or TNCs can.[113] The effect will be amplified if some of the city's residents decide to give up their personal motor vehicles for robotaxis. Personal motor vehicles have a very low utilization rate—they sit in driveways, on streets, or in parking facilities for most of the day. A profit-maximizing robotaxi company will aim for high utilization.[114] A smaller fleet serving the same travel demand could mean a lower environmental impact.[115]

One open question in robotaxi deployment is how often riders will be interested in being matched with strangers to share rides.[116] In principle, sharing all or part of a trip is a win-win. Riders pay a lower fare. Robotaxi companies serve two revenue-generating riders at the same cost. The challenge of ridesharing is it requires very high travel demand. The routing algorithm needs to find two riders traveling along similar routes at roughly the same time. TNCs have experimented with ridesharing programs such as

110. For an analysis of how surge pricing works based on public data, *see* Schneider, *supra* note 96.

111. Brad Templeton, *How Long Should a Robotaxi Last?*, FORBES (Sep. 25, 2023), https://www.forbes.com/sites/bradtempleton/2023/09/25/how-long-should-a-robotaxi-last [https://web.archive.org/web/20240119072423/https://www.forbes.com/sites/bradtempleton/2023/09/25/how-long-should-a-robotaxi-last].

112. Uber needs to position itself to be attractive both to drivers and to riders. This is why the company already performs some centralized management of both supply and demand through surge pricing. But as long as enough drivers are willing to drive, it is likely more tolerant of oversupply than of undersupply.

113. *See* Marco Pavone, *Autonomous Mobility-on-Demand Systems for Future Urban Mobility*, *in* AUTONOMOUS DRIVING: TECHNICAL, LEGAL AND SOCIAL ASPECTS 387, 396 (Markus Maurer, J. Christian Gerdes, Barbara Lenz & Hermann Winner eds., 2016) (estimating that Manhattan's taxi demand could be served with a robotaxi fleet about seventy percent the size of the current taxi fleet).

114. *See* Kaplan et al., *supra* note 98, at 117 (concluding that "utilization rates and annual mileage will ultimately serve as the limiting factors for robotaxi competitiveness").

115. As we discuss later, however, a smaller fleet does not necessarily mean fewer vehicle-miles traveled.

116. The terminology in this area is confusing. "Ridesharing" has been used to refer to carpooling, to shared trips in a single Uber or Lyft, and to Uber and Lyft generally (nominally because the passenger is sharing the ride with their driver). Here we use "ridesharing" to refer to separate trips simultaneously serviced by the same vehicle for at least a portion of each.

UberPool and LyftLine. But the results have been disappointing. In 2023, Lyft—not coincidentally the company with the smaller network—mostly gave up on shared rides.[117]

Robotaxi companies may have more success with sharing rides if they push fares low enough to grow the robotaxi market beyond the size of the TNC market. Today most commuters cannot afford to use TNCs for their daily trips to and from work. But the combination of automation and sharing could change these economics. And during peak periods, there are many potential riders coming from similar origin points heading to the same destination at the same time.[118]

Companies could also encourage shared rides by introducing new vehicle forms. As we mentioned above, in Zoox's robotaxis, passengers face each other.[119] Another possibility is compartmentalized vehicles, which might appeal to riders looking for safety and privacy.

Unfortunately, there's a tradeoff between market concentration and shared rides. The more robotaxi companies competing for riders, the less likely that any two riders will be on the same network requesting a ride along the same route at roughly the same time. But it might be possible for multiple companies' robotaxis to be deployed on the same network—or so we will argue in Part III.

C. Potential for Wider Adoption

The common vision for robotaxis is that they will not merely replace human-driven taxis, but that they will dramatically expand the market for

117. *See* Jackie Davalos, *Lyft Will Discontinue Pooled Rides, Launch New Airport Feature*, BLOOMBERG (May 11, 2023), https://www.bloomberg.com/news/articles/2023-05-11/lyft-will-discontinue-pooled-rides-roll-out-new-features [https://web.archive.org/web/20230511204902/https://www.bloomberg.com/news/articles/2023-05-11/lyft-will-discontinue-pooled-rides-roll-out-new-features]; Natalie Lung, *Lyft Revives Pooled Rides at Airports in Push for Cheaper Trips*, FORTUNE (May 19, 2025) https://fortune.com/2025/05/19/lyft-pooled-rides-at-airports-cheaper-trips [https://perma.cc/C27B-4QG2].

118. In the suburbs of Washington, D.C., some commuters meet at parking lots to share rides with strangers so that they can access faster, high-occupancy vehicle lanes. *See* Luz Lazo, *'Slugging' Culture in D.C. Region Threatened by Commuting Shifts*, WASH. POST (Jan. 14, 2023), https://www.washingtonpost.com/transportation/2023/01/14/slug-lines-virginia-commuting-pandemic [https://web.archive.org/web/20230114123251/https://www.washingtonpost.com/transportation/2023/01/14/slug-lines-virginia-commuting-pandemic].

119. *See* ZOOX, *supra* note 79.

taxi-like services in large part by replacing trips in personal motor vehicles.[120] But some companies are still committed to the traditional automotive business model.

The demise of Cruise, a robotaxi startup acquired by General Motors, is instructive. As we explain more below, after a 2023 incident in which the company misled the public by misleading reporters and regulators,[121] Cruise suspended its US robotaxi service. A year later, GM folded Cruise into its internal efforts to develop driver assistance features for the conventional vehicles it produces. In other words, GM has reverted to its traditional model of principally selling cars rather than rides.

GM is hardly alone in embracing this traditional approach. Mercedes already offers an automated driving feature—for certain freeways in certain conditions—on two of its premium models.[122] Many others are pursuing similar features. This traditional business model is understandable, especially if automakers ultimately decide to sell not only the vehicles but also subscriptions to use the automated driving features.[123] After all, like today's robotaxis, these features might also depend on substantial digital and human infrastructure behind the curtain.

For the robotaxi business model to compete, automated driving technologies need to mature. As we discussed above, robotaxis need to become cheaper. And there are other obstacles.

First, vehicle ownership generally entails significant fixed costs (to purchase or lease the vehicle and to insure it) and either objectively or subjectively smaller variable costs to then operate that vehicle (to fill it or charge it).[124] Given this, those who own a car that they are unable or unwilling to part with are likely to compare the purchase price of a robotaxi trip with the marginal cost of a trip in their individually owned vehicle.

Second, for the reasons we described above, robotaxis will face competition not only from personal motor vehicles but also from personal automated vehicles. Automated driving will not be limited to robotaxis.

120. Timothy B. Lee articulated one version of this vision in 2008. *See* Timothy B. Lee, *The Future of Driving, Part II: Life After Driving*, ARS TECHNICA (Oct. 12, 2008), https://arstechnica.com/features/2008/10/future-of-driving-part-2 [https://web.archive.org/web/20250717195358/https://arstechnica.com/features/2008/10/future-of-driving-part-2].

121. *See infra* Section I.C.1.

122. *DRIVE PILOT Support Speed of up to 95 km/h on German Motorways*, MERCEDES-BENZ GRP. (Dec. 17, 2024), https://group.mercedes-benz.com/innovations/product-innovation/autonomous-driving/drive-pilot-95-kmh.html [https://perma.cc/Y7Q4-48C7].

123. *See* Walker Smith, *supra* note 20.

124. Among other fixed and marginal costs, parking could be either fixed (monthly cost to park at home or at work) or marginal (incidental cost to park at a restaurant or an airport).

Third, many American car owners—and particularly families with children—use their cars as an extension of their homes. Some people literally live in their cars.[125] Many rely on them as mobile storage lockers for themselves and their families—for sports equipment, booster seats, diapers, mobility aids, and stuff that they want on hand or simply cannot keep elsewhere.[126] Many also treat their vehicles as public displays or private retreats that are decorated and provisioned for their personal functional and aesthetic sensibilities.[127]

Fourth, many Americans see their personal motor vehicle as giving them autonomy. What happens if you give up your car and the robotaxi company jacks up its prices? Or what if there's an earthquake, and you need to evacuate? We will explore these questions in Part III. For now, it suffices to say that how widely robotaxis will be adopted is an open question.

D. Regulation

There are many layers of regulation that apply to robotaxis. We consider two—automated driving safety regulation and robotaxi service regulation.

1. Safety Regulation

The fundamental challenge of automated driving safety regulation is that it is hard to assess the safety of an ADS without observing its long-term performance on the road.[128] An ADS that can safely navigate routine driving might still not be acceptably safe. The critical question is how it handles unanticipated edge cases. Over time, both NHTSA and state agencies have developed regulatory strategies that rely on monitoring and responding to safety incidents. We start with federal regulation.

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125. *See* Madeline Brozen, *Where You Go When Your Car Is Home*, TRANSFERS MAG., Jan. 2023, at 1.

126. This is why one of us has long anticipated a startup making little storage robots that can follow people around and dock onto a shared vehicle.

127. This is why there has long been discussion of shared vehicles with individual compartments like the train carriages of old.

128. This is why "[t]he best proxy for the safety of Avs is the trustworthiness of AV companies." Bryant Walker Smith, *Opening Statement of Professor Bryant Walker Smith for the U.S. Senate Commerce Committee's Hearing on Automated Driving*, STAN. CTR. FOR INTERNET & SOC'Y: BLOG (Feb. 4, 2026), https://cyberlaw.stanford.edu/blog/2026/02/opening-statement-of-professor-bryant-walker-smith-for-the-u-s-senate-commerce-committees-hearing-on-automated-driving-february-4-2026-2 [https://perma.cc/MFT5-PSNE]. *See generally* Bryant Walker Smith, *The Trustworthy Company*, 115 GEO. L.J. (forthcoming) (arguing for corporate trustworthiness as leading indicator of system safety).

In the absence of federal legislation specific to automated driving,[129] NHTSA is using its longstanding statutory authority to regulate vehicle safety generally. The National Traffic and Motor Vehicle Safety Act of 1966 ("the Safety Act") authorizes NHTSA to (1) conduct investigations, (2) seek recalls of defective vehicles or equipment, and (3) set safety performance standards.[130] NHTSA has used each of these authorities to address automated driving.

NHTSA has used its investigative power to mandate crash reporting.[131] In 2021, NHTSA issued a standing general order that requires companies testing automated vehicles on public roads to report crashes.[132] Serious crashes had to be reported within twenty-four hours, and all crashes, no matter how minor, had to be reported each month.[133] In 2025, the agency narrowed the reporting requirement to exclude some crashes with less than $1,000 of property damage, but most other reporting requirements remain in place.[134] NHTSA has received reports of hundreds of crashes and made redacted reports available on its website, although it doesn't provide the context that would make the reports easier to understand.[135]

129. *See, e.g.*, Walker Smith, *supra* note 22; Walker Smith, *Probably Legal*, *supra* note 21; Bryant Walker Smith, *Congress's Automated Driving Bills Are Both More and Less than They Seem*, STAN. CTR. FOR INTERNET & SOC'Y: BLOG (Oct. 23, 2017), https://cyberlaw.stanford.edu/blog/2017/10/congress%E2%80%99s-automated-driving-bills-are-both-more-and-less-they-seem [https://perma.cc/QP3L-U79L]; Bryant Walker Smith, *Here's Where Federal Automated Driving Law Stands Near the End of the Biden Administration*, STANFORD CTR. FOR INTERNET & SOC'Y: BLOG (Nov. 18, 2024, 6:25 PM) [hereinafter *Biden Admin*], https://cyberlaw.stanford.edu/blog/2024/11/heres-where-federal-automated-driving-law-stands-near-the-end-of-the-biden-administration [https://perma.cc/3PFD-AC6Y].

130. 49 U.S.C. § 30111(a) (authorizing the Secretary of Transportation to set standards to "meet the need for motor vehicle safety"); *id.* § 30118(a), (b)(1) (authorizing Secretary of Transportation to make decision as to vehicle defect by conducting investigations); *id.* § 30163(a)(2) (issue recalls) (authorizing Attorney General to enjoin "sale, offer for sale, or introduction or delivery for introduction" of defective motor vehicles).

131. Wansley, *supra* note 21, at 559–61.

132. *See* NAT'L HIGHWAY TRAFFIC SAFETY ADMIN, FIRST AMENDED STANDING GENERAL ORDER 2021-01 2 (Aug. 5, 2021) [hereinafter NHTSA 2021 SGO].

133. *Id.* at 5 ("Crashes that meet specified criteria must be reported within one calendar day after the manufacturer or operator learns of the crash, and other ADS crashes must be reported on a monthly basis."). The criteria for reporting accidents within one calendar day includes crashes involving ADS or Level 2 ADAS that occur on a "publicly accessible road;" where ADS or Level 2 ADAS "was engaged at any time during the period from 30 seconds immediately prior to the commencement of the crash;" and where the crash resulted in "any individual being transported to the hospital for medical treatment, a fatality, a vehicle tow-away, or an air bag deployment or involves a vulnerable road user"). *Id.* at 13–14.

134. *See* NAT'L HIGHWAY TRAFFIC SAFETY ADMIN, THIRD AMENDED STANDING GENERAL ORDER 2021-01 13 (Apr. 24, 2025) [hereinafter NHTSA 2025 SGO].

135. *See Standing General Order on Crash Reporting*, NAT'L HIGHWAY TRAFFIC SAFETY ADMIN. (Aug. 15, 2025) [hereinafter *NHTSA SGO Reporting*], https://www.nhtsa.gov/laws-regulations/standing-general-order-crash-reporting [https://perma.cc/9PJ8-YZT4]; *see also* TRANSFORMING TRANSP. ADVISORY COMM., *supra* note 13, at 51–52 (suggesting improvements to crash data collection and analysis).

NHTSA has used its recall power to remedy defective technologies.[136] Unless a company immediately initiates a recall on its own, these recalls often follow a pattern. NHTSA starts by opening an investigation into the company's technologies. The company and the agency exchange data. They negotiate over potential remedies. Then the company resolves the investigation by declaring a defect and issuing a recall, which takes the form of change to the company's software. In some cases, a recall can be carried out through over-the-air software updates.[137] In the last few years, Tesla, Waymo, Zoox, and several other companies have each issued recalls.[138] For example, Waymo initiated a recall after one of its automated vehicles crashed into a pickup truck hanging off a tow truck and another crashed into a telephone pole.[139]

NHTSA has not used its rulemaking power to affirmatively regulate automated driving.[140] The agency stated years ago that, given the rapid pace of technological change, it planned to regulate primarily through recalls.[141] But NHTSA has used its power to *exempt* vehicles and equipment from existing Federal Motor Vehicle Safety Standards ("FMVSSs"). In general, companies that integrate their ADS into FMVSS-compliant vehicles don't need an exemption. They can just "self-certify" that their automated vehicles are compliant.[142] But companies that build vehicles with certain kinds of unconventional designs may need an exemption. For years, NHTSA was slow in considering ADS-related exemption requests.[143] But starting in 2025,

136. *See* Wansley, *supra* note 21, at 563–65.

137. Bryant Walker Smith, *Over-the-Air Updates and Regulatory Recalls*, STANFORD CTR. FOR INTERNET & SOC'Y: BLOG (Feb. 20, 2024), https://cyberlaw.stanford.edu/blog/2024/02/over-air-updates-and-regulatory-recalls [https://perma.cc/K5XM-NFXL].

138. *See, e.g.,* NAT'L HIGHWAY TRAFFIC SAFETY ADMIN., PART 573 SAFETY RECALL REPORT 22V-037 (2022) (Tesla rolling stop recall); NAT'L HIGHWAY TRAFFIC SAFETY ADMIN., PART 573 SAFETY RECALL REPORT 25E-034 (2025) (Waymo gate barrier collision recall); NAT'L HIGHWAY TRAFFIC SAFETY ADMIN., PART 573 SAFETY RECALL REPORT 25E-029 (2025) (Zoox encroaching perpendicular agents recall); NAT'L HIGHWAY TRAFFIC SAFETY ADMIN., PART 573 SAFETY RECALL REPORT 22E-072 (2022), https://static.nhtsa.gov/odi/rcl/2022/RCLRPT-22E072-8020.PDF (Cruise unprotected left recall).

139. *See* NAT'L HIGHWAY TRAFFIC SAFETY ADMIN., PART 573 SAFETY RECALL REPORT 24E-013 2–3 (2024); NAT'L HIGHWAY TRAFFIC SAFETY ADMIN., PART 573 SAFETY RECALL REPORT 24E-049 2–3 (2024).

140. *See* Wansley, *supra* note 21, at 559–77 (explaining that, instead of setting standards, NHTSA has implemented an experimental regulatory system based on reporting, investigations, and recalls). NHTSA has completed a rulemaking to map some existing occupant-safety standards onto vehicles without certain features associated with conventional driving. *See id.* at 545–48.

141. *See* NAT'L HIGHWAY TRAFFIC SAFETY ADMIN., FEDERAL AUTOMATED VEHICLES POLICY 3 (2016) [hereinafter AV 1.0].

142. *See* 49 U.S.C. § 30115(a) (providing for self-certification).

143. *See* Walker Smith, *Biden Admin*, *supra* note 129 (describing instances where NHTSA "sat on" exemption requests until the companies eventually withdrew them).

NHTSA announced that it would expedite requests.[144] And shortly thereafter, it granted an exemption to Zoox.[145]

It is important to recognize that, under the Safety Act, FMVSS exemptions are limited either by purpose or by number of vehicles. But because NHTSA itself promulgates these standards, it can obviate the need for exemptions by changing the underlying standards—as it has already done in the case of certain occupant-protection standards.[146]

There is another layer of automated driving safety regulation at the state level.[147] We focus on the first two states where commercial robotaxi service became available, Arizona and California. They nicely illustrate the range of options.

Arizona's policy is relatively laissez-faire—although still arguably more stringent than the rules that apply to conventional driving. An Arizona statute expressly authorizes companies to operate automated vehicles on two conditions.[148] First, the company must provide the state's Department of Public Safety with a plan for how law enforcement can effectively interact with the vehicles.[149] Second, the company must provide the state's Department of Transportation ("DOT") with a written statement "acknowledging" that its vehicles comply with federal safety standards and Arizona's registration, licensing, and insurance requirements.[150] The company must also "acknowledg[e]" that its ADS can comply with the traffic law and achieve a "minimal risk condition"—which generally though

144. Letter from Peter Simshauser, Chief Counsel, Nat'l Highway Traffic Safety Admin., Letter Announcing Next Steps in NHTSA's Automated Vehicle Framework (June 13, 2025), https://www.nhtsa.gov/sites/nhtsa.gov/files/2025-06/part-555-letter-june-2025.pdf [https://perma.cc/9FGQ-RHTC] ("NHTSA is streamlining its exemption process for commercial deployment of vehicles and adopting a dynamic and flexible approach to evaluating these exemptions.").

145. Press Release, U.S. Dep't of Transp., NHTSA Issues First-Ever Demonstration Exemption to American-Built Automated Vehicles (Aug. 6, 2025) https://www.transportation.gov/briefing-room/nhtsa-issues-first-ever-demonstration-exemption-american-built-automated-vehicles [https://perma.cc/PVF5-N7D5].

146. *See* Walker Smith, *Biden Admin*, *supra* note 129.

147. *See* Bryant Walker Smith, *The Senate's Automated Driving Bill Could Squash State Authority*, STANFORD CTR. FOR INTERNET & SOC'Y: BLOG (Oct. 23, 2017, 3:44 PM), https://cyberlaw.stanford.edu/blog/2017/10/senate%E2%80%99s-automated-driving-bill-could-squash-state-authority [https://perma.cc/QT9N-U9C5] (noting "important role" that states play in regulating road safety).

148. *See* ARIZ. REV. STAT. ANN. § 28-9702 (2025). Automated driving activities in Arizona predated this statute. In fact, while Nevada has the distinction of being the first state to pass a law specific to automated driving, *see* Walker Smith, *Probably Legal*, *supra* note 21, at 501.

149. ARIZ. REV. STAT. ANN. § 28-9702(C)(1) (2025).

150. *Id.* §§ 28-9702(C)(2)(a), (d).

not necessarily involves pulling over to side of the road[151]—when it encounters a situation it cannot handle safely.[152]

Arizona does not specifically empower regulators to set independent safety standards. But it does authorize the DOT to suspend the registration of an automated vehicle after determining it "is not in safe mechanical condition and endangers persons on the highway."[153] And the statute makes it clear that the company that is testing or deploys the automated vehicle "may be issued a traffic citation or other applicable penalty if the vehicle fails to comply with traffic or motor vehicle laws."[154]

Arizona has succeeded at attracting testing to the state. But its approach may have also contributed to a fatal crash. In the late 2010s, before the enactment of Arizona's current automated driving statute,[155] Uber was attempting to develop an ADS with the goal of operating a robotaxi service. It was testing automated vehicles in Arizona with safety drivers.[156] In March 2018, one of Uber's vehicles struck and killed Elaine Herzberg in Tempe, Arizona.[157] Herzberg was walking her bike across a multi-lane boulevard in the evening.[158] The Uber ADS sensors detected Herzberg, but the software did not slow the vehicle until it was too late.[159] The safety driver didn't react in time because she was distracted by her smartphone.[160]

151. *See* Bryant Walker Smith, *Deep in the Weeds of the Levels of Driving Automation Lurks an Ambiguous Minimal Risk Condition*, STANFORD CTR. FOR INTERNET & SOC'Y: BLOG (Jan. 24, 2022), https://cyberlaw.stanford.edu/blog/2022/01/deep-weeds-levels-driving-automation-lurks-ambiguous-minimal-risk-condition [https://perma.cc/2AHA-HQPW].

152. ARIZ. REV. STAT. ANN. § 28-9702(C)(2)(b) (2025).

153. *Id.* § 28-9708(D) (2025).

154. *Id.* § 28-9702(C)(2)(c) (2025).

155. The statute largely codified the approach of a 2018 executive order issued by the state's then-governor shortly before Uber's crash. *See* Douglas A. Ducey of Ariz., Ariz. Exec. Order 2018-04 (Mar. 1, 2018); FACT SHEET FOR H.B. 2813, S. 55th Leg., 1st Sess. (Ariz. Mar. 4, 2021).

156. Bryant Walker Smith, *Uber's Fatal Crash*, STAN. CTR. FOR INTERNET & SOC'Y: BLOG (Mar. 19, 2018), https://cyberlaw.stanford.edu/blog/2018/03/ubers-fatal-crash [https://perma.cc/CYY3-HMDK].

157. NAT'L TRANSP. SAFETY BD., HIGHWAY ACCIDENT REPORT: COLLISION BETWEEN VEHICLE CONTROLLED BY DEVELOPMENTAL AUTOMATED DRIVING SYSTEM AND PEDESTRIAN 1 (2018) [hereinafter NTSB TEMPE REPORT]; Richard Gonzales, *Feds Say Self-Driving Uber SUV Did Not Recognize Jaywalking Pedestrian in Fatal Crash*, NPR (Nov. 7, 2019), https://www.npr.org/2019/11/07/777438412/feds-say-self-driving-uber-suv-did-not-recognize-jaywalking-pedestrian-in-fatal- [https://perma.cc/9J8V-MML8].

158. NTSB TEMPE REPORT, at 2.

159. *See id.* at v ("The ADS detected the pedestrian 5.6 seconds before impact. Although the ADS continued to track the pedestrian until the crash, it never accurately classified her as a pedestrian or predicted her path. By the time the ADS determined that a collision was imminent, the situation exceeded the response specifications of the ADS braking system.").

160. *See id.* at 43 ("[T]he vehicle operator was visually distracted, and by the time she raised her gaze from her cell phone to the road, she had only about 1 second to detect and respond to the pedestrian. By that time, she could not avoid the collision.").

The National Transportation Safety Board ("NTSB") investigated the crash and issued a report that criticized both the safety driver and Uber's safety practices.[161] Regulators might have been able to prevent the crash if they had asked Uber more questions about how it was monitoring safety drivers and preventing them from becoming complacent. After the crash, Arizona's governor ostensibly suspended Uber's right to operate automated vehicles in the state.[162] But Arizona didn't change its general approach to safety regulation.[163]

California's policy is more hands-on.[164] A California statute directs the state's Department of Motor Vehicles (DMV) to develop an application process for the testing and deployment of automated vehicles.[165] The statute requires all automated vehicles to comply with federal vehicle safety standards (unless exempted).[166] It also provides, however, that the DMV's application process "shall include any testing, equipment, and performance standards [that it] concludes are necessary" for safety.[167] This language suggests that the DMV may directly regulate ADS safety. (More generally, states already exercise broad authority over the operational safety of vehicles, including through driver regulation, rules of the road, and vehicle roadworthiness.)[168]

California's DMV issues three kinds of automated driving permits: testing (with a safety driver), driverless testing (without a safety driver in the vehicle), and deployment.[169] A company engaging in activities for which a permit is required is subject to specific reporting requirements.[170] The

161. *Id.* at v–vi (describing probable cause as driver's inattentiveness combined with Uber's "inadequate safety risk assessment procedures," "ineffective oversight of vehicle operators," and "lack of adequate mechanisms for addressing operators' automation complacency").

162. *See* Melissa Daniels, *Arizona Governor Suspends Uber from Autonomous Testing*, ASSOCIATED PRESS (Mar. 26, 2018), https://apnews.com/article/0ae96a5b23a542e39da252c4267ec3a5 [https://perma.cc/3XZG-ULEU]; Bryant Walker Smith, *A Sad Irony for Governor Ducey After Uber's Fatal Crash*, STAN. CTR. FOR INTERNET & SOC'Y: BLOG (Mar. 27, 2018), https://cyberlaw.stanford.edu/blog/2018/03/sad-irony-governor-ducey-after-ubers-fatal-crash [https://perma.cc/X7G4-UHVM].

163. Arizona did eventually enact a statute. *See* ARIZ. REV. STAT. ANN. § 28-9702 (2025).

164. One of us (Bryant) formally consults for the State of California. The DMV is currently updating its regulations.

165. CAL. VEH. CODE § 38750(c) (West 2025).

166. *Id.* § 38750(c)(1)(E).

167. *Id.* § 38750(d)(2).

168. *See* Walker Smith, *Probably Legal*, *supra* note 21.

169. To receive any of the three permits, a company must prove that it can satisfy a five-million-dollar judgment. CAL. CODE REGS. tit. 13, § 227.04(c) (2025). To receive a testing permit, a company must certify that its safety drivers have clean driver safety records and have completed a training program. *Id.* § 227.34(b)(1)–(2). To receive a driverless testing permit, a company must provide a statement of its ADS's ODD, a law enforcement interaction plan, and an explanation of its remote monitoring system. *Id.* § 227.38. This is currently being updated.

170. *Id.* § 227.50 (requiring annual report); *Id.* § 227.48 (requiring reporting of collisions resulting

company must disclose, among other information, the number of miles its automated vehicles drove on California roads and any crashes in which they were involved.[171] Unlike NHTSA, California doesn't let companies redact their narrative description of the crash. The combination of miles reporting and crash reporting gives the DMV a rough sense of a company's crash rate, though this must be understood in the context of the ADS's ODD.

To receive a deployment permit, a company must certify, among other things, that its vehicles have a two-way communication link with a remote agent and that they meet industry standards for cybersecurity.[172] It must also provide information about its testing on public roads in California and elsewhere, including the number of miles driven and any crashes during testing.[173] The DMV can use the company's track record in driverless testing to assess the risk of deployment. If the track record raises concerns, the DMV may decline to issue the deployment permit.

California currently doesn't require a company with a deployment permit to report miles or crashes. This is unfortunate, because although companies are still reporting crashes to NHTSA, the public is deprived of access to the crash narratives that NHTSA redacts. The DMV does, however, require a company with a deployment permit to report any recalls it issues.[174] And the DMV also has the power to suspend or revoke permits on several grounds, including if it determines that the company's "vehicles are not safe for the public's operation."[175]

The strengths and weaknesses of California's permitting system are illustrated by its experience with Cruise, the now defunct robotaxi subsidiary of General Motors. Cruise jumped through all the hoops—obtaining a testing permit, a driverless testing permit, and a deployment permit.[176] And in 2022, Cruise started to deploy a robotaxi fleet in San Francisco.[177] By the summer of 2023, Cruise's robotaxis were involved in some crashes that raised doubts about its technologies. After a crash between a Cruise robotaxi and a firetruck, the California DMV made Cruise cut its fleet in half.[178] Then in

in "damage of property or in bodily injury or death").

171. *Id.* § 227.50(b)(3)(B)(iii), (4).

172. *Id.* § 228.06(a)(1), (10).

173. *Id.* § 228.06(c)(7).

174. *Id.* § 228.12.

175. *Id.* § 228.20.

176. *Autonomous Vehicle Testing Permit Holders*, CAL. DEP'T MOTOR VEHICLES, https://www.dmv.ca.gov/portal/vehicle-industry-services/autonomous-vehicles/autonomous-vehicle-testing-permit-holders [https://perma.cc/5DEV-7UGP].

177. *See Autonomous Vehicles in San Francisco*, S.F. MUN. TRANSP. AGENCY, https://www.sfmta.com/projects/autonomous-vehicles-avs-san-francisco [https://perma.cc/UD7Y-Q3J8].

178. *See* Dara Kerr, *Driverless Car Startup Cruise's No Good, Terrible Year*, NPR (Dec. 30, 2023), https://www.npr.org/2023/12/30/1222083720/driverless-cars-gm-cruise-waymo-san-francisco-accidents

October 2023, a conventional vehicle (whose driver fled the scene) hit a pedestrian walking across the street, and the force of that collision propelled her into a Cruise robotaxi in an adjacent lane.[179] The robotaxi ran her over, stopped, and then started moving again, dragging her while she was pinned beneath the vehicle.[180]

Cruise then misled regulators and the public about the crash by focusing on the initial collisions and failing to mention the subsequent dragging.[181] When the California DMV learned the full story, it suspended Cruise's deployment permit.[182] The DMV said it was suspending Cruise's permits both because it had concluded that Cruise's ADS was not safe and because Cruise had misrepresented information related to safety.[183] The company paid a $1.5 million federal fine.[184] In December 2024, GM shut Cruise down while claiming that its work would be folded into GM's efforts to develop more advanced features on its production vehicles.[185]

Until recently, California's automated driving law didn't explicitly provide a way for police to enforce the traffic law when a company was operating automated vehicles with no safety driver behind the wheel. This loophole deeply concerned local officials. The City of San Francisco explained that its police and fire departments don't know what to do when a robotaxi blocked traffic or emergency vehicles.[186] In 2024, California enacted a statute that authorizes police to issue a "notice of autonomous vehicle noncompliance" against a company when one of its automated vehicles violates the traffic law.[187]

[https://perma.cc/29YK-JGJC].

179. Tripp Mickle & Cade Metz, *Cruise Says Hostility to Regulators Led to Grounding of Its Autonomous Cars*, N.Y. TIMES (Jan. 25, 2024), https://www.nytimes.com/2024/01/25/technology/cruise-crash-report-san-francisco.html [https://perma.cc/6HMX-TCQB].

180. *Id.*

181. *See* Trisha Thadani, *General Motors Scraps Robotaxi Development in New Fallout from 2023 Crash*, WASH. POST (Dec. 10, 2024), https://www.washingtonpost.com/technology/2024/12/10/gm-cruise-scraps-robotaxi [https://perma.cc/4DEX-MU86].

182. *See* Mickle & Metz, *supra* note 179.

183. *Id.*

184. Jack Ewing, *Cruise, G.M.'s Self-Driving Unit, Will Pay $1.5 Million Federal Fine*, N.Y. TIMES (Sept. 30, 2024), https://www.nytimes.com/2024/09/30/business/gm-cruise-nhtsa-fine.html [https://perma.cc/LR7H-A6QD].

185. *See* Thadani, *supra* note 181.

186. Kevin Truong, *When a Robotaxi Gets a Ticket, Who Is Accountable if There's No Driver?*, S.F. STANDARD (June 16, 2023), https://sfstandard.com/2023/06/16/san-francisco-wants-robotaxis-to-get-tickets-for-moving-violations [https://perma.cc/AHY9-LBP6].

187. CAL. VEH. CODE § 387502(a) (West 2024).

2. Service Regulation

Robotaxi companies may also be subject to another layer of regulation—regulation of the provision of transportation service. In Arizona and California, robotaxi regulation grew out of TNC regulation, which in a sense grew out of (or was imposed over) taxi regulation.

Taxi companies are often regulated as or akin to common carriers.[188] Many large municipalities restrict entry into the formal taxi market.[189] In some cities, taxi drivers own or lease a medallion that authorizes them to operate.[190] Fares are fixed by regulation, usually at a constant rate per mile.[191] And taxi companies are required to provide universal service—they cannot discriminate among riders.[192]

Municipalities justify each element of taxi regulation with different policy rationales. Entry restrictions are thought to reduce congestion, limit pollution, protect driver pay, and prevent taxi drivers from competing for riders in dangerous ways.[193] Fare regulation is seen as a remedy for imperfect information. Riders hailing taxis on the street cannot easily compare fares, so regulation ensures the fares are always the same.[194] The universal service requirement has distributive goals—providing mobility for all residents regardless of their race, sex, class, or neighborhood.[195]

The combination of entry restrictions, fare regulation, and a universal service requirement is also intended to create a system of implicit cross-subsidies.[196] The profits that taxis make in places and times with high travel demand (and thus less deadheading) subsidize the service they provide in places and times with low travel demand.[197] Without these regulations, new entrants might be able to "creamskim"—serve only the high value trips and thereby erode the profits that cross-subsidize other trips.[198] This was an early complaint about Uber and Lyft.

188. James B. Speta, *Southwest Airlines, MCI, and Now Uber: Lessons for Managing Competitive Entry into Taxi Markets*, 43 TRANSP. L.J. 101, 104 (2016).

189. Wyman, *supra* note 18, at 31.

190. *See, e.g.*, Speta, *supra* note 188, at 107 ("For example, the Municipal Code of Chicago required a medallion (license) to operate a taxicab, established the rates for taxi trips (and forbade any agreement to charge a greater rate), and set quality standards for vehicles.").

191. *Id.* at 114.

192. *Id.* at 107.

193. Wyman, *supra* note 18, at 68.

194. *Id.* at 40.

195. *Id.* at 67–68.

196. Speta, *supra* note 188, at 115–16.

197. *Id.* at 114.

198. *Id.* at 115.

It is hard to assess whether the benefits of traditional taxi regulations outweigh the costs. With entry restricted, the taxi industry had little incentive for innovation. It was startups, not incumbents, that introduced hailing by app. The system of cross-subsidies didn't always work. Many Brooklynites have hailed a cab in Manhattan only to watch the driver pull away after they gave their destination. But as defenders of taxi regulation have pointed out, many American cities experimented with deregulating taxis in the 1960s, 70s, and 80s only to find that fares rose and service quality declined.[199] In fact, most large cities that deregulated ultimately decided to bring back regulation.[200]

In the 2010s, taxi regulation faced a new challenge—the rise of app-based ridehailing. Uber and Lyft offered lower fares, often shorter wait times, seamless payment, a driver rating system, and a more convenient way to hail a ride.[201] They rapidly took market share away from taxis.[202] Uber and Lyft were also "regulatory entrepreneurs."[203] In many jurisdictions, their service was illegal or in a legal gray area. For example, while Uber initially focused on professional drivers that might be regulated by something like NYC's Taxi and Limousine Commission, it soon expanded to ordinary drivers who were freelancing. In some jurisdictions, legislators and regulators cracked down.[204] Uber and Lyft fought back by encouraging their customers to lobby their state representatives to legalize—and often preempt local regulation of—the transportation service they had come to prefer.[205]

In recent years, the TNC market has stabilized. Uber and Lyft have formed a duopoly, splitting the market about three-to-one.[206] They have both steadily raised their fares.[207] After their respective IPOs, they could no longer rely on venture capitalists to subsidize their rides and faced investor pressure to turn a profit. In hindsight, the low fares and high driver pay of ridehailing's early days were an unsustainable illusion—and arguably a predatory pricing scheme.[208] But despite the increased fares, TNCs are offering a better service

199. Paul Stephen Dempsey, *Taxi Industry Regulation, Deregulation & Reregulation: The Paradox of Market Failure*, 24 TRANSP. L.J. 73, 107–10 (1996).

200. *Id.* at 115–16.

201. Wyman, *supra* note 18, at 4, 8, 26–27, 56–57.

202. *See* Schneider, *supra* note 96.

203. *See* Elizabeth Pollman & Jordan M. Barry, *Regulatory Entrepreneurship*, 90 S. CAL. L. REV. 383, 385 (2017) (calling companies that "make[] changing the law a material part of its business plan" regulatory entrepreneurs).

204. *Id.* at 399.

205. *See id.* at 409 (recounting an example where Uber hired a team of lobbyists to "fight the legislative effort to override the veto").

206. Kaczmarski, *supra* note 19.

207. *See* Schneider, *supra* note 96.

208. Matthew T. Wansley & Samuel N. Weinstein, *Venture Predation*, 48 J. CORP. L. 813, 815 (2023)

than taxis did, at least if you measure by consumers' willingness to pay.

Municipalities and taxi companies should have taken the opportunity presented by app-based ridehailing to rethink taxi regulation. They should have been allowed to craft a new set of rules that apply equally to all vehicles-for-hire.[209] But that didn't happen. In many states, Uber and Lyft bypassed cities and went directly to state legislatures in their pursuit of a new legal category—TNCs—with a new set of rules different than the local rules that continue to apply to taxis.

Although often associated with their apps, the key feature of TNCs is their reliance on drivers using their own private vehicles.[210] TNCs are not subject to entry restrictions or to fare regulation that many municipalities still apply to taxis.[211] The imperfect information rationale for fare regulation is arguably obsolete because riders can compare fares by toggling between apps.[212] To the extent that certain rides are subsidized, it is because of strategic considerations by the companies or the drivers.

The content of TNC regulation varies by state. Arizona's rules focus on rider and driver safety. Arizona's TNC statute provides that the state Department of Transportation shall issue permits to TNCs that comply with the statute's requirements.[213] Before each ride, TNCs must disclose to riders the identity of the driver, the vehicle's license plate, and the fare.[214] After each ride, they must provide riders with an electronic receipt and preserve a digital record of the trip.[215] TNCs must disclose to drivers when the company's insurance policies apply to them.[216] And they must screen drivers by conducting criminal background and driving record checks and enforcing a zero tolerance policy for drugs and alcohol.[217]

California's TNC statute goes further. It allocates regulatory authority to the state's public utilities regulator, the California Public Utilities

209. Wyman, *supra* note 18, at 31 ("[R]egulators should treat all vehicles providing point-to-point transportation in response to customer requests as a unit . . . .").

210. Arizona defines a TNC as a business "that uses a digital network or software application to connect passengers to transportation network services provided by [TNC] drivers and that may but is not deemed to own, operate or control a personal motor vehicle of a [TNC] driver." ARIZ. REV. STAT. ANN. § 28-9551(3) (2025). California defines a TNC as a business "that provides prearranged transportation services for compensation using an online-enabled application or platform to connect passengers with drivers using a personal vehicle." CAL. PUB. UTIL. CODE § 5431 (West 2025).

211. *See* Wyman, *supra* note 18, at 32, 43.

212. *Id.* at 40.

213. ARIZ. REV. STAT. ANN. § 28-9552(A) (2025).

214. *Id.* § 28-9553(C).

215. *Id.* § 28-9553(D).

216. *Id.* § 28-9558.

217. *Id.* § 28-9554.

Commission ("CPUC").[218] Like Arizona, California requires that TNCs disclose to riders information about the driver and vehicle, disclose to drivers when the company's insurance policies apply, and conduct a criminal background check on drivers.[219] But California also mandates that TNCs meet specific minimum levels for insurance coverage that are higher than those that would otherwise apply to personal motor vehicles.[220] And it prohibits TNCs from disclosing a rider's personally identifiable information to third parties without consent.[221]

California takes modest steps to address the externalities that TNCs create. TNCs must develop a "greenhouse gas emissions reduction plan" with targets for increasing the proportion of drivers using electric vehicles.[222] And the California legislature granted San Francisco the authority to tax riders of traditional TNCs and robotaxis to fund the city's transportation operations and infrastructure.[223] California has also tried to encourage TNCs to expand mobility. They are required to charge their riders five cents per trip to contribute to the "TNC Access for All Fund," which supports accessible transportation.[224]

The development of robotaxis has long been connected with the rise of ridehailing. The leaders of the Google self-driving car program decided to pursue the robotaxi business model as they watched ridehailing take off.[225] Both Uber and Lyft tried to develop their own ADS. Uber founder Travis Kalanick once called robotaxis "existential" for his company.[226] But the reputation of Uber's automated driving program was damaged by revelations following its fatal crash in Arizona in 2018. And after their IPOs, neither Uber nor Lyft had the cash to sustain their programs, so they sold them.[227]

218. CAL. PUB. UTIL. CODE § 5440.
219. *Id.* §§ 5432, 5445.1, 5445.2.
220. *Id.* § 5433.
221. *Id.* § 5437.
222. *Id.* § 5450(c).
223. *Id.* § 5446.
224. *Id.* § 5440.5.
225. LAWRENCE D. BURNS & CHRISTOPHER SHULGAN, AUTONOMY 246–47 (2018).
226. Nick Statt, *Uber CEO Says Self-Driving Cars Won't Replace Human Drivers in the Near Term*, VERGE (Oct. 19, 2016), https://www.theverge.com/2016/10/19/13341130/uber-travis-kalanick-self-driving-cars-automation-jobs [https://perma.cc/L7KM-7RUG].
227. Lizette Chapman & Dana Hull, *Uber Sells Self-Driving Unit to Aurora, Takes Startup Stake*, BLOOMBERG (Dec. 7, 2020), https://www.bloomberg.com/news/articles/2020-12-07/uber-sells-self-driving-unit-to-aurora-takes-stake-in-startup [https://web.archive.org/web/20250726073842/https://www.bloomberg.com/news/articles/2020-12-07/uber-sells-self-driving-unit-to-aurora-takes-stake-in-startup]; *Woven Planet, a Subsidiary of Toyota, to Acquire Lyft's Self-Driving Car Division*, LYFT (Apr. 26, 2021), https://investor.lyft.com/news-and-events/news/news-details/2021/Woven-Planet-a-subsidiary-of-Toyota-to-acquire-Lyfts-self-driving-car-division [https://perma.cc/EF4R-R5QM].

The first robotaxi regulations have been strongly influenced by TNC regulations. Arizona applies its TNC regulations to robotaxis through incorporation by reference. An Arizona statute provides that: "An on-demand autonomous vehicle network may operate pursuant to [the state's TNC statute] except that any provision of [that statute] that by its nature reasonably applies only to a human driver does not apply to a fully autonomous vehicle operating with the [ADS] engaged . . . ."[228]

California's legislature has not enacted a statute specific to robotaxis (as opposed to TNCs, vehicles for hire, or automated driving more generally). Instead, the CPUC created its robotaxi regulations using its existing statutory authority over vehicles for hire.[229] In 2018, the CPUC created two pilot programs for robotaxis. The first pilot let companies with a vehicle-for-hire permit and a DMV testing permit offer rides in their robotaxis with a safety driver present.[230] The second pilot let companies with a vehicle-for-hire permit and a DMV driverless testing permit offer rides without a safety driver.[231] Companies participating in the pilots were prohibited from accepting payment from riders. And they were required to submit aggregate data on their operations.[232] Cruise, Waymo, Zoox, and three other companies obtained permits for at least one of the pilots.[233]

In 2020, the CPUC issued regulations for robotaxi deployment. Companies with a vehicle-for-hire permit and a DMV deployment permit were allowed to apply to the CPUC for a robotaxi deployment permit.[234]

228. ARIZ. REV. STAT. ANN. § 28-9704 (2025).

229. California's public utilities code defines a broad category of Transportation Charter Party Carriers (TCPs) that includes "every person engaged in the transportation of persons by motor vehicle for compensation, whether in common or contract carriage, over any public highway in this state." CAL. PUB. UTIL. CODE § 5360 (West 2011). TNCs are just one subcategory of TCPs. As one federal court has explained, "[t]he key distinguishing characteristic of TCPs, as opposed to traditional taxis, is that the transportation must be 'prearranged' rather than hailed on the street." *Overton v. Uber Techs., Inc.*, 333 F. Supp. 3d 927, 936 (N.D. Cal. 2018). The CPUC couldn't regulate robotaxi companies as TNCs because they don't meet the statutory definition of TNCs—they don't connect people with drivers. But they do meet the broader definition of a TCP.

230. Decision Authorizing a Pilot Test Program for Autonomous Vehicle Passenger Service with Drivers and Addressing in Part Issues Raised in the Petitions for Modification of General Motors, LLC/GM Cruise, LLC, Lyft, Inc., and Rasier-CA, LLC/UATC, LLC for Purposes of a Pilot Test Program for Driverless Autonomous Vehicle Passenger Service, Order Instituting Rulemaking on Regulations Relating to Passenger Carriers, Ridesharing, and New Online-Enabled Transportation Services, R. 12-12-011, at 4 (Cal. Pub. Utils. Comm'n May 31, 2018) [hereinafter CPUC Pilot Programs Order].

231. *Id.*

232. *Id.* at 39.

233. Decision Authorizing Deployment of Drivered and Driverless Autonomous Vehicle Passenger Service, Order Instituting Rulemaking on Regulations Relating to Passenger Carriers, Ridesharing, and New Online-Enabled Transportation Services, R. 12-12-011, at 5 (Cal. Pub. Utils. Comm'n Nov. 19, 2020) [hereinafter CPUC Deployment Order].

234. *Id.* at 3.

Companies that were approved were allowed to start charging riders.[235] The CPUC imposed two new obligations on applicants. First, they have to submit a "Passenger Safety Plan" that explains how they (1) minimize safety risks from other riders; (2) minimize safety risks from outside the vehicle; (3) ensure riders can safely identify the vehicle, enter, and exit; (4) enable riders to communicate with remote operators; and (5) collect and respond to rider complaints.[236] Second, after a company is approved to deploy, it has to submit detailed, trip-level data on each ride request and each ride.[237]

Two companies—Cruise and Waymo—applied to deploy a commercial robotaxi service in San Francisco.[238] In August 2023, the CPUC approved both requests.[239] But as we have seen, Cruise's robotaxi service did not last long. The CPUC suspended Cruise's robotaxi deployment permit after the DMV suspended Cruise's ADS deployment permit in the aftermath of its serious pedestrian crash in October 2023.[240] Waymo's robotaxi operations, however, have continued to grow. In March 2024, the CPUC approved Waymo's request to expand its service area in San Francisco down to Silicon Valley and to add a new service area in Los Angeles.[241]

So today, at least two states have considerable experience regulating an active commercial robotaxi service.[242] In the rest of this Article, we ask, how should they regulate?

II. CURBING EXTERNALITIES

We start with regulating externalities. Robotaxis will emit pollutants into the environment. They will contribute to wear and tear on physical infrastructure. They will cause congestion. They will passively surveil their surroundings, which could erode privacy. But so too will many other

235. *Id.*

236. *Id.* at 35.

237. *Id.* at 2 (indicating that participants must provide data, inter alia, on the "pick-up and drop-off locations for individual trips").

238. Press Release, *CPUC Approves Permits for Cruise and Waymo to Charge Fares for Passenger Service in San Francisco*, CAL. PUB. UTILS. COMM'N (Aug. 10, 2023), https://www.cpuc.ca.gov/news-and-updates/all-news/cpuc-approves-permits-for-cruise-and-waymo-to-charge-fares-for-passenger-service-in-sf-2023 [https://perma.cc/NW7N-3WGD].

239. *Id.*

240. *See* Rebecca Bellan, *California Agency Pulls Cruise's Commercial Robotaxi Permit Following DMV Action*, TECHCRUNCH (Oct. 24, 2023), https://techcrunch.com/2023/10/24/cpuc-pulls-cruise-robotaxi-permit-after-dmv-suspension [https://perma.cc/Q4ZR-XWDL].

241. *See* Cal. Pub. Utils. Comm'n, Letter Approving Waymo's Advice Letter (Mar. 1, 2024), https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/consumer-protection-and-enforcement-division/documents/tlab/av-programs/waymo-al-2-disposition-letter-20240301_signed.pdf [https://perma.cc/5QR9-78QZ].

242. Waymo now operates in other states as well—though for less time and, in some cases, with less oversight than in Arizona and especially California.

technologies and travel modes. In this Part, we consider how policymakers should respond to the externalities of robotaxis in a way that accounts for this broader context.

A. EXTERNALITIES AND MODE CHOICE

One might think there's an easy answer to the externalities robotaxis create: impose Pigouvian taxes, so the robotaxi companies internalize the costs. But personal motor vehicles, taxis, TNCs, and other modes of travel—whether automated or not—also create externalities. So policymakers must consider how externality regulation will affect choices among modes.

Burdening automated driving in ways that do not burden conventional driving will push people toward conventional driving. Burdening robotaxis in ways that do not burden personal automated vehicles will push people toward personal automated vehicles. If robotaxis offer net social benefits relative to those modes, these are not desirable outcomes.

But externality regulation that applies to *all* travel modes might not always be attainable.[243] The practicality and political feasibility of regulation can vary by mode. In some cases, robotaxis might be easier to regulate, and to at least some degree policymakers should take advantage of the opportunity.

We suggest a hierarchy of action:

- Internalize costs across all travel modes.
- Where this is not possible, internalize costs across motor vehicle modes.
- Where this is not possible, internalize costs across fleet-deployed motor vehicles.
- Where this is not possible, internalize costs across automated vehicles.
- Where this is not possible, internalize costs across robotaxis.

Costs can be internalized through taxation, market caps, performance requirements, or other regulatory mechanisms. If applied proportionately, the regulatory mechanisms should be automatically indexed so that the extent of a mode's internalization of its external costs rises along with its share of the market. In addition, when choosing what and how to regulate, we suggest prioritizing action on what are likely to be significant inflection

243. Walker Smith, *supra* note 13, at 674.

points that could lock the public, policymakers, and companies into one long-term path or another.

Take the example of motor vehicle emissions that we discuss below. Ideally, in our view, regulators would require that all new motor vehicles[244] achieve increasingly aggressive fuel efficiency standards. If that's not politically realistic, then it may be appropriate to begin with fleets—government vehicles, other vehicle pools, rental cars, and the like.[245] But imposing significant initial burdens on these fleets could significantly disadvantage them vis-à-vis private ownership models. And so, it may be appropriate to require fleet vehicles to meet a fuel efficiency standard that is somewhere between the standard for regular vehicles and the standard that would be ideal.

Or take the example of the third-party liability insurance required for motor vehicles. Countries in the European Union generally require vehicle owners and operators to have liability insurance that covers anywhere from millions of dollars of exposure to literally unlimited exposure.[246] Even the low end of this range is *a hundred to a thousand times greater* than minimum insurance requirements in most U.S. states. Ideally, in our view, states would dramatically increase insurance minimums across the board and index them to inflation.[247] States have not done so.[248] Some states, however, have required the companies testing or deploying automated vehicles to show financial responsibility in the millions of dollars.[249] Under our approach, the difference between the two requirements might not be so great, but this is at

244. Technically, each manufacturer's set of new vehicles. While this is called a "fleet," we use that term in a different way in this paragraph.

245. State and federal agencies may have flexibility and authority in their procurement capacity that they do not in their regulatory capacity. *See, e.g.*, 49 U.S.C. § 30103(b)(1) ("However, the United States Government, a State, or a political subdivision of a State may prescribe a standard for a motor vehicle or motor vehicle equipment obtained for its own use that imposes a higher performance requirement than that required by the otherwise applicable standard under this chapter.").

246. *See* Directive (EU) 2021/2118 of the European Parliament and of the Council, 2021 O.J. (L 430) 1; Council of Bureaux (AISBL), *Minimum Amount of Insurance Coverage* (Jan. 2026) (on file with the authors).

247. South Carolina required $10,000 of automotive liability insurance in 1963. Adjusted for medical inflation, this is equivalent to requiring about $230,000 today—and yet the state, like many others, currently requires only $25,000 in coverage for a single injury. S.C. CODE ANN. § 38-77-140 (2024).

248. Though North Carolina recently doubled its minimum. *Changes to the Rating of Automobile Insurance Policies, Effective July 1, 2025*, N.C. DEP'T OF INS., https://www.ncdoi.gov/changes-rating-automobile-insurance-policies-effective-july-1-2025 [https://perma.cc/32GA-HAD8]. This is commendable even as it is still far short of what we consider the ideal.

249. *See, e.g.*, NEV. REV. STAT. § 482A.060 (2025) (requiring that person that begins testing autonomous vehicles within State must submit "proof of insurance or self-insurance acceptable to the Department in the amount of $5,000,000"); FLA. STAT. § 316.86(1) (2015) (requiring that entity "performing the testing" of an ADS "submit to the department an instrument of insurance, surety bond, or proof of self-insurance . . . in the amount of $5 million").

least useful precedent—and, in fairness, does not seem to have dampened enthusiasm for automated driving.[250]

Finally, we recognize that even when internalizing externalities provides benefits to those with less money, it can also impose disproportionate costs on them. An increase of $1,000 in the price of a new car to include an important safety feature is negligible for someone who can afford a $150,000 car but significant for someone who can afford only a $15,000 car. So too is increasing the per-mile cost of a trip (whether by private automobile or robotaxi) by fifty cents.

Fortunately, internalizing costs is only half of the policy question. The other half is how to channel the societal gains. In the easiest case of governmental revenue, a government can return to households any additional funds it receives from, say, taxing carbon or setting a floor for the price of energy. If designed carefully, these rebates can ultimately enhance rather than diminish individual choice: Someone who chooses to travel an average amount by personal automobile might well break even if their rebate covers the additional costs of fuel, tolls, and parking. Meanwhile, someone who chooses to live closer to work or bicycle may well come out ahead. Even where the benefits are societal rather than governmental and abstract rather than fiscal, smart policies can equitably capture and return some of this gain.[251]

In this section, we address just some of the external costs of motor vehicle travel: pollution, wear-and-tear, congestion, and privacy. Of course, traffic injury is a national crisis, but it is beyond the scope of our present analysis.[252]

250. In fact, Nevada originally intended for its higher insurance requirement to function as an entry barrier for individuals and smaller companies that might irresponsibly test their automated creations on public roads. STANFORD CENTER FOR INTERNET AND SOCIETY, *How an (Autonomous Driving) Bill Becomes Law*, at 1:05:40–1:06:07 (YouTube Nov. 12, 2012), https://www.youtube.com/watch?v=gx6D55poYdk [https://perma.cc/7PL7-G93B]. And Florida intended its higher insurance requirement to in effect delegate safety regulation to the insurance industry. Marc Scribner, *How Florida Hit the Gas on Self-Driving Car Development*, COMPETITIVE ENTER. INST. (Sep. 26, 2019), https://cei.org/opeds_articles/how-florida-hit-the-gas-on-self-driving-car-development [https://perma.cc/8U56-HXQH].

251. We do recognize the irony of reimagining broader governmental philosophy and policy in a discussion ostensibly on second-best solutions.

252. On this point, *see, e.g.*, TRANSFORMING TRANSP. ADVISORY COMM., *supra* note 13. For a broad vision of road traffic safety, to which automated driving might contribute, see Bryant Walker Smith, *Road Traffic Safety*, NEWLYPOSSIBLE.ORG (Sep. 26, 2022), https://newlypossible.org/wiki/Road_traffic_safety [https://perma.cc/CG7V-XN45].

B. POLLUTION

A critical externality of motor vehicle use is air pollution. Tailpipe emissions from traditional gasoline and diesel vehicles account for about one-fifth of greenhouse gas emissions in the United States.[253] And tailpipes also emit other gases and particulates harmful to human health.[254]

The gradual electrification of the vehicle fleet is reducing its per-mile carbon footprint.[255] In the most recent quarter, almost nine percent of new vehicles sold in the United States were battery electric.[256] And the United States lags many countries in the developed world in electric vehicle adoption. In Norway, about eighty-nine percent of new vehicles sold in 2024 were electric.[257]

The Biden administration prioritized electrification of the vehicle fleet. The Inflation Reduction Act provided tax credits for electric vehicles and charging stations.[258] The U.S. Environmental Protection Agency issued a new tailpipe emission rule that would effectively require half the new cars sold in 2032 to be electric (or use an alternative fuel).[259] And the U.S. Department of Transportation has set a fuel economy standard that would require the cars that each automaker sells to average sixty-five miles per

253. *See Fast Facts on Transportation Greenhouse Gas Emissions*, U.S. ENV'T PROT. AGENCY (June 6, 2025), https://www.epa.gov/greenvehicles/fast-facts-transportation-greenhouse-gas-emissions [https://perma.cc/8MEB-GB77].

254. OFF. TRANSP. & AIR QUALITY, U.S. ENV'T PROT. AGENCY, EPA-420-F-23-014, TAILPIPE GREENHOUSE GAS EMISSIONS FROM A TYPICAL PASSENGER VEHICLE 2–3 (2023).

255. Specifically, nonpoint source pollution of the byproducts of combustion. EVs still require energy to be produced somewhere, and they still pollute through mechanical means (such as tire wear). *See supra* note 10 and accompanying text.

256. *U.S. Share of Electric and Hybrid Vehicle Sales Reached a Record in the Third Quarter*, U.S. ENERGY INFO. ADMIN. (Dec. 4, 2024), https://www.eia.gov/todayinenergy/detail.php?id=63904 [https://perma.cc/K2VT-46SL].

257. Nerijus Adomaitis, *In Norway Nearly All New Cars Sold in 2024 Were Fully Electric*, REUTERS (Jan. 2, 2025), https://www.reuters.com/business/autos-transportation/norway-nearly-all-new-cars-sold-2024-were-fully-electric-2025-01-02 [https://perma.cc/WL5P-AG83].

258. *See* 26 U.S.C. § 30C(a) (allowing credit of the cost of "any qualified alternative fuel vehicle refueling property"); 26 U.S.C. § 30D(a) (allowing credit for "each new clean vehicle placed in service by the taxpayer").

259. *See* Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles, 89 Fed. Reg. 27842 (Apr. 18, 2024) (to be codified at 40 C.F.R. pts. 85, 86, 600, 1036, 1037, 1066, 1068).

gallon.[260] Since 2025, The Trump administration or Congress has reversed many of these steps.[261]

Some states have gone further—or at least have tried to.[262] California law requires that all new passenger vehicles sold in the state in or after 2035 be powered by something other than gasoline or diesel.[263]

The robotaxi business model is well-suited to electric vehicles. Robotaxis are being deployed in dense, urban areas. They are never too far from a charging station. A robotaxi company can monitor when its vehicles need to be recharged, and its routing algorithms can plan its trips accordingly. Robotaxi riders being shuttled around a city don't suffer "range anxiety" the way that a human driver might on a long-distance trip. Charging does currently require taking a robotaxi out of operation for potentially longer than a stop at a gas station, but this may eventually be addressed with better batteries, faster charging, charging-in-motion, and even battery swapping (which is likely more manageable within a fleet than between private vehicles).

Policymakers should mandate that all robotaxis be electric or alternative-fuel vehicles.[264] California has already enacted a statute that requires any automated vehicle in model year 2031 or later to be electric.[265]

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260. 49 C.F.R. § 531.5 (2024); *see also* Corporate Average Fuel Economy Standards for Passenger Cars and Light Trucks for Model Years 2027 and Beyond and Fuel Efficiency Standards for Heavy-Duty Pickup Trucks and Vans for Model Years 2030 and Beyond, 89 Fed. Reg. 52540 (June 24, 2024), (to be codified at 49 C.F.R. pts. 523, 531, 533, 535, 536, 537) (establishing Corporate Average Fuel Economy (CAFE) standards). *But see* Resetting the Corporate Average Fuel Economy Program, 90 Fed. Reg. 24518, 24521 (June 11, 2025) (to be codified at C.F.R. pts. 531, 533, 535) (concluding that NHTSA had applied factors to determine 2024 standards that were contrary to law); NHTSA *Interpretive Rule Asserts Authority to Reset CAFE Standards*, COLUM. L. SCH. SABIN CTR. FOR CLIMATE CHANGE L., https://climate.law.columbia.edu/content/nhtsa-interpretive-rule-asserts-authority-reset-cafe-standards [https://perma.cc/B8PR-UMDN].

261. Lisa Friedman, *Trump Administration Erases the Government's Power to Fight Climate Change*, N.Y. TIMES (Feb. 12, 2026), https://www.nytimes.com/2026/02/12/climate/trump-epa-greenhouse-gases-climate-change.html [https://perma.cc/363U-A6UV].

262. Camila Domonoske, *Upending Norms, the Senate Votes to Undo California's EV Rules*, NPR (May 22, 2025), https://www.npr.org/2025/05/22/nx-s1-5387729/senate-california-ev-air-pollution-waiver-revoked [https://perma.cc/2GSG-F48Y] (reporting on Senate's vote to overturn waiver allowing California to set stricter air pollution standards for cars).

263. CAL. CODE REGS. tit. 13, § 1962.4 (2025). *But see* Complaint for Declaratory and Injunctive Relief, United States v. California Air Resources Board, No. 2:26-cv-00450 (E.D. Cal. Mar. 12, 2026), https://www.justice.gov/opa/media/1430886/dl?inline [https://perma.cc/8YRK-EHMY] (seeking to block California's law). For more on this, see, e.g., Dan Farber, Does Federal Law Still Preempt State Standards relating to Fuel Efficiency?, Legal Planet (Mar. 12, 2026), https://legal-planet.org/2026/03/12/does-federal-law-still-preempt-state-standards-relating-to-fuel-efficiency [https://perma.cc/LN3M-T7KR].

264. We generally mean electric vehicles, but we recognize that there are potential alternatives such as hydrogen and that EVs may be poorly suited to rural service areas that lack charging or battery-swapping infrastructure.

265. CAL. VEH. CODE § 38750(i)(1) (West 2025).

There's no reason to wait that long. The large U.S. companies that are deploying or developing robotaxis are using electric vehicles today—Waymo's Jaguar I-Pace, Zeekr minivan, and Hyundai Ioniq; Zoox's bespoke electric vehicle; and all of Tesla's models.[266] And none have announced plans to use gasoline-powered vehicles in the future. An electric vehicle mandate for robotaxis would likely not face the opposition that a broader requirement could. And it would have the effect of setting a market floor that others could not subsequently undercut.

An electric vehicle mandate will not eliminate robotaxis' contribution to air pollution. Increasing demand for electricity can increase emissions if that electricity is generated by burning fossil fuels. Tires, brake pads, and other vehicle parts exposed to heat or friction generate particles that can harm the environment and human health.[267] Supply chains for vehicles and data centers for automated driving also have significant environmental impacts. But here mode-neutral environmental regulation is likely the best solution.

C. WEAR-AND-TEAR

Motor vehicles also cause wear-and-tear on the roads. State and federal governments address this externality by charging excise taxes on gasoline.[268] Revenue from gas taxes can—and in some states, must—be spent on transportation infrastructure.[269] The rationale for a gas tax is that gas consumption roughly tracks miles driven, so the tax functions as a user fee.

As motor vehicles have become more fuel-efficient and as electric vehicles have increased in popularity, though, the connection between the gas tax and VMT is becoming attenuated. To make matters worse, the federal gas tax and some state gas taxes are not indexed to inflation.[270] Although the

266. *See supra* notes 78–79 and accompanying text.

267. *See* Jim Robbins, *Road Hazard: Evidence Mounts on Toxic Pollution from Tires*, YALE ENV'T 360 (Sep. 19, 2023), https://e360.yale.edu/features/tire-pollution-toxic-chemicals [https://perma.cc/B8FP-UF99].

268. *See How Much Tax Do We Pay on a Gallon of Gasoline and on a Gallon of Diesel Fuel?*, U.S. ENERGY INFO. ADMIN. (Aug. 21, 2024), https://www.eia.gov/tools/faqs/faq.php?id=10&t=5 [https://perma.cc/4NUR-F5L4] (noting federal excise taxes on gasoline of 18.4 cents per gallon and average state excise taxes on gasoline of 32.61 cents per gallon). The federal excise tax rate is codified at 26 U.S.C. § 4041(a)(3)(A).

269. The federal gas tax contributes to the Highway Trust Fund, which funds both highways and mass transit. *See* CONGRESSIONAL BUDGET OFFICE, THE STATUS OF THE HIGHWAY TRUST FUND: 2023 UPDATE 1 (2023). State gas taxes are often used to cover roadway expenses. *See* Adam Hoffer & Jacob Macumber-Rosin, *Gas Taxes by State, 2024*, TAX FOUND. (Aug. 6, 2024), https://taxfoundation.org/data/all/state/state-gas-tax-rates-2024 [https://perma.cc/759R-RMTE] (describing use of gas taxes to fund road construction and maintenance).

270. Janelle Fritts, *Gas Taxes by State, 2021*, TAX FOUND. (July 28, 2021), https://taxfoundation.org/data/all/state/state-gas-tax-rates-2021 [https://perma.cc/2UF3-VFC3]; *see also* Theodore J. Kury, *The Gas Tax's Tortured History Shows How Hard It Is to Fund New Infrastructure*, PBS (June 22, 2021), https://www.pbs.org/newshour/politics/the-gas-taxs-tortured-history-shows-how-

gas tax today still generates revenue with the salutary effect of promoting electric vehicles, at some point it will be necessary to find other ways to finance surface transportation.

The simplest alternative to a gas tax is a VMT tax—a per mile charge to use the public roads. Four states are already implementing VMT taxes for electric vehicles.[271] These states offer electric vehicle owners the choice of paying a fixed annual fee or paying a VMT tax capped at the level of the annual fee.[272] Hawaii plans to take away the choice and require all electric vehicle owners to pay its VMT tax in 2028.[273]

A shift to electric vehicles may increase wear-and-tear on the roads because batteries make electric vehicles heavier than similar internal combustion engine vehicles.[274] In a world where all motor vehicles were electric and an upstream carbon tax addressed the broader environmental burden of energy production, a weight-adjusted VMT tax might be the optimal solution. Short of that, tweaking traditional fuel taxes by properly indexing them to inflation, adjusting them for fleetwide fuel efficiency, and using them to provide a floor for the price of fuel could address wear-and-tear while capturing some of the larger externalities of internal combustion engines.

D. CONGESTION

Congestion is an externality that all motor vehicles can create. But robotaxis may exacerbate congestion by satisfying latent travel demand or creating new travel demand.[275] Riders might find travel in a robotaxi less costly. The cost reduction could be financial: a robotaxi company might charge fewer cents per mile than a traditional TNC would. It could be about opportunity cost: a passenger in an automated vehicle might be able to sleep or do work that a driver could (and should) not. Or it could be psychological: riding may be less stressful than driving, especially during congested periods. The cost reduction might also encourage people to make different

hard-it-is-to-fund-new-infrastructure [https://perma.cc/NWS2-L5M7] (noting efforts to index gas tax to inflation).

271. Jacob Macumber-Rosin & Adam Hoffer, *Vehicle Miles Travelled Taxes Rollout Across States*, TAX FOUND. (May 9, 2024), https://taxfoundation.org/blog/state-vmt-vehicle-miles-traveled-taxes [https://perma.cc/JU2F-XN7U] (noting programs in Hawaii, Oregon, Utah, and Virginia).

272. *Id.*

273. *Id.*

274. Blake Shaffer, Maximilian Auffhammer & Constantine Samaras, *Make Electric Vehicles Lighter to Maximize Climate and Safety Benefits*, NATURE COMMENT (Oct. 12, 2021), https://www.nature.com/articles/d41586-021-02760-8 [https://perma.cc/G8FW-W59F].

275. *See* Walker Smith, *supra* note 5, at 1405–08 (discussing induced demand).

decisions about where they live or work. In each case, the benefits could lead people to take more trips and longer trips.

How much congestion robotaxis create will depend not only on how many people take rides and how long those trips take, but also how efficient the networks are. As we mentioned in Part I, Waymo's robotaxis in San Francisco are deadheading over 40% of the time.[276] The robotaxi companies' private incentives to reduce deadheading don't capture all the social costs of congestion, so regulation can and should supplement that incentive. But it is important to remember that personal cars have their own form of deadheading: the miles they drive while cruising in search of parking.

Some U.S. cities have VMT taxes that apply only to certain modes, which function in some ways like a congestion tax. As we mentioned in Part I, the California legislature gave the City of San Francisco the authority to tax TNCs and robotaxis.[277] In 2019, San Francisco voters approved a tax, now called the Traffic Congestion Mitigation Tax, at the ballot box.[278] Riders in a gasoline vehicle who request to ride solo are taxed up to 3.25%.[279] Riders in an electric vehicle and riders who request to share their ride are taxed 1.5%.[280] In some respects, the tax is well-designed. The tax is a fixed percentage of the fare, so it should scale with VMT and travel demand. But because it only applies to TNCs and robotaxis, it distorts the market in favor of personal motor vehicles.

We are less sure of the politics of more ambitious visions of VMT taxation in which continuous monitoring facilitates dynamic—that is, demand-variable—pricing. As a general matter, Americans seem skeptical of devices that are attached to their cars for the purpose of updating "the government" on their travel. This is understandable.

Instead, we favor a mix of mechanisms that, in combination, generate revenue above an excise tax on gas or carbon, serve as a proxy for the use of valuable road space, and accordingly help to manage travel demand. These include congestion prices in urban centers, other forms of variable tolling on major roadways and bottlenecks, and market-rate parking rates. As famous photos comparing the road space used by people on foot, in a bus, on bikes,

276. *See* Campbell, *supra* note 109.

277. *See* CAL. PUB. UTIL. CODE § 5446.

278. *Traffic Congestion Mitigation Tax*, CITY & CNTY. S.F. TREASURER & TAX COLLECTOR, https://sftreasurer.org/business/taxes-fees/traffic-congestion-mitigation-tax-tcm [https://perma.cc/5ZZL-RCZV] (last visited Sep. 26, 2025).

279. *Id.*

280. *Id.*

and in cars suggest,[281] the key is to charge for road space in a way that optimizes that use.[282]

Congestion pricing has been implemented in London, Milan, Singapore, and Stockholm.[283] In January 2025, after much drama, New York City implemented the first general purpose congestion tax in the United States.[284] The initial results are promising. Travel times on the bridges and tunnels leading to lower Manhattan have fallen.[285] But it is too early to predict the long-term equilibrium.

An important point here is that there is no definitive solution to congestion: like popular restaurants, popular places and routes at popular times will be crowded. But there are still important policy choices about what that crowd looks like—and who can get through. If single- or zero-occupancy motor vehicles are queued, can people in communal and active modes still move? Do emergency vehicles have a path? If automated driving increases both demand and capacity, the result could be even more vehicles but no greater mobility.[286] Given this, it is essential to start answering these questions before automated vehicles start eclipsing conventional vehicles.

E. PRIVACY

Loss of privacy is a hidden externality—and one with which automated driving has a complicated relationship.[287] We see privacy as playing a nuanced but ultimately important role in advancing the important societal

281. *See, e.g.*, Jarrett Walker, *The Photo That Explains Almost Everything*, HUMAN TRANSIT (Sep. 21, 2012), https://humantransit.org/2012/09/the-photo-that-explains-almost-everything.html [https://perma.cc/KT4E-NBDY].

282. Brad Templeton gave us the interesting suggestion of road-square-foot-per-second fee, though as with a demand-variable VMT tax, we doubt its political viability. *See also* Jack Hayes, *Road Reservation Proposal2*, YOUTUBE (June 20, 2023), https://www.youtube.com/watch?v=d8vF6r0-XpM [https://perma.cc/72D4-969D].

283. Erica Veitch & Ekaterina Rhodes, *A Cross-Country Comparative Analysis of Congestion Pricing Systems: Lessons for Decarbonizing Transportation*, *in* CASE STUDS. ON TRANSP. POL'Y 1, 6, 21 (2024).

284. Winnie Hu & Ana Ley, *New York City Welcomes Congestion Pricing with Fanfare and Complaints*, N.Y. TIMES (Mar. 5, 2025), https://www.nytimes.com/2025/01/05/nyregion/nyc-congestion-pricing-tolls.html [https://perma.cc/RAU9-G2RM].

285. Ana Ley, Winnie Hu & Keith Collins, *Less Traffic, Faster Buses: Congestion Pricing's First Week*, N.Y. TIMES (Jan. 13, 2025). https://www.nytimes.com/2025/01/13/nyregion/congestion-pricing-nyc.html [https://perma.cc/ZW8G-PHLF].

286. *See* Walker Smith, *supra* note 5, at 1420.

287. On privacy generally, see, e.g., Airbnb, Inc. v. City of New York, 373 F. Supp. 3d 467 (S.D.N.Y. 2019); Rory Van Loo, *Privacy Pretexts*, 108 CORNELL L. REV. 1, 33 *et seq.* (2022); Ira S. Rubinstein & Bilyana Petkova, *Governing Privacy in the Datafied City*, 47 FORDHAM URB. L.J. 755, 805 (2020); Aziz Z. Huq, *The Public Trust in Data*, 110 GEORGETOWN L.J. 333 (2021); Andrew Guthrie Ferguson, *Digital Rummaging*, 101 WASH. U. L. REV. 1473 (2024).

values of freedom and community. Safety can preserve a person's privacy.[288] Surveillance can impede a person's ability to act on their own and to form relationships with others.

An ADS aims to generate a three-dimensional, 360-degree view of its surroundings.[289] That is why automated vehicles are outfitted with a suite of sensors. Those sensors are constantly receiving data about the objects in the vehicle's vicinity. As a consequence, any person who passes within the range of the sensors will likely (and indeed should) be perceived by these sensors.

A high-fidelity perception system is critical to ADS safety. An ADS can choose a safe path only if it knows where people, animals, and objects are moving in real time. Indeed, one of the ways that ADSs might improve on human drivers is by detecting and tracking objects that a driver might miss.[290] If stored, ADS perception data are also valuable for crash investigations, though more data does not necessarily mean more certainty. In addition, insights from these data might be useful to important research that has little to do with automated driving.

It might seem as though the privacy interests affected are insignificant. ADS sensors will only pick up what can be seen from a public roadway. Many of these places will also be surveilled by business or home monitoring systems. In a conventional sense, there is little reasonable expectation of privacy on a sidewalk or a front porch.[291]

But we think the privacy risks are substantial. If automated driving succeeds commercially—and here we are talking not only about robotaxis—then surveillance will become pervasive.[292] Automated vehicles will frequently pass by your home, your workplace, and every third place you visit. Their powerful sensors in combination with onboard and offboard computing power will add considerably to existing and growing surveillance by private and public actors.

288. Serious roadway crashes deprive their victims of privacy in many ways, in both the short-term and the long-term.

289. WAYMO, *supra* note 36, at 14 ("To meet the complex demands of autonomous driving, Waymo has developed an array of sensors that allow our vehicle to see 360° degrees, both in daytime and at night, and up to nearly three football fields away. This multi-layered sensor suite works together seamlessly to paint a detailed 3D picture of the world, showing dynamic and static objects including pedestrians, cyclists, other vehicles, traffic lights, construction cones, and other road features.").

290. Wansley, *The End of Accidents, supra* note 20, at 271–72.

291. Though we don't want to overstate this. *See* Matthew Guariglia & Lisa Femia, *You Really Do Have Some Expectation of Privacy in Public*, ELECTRONIC FRONTER FOUNDATION (Sept. 6, 2024), https://www.eff.org/deeplinks/2024/09/you-really-do-have-some-expectation-privacy-public [https://perma.cc/RET5-FLWC].

292. *See* Walker Smith et al., *supra* note 12, at 7; David Sella-Villa & Michael Hodgson, *Privacy in the Age of Active Sensors*, 92 UKMC L. REV. 1, 4 (2023).

Automated driving companies might also, among others, quietly become agents of law enforcement.[293] Increased monitoring could have real benefits for deterring crime or apprehending suspects. But if a city councilor proposed to have the police department build a system of pervasive surveillance, at a minimum we would have a debate about whether the public safety benefits outweighed the privacy harms.[294] The deployment of robotaxis might bring about the same privacy loss without any public debate. Courts have already issued warrants to robotaxi companies for sensor data.[295] And police may not always need to get a warrant. After a deliberate explosion in a Cybertruck in Las Vegas, for example, Tesla quickly made information from that vehicle and from its network available to law enforcement.[296]

Waymo and its erstwhile rival Cruise both disclosed that they have provided ADS video data to the police. Waymo claimed that it generally only shares data under a warrant or court order.[297] The company has stated that, if the police make a request that is overbroad, "we try to narrow it, and in some cases we object to producing any information at all."[298] Cruise likewise stated that it "disclose[s] relevant data only in response to legal processes or exigent circumstances, where we can help a person who is in imminent danger."[299] Both of these statements are carefully hedged, and they have not been independently verified beyond some open records requests. These dynamics evoke past (and indeed current) debates about the relationship between telecommunications companies and federal investigators.

293. *See* Walker Smith et al., *supra* note 12, at 22.

294. Hopefully. *See* Mike Katz-Lacabe, *Anaheim Police Buy a $755,000 Nyxcell Cell Site Simulator*, CTR. FOR HUM. RTS. & PRIV., https://www.cehrp.org/issues/cell-site-simulator [https://perma.cc/C6HB-T2D2]; Jessica Glenza & Nicky Woolf, *Stingray Spying: FBI's Secret Deal with Police Hides Phone Dragnet from Courts*, GUARDIAN (Apr. 10, 2015), https://www.theguardian.com/us-news/2015/apr/10/stingray-spying-fbi-phone-dragnet-police [https://perma.cc/2DXJ-8SM4]; Kate Martin, *Documents: Tacoma Police Using Surveillance Device to Sweep up Cellphone Data*, NEWS TRIB. (Feb. 25, 2016), https://www.thenewstribune.com/news/local/article25878184.html [https://perma.cc/V9BR-ULSA].

295. Julia Love, P*olice Are Requesting Self-Driving Car Footage for Video Evidence*, BLOOMBERG (June 29, 2023), https://www.bloomberg.com/news/articles/2023-06-29/self-driving-car-video-from-waymo-cruise-give-police-crime-evidence [https://perma.cc/6R42-9DGD].

296. Trisha Thadani & Shannon Najmabadi, *Elon Musk Offers Personal Aid in Las Vegas Cybertruck Explosion Probe*, WASH. POST (Jan. 3, 2025), https://www.washingtonpost.com/technology/2025/01/03/elon-musk-telsa-cybertruck-explosion-data [https://web.archive.org/web/20250103154432/https://www.washingtonpost.com/technology/2025/01/03/elon-musk-telsa-cybertruck-explosion-data].

297. Love, *supra* note 295; *see also Hit the Road, Mac: The Future of Self-Driving Cars, Hearing Before S. Comm. on Com., Sci., and Transp.*, 119th Cong. 2 (2026), https://www.commerce.senate.gov/2026/2/hit-the-road-mac-the-future-of-self-driving-cars [https://perma.cc/S63G-ZB82], 1:04:53–1:06:40 (testimony of Waymo and Tesla Representatives).

298. Love, *supra* note 295.

299. *Id.*

Companies have strong incentives to stay in the good graces of law enforcement because policing requires discretion. Every time an automated vehicle is involved in a crash or at least arguably violates a traffic law is an opportunity for the police to use their discretion to benefit the automated driving company. So companies may decide to curry favor with police by voluntarily sharing videos and other data that will be useful for their investigations.

So how can regulation reduce privacy risks while not inhibiting the development and deployment of safe automated vehicles?

We would prefer to see these risks addressed as part of a much broader privacy framework. These challenges are not limited to robotaxis or automated vehicles more generally or advanced motor vehicles even more generally. They also exist for aerial drones, sidewalk robots, smartphones, doorbell cameras, a wide range of other consumer-facing connected devices, and an even wider range of more obscure applications.[300]

In the absence of such an approach, policymakers should use their existing authority to scrutinize the data practices of companies within that authority. Unfortunately, this is likely to result in different rules for similar actors. If, for example, an agency has authority over robotaxis but not automated driving companies more generally, then rules for robotaxis might look different than rules for automated driving more generally. But these discrepancies might be useful in experimenting and ultimately incentivizing efforts to harmonize.

What might this scrutiny look like? It could focus on an admittedly nebulous category of "privacy-sensitive data" that could reveal personally identifiable information. And it could specify processes by which companies may seek to use those data for purposes other than operating and improving their automated vehicles—including sharing those data with affiliated companies (like Google or Amazon) or with law enforcement.

To be sure, these rules will impose a compliance burden. Affected companies will need to keep track of who has access to privacy-sensitive ADS data and monitor them. And like many privacy regulations that apply to a company's internal operations, these rules will not be easy to enforce. Regulators may need to rely on whistleblowers. But if we do not take action to protect privacy before automated vehicles are widely deployed, we may be sleepwalking into a regime of pervasive surveillance.

300. For example, consider license plate readers.

III. PROTECTING RIDERS

The easiest way to protect riders is to give them choices—provided that those choices are not skewed. Competition can force firms to lower fares, improve service, and invest in innovation. Today, robotaxis are providing healthy *inter*modal competition by offering an alternative to TNCs, taxis, and personal cars. But there might not be much *intra*modal competition among robotaxi companies. As we explained in Part I, robotaxis create economies of scale and network effects that favor concentration. In many U.S. cities today, the TNC market is an Uber-Lyft duopoly.[301] The robotaxi market could easily become a Waymo monopoly. And if robotaxis start to replace other modes, a robotaxi monopoly could be more dangerous.

To be sure, market concentration is a possibility but not a certainty. Robotaxis may involve a variety of technologies and business cases. As technologies improve and their costs decline, automated vehicles or even ADSs that can be added to existing vehicles may become surprisingly cheap to make, buy, and even operate. This seems especially likely if the ADSs of the future are less reliant on numerous sensors, highly detailed maps, and remote human assistants. Some may even be open source. This could create competition among vehicle owners, among providers of automated driving services, and among automated travel modes. Concentrations, if they exist at all, might turn up in surprising places. If would-be passengers can simply rely on their own personal AI agent to automatically find—and even negotiate for—a ride, then public-facing platforms such as Uber or Amazon may lose some of their brand and market power.

But we think the risk of market concentration is real enough that it is worth anticipating. So in this Part, we recommend a two-step approach to rider protection. First, policymakers should put a thumb on the scale for new competitors. Second, they should take steps now to preserve rider autonomy in a concentrated market.[302] We hope that preventing monopoly abuse or neglect long before a monopoly arises will not just protect riders—it will give them the peace of mind to use robotaxis instead of personal motor vehicles.

301. Kaczmarski, *supra* note 19.

302. Early steps can have significant effects later. *See* Bryant Walker Smith, Address at the Fourth International Conference on the Future Rule of Law and Digital Law 2 (Dec. 16, 2023), https://newlypossible.org/files/presentations/2023-12-16_AcademicVisionforAI.pdf [https://perma.cc/6WSV-5K64] ("Today's insights and interventions could have profound effects tomorrow—akin to nudging an asteroid while it is still billions of miles from Earth.").

A. PROMOTING COMPETITION

How can robotaxi regulators promote competition and encourage innovation among robotaxi companies? We argue that they should permit open entry, ban contracts that lock in riders, and enable one-stop access to competing networks. But before we turn to these proposals, we want to emphasize a subtle reason why competition is especially important in the robotaxi market: it may create redundancy that will prove valuable for safety.

1. Competition and Safety

The development of a safe ADS would create tremendous social value. In 2023, there were 40,901 people killed in motor vehicle crashes in the United States and approximately 2.4 million people injured.[303] NHTSA estimates that the annual social cost of crashes—including both the direct economic costs and the implied costs of death and injuries using the value of a statistical life—is about $1.37 trillion.[304] Therefore, an ADS only needs to modestly improve on the safety performance of human drivers to be worth tens of billions in social benefits each year. If automated driving can achieve the safety gains that its developers are hoping for, the tens of billions of dollars of capital that have been invested to date may be *below* the socially optimal level.

If more companies invest in developing an ADS, more ideas will be pursued. Any particular corporate research lab is limited by the idiosyncrasies of its leadership and the path dependence of its development approach. But as long as competing labs exist, engineers who cannot get their managers to greenlight their ideas can take them elsewhere. And the more ideas that get pursued, the greater likelihood that they will make a real difference for safety—individually or in combination.

There is a special reason to care about independent development in this context. In safety engineering, redundancy is a virtue. Many safety-critical systems, like commercial airplanes, are designed to be redundant.[305] If one

303. NAT'L HIGHWAY TRAFFIC SAFETY ADMIN., TRAFFIC SAFETY FACTS 2023: A COMPILATION OF MOTOR VEHICLE TRAFFIC CRASH DATA 100 (2025), https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813738 [https://perma.cc/EP62-A5AY].

304. NAT'L HIGHWAY TRAFFIC SAFETY ADMIN., THE ECONOMIC AND SOCIETAL IMPACT OF MOTOR VEHICLE CRASHES, 2019 1 (2023), https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813403 (estimating that "total value of societal harm" of traffic crashes in 2019 was $1.37 trillion) [https://web.archive.org/web/20231118005255/https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813403].

305. Or at least they are supposed to be. *See* Mike Baker & Dominic Gates, *Lack of Redundancies on Boeing 737 MAX System Baffles Some Involved in Developing the Jet*, SEATTLE TIMES (Mar. 27, 2019), https://www.seattletimes.com/business/boeing-aerospace/a-lack-of-redundancies-on-737-max-system-has-baffled-even-those-who-worked-on-the-jet [https://web.archive.org/web/202507190135

subsystem fails, a backup system not vulnerable to the same failure mode can step in. This may be why some companies are developing ADSs that combine modular and pure end-to-end approaches.[306] It is possible that an even more robust system could be developed by combining two systems developed by independent companies into one redundant system—if competition is not cut off prematurely.

Similarly, different companies might develop different—and ultimately complementary—approaches not only to design but also to safety validation and verification. Multiple approaches to simulation, for example, could help to increase both the accuracy of and confidence in methods for demonstrating and monitoring the safety of automated vehicles.

We recognize the irony in advocating for competition on the ground that it could produce an outcome where two competitors eventually merge their technologies. But that is largely the path that the aviation industry followed—a period of competition on safety followed by cooperation on safety. And even if robotaxi companies ultimately converge on ADS design, they can still compete on service quality, wait times, and price.

Competition in the robotaxi industry may also improve the transportation system's resilience to cyberattack. If one robotaxi company's system is hacked and has to ground its fleet, a competitor could serve the riders who might otherwise have been stranded. If competing robotaxi companies use different cybersecurity strategies, it may be more difficult for hackers to disrupt them both simultaneously.

2. Open Entry

Now we turn to our proposals for promoting competition—starting with open entry. The term "open entry" has three meanings in this context. It means that any company can enter the market. It means that any company can deploy as many vehicles as it chooses. And it means that companies can, through APIs and common data specifications, market the services of their competitors.[307]

52/https://www.seattletimes.com/business/boeing-aerospace/a-lack-of-redundancies-on-737-max-system-has-baffled-even-those-who-worked-on-the-jet].

306. *See* Lee, *supra* note 42.

307. *See, e.g.*, *The Act on Transport Services–Mobility Is a Service*, FUTURE MOBILITY FIN. (June 2, 2020), https://futuremobilityfinland.fi/cases/the-act-on-transport-services-mobility-is-a-service [https://web.archive.org/web/20250829104854/https://futuremobilityfinland.fi/cases/the-act-on-transport-services-mobility-is-a-service]; *Mobility Data Specification*, L.A. DEP'T OF TRANSP. (Oct. 31, 2018), https://ladot.lacity.gov/sites/default/files/documents/what-is-mds-cities.pdf [https://web.archive.org/web/20250504185342/https://ladot.lacity.gov/sites/default/files/documents/what-is-mds-cities.pdf].

All three senses of open entry are relevant to competition. As we have seen, the robotaxi business model relies on economies of scale. Robotaxi companies will need to deploy large fleets in many cities to overcome the fixed costs of developing an ADS. A company raising capital to challenge Waymo needs to be able to reassure its investors that it will be permitted to fight for the whole market and try to grow it. Restricting entry could entrench a Waymo monopoly and reduce socially valuable safety innovation.

Open entry in service regulation is compatible with pre-deployment scrutiny in safety regulation. California illustrates this possibility. As we explained in Part I, the California DMV requires companies testing or deploying automated vehicles to apply for permits.[308] When a company applies for a deployment permit, the DMV can consider whether the applicant's track record during testing in California or testing or deployment elsewhere supports deployment in California. The CPUC then conditions entry to the robotaxi market on the DMV issuing a deployment permit.[309] The combination of pre-deployment safety scrutiny and otherwise open entry protects the public without reducing competition from responsible entrants.

Open entry will create externalities—more pollution, wear-and-tear, congestion, and surveillance. It could also enable an entrenched competitor to flood a market as a defensive mechanism. But restricting entry is an overly crude tool to curb them. The proposals we provided in Part II are more targeted means to regulate externalities.

Open entry also does not mean tying the hands of government when it acts as a market participant rather than a regulator. Transit operators, for example, should be able to exclusively partner with robotaxi companies to extend the reach of their networks. In fact, Waymo has already announced plans to operate a transit service for Chandler, Arizona.[310] And certain roadways owned by government agencies—such as airport access roads—might merit special rules. San Francisco is experimenting with a pilot program that allows Waymo robotaxis to use an otherwise car-free stretch of Market Street.[311]

308. *See* CAL. CODE REGS. tit. 13, §§ 227.04, 227.38, 228.06 (2025).

309. *See* CPUC Deployment Order, *supra* note 233, at 17 (requiring applicants to "possess a 'Permit to Deploy Autonomous Vehicles on Public Streets' from the DMV").

310. *See* Lauren De Young, *Chandler Is 1st U.S. City to Launch Cheap Waymo Public Transit Rides*, AZ CENT. (Sep. 23, 2025), https://www.azcentral.com/story/news/local/chandler/2025/09/23/chandler-waymo-first-u-s-robotic-transit-service/86298041007 [https://perma.cc/2Z77-UMJ2].

311. *See* Press Release, Daniel Lurie, Mayor, San Francisco, Mayor Lurie Announces Next Phase of Waymo Operations on Market Street to Drive Downtown's Comeback with New Transportation Options Coming to Market Street August 26 (Aug. 21, 2025) https://www.sf.gov/news-mayor-lurie-announces-next-phase-of-waymo-operations-on-market-street-to-drive-downtowns-comeback-with-new-transportation-options-coming-to-market-street-august-26 [https://perma.cc/C2Y3-5EX8].

3. Lock-in Contracts

Policymakers should also prevent robotaxi incumbents from locking in riders. A new entrant will likely need to heavily subsidize their rides until they can get enough riders on the network to bring deadheading down to a tolerable level. This is part of why Uber and Lyft burned through billions while they were building up their networks.[312] On the other hand, this is also how cell companies initially funded their expensive networks—and yet pay-as-you-go plans are now thriving.

A robotaxi monopolist could entrench its position by offering its service as a subscription contract. Waymo is already offering subscriptions for teenage riders.[313] Subscriptions would make it hard for a new entrant to get riders to switch networks. Even if the new entrant offered a better service or a lower fare, subscribers would have no reason to consider switching until it came time to renew their subscriptions. So, the new entrant would need more time and money to build up network effects.

Consider how competition would play out if an incumbent monopolist had a more extensive ODD than a new entrant. If riders buy individual rides rather than a subscription, the new entrant has a fighting chance. It could gain a foothold in the market by serving some smaller segment of travel demand. Riders could choose the new entrant for individual trips in its limited service area and the incumbent for individual trips to places the new entrant doesn't serve. If, however, riders buy one subscription to serve all of their travel needs, a new entrant cannot compete until it can serve a comparably extensive area.

There is nothing inherently anticompetitive about subscription contracts. They can help businesses and riders plan their budgets more easily and hedge against risk that demand or fares will change. And—as we discuss more below—people might be more willing to give up their personal motor vehicles if they knew the price would be predictable.[314] But the combination of incumbents with market power, network effects, new entrants with limited ability to serve the whole market, and rider lock-in could create a formidable barrier to entry.

So, here is our proposal: instead of banning subscription contracts, policymakers can simply require that riders be allowed to cancel their

312. *See* Wyman, *supra* note 18, at 15. But they sustained those subsidies for years after they built up their networks. *See* Wansley & Weinstein, *supra* note 208, at 818.

313. *See Waymo Teen Accounts Offer Peace of Mind for Phoenix Families*, WAYMO (July 8, 2025), https://waymo.com/blog/2025/07/waymo-teen-accounts [https://perma.cc/CAE9-T6YQ].

314. The peace of mind that riders get from subscriptions can be inefficient. Riders who pay a fixed, upfront cost for a subscription don't internalize the costs of taking an additional trip.

subscriptions and receive a pro rata refund at any time. That approach would allow riders to gain greater certainty about fares while making it easier for new entrants to get them to switch. The competitors would not have to buy riders out of their existing contracts. A light thumb on the scale for new entrants would make it harder to maintain a monopoly.

4. One-Stop Access to Competing Networks

Policymakers, transit agencies, and even some companies have long recognized the potential for the integrated provision of what is often called "mobility as a service" ("MaaS"). To find the best—or the cheapest—way to get from one point to another, a traveler should not need to consult and compare multiple apps or engage in multiple transactions.

Public transit agencies have long recognized the value of a single rider interface (even if their implementation has been limited). To cite just two examples of many, New York's Omny cards and London's Oyster cards each work on a set of transit services that have a variety of operators. And both the New York Metropolitan Transportation Authority and Transport for London provide API access to their real-time transit data to allow independent developers to create apps and other tools for riders.[315]

Others have an even broader vision for transport data. The Mobility Data Specification developed by the City of Los Angeles offers a "common language" for transport data.[316] GTFS and GTBS offer similar common frameworks for transit and bikeshare, respectively.[317] Finland mandates that both public and private providers of transportation and parking services facilitate third-party access to their schedules and prices.[318] The "multimodal digital mobility services" regulation originally envisioned—though now largely abandoned—by the European Commission would have expanded aspects of Finland's approach to the entire European Union.[319]

315. *Developer Resources*, MTA, https://www.mta.info/developers [https://perma.cc/GV9R-GW86]; *Transport for London Unified API*, TRANSPORT FOR LONDON, https://api.tfl.gov.uk [https://perma.cc/YPR9-ZB3B].

316. LADOT, MOBILITY DATA SPECIFICATION (2018), https://ladot.lacity.gov/sites/default/files/documents/what-is-mds-cities.pdf [https://perma.cc/6SRF-XFUA]; OPEN MOBILITY FOUND., *Mobility Data Specification*, https://github.com/openmobilityfoundation/mobility-data-specification (last updated June 4, 2025) [https://perma.cc/SH6P-ADJE].

317. GEN. TRANSIT FEED SPECIFICATION, https://gtfs.org [https://perma.cc/R3K4-TVAE]; GEN. BIKESHARE FEED SPECIFICATION, https://gbfs.org [https://perma.cc/7QZ8-LL92].

318. Act on Transport Services 320/2017 (Fin.), https://www.traficom.fi/en/regulations/act-transport-services [https://perma.cc/BN64-63HJ].

319. European Parliament Legislative Train Schedule JD 23-24, *Legislative Proposal on Multimodal Digital Mobility Services–Q4 2022*, https://www.europarl.europa.eu/legislative-train/spotlight-JD%2023-24/file-multimodal-digital-mobility-services [https://perma.cc/N255-VVFP]; BACK-ON-TRACK EUROPE, *Single Ticketing: A Broken Promise?*, https://back-on-track.eu/a-broken-

Many internet platform companies show offers from different providers for identical, equivalent, or comparable products and services—think Google Shopping or Amazon's third-party sellers or, in the case of transportation, Rome2Rio and (in China) Baidu Maps.

As we noted earlier, AI agents could obviate the need for or power of some of these platforms; users could simply direct their personalized agents to find and book whatever ride suits them the best. But integrated apps, backend platforms, public APIs, and common data standards could still increase the effectiveness of—and reduce the transactions costs for—these searches.

Regulators can build on this important MaaS foundation by enabling one-stop access to competing networks of vehicular rides of all kinds. Smaller providers should have the option but not the obligation to offer their services through third-party platforms. In contrast, it may be prudent to require dominant providers to facilitate this kind of third-party access.

B. Preserving Autonomy

Even if policymakers permit open entry, limit lock-in, and enable one-stop access to competing networks, the robotaxi market may still be highly concentrated. Even with integration, the economies of scale may still tilt the market against competition. So, policymakers need to prepare for a world where one company dominates the robotaxi market. The benefits of preventing monopoly abuse are twofold. First, it protects riders should a monopoly arise. Second, it might provide people the peace of mind they need to give up their personal motor vehicles and switch to robotaxis today.

The appeal of personal motor vehicle ownership is autonomy. If you have the keys to the car in your driveway, you can at least in theory travel where you want and when you want at a price that you can anticipate. For many Americans, it is difficult to imagine living without access to their own car or truck. Yet in New York and other transit-rich cities around the world, many residents with the means to buy a personal motor vehicle choose not to own one. They have confidence that the transportation system will give them at least as much autonomy as a personal motor vehicle.

Suppose you were a New Yorker whose Texan friend was about to move to Manhattan. She has always lived in a household with a personal motor vehicle. How could you persuade her that she doesn't need a car in her new city? You could say that the subway will take her almost everywhere she would want to go in the city, that it runs twenty-four hours a day and

promise-is-a-very-bad-start (Feb. 13, 2025) [https://perma.cc/6XAG-34N4].

seven days a week, that the fare is always $3.00, and that the wait for a train is usually not long. You could say all this with confidence in part because the subway is run, and its fares and service are set, by a public agency.

This is the kind of argument that cities and robotaxi developers will need to make. Residents will need to be confident that robotaxis will take them almost everywhere they would want to go in the region, that they run twenty-four hours a day and seven days a week, that the fare is low and varies predictably with demand, and that the wait for a ride is usually not long.

But the critical difference is that robotaxis will not necessarily be run by a government. If they are profitable, then they will attract corporations—or even just one monopolist—aiming to maximize profits. How could these companies be trusted not to take advantage of riders?

One solution to this problem is to bring robotaxis under public ownership. Another solution is to regulate robotaxi companies as utilities. Either solution would provide reassurance about service coverage, fares, and wait times. But they would do so at the cost of reducing competition and innovation.

We think it is possible for regulation to protect the public from monopoly abuse while still promoting competition. We propose transparent and rider-neutral fares and proactive planning for emergencies and other contingencies.

1. Transparent and Rider-Neutral Fares

In a competitive market, robotaxi companies will be price takers. They will charge the fare that other robotaxi companies are charging or lose market share. But in a concentrated market, robotaxi companies may engage in price discrimination. They may offer each rider an individually tailored fare just below their willingness-to-pay, so they can extract more surplus from riders who are willing to pay higher fares. And robotaxi companies may be able to make informed predictions about what each rider would be willing to pay based on data about their past choices or the choices of similarly situated riders.

This is what has happened in the TNC market. Uber's increasing profitability has been fueled by increasing algorithmic price discrimination—sometimes called "personalized" or "surveillance" pricing.[320]

320. *See* Len Sherman, *How Uber Became a Cash-Generating Machine*, MEDIUM (June 23, 2025), https://len-sherman.medium.com/how-uber-became-a-cash-generating-machine-ef78e7a97230 [https://perma.cc/ZD64-RNFB].

Price discrimination is not necessarily undesirable. In fact, if consumers are perfectly informed and perfectly rational, it can be economically beneficial.[321] A company that tailors its prices to individual customers will serve more customers than a company that charges every customer the same price. In economic terms, the price discriminating company expands output. These gains, though, come with complicated distributive effects.[322] Price discrimination transfers surplus from consumers to producers (and their shareholders), which can be a regressive transfer of wealth. But if low-income riders are more price-sensitive than high-income riders, price discrimination might benefit them by providing them with an individually-tailored fare that is lower than an untailored fare might be. From a social welfare perspective, it is hard to know whether the costs of price discrimination outweigh the benefits.

In general, the law does not ban price discrimination. Companies are free to tailor their prices, and customers can accept or reject them. But there's always been one important exception to the general tolerance of price discrimination: the monopolization of a necessary good or service. The classic example is from the transportation industry: railroads.[323] Suppose that a farmer needs to transport perishable crops to market and that the only feasible means to transport them is a railroad controlled by one company. If the railroad knows this and can discriminate on price, it will extract almost all the value of the crop, even if it results in the farmer suffering a net loss. In the moment, the farmer will still take the deal because the losses would otherwise be greater. But a farmer who anticipates the temporary monopoly trap will not grow the crop in the first place.

Now come back to robotaxis. A robotaxi company's pricing algorithms may be able to infer which riders have given up their personal motor vehicles. A rider with access to a personal motor vehicle will have a relatively elastic demand for robotaxi rides. When the fare rises too high, they will drive instead. A rider without access to a personal motor vehicle will have an inelastic demand. When the fare rises, they will grudgingly pay it. An individual rider's behavior—how often they see a fare and decide not to request a ride—will indicate whether they have alternative means of travel. And a robotaxi company with market power will charge the riders with no alternatives a higher fare. Riders who anticipate this trap will not want to give up their personal motor vehicle.

321. *See* Oren Bar-Gill, Cass R. Sunstein & Inbal Talgam-Cohen, *Algorithmic Harm in Consumer Markets*, 15 J. LEGAL ANALYSIS 1, 1 (2023).

322. *Id.*

323. MORGAN RICKS, GANESH SITARAMAN, SHELLEY WELTON & LEV MENAND, NETWORKS, PLATFORMS & UTILITIES 15–16 (2022).

Common carrier regulation responds to the problem of temporary monopolization. As we saw in Part I, taxi regulation combined universal service, fare regulation, and restricted entry.[324] The idea behind universal service was that every rider should receive the same service for the same per mile fare. Transportation companies could not engage in price discrimination. The problem with common carrier regulation, however, was that companies could not compete by offering lower fares. So they had little incentive to cut costs or innovate.

Policymakers should protect riders by requiring robotaxi companies to have transparent and rider-neutral fares. By "transparent fares," we mean that robotaxi companies must submit the fare they charge for each ride to a public regulator. In California, the CPUC is already requiring robotaxi companies to submit basic information about each ride request and each ride, including the origin and destination points, the VMT during the ride, and the deadheading VMT before the ride.[325] We would have companies submit one more data point: the fare charged.

By "rider-neutral fares," we mean that robotaxi companies may not use data about an individual rider's past choices in setting fares. They must charge the same fare to every rider requesting a ride from the same origin to the same destination under the same demand conditions. A company's pricing algorithms may include the distance to be traveled and the expected deadheading miles to be traveled as a result of providing the ride. But pricing algorithms should not include information about the individual rider's willingness to pay or any information that could be used as a proxy for the individual rider's willingness to pay.

Transparent and rider-neutral fares would prevent robotaxi companies from engaging in price discrimination. A rider who gave up their personal motor vehicle would pay the same fare as a rider who kept theirs. And regulators would be able to track compliance easily. They could analyze the fare data to verify that rides with similar origin and destination points at similar times had similar fares. Rider-neutral fares would not mean that every rider pays the same per mile fare. Fares could still vary with travel demand, so regulation wouldn't subsidize sprawl.

Unlike common carrier regulation, transparent and rider-neutral fares wouldn't foreclose price competition. A new entrant would be free to enter the market and undercut the incumbent's fares. In fact, transparent pricing might facilitate entry by letting a prospective entrant know what kind of fares

324. Wyman, *supra* note 18, at 31–32.
325. CPUC Deployment Order, *supra* note 233, at 105–06.

it would need to offer to be viable. The possibility of entry would preserve incentives to cut costs and innovate.

We anticipate three objections. First, it might be argued that transparent fares will facilitate tacit collusion. Robotaxi companies might find it easier to coordinate on an oligopoly fare if they knew exactly what their competitors were charging for every ride. We think that is right, but we doubt it will make much of a difference. Without transparent fares, robotaxi companies could simply collude, intentionally or unintentionally, through forms of direct or indirect algorithmic coordination.

Second, what if robotaxi companies replace individualized price discrimination with microtargeted group price discrimination? A robotaxi company could, for example, take into account historical demand in small geographic areas when setting fares. Your fares might not rise because you give up your car, but because your neighbors gave up *their* cars. We acknowledge that there's a difficult tradeoff between the benefits of demand-variable pricing and the psychic costs of microtargeted price discrimination. It might make sense to limit the granularity of demand-variable pricing to census tracts or neighborhoods.

Third, what if one robotaxi company monopolizes the industry and just raises its fares across the board? The simple answer is that the high fares will attract other companies to enter the market—especially since those fares will be transparent and lock-in contracts will be banned. But this is not a complete answer because the combination of network effects and the high, fixed costs to enter the market may still slow entry, and high fares could cause hardship unless and until another company enters the market.

We would have policymakers use the credible threat of utility regulation to prevent abuse. Legislators could give regulators statutory authority to set fares if they deem it necessary to ensure affordable mobility. If a robotaxi monopolist raises its fares under a system of transparent and rider-neutral fares, everyone would be able to see that fares are rising, and a large portion of the population would have a stake. Regulators could then propose fixing fares. If the robotaxi monopolist took the hint and reduced its fares, problem solved. If it didn't take the hint, regulators could impose more aggressive utility regulation. But we think utility regulation should be a last resort if competition does not lead to adequate service at acceptable fares.

2. Emergency Planning

One emotionally salient advantage of personal motor vehicle ownership is the perception of mobility during emergencies. If the forecast says you are in the path of a hurricane, you can board up the windows, pack your bags and pets, and drive to safety before the storm hits (assuming you can find a place to fuel or charge your car). Even if the chance of an emergency that would require evacuation is slim, knowing that you could escape might give you peace of mind. Robotaxi regulation needs to provide the same peace of mind as personal motor vehicle ownership.

San Franciscans now have good reason to worry that robotaxis will not be available in emergencies. On December 20, 2025, a fire at a Pacific Gas & Electric substation caused a widespread blackout.[326] In large parts of the city, traffic lights went dark.[327] Many of Waymo robotaxis stopped in the middle of the street, and some got stranded in intersections, blocking traffic.[328] Waymo suspended its service and didn't resume operation until the following day.[329]

Emergencies—including ones far greater than a blackout—could create many challenges: drastic changes to road environments, loss of communications, overwhelmed remote assistants and retrieval crews, mass dependency on robotaxis, and stopped automated vehicles becoming obstructions.

In the absence of regulation, robotaxi companies will have insufficient incentives to prepare for emergencies. As we saw above, they will likely maintain fleets with fewer vehicles than would be socially desirable in an emergency.[330] A profit-maximizing robotaxi company will set the number of vehicles in its fleet by calculating when the marginal revenue gained by

326. Julie Johnson & Megan Fan Munce, *Massive San Francisco Power Outage Darkened Entire Neighborhoods for* Hours, S.F. CHRON. (Dec. 21, 2025), https://www.sfchronicle.com/sf/article/pg-e-outage-40-000-customers-without-power-21254326.php [https://web.archive.org/web/20260101222326/https://www.sfchronicle.com/sf/article/pg-e-outage-40-000-customers-without-power-21254326.php].

327. *Id.*

328. Aidin Vaziri, *Waymo Robotaxis Are Back on San Francisco Streets After Blackout*, S.F. CHRON. (Dec. 21, 2025), https://www.sfchronicle.com/bayarea/article/waymo-san-francisco-power-outage-21255470.php [https://web.archive.org/web/20260108105820/https://www.sfchronicle.com/bayarea/article/waymo-san-francisco-power-outage-21255470.php].

329. *Id.*; *see also* Bryant Walker Smith, *On Waymo's Traffic Jams*, CTR. FOR INTERNET & SOC'Y, (Dec. 21, 2025), https://cyberlaw.stanford.edu/blog/2025/12/on-waymos-traffic-jams [https://perma.cc/MW4Z-HUWU]; Bryant Walker Smith, *Answers to the Democratic Questions for the Record of the Senate Committee on Commerce, Science, and Transportation's Hearing on the Future of Self-Driving Cars* 5–6 (Feb. 27, 2026), https://newlypossible.org/files/2026SenateAnswers.pdf [https://perma.cc/9APU-FQRL].

330. *See supra* Section I.B.3.

adding another vehicle would surpass the marginal cost. A fleet large enough to serve peak demand may include many vehicles that would sit idle during periods of average demand. The cost of storing, maintaining, and cleaning the vehicles that would be used only during peak demand could outweigh the revenue that they would generate.

Demand-variable pricing partially mitigates this problem. If a company can charge a higher per mile fare in peak demand, a larger number of vehicles will generate enough peak demand revenue to offset the losses in periods of average demand. But peak demand in non-emergency situations—the Tuesday morning rush hour—may still be a fraction of peak demand in an emergency.

More importantly, robotaxi companies will not be able to set fares at market prices in some emergencies because of "price-gouging" laws. Price-gouging is a special case of demand-variable pricing. In an emergency, demand for certain goods—water, food, gasoline—can spike. Sellers can temporarily raise their prices—sometimes exponentially—and profit from the increased demand.

Most states have enacted statutes that ban price-gouging. For example, a California statute provides that, if the government declares a state of emergency, a business may not raise the price of certain essential goods and services more than ten percent above the price it was charging before the emergency.[331] The statute contains an exception that lets a business increase its price above that level if it can "prove that the increase in price was directly attributable to additional costs" it had to pay as a result of the emergency and the price is not more than ten percent "greater than the total of the cost to the seller plus the markup customarily applied by that seller for that good or service."[332]

The basic intuitions behind price-gouging laws are about fairness.[333] Sellers should not be able to take advantage of buyers in temporary monopoly situations: the gas station should not be able to charge you $100 a gallon as you are fleeing the storm. Fairness also suggests that the rich should not be able to hoard scarce necessities: in a pandemic, ventilators should be available to more than just billionaires.

Although price-gouging laws are popular with legislators, they are unpopular with economists. There are three standard criticisms. First, they

331. CAL. PENAL CODE § 396 (West 2025).

332. *Id.* § 396(b).

333. For a defense, see Christopher Buccafusco, Daniel Hemel & Eric Talley, *The Price of Fairness*, 84 OHIO ST. L.J. 389 (2023); Kaitlin Ainsworth Caruso, *Price Gouging, the Pandemic, and What Comes Nex*t, 64 BOS. COLLEGE L. REV. 1799 (2023)

reduce sellers' incentives to stockpile inventory to prepare for emergencies and to increase production during emergencies.[334] Second, they encourage consumers to hoard rather than just buying what they need.[335] Third, they allocate goods and services to buyers who show up first instead of buyers with a higher willingness to pay (plus, of course, the actual ability to pay).[336]

Repealing price-gouging laws—or exempting robotaxi companies from those laws—would create an incentive to maintain larger fleets for emergencies. But this salutary incentive must be weighed against the cost to peace of mind: people who fear that they will be price-gouged in an emergency will be less likely to give up their personal motor vehicles.

Policymakers can instead solve the problem of robotaxi service in emergencies by ensuring that the industry as a whole maintains a fleet that is sufficient to serve the state's emergency plans.[337] Emergency management officials could determine the overall size of the fleet. Then robotaxi regulators could periodically apportion responsibility to individual companies according to their market share. The fleet would need to be "available"—ready to deploy on demand. The state could provide a subsidy to each company equivalent to the loss they incur from maintaining these additional vehicles. Alternatively, regulators could create incentives that reward dynamic expansion capacity. This extra capacity might simply include more robotaxis. But it could also include ready and reliable access to buses and, if those buses are conventional, human drivers.

In some emergencies, public authorities need to mandate evacuation. If a significant portion of the population relies on robotaxis, robotaxis need to be part of the evacuation plan. Emergency management officials should be given the authority to temporarily control how robotaxis are deployed in an evacuation. Robotaxi companies should be required to prioritize ride requests within an evacuation zone and to offer evacuation rides for free. Public authorities can reimburse the companies for the cost of providing the service.

Emergency management officials and robotaxi regulators should not wait until an emergency arises to verify if robotaxi companies can meet their obligations. They should require that robotaxi companies—as well as providers of automated driving for personal motor vehicles—participate in simulations in which they test how companies would respond to different

334. *See* Caruso, *supra* note 333, at 1838.

335. *See* Buccafusco et al., *supra* note 333, at 403; Caruso, *supra* note 333, at 1838.

336. *See* Caruso, *supra* note 333, at 1838.

337. The Civil Reserve Air Fleet offers an instructive example. *See Civil Reserve Airfleet*, U.S. DEP'T OF TRANSP. (Feb. 23, 2024), https://www.transportation.gov/mission/administrations/intelligence-security-emergency-response/civil-reserve-airfleet-allocations [https://perma.cc/C6K2-ELCZ].

types of emergencies. These simulations would serve as an audit to confirm that robotaxi companies maintain a sufficiently large available fleet and have robust break-the-glass operational plans that account for abnormal roadway conditions, disrupted connectivity, staffing shortages, and other logistical impediments.

These simulations should highlight details that might otherwise be overlooked. Will the kind of all-electric fleet that we encourage in this Article suffice in an evacuation? Will robotaxis still function if roadways become unidirectional, if thousands of officers are manually directing drivers at hundreds of intersections, if debris or water is covering roads, and if communications are down (or if remote assistants are overwhelmed)? If not, will these vehicles block roads in a way that further stymies evacuation and emergency response? Careful emergency planning will help build confidence that it is safe to live without owning a personal motor vehicle.

IV. REDESIGNING MOBILITY

It is easy to envision how robotaxis might fail as a business.[338] They might not achieve an acceptable level of safety or a sufficiently lucrative ODD. They might not become cheap enough to compete with traditional taxis and TNCs. They might successfully compete with these modes in high demand areas but not provide a service that is convenient or reliable enough to replace personal motor vehicles. Indeed, as personal motor vehicles have generally proven more popular than taxis in many parts of the country, automated personal motor vehicles may prove to be more popular than robotaxis.

But what if robotaxis succeed as a business? What if they become sufficiently safe, convenient, reliable, and affordable that they serve the mobility needs of most of the residents of some metropolitan areas? That would create the opportunity to redesign our transportation system. This topic merits its own article. Here we just touch briefly on three issues: liberating land, refocusing transit, and expanding access.

A. LIBERATING LAND

Most U.S. cities are oriented around the automobile. Even in the densest neighborhoods, some of the most valuable land is used for parking lots and garages. Most streets are designed to prioritize automobile use—more lanes for motor vehicles and curbside parking, less space for the cyclists and pedestrians who are relegated to both the literal and the metaphoric margins

338. As we caution throughout this Article, they could also succeed as a business case and nonetheless fail society in important ways.

of the transportation system. And only a few U.S. cities have mass transit that serves enough of the travel demand with enough frequency, speed, and reliability to compete with personal motor vehicles.

Urban planners have long argued that cities do not have to be like this. Tokyo's transit is so fast, frequent, extensive, and reliable that the city has about 0.32 motor vehicles per household. Copenhagen's streets are so safe and convenient for cyclists and pedestrians that 49% of commuters travel by bike. And in New York City, despite decades of neglect, the subway is still useful enough that 56.7% of households do not own a car.[339] It is important to recognize that space is a limiting factor: if cars had more space, there would be more cars.

Some urban planners are skeptical about the deployment of automated vehicles (including personal motor vehicles as well as robotaxis) precisely because they think automated driving will entrench the automobile, set back fragile gains for cyclists and pedestrians, and undermine support for transit. And some of their fears are grounded in facts. For over a decade now, pundits have been invoking a self-driving future to oppose investments in other modes of transportation.[340]

We think that robotaxis have the potential to preserve what people like about the automobile without requiring cities to revolve around the automobile.

Cities could start by changing the economics of parking. As many have explained, free parking is at the root of many urban problems, from the high cost of urban construction to suburban sprawl.[341] In recent years, some states and cities have repealed laws that mandated a minimum number of parking spaces for certain land uses. But in most cities, politicians are reluctant to abolish parking requirements or charge a market price because many of their constituents rely on personal motor vehicles. And those vehicles spend most of the day in parking.

Robotaxis will spend most of their days moving, so the companies that own them can maximize their revenue. Even overnight, robotaxis can be

339. Justin Fox, *New York Isn't the Only Place You Don't Need a Car*, BLOOMBERG (Sep. 24, 2025), https://www.bloomberg.com/opinion/articles/2025-09-24/new-york-isn-t-the-only-place-you-don-t-need-a-car [https://perma.cc/M7KV-6S8L].

340. *See, e.g.*, Jim Epstein, *Self-Driving Cars Are Coming Fast, So Why Should We Spend a Dime Rebuilding Amtrak?*, REASON (May 24, 2015), https://reason.com/2015/05/24/self-driving-cars-amtrak [https://perma.cc/4KPQ-BWRF]. For an early warning, see Bryant Walker Smith, *The Impact of Automation on Environmental Impact Statements*, STAN. CTR. FOR INTERNET & SOC'Y (Oct. 1, 2013), https://cyberlaw.stanford.edu/blog/2013/10/impact-automation-environmental-impact-statements [https://perma.cc/KG5X-VNMT].

341. *See* DONALD SHOUP, THE HIGH COST OF FREE PARKING (2d ed. 2017).

used to transport goods. When robotaxis stop for charging, cleaning, and maintenance, they can be compactly stored on private property.[342] If robotaxis succeed, much of the urban land we currently devote to parking lots and garages can be converted to apartments, stores, and parks.

If people have access to a wide range of robotaxis, they will no longer need to own a single vehicle that does everything and goes everywhere. If you need (or believe that you might at some point want to use) a pickup truck, then you might buy a pickup truck. And once you own it, especially if you own no other motor vehicles, you will expect to be able to drive it and park it everywhere. But if you have access to a robotaxi truck or can take a reliable robotaxi to reach a conventional truck located outside the city, then it may not be necessary to drive your own truck everywhere. This may give communities much more flexibility in reimagining themselves.

Redesigning streets is key.[343] Robotaxis will not need to park at the curbside—though they will need space to pull over to pick up and drop off riders. Robotaxis may also be able to serve the same travel demand with a smaller fleet—especially if they become as familiar as an elevator. This could give cities an opportunity to reclaim street space for protected bike lanes or wider sidewalks. And robotaxis are likely to be friendlier to cyclists and pedestrians in a way that could facilitate living streets with mixed modes.

B. Refocusing Transit

Cities could also rethink how they invest in transit. An important advantage of transit is throughput. More people can fit on a subway car or a bus than in a set of cars that occupy the same space.[344] Far more commuters in New York can travel from Harlem to Midtown at rush hour on the subway under Lexington Avenue than in traffic on the street above it.

Robotaxis might not change the logic of throughput. It is possible that robotaxis could increase vehicle capacity (if the vehicles have closer lateral and longitudinal spacing, smoother flows, or fewer crashes) and otherwise increase person capacity (if people share rides). They likely will not, however, compete with the Lexington Avenue subway in the foreseeable future.

342. Albeit not wholly without problem. *See* Joe Wilkins, *Waymo's Self-Driving Taxis Have a Hilarious Problem That's Driving People Bananas*, FUTURISM (May 31, 2025), https://futurism.com/waymo-taxi-protest-noise [https://perma.cc/3NRE-MUFB] (describing noise complaints from neighbors of Waymo depots).

343. *See* Walker Smith, *Managing Autonomous Transportation Demand*, *supra* note 5, at 1417–20.

344. Walker, *supra* note 281.

But most transit in the United States is not like the Lexington Avenue subway, which runs with two-minute headways at rush hour. Some transit agencies operate buses or trains that run every half hour or less. Some run buses that are mostly empty—and that may be stuck in congestion caused primarily by single-occupant vehicles. Some of these low-throughput transit lines may be justified given the realistic alternatives, but it is possible we can do better.

If robotaxis are cheap enough to replace personal motor vehicles, they may be able to replace low-throughput transit lines—provided that policymakers continue to subsidize low-income riders who relied on those lines.

C. Expanding Access

Mobility creates positive externalities. We benefit not just when it is easier for us to travel, but when it is easier for our friends, family, and coworkers to travel—provided that the negative externalities are managed. Current transportation policy is full of subsidies, both obvious and hidden. Many of those hidden subsidies perversely encourage personal motor vehicle ownership,[345] but some are worth keeping. If robotaxis start to replace other modes of travel, to what extent should governments subsidize robotaxi rides for those whose mobility needs would not be adequately served by the market? We consider three issues: people with low incomes, people with disabilities, and sparsely populated areas.

1. People with Low Incomes

The case for subsidizing the mobility of people with low incomes is straightforward. Mobility enables economic opportunity, educational advancement, and civic participation. Targeted mobility subsidies can reduce economic inequality and increase social mobility.

Existing policy subsidizes the mobility of low-income people with both implicit and explicit subsidies (while, in other ways, increasing the price of that mobility). The implicit subsidy is providing transit to the general public at fares below the cost of providing the service.[346] Everyone can benefit from the low fares, but riders with modest incomes may benefit the most. The explicit subsidy is providing discounted fares for low-income riders.[347] (The

345. *See* Gregory H. Shill, *Should Law Subsidize Driving?*, 95 N.Y.U. L. REV. 498, 506–77 (2020).

346. Yonah Freemark, *A Note on Transportation Subsidies*, TRANSP. POL. (Sep. 21, 2011), https://www.thetransportpolitic.com/2011/09/21/a-note-on-transportation-subsidies [https://perma.cc/SC2X-AVJV] (noting that "almost every city around the world" subsidizes train and bus services).

347. For example, in the San Francisco Bay Area, the Clipper START program subsidizes mobility for low-income people. *See* CLIPPER START, https://www.clipperstartcard.com/s [https://perma.cc/

price increase comes in part from the land use policies, discussed above, that push low-income people far away from city centers.)

A subsidy designed to improve the living standards of low-income people raises the question: is a targeted subsidy superior to an unrestricted cash transfer? An unrestricted cash transfer respects autonomy by letting recipients decide for themselves how they want to allocate their budget. They might want to spend less on transportation than their share of a mobility subsidy would provide. A targeted subsidy would distort spending away from what some recipients would prefer.

We acknowledge the force of the critique, but we think targeted mobility subsidies to low-income people are smart politics. Unrestricted cash transfer programs are hampered by the (likely false[348]) perception that the recipients will squander the money. One critical advantage of transportation subsidies is that voters understand that transportation is a necessity, so they can trust that the money will be put to good use.[349]

Legislators should enact a means-tested subsidy for robotaxi service. The right time to adopt this subsidy is when robotaxis start to replace low-throughput transit. Low-income people who relied on those routes will need a substitute, and robotaxi fares may be higher than transit fares. A similar argument can be made for low-income people who rely on personal motor vehicle ownership at the time that on-street parking becomes less available or more expensive. They may not be able to afford the increased cost of private parking, so subsidized robotaxi service may be the only realistic replacement. Even a modest subsidy could be consequential for the mobility of people with limited means.

2. People with Disabilities

For people with disabilities, subsidies need to take a different form. At the outset, it is important to recognize the incredible diversity among people with disabilities. A person who is blind may have very different mobility challenges than a person who uses a wheelchair. People who use wheelchairs may also have very different mobility challenges depending on their other abilities (such as significant upper-body strength and agility) or disabilities (such as deafness or mental impairment).

5SFN-WXXC].

348. *See* Miranda Perry Fleischer & Daniel Hemel, *The Architecture of a Basic Income*, 87 U. CHI. L. REV. 625, 651–52 (2020) (discussing evidence on how recipients use direct cash transfers).

349. *Report: 98 Percent of U.S. Commuters Favor Public Transportation for Others*, THE ONION (Nov. 29, 2000), https://theonion.com/report-98-percent-of-u-s-commuters-favor-public-trans-1819565837 [https://perma.cc/A8TZ-YUY8].

So, we might start—but cannot end—this discussion with people who use electric mobility scooters or other devices that cannot easily get or fit into conventional vehicles. They need access to spacious vehicles with a ramp or a lift, sometimes called Wheelchair Accessible Vehicles ("WAVs").

As we mentioned in Part I, California has attempted to expand mobility by requiring TNC riders to contribute five cents per trip to the TNC Access for All Fund.[350] The CPUC is directed to distribute those funds to businesses or nonprofits that provide transportation to people with disabilities, especially people who require a WAV.[351] A TNC can avoid charging the fee if the CPUC determines that it is providing a sufficient level of WAV service.[352] And the CPUC can also offset the amount due by the amount a TNC invests in improving its WAV service.[353]

The introduction of robotaxis creates an opportunity to redesign vehicles to make them more accessible. It may be feasible to require that all robotaxis be WAVs. Then regulators would not have to monitor the level of service provided to people with disabilities, as the CPUC is doing now. They would receive the same service as everyone else—that is, unless they need the assistance that bus, paratransit, and taxi drivers often provide as an official or unofficial part of their jobs.

It is possible, though, that the cost of making every robotaxi a WAV will prove prohibitive. In that case, legislators could adopt a policy like California's. Either taxpayers generally or robotaxi and TNC riders specifically could contribute to a public fund. Then regulators could offer those funds to companies that operate WAVs. The downside of this approach is that regulators would need to monitor service levels to make sure that riders who need WAVs aren't enduring unreasonable waits.

NHTSA can encourage the development of accessible robotaxis today. As we saw in Part I, companies introducing automated vehicles that do not meet NHTSA's Federal Motor Vehicle Safety Standards need an exemption from the agency.[354] NHTSA could announce that it will prioritize exemption

350. CAL. PUB. UTIL. CODE § 5440.5(a)(1)(B); *see also* CAL. PUB. UTILS. COMM'N, TRANSPORTATION NETWORK COMPANY (TNC) ACCESS FOR ALL PROGRAM (2023), https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/consumer-protection-and-enforcement-division/documents/tlab/accessforall/tnc-access-for-all_factsheet_2024-final.pdf [https://perma.cc/26DD-GGH3].

351. CAL. PUB. UTIL. CODE § 5440.5(a)(1)(C).

352. *Id.* § 5440.5(a)(1)(G).

353. *Id.* § 5440.5(a)(1)(B)(ii).

354. *See, e.g.*, Letter from Paul A. Hemmersbaugh, Chief Counsel, Nat'l Highway Traffic Safety Admin., to Chris Urmson, Dir., Self-Driving Car Project, Google, Inc. (Feb. 4, 2016), https://www.nhtsa.gov/interpretations/google-compiled-response-12-nov-15-interp-request-4-feb-16-final [https://perma.cc/VC75-LHDE]; Walker Smith, *Probably Legal*, *supra* note 21; Walker Smith,

requests for automated vehicles that are also WAVs[355]—a small step that nonetheless may have an important signaling effect. That might persuade some ADS developers to experiment with more accessible vehicle designs. And, if and when it is clear that accessible robotaxis are financially viable, regulators should mandate them.

3. Sparsely Populated Areas

The case for subsidizing mobility in sparsely populated regions is more complicated. Policymakers have long sought to diminish geographic disparities in the availability and price of transportation service. In taxi regulation, the combination of entry restrictions and universal service requirements ensures that the profits taxis make in high demand areas cross-subsidize service in low demand areas.[356] Transit budgets often work similarly. Very few transit lines manage to break even on farebox revenue alone. But that revenue plus subsidies based in part on ridership numbers support less popular routes in sparsely populated areas.[357]

In the absence of subsidies, robotaxis are more likely to be deployed—and likely to be cheaper on a per mile basis—in places with high travel demand. This dynamic plays out on two levels. On a local scale, robotaxis are likely to be cheaper in cities than in their surrounding suburbs and exurbs. On a national scale, robotaxis are more likely to be deployed in large metropolitan areas than in smaller metropolitan areas or rural areas.

The policy case for local, place-based subsidies is weak. If the deployment of robotaxis reduces the absolute per mile cost of travel, it will increase demand for longer trips. That could facilitate commutes to city centers from suburbs and exurbs and shift development to places where it will have a greater environmental impact. This is how robotaxis might encourage sprawl.[358]

But that analysis is incomplete. Even if actual and perceived travel costs were to decline overall, shorter trips in densely populated areas are still likely to cost less than longer trips in sparsely populated areas. Robotaxis might

Biden Admin, *supra* note 129. Although NHTSA's authority to grant FMVSS exemptions is constrained, the agency can change the underlying standards. *See id.*

355. A statute that authorizes exemptions requires the Secretary to find that an exemption "is consistent with the public interest." 49 U.S.C. § 30113(b)(3)(A).

356. Speta, *supra* note 188, at 115.

357. Subsidies also support intercity transportation networks. When railroads and airlines were regulated, regulators aimed to equalize per mile fares. Ganesh Sitaraman, Morgan Ricks & Christopher Serkin, *Regulation and the Geography of Inequality*, 70 DUKE L.J. 1763, 1769 (2021). After deregulation, Congress replaced rate-setting with subsidy schemes, such as the Essential Air Service program. *Id.* at 1792.

358. *See* Walker Smith, *supra* note 5, at 1417–18.

also enable "distributed density"—more dense pockets of development within already urbanized areas—if land use regulation can be liberalized to allow it.[359] If, however, a government attempts to equalize the per mile cost of travel, it will be effectively subsidizing sprawl.

It might be argued that local, place-based subsidies will help low-income neighborhoods. In some U.S. metropolitan areas, average incomes are higher in the city than in the surrounding suburbs and exurbs. But if the policy goal is subsidizing mobility for low-income people, the most efficient intervention is means-based subsidies, not place-based subsidies.

There may, however, be a *political* justification for local, place-based subsidies. If cities make driving or parking more expensive, they may face opposition from suburban commuters. The opposition might be particularly intense if suburbanites pay much higher per-mile fares for robotaxis and are thus less willing to replace their personal motor vehicles. In that case, place-based subsidies could be a kind of compromise: suburbanites give up their cars, and in exchange they get cheaper robotaxi service. But the cost of the compromise is encouraging sprawl.

The case for subsidies at the national level is different. In the absence of subsidies, large metropolitan areas might switch to robotaxis while smaller metropolitan areas and rural areas remain dependent on personal motor vehicles. If the primary advantage of robotaxis is economic, this might be an acceptable outcome. Even the most zealous transit advocates do not call for subways to be built under Topeka, even though it might expand mobility. But we can see a case for subsidizing robotaxis in less dense regions if robotaxis provide other benefits and if subsidies provide an important and preferably temporary boost over a critical adoption hump.

More broadly, these risks and opportunities are also why we advocate for more holistic and whole-stream approaches, such as a carbon tax that is collected and rebated per capita, that empower people to make their own choices while simultaneously reducing the externalities that distort those choices.

359. *See* David Schleicher, *How Land Use Law Impedes Transportation Innovation*, *in* EVIDENCE AND INNOVATION IN HOUSING LAW AND POLICY (Lee Anne Fennell and Benjamin J. Keys eds., 2017).

CONCLUSION

We recognize that some advocates are skeptical about robotaxis.[360] They have been working to build a transportation system that relies less on cars and more on walking, biking, and mass transit. They worry that the deployment of robotaxis will undermine those efforts and entrench the automobile. And they do not want the transportation system to privilege the interests of large automakers and other tech companies.

We share these concerns. We recognize what Zipcar's founder has described as a choice between "heaven or hell"[361]—and the many gradations between those two extremes. Automated driving is like the internet: a tool that opens up possible futures, some better and some worse.[362] Its use can and should be subjected to democratic control. With careful regulation, the introduction of robotaxis can liberate cities from the worst effects of the automobile—and thereby save lives, expand mobility, and make cities more livable.

360. *See, e.g.*, Kevin Troung, *We Spoke to One of the Activists 'Coning' Cruise and Waymo Robotaxis in San Francisco*, S.F. STANDARD (July 7, 2023), https://sfstandard.com/2023/07/07/we-spoke-to-one-of-the-activists-coning-cruise-and-waymo-robotaxis-in-san-francisco [https://perma.cc/QF3H-Y6ZP].

361. Robin Chase, *Will a World of Driverless Cars Be Heaven or Hell?*, BLOOMBERG CITYLAB (Apr. 3, 2024), https://www.bloomberg.com/news/articles/2014-04-03/will-a-world-of-driverless-cars-be-heaven-or-hell [https://perma.cc/JR46-XETR].

362. *See* Boaz Miller, *Is Technology Value-Neutral?*, 46 SCI., TECH. & HUM. VALUES 53 (2021); Per Sundström, *Interpreting the Notion that Technology Is Value-Neutral*, 1 MED. HEALTH CARE & PHIL. 41 (1998).