ITERATIVE AUTONOMOUS VEHICLE REGULATION AND GOVERNANCE:

HOW DISTRIBUTED REGULATORY EXPERIMENTS AND INTER-REGIONAL COOPETITION WITHIN FEDERAL BOUNDARIES CAN NURTURE THE FUTURE OF MOBILITY

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Abstract

Despite all the hype about the coming age of autonomous vehicles (AVs), the technology remains in early stages and may not reach mass adoption until thirty years later according to a leading industry expert. As AV technologies take many different shapes in the coming decades, it will be crucial to have government support and an iterative model of AV regulation and governance in place that can evolve alongside the technology.

Based on empirical studies of existing AV regulations and pilot programs in over 50 states and localities in the U.S. as well as 25 countries internationally, this paper proposes a regulatory model involving distributed, iterative AV governance and a federal backstop to facilitate inter-regional coopetition in America. Under this regime, state and local governments overseeing AV pilots can obtain important information about fast-moving AV technologies necessary for informed regulatory experiments and rapidly adjust policies in response to public feedback; the federal government will provide for key minimum rules to prevent deregulatory races to the bottom among states and offer a model AV code to reduce fragmentation and lead the march towards a national AV regime. Both care and support are needed along the way to nurture the future of mobility, as safety, efficiency, and societal welfare of enormous magnitudes are at stake in this technological and regulatory evolution.

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Autonomous vehicles seemed to be just around the corner a few years ago. But as many AV makers miss their own deadlines for launching self-driving cars, it is apparent that the technology will not reach mass adoption any time soon: Tesla, Waymo (which is widely seen as the industry leader), and General Motors promised at various points that unrestricted, completely autonomous cars would arrive in 2017, 2018, and 2019 respectively;[1] none have come yet, with ever more carmakers attaching increasingly complex conditions to their AV promises.[2] Ford CEO Jim Hackett acknowledges that the industry "overestimated the arrival of autonomous vehicles."[3] Chris Urmson, the linchpin of Waymo's technology, says that self-driving cars will only appear gradually over the next 30 to 50 years.[4] Even then autonomous cars won't be able to drive in all conditions, says Waymo's current CEO.[5] The complex driving environment in urban settings present many edge cases not common in AI learning data, which humans can handle by using general knowledge and on-the-fly reasoning but machines struggle with since they have not seen these situations before.[6]

Many now instead focus on simpler applications of AV technologies that are more likely to be commercially feasible in the foreseeable future rather than full-fledged passenger AVs. For instance, AV startup TuSimple works on commercial trucking AV technology that delivers cargo from hub to hub on freeways which present a much less complex driving environment than urban

1. *Driverless Cars are Stuck in a Jam*, THE ECONOMIST (Oct. 10, 2019), https://www.economist.com/leaders/2019/10/10/driverless-cars-are-stuck-in-a-jam.

2. Aarian Marshall, *Ford Taps the Brakes on the Arrival of Self-Driving Cars*, WIRED (Apr. 9, 2019, 8:44 PM), https://www.wired.com/story/ford-taps-brakes-arrival-self-driving-cars.

3. *Id.*

4. *Driverless Cars Are Stuck in a Jam*, *supra* note 1.

5. Shara Tibken, *Waymo CEO: Autonomous Cars Won't Ever Be Able to Drive in All Conditions*, CNET (Nov. 13, 2018, 9:25 AM), https://www.cnet.com/news/alphabet-google-waymo-ceo-john-krafcik-autonomous-cars-wont-ever-be-able-to-drive-in-all-conditions.

6. *Driverless Cars Are Stuck in a Jam*, *supra* note 1.

streets.[7] Nuro, another startup which has received $940 million in funding from Softbank, focuses on developing vehicles that deliver groceries and the compact and passenger-free design of their cars is less risky with regards to passenger safety.[8] Others, notably in China, turn the idea of AV on its head by making roads smarter about cars instead of (or in addition to) making cars smarter about roads by installing sensors and network equipment on roads to create a more AV-friendly environment.[9]

In short, AV technologies will take quite some time to mature, and will likely take many different shapes and need significant investment along the way, both private and public.[10] Improvement in AI technology requires large amounts of data from real-world driving which takes time and money.[11] Transforming roads to fit cars demands significant infrastructure investment, active government involvement, and broad-based stakeholder participation to shore up the supporting technology and associated infrastructure.[12] As the technology evolves, regulations will need to adapt too.

This paper makes the case for an iterative model of AV regulation and governance, characterized by government support, evolutionary pilots in states and localities, and a federal backstop to maintain healthy inter-regional coopetition as AV technologies evolve. It first explores the strong positive externalities AVs can create, not just in terms of greater convenience and lower costs for consumer mobility, but also the significant environmental and economic improvements the technology can bring to the public at large.[13] Akin to subway or urban transit infrastructure in general, autonomous vehicles harbor the promise of transforming the modern urban landscape by significantly expanding the effective area of cities, thereby easing the overcrowding in major metropolises, and promoting commerce and trade by offering greater connectivity.[14] The technology thus calls for more government support to accelerate its development and bring public benefits when private firms may not have the full incentive or capability to invest in and improve the associated infrastructure.[15]

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7. TUSIMPLE, https://www.tusimple.com (last visited Oct. 21, 2020).

8. Tim Higgins, *SoftBank Invests $940 Million in Nuro for Driverless Deliveries*, WALL ST. J. (Feb. 11, 2019, 2:17 PM), https://www.wsj.com/articles/softbank-invests-940-million-in-nuro-for-driverless-deliveries-11549893721.

9. *Chinese Firms are Taking a Different Route to Driverless Cars*, THE ECONOMIST (Oct. 12, 2019), https://www.economist.com/business/2019/10/12/chinese-firms-are-taking-a-different-route-to-driverless-cars.

10. *See* Higgins, *supra* note 8 (discussing private sector investment); *Chinese Firms Are Taking a Different Route to Driverless Cars, supra* note 9 (discussing infrastructure investment in China).

11. *Driverless Cars are Stuck in a Jam*, *supra* note 1.

12. *Chinese Firms are Taking a Different Route to Driverless Cars*, *supra* note 9.

13. *See generally* TUSIMPLE, *supra* note 7 (explaining the advantages of an autonomous fleet regarding efficiency, safety, and low operating costs); Higgins, *supra* note 8 (discussing an economic advantage of driverless deliveries in suburban areas).

14. CLAY MCSHANE & JOEL A. TARR, THE HORSE IN THE CITY: LIVING MACHINES IN THE NINETEENTH CENTURY 171 (2007); Andreas Sandre, *Silicon Valley No More?*, HACKERNOON (Feb. 25, 2019), https://hackernoon.com/silicon-valley-no-more-bc04c9197e6b; Kevin Roose, *Silicon Valley Is Over, Says Silicon Valley*, N.Y. TIMES (Mar. 4, 2018), https://www.nytimes.com/2018/03/04/technology/silicon-valley-midwest.html.

15. *Driverless Cars Are Stuck in a Jam*, *supra*, note 1; *Chinese Firms are Taking a Different Route to Driverless Cars*, *supra*, note 9.

As AV technologies rapidly evolve towards the future of mobility, regulators also need to constantly reinvent themselves and build pilot projects as well as regulations that can adapt to the many iterations of autonomous technologies.[16] Faced with technological and legal uncertainty, this paper proposes an adaptive, flexible, and participatory system where regulators, the general public, and other stakeholders can learn from existing pilots and adjust regulations and expectations along the way. This model is to be contrasted with *ex ante* regulatory structures that attempt to determine the rules before the technology is deployed, which can often lead to fierce debates about how to manage the tradeoffs between innovation and risk without having sufficient facts to support either side.[17] Here instead, the iterative governance model of autonomous vehicles seeks to "bring together diverse stakeholders to produce a collaborative governance system rather than a resource-draining adversarial battle," and envisions "a governance process rather than intractable regulatory rules."[18]

After examining AV legislation, executive orders, and pilots from over 40 states, 25 countries, many cities and localities, and Congress, this paper identifies key elements of successful AV regulations and pilots that contribute to an iterative model of AV governance and important AV rules that need further clarity and consistency. Regular feedback from AV trials based on reliable indicators of safety performance, flexible and clear regulatory institutions, and a commitment to public engagement are found to be critical to the AV evolution.[19] Regulators across America (and around the world) would be wise to note these elements.

Critically, the U.S. federal government also has a huge role to play in setting the rules of the game. To be sure, states and localities are the most dynamic testing grounds of AV technologies in America (and will likely stay so in the foreseeable future) and the federal government should not preempt regulatory experiments so vibrantly underway across the country.[20] But Washington can foster healthy inter-regional coopetition by setting the boundaries of state competition to avoid deregulatory races to the bottom and by encouraging state cooperation and standardization through investment in a model AV code.[21] A regime with dynamic, distributed regulatory experiments within federally administered boundaries will best support an iterative model of governance as technology and regulation evolve in tandem.

16. Gregory Mandel, *Regulating Emerging Technologies*, 1 L., INNOVATION & TECH. 75, 75–76 (2009).

17. *Id.*

18. *Id.*

19. *See generally* NATIONAL LEAGUE OF CITIES, *Autonomous Vehicle Pilots Across America* 28 (Oct. 17, 2018), https://www.nlc.org/sites/default/files/2018-10/AV%20MAG%20Web.pdf [hereinafter *Municipal AV Pilots Report*] (describing best practices in AV pilot programs in American cities); *Chinese Firms are Taking a Different Route to Driverless Cars*, *supra* note 9 (describing Chinese regulations on AVs).

20. Edward Graham, *Self-Driving Legislation Sputters in 2018, and 2019 Prospects Aren't Much Better*, MORNING CONSULT (Dec. 20, 2018), https://morningconsult.com/2018/12/20/self-driving-legislation-sputters-in-2018-and-2019-prospects-arent-much-better.

21. GOOGLE, *Comments on Federal Automated Vehicles Policy*, NHTSA Docket 20160090 (Nov. 22, 2016).

II. AVs' Positive Externalities

While consumer benefits from AVs such as lower travel costs and greater convenience can be internalized by market incentives, the strong positive externalities of AV technologies might not be fully captured by private sector innovation.[22] This part of the paper examines some key aspects of such positive externalities such as AVs' potential to: (1) improve safety; (2) ease congestion; and critically (3) promote real estate value, retail activities, trade and commerce, and in turn general economic growth.

The first among these externalities is the improved safety from eliminating driver error, which is predicated on mass adoption. Over 37,000 people are killed in traffic accidents each year in America and over 1.25 million globally,[23] or respectively more than 100 and 3,200 every day. Over 90% of these accidents are caused by driver error[24] and 39% of crash fatalities involve alcohol use by one of the drivers.[25] Simply having certain assistive AV technology can prevent nearly a third of crashes and fatalities, according to the Insurance Institute for Highway Safety.[26] Removing all driver error will likely create an even bigger improvement—eliminating 90% of traffic accidents would mean saving more than 33,000 lives in America alone.[27] Based on estimates of the value of life derived from market data for risky jobs at $3–9 million per life[28] (or an average of $6 million)—which are necessarily crude measures and may only capture very limited aspects of human lives but do offer a sense of their significance—lives saved from eliminating driver error would translate into at least $200 billion in prevented losses to the American economy, equivalent to accelerating annual U.S. GDP growth by 50%.[29]

However, with slower than expected adoption, AV technologies' safety improvements will be limited absent external intervention. Individual auto consumers' purchase decisions will be based on the marginal safety improvement from the one vehicle they buy. But in many ways their safety depends more on other cars' behavior—if fellow human drivers are still making the kind of mistakes which cause the vast majority of accidents today, consumers

22. *See generally* Higgins, *supra* note 8 (discussing convenience of AVs for consumers); Marshall, *supra* note 2 (explaining the limitations on AVs).

23. *Quick Facts 2016*, NAT'L HIGHWAY TRAFFIC SAFETY ADMIN. (Feb. 2018), https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812451; *Road Traffic Deaths*, WORLD HEALTH ORG. (accessed Dec. 2019), https://www.who.int/gho/road_safety/mortality/en.

24. *Critical Reasons for Crashes Investigated in the National Motor Vehicle Crash Causation Survey*, NAT'L HIGHWAY TRAFFIC SAFETY ADMIN. (Feb. 2015), https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812115.

25. JAMES M. ANDERSEN ET AL., AUTONOMOUS VEHICLE TECHNOLOGY: A GUIDE FOR POLICY MAKERS 16 (RAND Corp. (2016)).

26. Ins. Inst. for Highway Safety, *New Estimates of Benefits of Crash Avoidance Features on Passenger Vehicles*, STATUS REP. (May 20, 2010), https://web.archive.org/web/20190117034648/https://www.iihs.org/iihs/sr/statusreport/article/45/5/2.

27. *Road Traffic Deaths, supra* note 23.

28. W. Kip Viscusi, *The Value of Life in Legal Contexts: Survey and Critique*, 2 AM. L. & ECON. REV. 195, 195 (2000).

29. American GDP growth currently stands at a 2% annualized rate, or a growth of about $400 billion per year from a base of $20 trillion. *U.S. Economy at a Glance*, BUREAU OF ECON. ANALYSIS, U.S. DEP'T OF COMMERCE, https://www.bea.gov/news/glance (last modified Sept. 19, 2018).

will not be much safer simply because they are riding a self-driving car. As long as a critical mass of human-driven cars still occupy most road space, accident rates may remain at a relatively high level. The lack of coordination in AV adoption could thus create a chicken-and-egg problem where the safety externality of the technology becomes a hinderance to its success without significant investment to accelerate adoption.

Similarly, AV technologies' promise to reduce congestion can be enormously beneficial, but it also hinges on mass adoption. In 2017, highway congestion caused 8.8 billion hours of delay and the use of 3.3 billion gallons of additional fuel, at a cost of $166 billion to highway users.[30] Congestion can also involve costs to non-road users: another study estimated that highway congestion cost businesses in one major metropolitan area up to $1 billion per year in increased production and distribution costs, over and above the costs borne by highway users themselves.[31]

Mass adoption of AV technologies can dramatically alter congested highways. More than 65% of the instances of highway congestion are caused by factors that AVs can significantly alleviate: traffic incidents (which account for 25% of congestion) and roadway bottlenecks (the other 40% of the cause).[32] As discussed above, complete replacement of human-driven cars by AVs can eliminate over 90% of current traffic accidents. That means complete replacement would also reduce 22.5% of all congestion (ninety percent multiplied by twenty five percent). Roadway bottlenecks, a result of the number of vehicles approaching a highway's capacity, can also be substantially reduced given the better coordination between AVs. Much like Uber's central dispatch system of drivers, AVs can talk with each other and avoid congested roads automatically, in a split second, without the need for time-consuming human processing of road information.[33] A McKinsey study found that AVs can reduce time per trip (a proxy for congestion) by 10% even when accommodating 30% more transit demand,[34] a sign that AVs can solve bottlenecks with great efficiency and save the economy billions of dollars each year. Adding that 10% reduction of congestion to the 22.5% coming from reduced accidents, AVs can reduce total costs of congestion by about $166B multiplied by the sum of 10% and 22.5%, which would result in $54B in savings, equivalent to another 13.5% in accelerating annual U.S. GDP growth. The benefits from such coordinated and uncongested traffic, however, again depend on having a critical mass of AVs. As long as human drivers remain substantial parts of the road-vehicle

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30. DAVID SCHRANK ET AL., TEX. A&M TRANSP. INST., 2019 URBAN MOBILITY REPORT 1, https://static.tti.tamu.edu/tti.tamu.edu/documents/mobility-report-2019.pdf.

31. GLENN WEISBROD ET AL., TRANSP. RESEARCH, BD., NAT'L RESEARCH COUNCIL, ECONOMIC IMPLICATIONS OF CONGESTION 5 (2001), http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_463-a.pdf.

32. CAMBRIDGE SYSTEMATICS, INC., TRAFFIC CONGESTION AND RELIABILITY: TRENDS AND ADVANCED STRATEGIES FOR CONGESTION MITIGATION, at ES-3 (2005), https://ops.fhwa.dot.gov/congestion_report/congestion_report_05.pdf.

33. Neil Patel, *How Uber Uses Data to Improve Their Service and Create the New Wave of Mobility* (Apr. 17, 2017), https://neilpatel.com/blog/how-uber-uses-data/.

34. Eric Hannon et al., *The Road to Seamless Urban Mobility*, MCKINSEY QUARTERLY (Jan. 16, 2019), https://www.mckinsey.com/business-functions/sustainability/our-insights/the-road-to-seamless-urban-mobility.

coordination process, the positive congestion savings from AV technologies can be difficult to achieve.

AV's promotion of commercial activities in general may be an even larger externality not fully captured by the current debate about its potential. In broad strokes, AVs will: (1) boost the value of once-inconvenient real estate and ease urban overcrowding; (2) promote urban retail activities through greater passenger/consumer connectivity; and (3) lead to more efficient and vibrant trade and commerce with self-driving commercial vehicles, such as autonomous trucks that deliver cargo to ports or warehouses.

Because riders will be freed from the duty of looking after their vehicles, they can better relax, enjoy entertainment services, or even work during their commute. AVs could free as much as fifty minutes a day for users according to a study by McKinsey, and the time saved by commuters every day might add up globally to a mind-blowing one billion hours—equivalent to twice the time it took to build the Great Pyramid of Giza.[35] As the cost of time spent in cars declines, commuter willingness to travel longer distances to and from work will increase.[36] This can dramatically transform the urban landscape as people will be more willing to locate further from urban cores.

More dispersed patterns of land use surrounding metropolitan regions can generate significant real estate value increase for once remote areas, just as the rise of the automobile and electric trolleys led to the emergence of suburbs.[37] For example, a Boston land speculator built one of the first electric trolley lines in America connecting his suburban landholdings in Brookline with downtown Boston, and in 1891 the value of his Brookline real estate had increased by 20 million dollars over the previous five years,[38] or about 560 million in today's terms.[39] Scaling such an increase to the hundreds if not thousands of metropolitan regions across America, the land value generated from the adoption of the electric trolley can easily reach the scale of tens, if not hundreds, of billions of dollars.[40] It is not hard to imagine autonomous vehicles bringing similar land value generation as their adoption makes two-hour or even three-to-four-hour commutes much more bearable since travel will become essentially the same as another space for personal activities. A less dense urban environment can also significantly alleviate the overcrowding of many major metropolitan areas and problems, such as skyrocketing housing prices and

35. Michele Bertoncello & Dominik Wee, *Ten Ways Autonomous Driving Could Redefine the Automotive World*, MCKINSEY & CO. (June 1, 2015), https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/ten-ways-autonomous-driving-could-redefine-the-automotive-world.

36. *Id.*

37. CLAY MCSHANE & JOEL A. TARR, THE HORSE IN THE CITY: LIVING MACHINES IN THE NINETEENTH CENTURY 171 (2007).

38. *Id.*

39. Ian Webster, *Why A Dollar Today is Worth Only 4% of a Dollar in 1891*, OFF. DATA FOUND. (updated Aug. 12, 2020), http://www.in2013dollars.com/us/inflation/1891.

40. There are at least 227 metropolitan regions whose land value is of the same order of magnitude as Boston's today. *See* David Albouy et al., *Metropolitan Land Values*, 100 REV. ECON. & STAT. 454, 454 (2018).

stressed urban infrastructure, thereby improving quality of life of existing urban centers.[41]

While one might argue that dispersing the population may reduce benefits of aggregation effects from industries being situated closer together, what the dispersion really creates is an opportunity for a new equilibrium, where if the benefits of accommodating more talent within a metropolitan area outweigh any reduction in aggregation effects, the urban economy will evolve as such; and if the reverse is true, the status quo would not change much. Given the overcrowding in many urban centers such as New York and San Francisco, as residents' flee from Silicon Valley due to high costs of living suggests,[42] there is strong reason to believe that the former is true and the existing equilibrium is not ideal since people would even move to places so far away from centers of aggregation effects for better opportunities. In addition, even if current centers of metropolises were to somehow remain largely similar in terms of its density due to the balance of aggregation effects, what AVs can create is *extra* space for *new* talent coming from the outside to share the aggregation effects as new modes of transportation expand the radius of accessible aggregation effects, instead of just moving existing talent further away from the center. As a result, AVs can create completely new economic activities without necessarily undermining existing economic ecosystems. While it is hard to quantify the exact effect of that impact, it is directionally clear that significant new economic dynamism is likely to result from expanded access to opportunities.

Greater connectivity between urban areas as a result of AV adoption can also boost retail activities. Evidence globally has shown the positive effects of urban transit systems on retail amenities: a study on Beijing's subway neighborhoods, for example, demonstrated that following the opening of a subway station, restaurant openings within 400 meters of the station on average increased by 48.4%.[43] Given AVs' effect on broadening urban space and providing greater mobility and connectivity, the scope of retail activities can similarly increase as a result.

Last but not least, AVs can make trade and commerce more efficient and vibrant by filling the gap of truck drivers and reducing the cost of delivery. The U.S. trucking industry is experiencing a shortage of 60,800 drivers in 2019 and the deficit is expected to double to 160,000 in a decade.[44] Deploying self-driving trucks can fill this gap and provide greater logistical capacity to support America's domestic commerce as well as imports and exports. Moreover, using AVs can save significant labor costs—driver salary accounts for 40% of the

41. Arantxa Herranz, *Urban Overcrowding and Rural Depopulation: Are There Any Solutions to These Problems?*, TOMORROW. MAG (Apr. 15, 2019), https://www.smartcitylab.com/blog/inclusive-sharing/urban-overcrowding-and-rural-depopulation-are-there-any-solutions-to-these-problems/.

42. Roose, *supra* note 14; Sandre, *supra* note 14.

43. Siqi Zheng et al, *Transit Development, Consumer Amenities and Home Values: Evidence from Beijing's Subway Neighborhoods*, 33 J. HOUSING ECON. 22, 30 (2016). General restaurant openings in the "vicinity" of the station increased by 18.6% per year. *Id.* at 29.

44. Thomas Black, *U.S. Truck Driver Shortage is on Course to Double in a Decade*, BLOOMBERG (July 24, 2019, 12:00 AM), https://www.bloomberg.com/news/articles/2019-07-24/u-s-truck-driver-shortage-is-on-course-to-double-in-a-decade.

cargo delivery business's overall costs and current autonomous trucks can be less than 50% as expensive on a per-mile basis, which is on top of the 7–13% fuel cost savings AVs can achieve compared to conventional trucks.[45] Besides the benefits to consumers, these enormous cost savings can make trade and commerce much more efficient and in turn boost activities which will benefit the US economy as a whole—for instance, lower-cost delivery will encourage more online purchase activities due to lower shipping costs and create more opportunities for merchants and more retail jobs. But again, much of the benefit is an externality to AV makers and industry participants—they only capture a fraction of the value of US economic activities.

Beyond the benefits to safety and congestion, further improvements to real estate, retail, and trade/commerce will have far-reaching implications for the general economy as the growth of these sectors will add to the GDP, employment, and government tax revenues. This is particularly important for states and localities, the main engine of the AV revolution,[46] as many of them have explicitly acknowledged the economic objectives of their AV efforts, e.g., "attract[ing] jobs stemming from this developing industry,"[47] "enhancing [the state's] economic competitiveness,"[48] "promot[ing] economic growth, bring[ing] new jobs, . . . and foster[ing] economic productivity,"[49] and "improv[ing] . . . commerce across the state."[50]

Given these strong positive externalities AVs can generate which are not fully accounted for by private sector incentives, government intervention (e.g., in the form of investment) is thus needed to accelerate its development and bring home the enormous benefits of the technology.

III. GOVERNMENT SUPPORT: LEVERS AND EXAMPLES

As Part I of this paper shows, the evolution of AV technologies requires government support along the way to fully realize its benefits. This part of the paper investigates different forms of government support and how they can encourage the development of AV technologies as part of the iterative governance model.

Governments can pull a wide variety of levers to encourage the development of AV technologies, with current examples ranging from: (1) active, regular dialogue with stakeholders; (2) symbolic gestures through

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45. Yijing Wang, *TuSimple CEO: Our L4 Trucks Earn Thousands of Dollars Every Week, But We are Still Far from Profitability*, 36KR (Dec. 10, 2018), https://36kr.com/p/5165891; Yaqiong Shi, *PlusAI Completed A+ Round, to Build a Thousand Self-Driving Heavy Trucks in Two Years*, 36KR (Nov. 14, 2018), https://36kr.com/p/5162063.

46. *See infra* Section V.A.

47. MICH. DEP'T OF TRANSP. & CTR. FOR AUTOMOTIVE RESEARCH, AUTOMATED VEHICLE INDUSTRY ACTIVITIES IN MICHIGAN 1 (May 2017), https://www.michigan.gov/documents/mdot/Automated_Vehicle_Industry_Activities_in_Michigan_572947_7.pdf.

48. FLA. STAT. § 339.175(7).

49. Ariz. Exec. Order No. 2015-09 (Aug. 25, 2015), https://azgovernor.gov/file/2660/download?token=nLkPLRi1.

50. Ariz. Exec. Order No. 2018-04 (Mar. 1, 2018), https://azgovernor.gov/sites/default/files/related-docs/eo2018-04_1.pdf.

clarifying legislations to more substantive forms of encouragement including (3) direct investment in the technology and support for value chain components surrounding AV technologies; (4) building out road, data, and communication infrastructure; (5) favorable tax treatment; and (6) zoning law reforms accommodating AVs.

The city of San Jose, for example, first organized a stakeholders' roundtable hosted by its mayor and attended by more than 30 private sector AV developers as well as local transportation department leadership.[51] This event opened a productive dialogue in which the companies asked for infrastructure assistance such as curbside drop-off space and electric vehicle charging stations, and the city in turn requested a data sharing agreement and transit options for specific neighborhoods and "use cases."[52] San Jose later opened a formal Request for Information and received 31 responses from firms encouraged by the initial conversation,[53] which led to a successful launch of its AV pilots currently undergoing trials.[54]

Many states and cities have also clarified their laws to expressly allow AVs, signaling a supportive environment.[55] Florida's HB 7027 bill, enacted in 2016 and an example of such laws, permits operation of autonomous vehicles on public roads by individuals with valid driver's licenses.[56] These laws were not necessary as the states had no existing laws prohibiting such programs, but the legislatures wanted to encourage the pilots; in many cases state legislation and executive orders also directed agencies to develop a procedure for approving pilots and often concurrently established committees to study the issue.[57]

Arizona Governor Doug Ducey's informal support of AV technologies is a case in point of how these gestures might help foster a dynamic AV industry. As a state leader, he already had a reputation for favoring innovation and technology-friendly regulations—he fired a state regulator for attempting to block Uber and Lyft operations in Arizona.[58] In a friendly gesture to the AV industry, Governor Ducey invited Uber's leadership "to visit the Phoenix area to consider using the state as a proving ground."[59] Partly as a result, Arizona cities such as Tempe, Mesa, Gilbert, and Chandler have found themselves home to two of the most high-profile AV pilots in the country.[60]

These informal ways of showing support for AVs are not particularly costly, and they can provide important signals to AV firms and kickstart industry developments in the region.

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51. MUNICIPAL AV PILOTS REPORT, *supra* note 19.
52. *Id.*
53. *Id.*
54. San José MOTI, *San José's Autonomous Vehicle Pilot Program: Lessons for Cities*, MEDIUM (May 15, 2019), https://medium.com/sanjoseway/san-jose-autonomous-vehicle-pilot-lessons-f75149d67c01.
55. NAT'L CONF. OF STATE LEGISLATURES, TABLE: ENACTED STATE LEGISLATION, http://www.ncsl.org/research/transportation/autonomous-vehicles-self-driving-vehicles-enacted-legislation.aspx (last visited Oct. 21, 2020) [hereinafter STATE AV LEGISLATION].
56. *Id.*
57. MUNICIPAL AV PILOTS REPORT, *supra* note 19, at 6–7.
58. *Id.* at 7.
59. *Id.*
60. *Id.*

Direct government investment and other economic incentives can significantly accelerate AV development, as experiences both in America and internationally have demonstrated. Congress passed a spending bill in 2018 to invest $100 million in AV testing and research, with $60 million "to fund demonstration projects that test the feasibility and safety" of AVs and $40 million for research into AV safety and its impact on U.S. employment.[61] In September 2019, the U.S. Secretary of Transportation announced the recipients of the $60 million in grants to AV pilot projects across seven states to fund testing and demonstration of AV-related technologies such as "connectivity, visibility, and high-definition mapping technologies" as well as AV applications for on-demand ridesharing and trucks in rural areas and work zones.[62] Moreover, the Department of Transportation has awarded $50 million to Columbus, Ohio for winning DoT's Smart Cities Challenge, with part of the grant (although unclear how much) going to fund AV technologies.[63] The city has used the funding to launch a self-driving shuttle pilot involving a $1 million contract to AV-providers, and it has accumulated 15,246 riders as of August 2019.[64] The Federal Highway Administration also runs the Advanced Transportation and Congestion Management Technologies Deployment program, which has awarded $12 million in the past few years to state projects that explicitly mention autonomous vehicles in their purposes, although most of the funding under the program goes to other transportation technologies such as connected vehicle technologies.[65]

Many states and cities are actively involved as well. Florida is a leading state on this front: in enacting SB 2500 in 2019, the state has earmarked $1 million for the study and development of innovative options for transit including the "study of smart city innovations and autonomous vehicle services;" moreover, its HB 311 bill (also enacted in 2019) has authorized the Florida Turnpike Enterprise to enter into agreements (including with private

61. David Shepardson, *U.S. Spending Plan Include $100 Million for Autonomous Cars Research, Testing*, REUTERS (Mar. 21, 2018, 9:01 PM), https://fr.reuters.com/article/idUSKBN1GY074.

62. Brittney Kohler, *New Autonomous Vehicle Grants Announced, Congress Contemplates Legislation*, NAT'L LEAGUE OF CITIES (Sept. 24, 2019), https://citiesspeak.org/2019/09/24/new-autonomous-vehicle-grants-announced-congress-contemplates-legislation; U.S. DEP'T OF TRANSP., AUTOMATED DRIVING SYSTEM DEMONSTRATION GRANTS (last updated Sept. 18, 2019), https://www.transportation.gov/av/grants.

63. Heather Kelly & Matt McFarland, *Columbus Wins $50 Million DoT Smart Cities Challenge*, CNN (June 23, 2016, 4:09 PM), https://money.cnn.com/2016/06/23/technology/columbus-smart-cities/index.html.

64. *Self-Driving Shuttles*, SMART COLUMBUS, https://smart.columbus.gov/projects/self-driving-shuttles (last visited Oct. 21, 2020); Carrie Ghose, *Scioto Mile Self-Driving Shuttle Shutting Down, Focus Shifts to Linden*, COLUMBUS BUS. FIRST (Sept. 13, 2019, 2:48 PM), https://www.bizjournals.com/columbus/news/2019/09/13/scioto-mile-self-driving-shuttle-shutting-down.html.

65. U.S. DEP'T OF TRANSP., FED. HIGHWAY ADMIN., FY 2018 ADVANCED TRANSPORTATION AND CONGESTION MANAGEMENT TECHNOLOGIES DEPLOYMENT (ATCMTD) PROJECT AWARDS (last modified Apr. 10, 2020), https://ops.fhwa.dot.gov/fastact/atcmtd/2018/awards/index.htm; U.S. DEP'T OF TRANSP., FED. HIGHWAY ADMIN., FY 2017 ADVANCED TRANSPORTATION AND CONGESTION MANAGEMENT TECHNOLOGIES DEPLOYMENT (ATCMTD) PROJECT AWARDS, https://ops.fhwa.dot.gov/fastact/ atcmtd/2017/awards/index.htm (last modified Apr. 10, 2020); U.S. DEP'T OF TRANSP., FED. HIGHWAY ADMIN., FY 2016 ADVANCED TRANSPORTATION AND CONGESTION MANAGEMENT TECHNOLOGIES DEPLOYMENT (ATCMTD) PROJECT AWARDS (last modified Apr. 10, 2020), https://ops.fhwa.dot.gov/fastact/atcmtd/fy16awards/index.htm; *Fixing America's Surface Transportation Act or "FAST Act", Advanced Transportation and Congestion Management Technologies Deployment* U.S. DEP'T OF TRANSP. FED. HIGHWAY ADMIN., (Feb. 2016), https://www.fhwa.dot.gov/fastact/factsheets/advtranscongmgmtfs.cfm.

entities) to fund, construct, and operate facilities "for the advancement of autonomous and connected innovative transportation technologies."[66] Arlington, Texas has also invested in testing small-scale AV technologies by directly leasing two French-produced shuttles and operating a fixed-route AV pilot, with overwhelmingly positive responses from local residents.[67]

International examples (particularly from China) better illustrate the scale of investment that could be made here and underscores the urgency of stronger U.S. government involvement in the context of international technological competition. The Shanghai municipal government, for instance, has announced plans in September 2019 to set up investment funds of up to $15 billion for AI technologies (including autonomous vehicle technologies) developed or deployed in the city's pilot.[68] This is 15 times the amount the U.S. federal government has earmarked for AVs and more than the entire world's venture capital investment in AV technologies in 2017 and 2018 combined,[69] and Shanghai is but one of many Chinese cities that have invested in AV technologies.[70] This comparison should give U.S. policymakers pause and offer a reason to consider how America can strengthen its commitment to technological investment and avoid being surpassed by China in the autonomous vehicle tech race.

Shanghai also offers a 15% corporate income tax break for eligible firms and a 30% direct subsidy for an eligible company's first batch of innovative AI products like AVs, as well as other cash prizes for individuals and firms.[71] While the ultimate effect of such economic incentives is still to be seen since the Shanghai program is but a few months old, firms such as TuSimple, a leading

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66. STATE AV LEGISLATION, *supra* note 55.

67. *Id.* at 12–21.

68. Shanghai Municipal Commission of Economy and Information Technology, 关于建设人工智能上海高地 构建一流创新生态的行动方案, [*Action Plan for Building Artificial Intelligence Shanghai Heights and Building a First-Class Innovation Ecosystem*], SHANGHAI MUN. PEOPLE'S GOV'T (Sept. 25, 2019), http://www.shanghai.gov.cn/nw2/nw2314/nw2319/nw12344/u26aw62725.html [hereinafter Shanghai Municipal Commission].

69. Ian Agar, *The Top VC Investors in Autonomous Vehicle Tech*, PITCHBOOK (Aug. 27, 2019), https://pitchbook.com/news/articles/the-top-investors-in-autonomous-vehicle-tech.

70. *See, e.g.*, 京雄高速将设自动驾驶车道, [*Jingxiong Expressway will Set up an Autonomous Driving Lane*], BEIJING NEWS (Mar. 28, 2019, 7:17 PM), http://www.xinhuanet.com/tech/2019-03/28/c_1124292511.htm; *see also* Geng Jiang, Yun, 浙江将建设超级高速公路，全面支持自动驾, [*Zhejiang will Build a Super Highway to Fully Support Autonomous Driving*], THE PAPER (Feb. 23, 2018, 9:12 AM), https://www.thepaper.cn/newsDetail_forward_2006063; *see also China Builds Site to Test Autonomous Cars in Highway Conditions*, BLOOMBERG NEWS, (Apr. 18, 2019, 4:27 AM) https://www.bloomberg.com/news/articles/2019-04-18/china-builds-site-to-test-autonomous-cars-in-highway-conditions?srnd=hyperdrive.

71. Shanghai Municipal Commission, *supra* note 68.

autonomous truck company, have actively participated in these programs[72] and appear to be doing pretty well.[73]

It is worth noting that the Shanghai pilot provides support for parts of the AV value chain beyond AV-making itself. It offers subsidies for firms developing communication technologies that support AVs, such as 5G and connected vehicle technologies.[74] With a more complete and developed value chain, AV firms will be better able to focus on developing core technology and take advantage of complementary assets in the surrounding area. Shanghai's example provides some guidance for American cities such as Chandler, Arizona, which is "eager to support the ever-expanding AV activities by encouraging companies that provide components to come to Chandler."[75]

The technical challenges of developing AVs adapted to all climates and scenarios demonstrates the need for other road infrastructures to support AVs, which often require government involvement. Florida, for example, has created the Multi-use Corridors of Regional Economic Significance Program within their Department of Transportation through the enactment of SB 7068 in 2019 to "advance the construction of regional corridors that are intended to accommodate multiple modes of transportation and multiple types of infrastructure . . . addressing issues such as[a]utonomous, connected, shared, and electric vehicle technology."[76] California has also authorized and encouraged using funds under its Road Maintenance and Rehabilitation Program to deploy advanced technologies and communications systems in transportation infrastructure that accommodate "provision of infrastructure-to-vehicle communications for transitional or fully autonomous vehicle systems."[77]

International efforts have been even more aggressive in building out AV infrastructure. Singapore has built an entire town dedicated to supporting AV testing with "a mini hill to check how vehicle sensors perform when they can't see directly ahead, mock skyscrapers to mimic the radio interference from tall buildings and a rain machine to simulate the island's frequent tropical downpours."[78] Due in no small part to this testing infrastructure, the country has been ranked second of the 25 countries examined in KPMG's 2019 Autonomous

72. TuSimple, 图森未来入选上海首批人工智能试点应用场景 将在临港地区开展"AI+交通"示范运营, [*Tucson is Selected as the First Batch of Artificial Intelligence Pilot Application Scenarios in Shanghai in the Future, and will Carry out "AI + Transportation" Demonstration Operations in Lingang Area*], WEIXIN (Apr. 25, 2019), https://mp.weixin.qq.com/s?__biz=MzI1MDYyMzI1Nw==&mid=2247485008&idx=1&sn=322bc3692a68458bdbfdb2d2aa1c7221&chksm=e9fe2226de89ab3011a85ee3532c716c0607c981bb77e593f37920de7fbae48a7b747980219e&token=774440727&lang=zh_CN#rd.

73. *TuSimple Announces Oversubscribed Round of Series D Investment at $215 Million*, PR NEWSWIRE (Sept. 17, 2019), https://www.prnewswire.com/news-releases/tusimple-announces-oversubscribed-round-of-series-d-investment-at-215-million-300919294.html.

74. Lingang Technology City, 图解 | 一图看懂临港新片区集聚发展人工智能产业政策, [*A Picture to Understand the Policy of Agglomeration and Development of Artificial Intelligence Industry in Lingang New Area*], WEIXIN (Dec. 15, 2019), https://mp.weixin.qq.com/s/MqriUQXkrlLhhwUA8pyUiQ.

75. MUNICIPAL AV PILOTS REPORT, *supra* note 19, at 31.

76. STATE AV LEGISLATION, *supra* note 55.

77. *Id.*

78. Kyunghee Park & Krystal Chia, *Singapore Built a Dedicated Town for Self-Driving Buses*, BLOOMBERG NEWS (June 5, 2018, 4:00 PM), https://www.bloomberg.com/news/features/2018-06-04/singapore-built-a-town-to-test-autonomous-self-driving-vehicles.

Vehicles Readiness Index.[79] Elsewhere, Chinese cities and provinces, including Beijing and Zhejiang, have embarked on projects in the past two years building "smart roads" equipped with sensors, radars, communication devices, and cloud-based terminals to achieve road-vehicle coordination, where roads talk to cars to relay road information so that AVs can anticipate road blocks in advance and navigate accordingly.[80] The road devices essentially give AVs extra eyes that allow the cars to "see" further and make decisions based on more complete information, alleviating a significant technical challenge of AV visibility and information scarcity (particularly in extreme weather conditions) and thereby improving safety and efficiency as well as reducing AV technologies' time to market.[81] These smart roads are expected to extend hundreds of miles and raise vehicle speeds by twenty to thirty percent.[82]

Beyond roads, data and Internet infrastructure is critical too. Finland has enacted laws that will "integrate detailed location data on roads, signs, traffic lights, and other control mechanisms for AV operators to use"; it is also set to repaint the continuous yellow lines on Finnish roads in white, partly as these are easier for machines to detect.[83] Spain is building out a communication infrastructure for AVs: in October 2018, the Spanish Directorate General of Traffic awarded a $3.9 million smart mobility contract to a consortium that "aims to establish a real-time system through which vehicles can connect and exchange traffic information."[84]

Favorable tax treatment can encourage AV development while additional tax burdens can hinder autonomous efforts. Florida's HB 311 bill, enacted in 2019, prohibits local governments from imposing any tax, fee, or other requirement on automated driving systems or autonomous vehicles on top of any tax or fee applied to non-autonomous vehicles.[85] This protects AVs from excessive local taxation and eases the economic burden of developing AV technologies.[86] In contrast, Nevada's bill AB 69, which became law in 2017, imposes an excise tax on autonomous ride-sharing services that can burden AV firms.[87]

Arizona offers another possible form of government support through zoning law reforms. Officials of Chandler, Arizona have modified their zoning development code to reduce parking requirements by up to forty percent and

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79. Richard Threlfall, *2019 Autonomous Vehicles Readiness Index*19, KPMG, https://home.kpmg/xx/en/home/insights/2019/02/2019-autonomous-vehicles-readiness-index.html (last visited Oct. 21, 2020) [hereinafter INTERNATIONAL AV REPORT].

80. *Beijing-Xiong'An Highway to Add Autonomous Vehicle Lane*, XINHUA NET (Mar. 28, 2019, 7:17 PM), http://www.xinhuanet.com/tech/2019-03/28/c_1124292511.htm; Jiang, *supra* note 70; *China Builds Site to Test Autonomous Cars in Highway Conditions*, BLOOMBERG NEWS (Apr. 18, 2019, 4:27 AM), https://www.bloomberg.com/news/articles/2019-04-18/china-builds-site-to-test-autonomous-cars-in-highway-conditions?srnd=hyperdrive.

81. Jiang, *supra* note 70

82. *Beijing-Xiong'An Highway to Add Autonomous Vehicle Lane*, *supra* note 80; Jiang, *supra* note 70.

83. INTERNATIONAL AV REPORT, *supra* at note 79, at 19.

84. *Id.* at 31.

85. STATE AV LEGISLATION, *supra* note 55.

86. *Id.*

87. *Id.*

encourage passenger loading zones as drop off and pick up locations for autonomous vehicles and ridesharing.[88]

While the pursuit of AVs these days might seem a predominantly private endeavor, it has inextricable government links. The Defense Advanced Research Projects Agency (DARPA), an agency under the Department of Defense responsible for the development of emerging technologies for military use, made the first push for autonomous vehicles.[89] In 2004, it offered a $1 million cash prize for the first builder of a self-driving car that drove 142 miles through the Mojave Desert, in order to spur the development of technologies needed to create the first fully autonomous ground vehicles.[90] While every vehicle in that first race "crashed, failed, or caught fire," it fostered a community of innovators, engineers, programmers and developers who believed that self-driving cars were possible.[91] DARPA offered larger prizes and even greater challenges in several follow-up competitions, in which AV technologies demonstrated vast improvements.[92] Defense and commercial applications of autonomous vehicles proliferated in their wake.[93]

Today's AV technologies are at another crossroads that may shape the future of human society. Perhaps another push from the government, not unlike DARPA's in the early 2000s, is needed to bring the promise of autonomous vehicles to life as the technology goes through many iterations.

IV. ITERATIVE AV PILOTS: KEY ELEMENTS

This part of the paper examines successful pilots from states and cities in America as well as other countries and identifies certain key elements for success that have emerged in achieving an iterative model of AV governance. It offers a guide for policymakers on AV pilot best practices regarding three key elements:

1) reasonably detailed information reporting requirements, covering, for example, frequency of AV disengagements and other aspects of AV design and performance;
2) flexible and fast-moving regulatory institutions that can respond rapidly to changes in the AV industry, often in the form of small oversight groups composed of industry stakeholders and informal agreements (as opposed to formalized written agreements) with AV makers, with authority ideally vested in a single, dedicated agency; and

88. MUNICIPAL AV PILOTS REPORT, *supra* note 19, at 31.

89. *See* Alex Davies, *Inside the Races That Jump-Started the Self-Driving Car*, WIRED (Nov. 10, 2017, 7:00 AM) https://www.wired.com/story/darpa-grand-urban-challenge-self-driving-car (documenting DARPA's funding of the first ever autonomous vehicle race).

90. *Id.*; Matthew Williams, *The Drive for Autonomous Vehicles: The DARPA Grand Challenge*, HEROX, https://www.herox.com/blog/159-the-drive-for-autonomous-vehicles-the-darpa-grand (last visited Oct. 21, 2020).

91. Davies, *supra* note 89.

92. Williams, *supra* note 90.

93. *Id.*

3) active community engagement and public education to build popular acceptance and smooth the adoption of AV technologies, through pilots open to the public, education and information sessions, and regular surveys to gauge public opinion and adjust pilot programs accordingly.

As the evidence discussed below shows, these three elements can play a significant role in facilitating iterative governance where regulators and other stakeholders can shape the technology in socially desirable ways as it evolves.

A. Information Reporting Requirement

To ensure iterative improvements in AV technologies that benefit the general public, it is key to obtain relevant information from private sector experimentation to guide future regulation on AV safety, privacy, cybersecurity, and other concerns. As Mandel has pointed out, it is imperative to have a system of "data gathering, followed by result evaluation, followed by modifications to the system as warranted, in a continuing cycle until industry and scientific understanding has matured" for an iterative governance model to work.[94] Without sufficient initial data input, it is not practical to develop such a virtuous cycle of continuous feedback.[95] AV firms should therefore produce information related to AV design, performance, and operation as a condition of participating in state and local pilots. Governments, however, need to pay more attention to building a streamlined and consistent regime of information reporting requirements.

Multiple cities, states, and countries have demanded reporting from AV firms that conduct pilots within their borders, but often with divergent requests on what the governments want. This fragmentation has created an exacting burden to comply with different regimes for firms who have national (or even international) ambitions.[96] Boston, for example, requires quarterly public reports and qualitative data sharing[97] on broad metrics such as testing records, crash reports, and safety assessments, as well as vehicle and operator information.[98] In California, in addition to the above information, the state DMV also asks for data on disengagements, which are deactivations of autonomous driving that require human intervention, a sign of AV failure.[99] The AV START Act, a federal bill that passed the House but got stuck in the Senate, offers another list of disparate types of information that must be included in a "safety evaluation report" which include: system safety; data recording; cybersecurity; human-machine interface; crashworthiness; documentation of

94. Mandel, *supra* note 16, at 85.

95. *Id.*

96. 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, 127–28 (2019).

97. MUNICIPAL AV PILOTS REPORT, *supra* note 19, at 23.

98. Mass. Exec. Order No. 572 (Oct. 20, 2016), https://www.mass.gov/executive-orders/no-572-to-promote-the-testing-and-deployment-of-highly-automated-driving.

99. Testing of Autonomous Vehicles, CAL. CODE REGS. tit. 12, §§ 227.38, 227.50, https://www.dmv.ca.gov/portal/wcm/connect/a6ea01e0-072f-4f93-aa6c-e12b844443cc/DriverlessAV_Adopted_Regulatory_Text.pdf?MOD=AJPERES.

capabilities; post-crash behavior; account for applicable laws; and automation function.[100]

For an international example of how complex reporting requirements can become, in Singapore, autonomous driving trials "require vehicles to be fitted with a black box that continuously collects 17 data sets (steering angle, speed, camera footage etc.) and sends much of it to the Land Transportation Authority in real time."[101] Before the trials were in place, in preparation for a formal bidding process for contracts to offer autonomous buses and on-demand robo-taxis there, the Singapore government also launched a so-called Request for Information (RFI) that asked for extremely detailed information including vehicle specifications, business model, and data and intellectual property ownership.[102] For instance, the RFI includes questions on the fare structure, the nature of sensors to detect waiting bus passengers, plan for fixing defective vehicles, and size of maintenance facilities.[103] The RFI document is 122 pages long, compared to just four pages of the RFI required for companies to test driverless cars in Washington, D.C.[104] If AV makers can provide such detailed information, as the winner in the Singaporean bidding did,[105] regulators can have a much more nuanced understanding of how the technology works and can better compare AVs from different firms.

All these regimes, which are but a sample of the labyrinth of divergent reporting requirements in America and worldwide, have non-trivial differences with which AV firms have to expend significant resources to comply.[106] Under the status quo, firms operating in multiple regions will have to comply with many of these disparate requirements which can unnecessarily waste resources and slow AV technologies.

To avoid duplicative expenditures, provide clarity on AV reporting, and in turn facilitate the AV evolution, it is thus important to establish common standards for AV pilot information requirements with industry participation and regional cooperation to aid rule-making. California's disengagement report requirement provides a good example of how this can be achieved. Since starting to track average disengagements per 1,000 AV miles traveled in the AV pilots there, California has seen this metric consistently trending downward after 2015, starting from sixteen disengagements per 1,000 miles in early 2015 and leveling off since late 2016 at five per 1,000 miles, or one disengagement every

100. AV START Act, S.1885, 115th Cong. § 9 (2017).

101. Alex Webb, *Singapore Knows the Future of Driverless Tech*, BLOOMBERG OPINION (June 1, 2018, 7:00 AM), https://www.bloomberg.com/opinion/articles/2018-06-01/this-tiny-country-knows-the-future-of-driverless-tech.

102. *Id.*

103. *Id.*

104. *Id.*

105. *Id.*

106. *See* Grace Strickland & John McNelis, *Autonomous Vehicle Reporting Data is Driving AV Innovation Right off the Road*, TECHCRUNCH (Aug. 1, 2020), https://techcrunch.com/2020/08/04/autonomous-vehicle-reporting-data-is-driving-av-innovation-right-off-the-road/ ("Developing and operating a robust system of virtual testing may present a high expense to AV companies"); *see, e.g.*, Testing of Autonomous Vehicles, CAL. CODE REGS. tit. 12, §227.38, §227.50; MUNICIPAL AV PILOTS REPORT, *supra* note 19, at 23; Webb, *supra* note 101 (describing divergent reporting requirements at the city, state, and international level).

200 miles driven.[107] By this measure, it seems AVs in California are seeing less and less need for human intervention, a sign that they are getting better at handling edge cases. Perhaps other states should adopt a similar standard to foster safety improvements.

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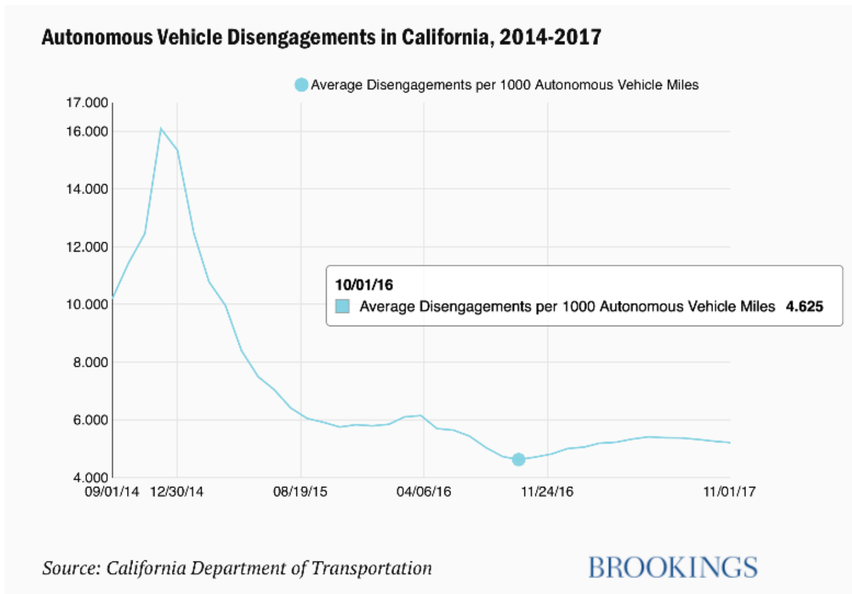

But the disengagement reporting requirement has "irked automakers who said those statistics give a misleading impression of safety."[109] AV experts say the quality of miles driven autonomously matter more than the total number of miles driven.[110] Roads in San Francisco, for instance, are arguably more complex than Silicon Valley towns such as Mountain View, Palo Alto, and Cupertino—so much so that Cruise's CTO says "every minute of testing in San Francisco is about as valuable as an hour of testing in the suburbs."[111]

This debate about the accuracy of disengagements as a proxy for AV safety illustrates the need for industry participation in establishing AV pilot reporting standards. It is natural that a regulator may not understand the technology better than industry experts. As Balleisen writes in his evaluation of how public-private co-regulation can be effective, "[w]ith considerably more knowledge

107. Jack Karsten & Darrell West, *The State of Self-Driving Car Laws Across the U.S.*, THE BROOKINGS INSTITUTION (May 1, 2018), https://www.brookings.edu/blog/techtank/2018/05/01/the-state-of-self-driving-car-laws-across-the-u-s.

108. *Id.*

109. Cecilia Kang, *Where Self-Driving Cars Go to Learn*, N.Y. TIMES (Nov. 11, 2017), https://www.nytimes.com/2017/11/11/technology/arizona-tech-industry-favorite-self-driving-hub.html.

110. Andrew J. Hawkins, *California's Self-Driving Car Reports Are Imperfect, But They're Better Than Nothing*, THE VERGE (Feb. 13, 2019, 2:04 PM), https://www.theverge.com/2019/2/13/18223356/california-dmv-self-driving-car-disengagement-report-2018.

111. *Id.*

about the peculiarities of a given business or sector, non-governmental regulators can more effectively tailor a regulatory plan that makes sense for that . . . industry."[112] Contributions from the AV industry on what kind of improvements on, or alternatives to, current pilot reporting standards may therefore be helpful. For instance, if simple numbers on disengagement per 1,000 miles are inaccurate or misleading, perhaps the industry can advocate for more accurate metrics such as a breakdown of aggregate disengagement data by different road types and the varying levels of road complexity of the locations where these disengagements occur or the categories of reasons why the disengagements happened. The current form of disengagement reports that California requires firms to fill already includes data on road types (including interstate, freeway, highway, rural road, street, or parking facility) and descriptions of facts surrounding the disengagements.[113] It should not be too burdensome to include a bit more data on, for instance, the city/town in which the disengagements happened (which can help with understanding road complexity) and to standardize certain categories of disengagement causes (as current descriptions from firms can vary significantly).[114] Alternatively, firms can work together to develop substitute metrics that replace disengagement reports which can provide more accurate assessments of AV testing safety, via industry associations or other forms of private sector collaboration.

Beyond industry insiders' expertise in the technology, such private sector collaboration in rulemaking also has the advantage of facilitating cooperation and achieving greater buy-in. As Balleisen explains:

> Relations between public regulators and regulated industries have often become intensely adversarial. . . . [P]rivate regulators [such as industry associations] generally maintain much better relationships with the firms they oversee, since the latter view them as insiders to the industrial community, or in the case of company-based ethics and compliance programs, insiders to the corporation, rather than as snooping interlopers. As a result, the oversight activities of non-

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112. Edward J. Balleisen, *The Prospects for Effective Co-Regulation in the United States: A Historian's View from the Early Twenty-First Century*, *in* GOVERNMENT AND MARKETS: TOWARD A NEW THEORY OF REGULATION, 443, 455 (Edward Balleisen & David Moss eds., 2009).

113. STATE OF CALIFORNIA DEPARTMENT OF MOTOR VEHICLES, *2019 Autonomous Vehicle Disengagement Reports* (Mar. 2019), https://www.dmv.ca.gov/portal/wcm/connect/0b712ccd-1e7e-41eb-84fc-f16af0ce6265/ol311r.pdf?MOD=AJPERES&CVID= (download under 2019 Disengagement Reports).

114. *Compare* Apple, *Annual Report of Autonomous Vehicle Disengagement*, STATE OF CAL. DEP'T OF MOTOR VEHICLES (2018), https://dmvpublicaffairs.wetransfer.com/downloads/aa7273691c5e8dded0c34132a6ad6ae020190711163626/5e2bae (showing Apple's disclosed causes for disengagements are relatively simple and include "manual takeover," "controls," and "communication"), *with* Waymo, *Annual Report of Autonomous Vehicle Disengagement*, STATE OF CAL. DEP'T OF MOTOR VEHICLE (2018), https://dmvpublicaffairs.wetransfer.com/downloads/aa7273691c5e8dded0c34132a6ad6ae020190711163626/5e2bae (offering more detailed descriptions such as "unwanted maneuver of the vehicle that was undesirable under the circumstances," "perception discrepancy for which a component of the vehicle perception system failed to detect an object correctly," and "hardware discrepancy for which our vehicle's diagnostics received a message indicating a potential performance issue of a hardware component of the self-driving system or a component of the base vehicle discrepancy"), https://dmvpublicaffairs.wetransfer.com/downloads/aa7273691c5e8dded0c34132a6ad6ae020190711163626/5e2baehttps://dmvpublicaffairs.wetransfer.com/downloads/aa7273691c5e8dded0c34132a6ad6ae020190711163626/5e2bae.

> governmental institutions are far less likely to provoke outright defiance from regulated firms and can rely more effectively on techniques of persuasion and informal social sanctions, including public disclosure/shaming, to address problematic behavior.
>
> . . .
>
> [W]hen representatives of businesses throughout a particular industry take the time to hammer out aspirational principles and codes of conduct to guide corporate decision-making, and when corporate leaders evince real dedication to the implementation of those guidelines . . . this kind of participation can . . . generate far deeper internal commitment than external rule-setting by government, commitment that can have more long-lasting impact than mere fear of running afoul of the law.[115]

As Section V.B of this paper explains, regional collaboration on these reporting standards will also be critical in avoiding fragmentation. Fortunately, private sector collaboration often has the inherent advantage of being applicable across geographies, as firms tend to span different regions, which means private sector collaboration and regional cooperation can often go hand in hand. Part V will also explore the role of the federal government in establishing a minimum standard for information reporting requirements that will undergird this private-public rulemaking process in states and cities.

B. Flexible, Fast-Moving, and Focused Regulatory Institutions

AV technologies can change rapidly and confound regulators who cannot move fast enough. Portland, one of the leading American cities running AV pilots, notes that "the technology improves so quickly that some of the projects they were considering a year ago no longer seem as appealing or useful."[116] A model of iterative governance thus requires regulatory institutions that are flexible, fast-moving, and dedicated to AV regulation to adapt to this rapidly evolving challenge.

One strategy successful cities have adopted to encourage a flexible AV regime is to avoid formal, ossified written agreements with AV providers. For instance, Pittsburgh did not develop memoranda of understanding or other written agreements with companies that launched AVs on its streets, reasoning that "written agreements require months of negotiations and prevent the city from fostering a nimble and adaptive environment necessary to embracing technological innovation."[117] Similarly, Boston's AV testing plan is "flexible and designed to avoid renegotiations."[118] The city expects AV providers to raise issues with the city as they arise and ask for permission to change the terms of the pilot—Optimus Ride is a good example and it has received permission to run their vehicles in fog and rain for learning purposes as the need arose.[119] Both

115. Balleisen, *supra* note 112, at 457–59.
116. MUNICIPAL AV PILOTS REPORT, *supra* note 19, at 24.
117. *Id.* at 26.
118. *Id.* at 23.
119. *Id.*

cities have seen active participation from AV makers as well as positive public responses, and are currently expanding their AV pilots.[120]

Moreover, having a single government organization dedicated to AV regulation provides regulatory clarity. Providing firms with a single point of contact can streamline the communication and cooperation between regulators and private companies, as well as reduce potential turf wars between agencies. Singapore, for example, leads KMPG's score on policy and regulation partly for having a dedicated AV agency within its department of transportation, which "improves AV coordination and reduces confusion around who does what."[121] American states including Ohio, Michigan and Massachusetts are also encouraging AV development and adoption by setting up a single coordinating organization.[122]

Furthermore, leading governments in America have established nimble multi-stakeholder oversight groups or advisory committees to help regulators adopt rapid policy changes. Michigan has created a council to advise the governor on recommendations for AV policies in the state, with members composed of private sector (including insurance interest representatives), executive branch (police, insurance, tech departments), and legislative branch leaders.[123] Partly as a result, Michigan has become one of the fastest-moving states when it comes to AV lawmaking: among the 37 states currently with laws on AV regulation, Michigan has the second highest number of bills enacted, only behind California and far surpassing the vast majority of states.[124] The speed of lawmaking has helped ready the state for autonomous vehicles and attracted more industry players. A startup testing self-driving shuttles in Detroit, for example, has said that it is "working in Michigan because of this legislation [on opening up public roads to AV testing]."[125] The company started in Boston but decided to "do this in Michigan because the laws are in place."[126]

Similarly, Arizona Governor Ducey also "set up a 'Self-Driving Vehicle Oversight Committee' comprised of transportation, public safety, insurance, and other regulators to advise 'how best to advance the testing and operation of self-driving vehicles on public roads.'"[127] With the help of this small but nimble group of advisors, Arizona has attracted high profile AV companies such as Waymo and Uber and is one of the industry's favorite testing grounds, if not the favorite.[128]

These regulatory institutions give governments flexibility, efficiency, and focus in adapting to the fast-changing AV landscape. State and local

120. *Id.* at 23, 26–27.

121. INTERNATIONAL AV REPORT, *supra* note 79, at 10.

122. *Id.*

123. MICH. DEP'T OF TRANSP. & CTR. FOR AUTOMOTIVE RES., *supra* note 47, at 25–26.

124. *See* STATE AV LEGISLATION, *supra* note 55, at 1 (showing the legislation enacted by Michigan regarding autonomous vehicles).

125. Greg Tasker, *Michigan Continues To Take The Lead in Autonomous Vehicle Legislation*, DRIVEN (Mar. 06, 2018), http://www.detroitdriven.us/features/Michigan-continues-to-take-the-lead-in-autonomous-vehicle-legislation.aspx.

126. *Id.*

127. Kang, *supra* note 109.

128. *Id.*

governments can follow the examples set by some of the most successful AV pilots in the world to improve their AV readiness and make AVs work for their regions' goals as the technology evolves.

C. Community Engagement and Public Education

Faced with public fear of uncertainties from AV technologies, one of the best ways to facilitate adoption is through community engagement. Having public-facing AV pilots, AV education events, and community input in policymaking can help people understand how AVs work, whether they like AVs, and how AVs can fit into the urban transportation ecosystem as governments strive to achieve public acceptance and adapt AV programs to their particular needs through the many iterations of the technology.[129]

A case in point is Arlington, Texas, where the government ran an AV shuttle pilot that carried passengers between parking lots and sporting/concert venues and that was also open to the public instead of being available only to a select group.[130] The pilot operated on a route closed to other traffic and had an operator onboard to answer questions and assist the public, which provided a safe introduction to AV operations.[131] With over 1,500 rides offered, passengers surveyed at the end of their rides reported an overwhelmingly positive experience and passengers said they would repeat the autonomous shuttle experience or recommend it to others.[132] With the success of this initial phase, Arlington officials feel optimistic and the city has expanded the pilot to on-street testing.[133]

The Arlington example offers a key lesson that policymakers elsewhere would be remiss to ignore.[134] In Arlington, AV technologies were tested and verified by the public, and new iterations only followed after confirmation of public acceptance.[135] Using public opinion as a guiding stone can be key to the success of AV iterative governance.[136]

Using the same tool of public opinion survey but targeting wider segments of the public, the city of Pittsburgh also saw its people embracing the technology six months after Uber's AVs arrived on city streets.[137] In addition to surveying riders, most of whom reported that the AVs performed better than human drivers, Pittsburgh asked cyclists or pedestrians in the city as well and they were overwhelmingly positive about sharing the road with AVs.[138] To be sure, not everyone was happy—frequent drivers did have their complaints, although those

129. *See generally* MUNICIPAL AV PILOTS REPORT, *supra* note 19 (explaining that community engagement and public education will help the public to accept an AV presence).

130. *Id*. at 20–21.

131. *Id.* at 21.

132. *Id.*

133. *Id.*

134. *See id.* at 12 (explaining that the Arlington example shows that policymakers must use the public's opinion to implement AV technologies).

135. *Id*. at 20–21.

136. *See id.* at 12 (explaining that public opinion is imperative to the success of AV iterative governance).

137. *Id*. at 26–27.

138. *Id.* at 27.

mostly pertained to how AVs move too slowly.[139] As the public gets increasingly comfortable with self-driving cars on the street, the city has laid the groundwork for introducing larger scale pilots and more complex iterations of the technology in the future.[140]

Beyond polling, leading AV towns engage the local community through educational demos to gradually build trust, often working with the private sector.[141] When Waymo brought the first AV demonstration to Chandler, Arizona in 2015, several thousand people showed up to ask questions and see the software and hardware up close.[142] The company even brought its vehicles to the mayor's State of the City address to showcase their willingness to share the work with the public.[143] This transparency helped to establish public trust in AV technologies, building momentum for moving forward with the pilot.[144] Similarly, Boston held an "AV petting zoo" to familiarize its citizens with the technology.[145] The Texas Mobility Summit in 2016 and 2017 and the South by Southwest conference in 2017 also provided public demos and opportunities for engagement in addition to a community brainstorming session held in the city of Tampa.[146]

When AVs are coming to the roads, having public input in deciding how they should be regulated provides another chance for getting the community involved and shaping the technology in ways that fit public needs.[147] San Jose, for instance, has hosted public engagement sessions "to learn how different segments of the population want to utilize this technology, be it for recreation, commuting, assistance for aging populations and so on."[148] The city sees potential for AVs to "connect[] . . . [its] airport and train station, linking the downtown area and neighborhoods with a significant number of jobs, and serv[e] vulnerable populations like formerly homeless veterans by connecting them to public transit."[149] With self-driving cars serving community needs, it will be easier to encourage public adoption as people see how AVs can fit into their lives.[150] By the same token, Pittsburgh is bringing stakeholders such as seniors, families, cyclists, employers, and workforce access advocates to working groups that will recommend policies necessary for both piloting and full deployment "to create a unified vision of what the public wants AVs to provide for the city."[151]

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139. *Id.*
140. *Id*.
141. *See id*. at 30–31 (outlining the city of Chandler, Arizona, welcoming Waymo when the company brought the first AV demonstration to Chandler in 2015).
142. *Id.* at 31.
143. *Id.*
144. *Id*.
145. *Id.* at 15.
146. *Id.*
147. *See id*. at 28–29 (showcasing San Jose's best practices of using community engagement to get the public involved in shaping AV technology).
148. *Id.* at 29.
149. *Id.*
150. *Id.*
151. *Id.* at 27.

An iterative governance model of AV technologies cannot happen in a vacuum without public support.[152] To ensure its acceptance, engaging the community along every step of the technology's development can engender trust and understanding.[153] At least in Pittsburgh, AVs have become so commonplace to the extent of being "old news" that the city does not anticipate public pushback for future iterations of the technology.[154]

V. RULES OF THE GAME: INTER-REGIONAL COOPETITION WITHIN EVOLVING FEDERAL BOUNDARIES

As AVs go through its iterations toward mass adoption, what role should the federal government play in this fast-changing industry? This part of the paper argues that the federal government should not try to preempt state and local AV regulations at this point of the AV life cycle, as the ultimately doomed AV START Act did, before it has developed its own substantive rules.[155] It should rather allow regional experimentation while AV technologies are still evolving and only set certain minimum standards that states and localities can build upon in their more flexible regulatory experiments without the interstate competition degrading into a race to the bottom.[156] In the meantime, the federal government can facilitate the drafting of a model AV code and its eventual adoption by states when the technologies and rules become more clearly developed. Such a collaborative model between the federal government and states can foster a healthy iterative regulatory model which allows flexible and fast-moving AV pilots, while also maintaining the basic rules of the inter-regional coopetition that is simultaneously competitive and cooperative. In time, the federal government can promulgate final, mandatory rules when technological development largely settles regulatory questions. The tripartite move from federal minimum standards to a model AV code and eventually to final mandatory rules allows for an iterative model of AV development and governance.

A. Federal Preemption Without Federal Rules

The House passed the AV START Act in 2017 to set a national standard for self-driving cars.[157] It was ambitious in attempting to regulate AV safety, privacy, and cybersecurity through the National Highway Transportation Safety Administration (NHTSA), limit the number of AVs exempt from current auto

152. *See id.* at 26–27 (using the city of Pittsburgh as an example of the public's support of the interplay between state and local governments is critical in the implementation of AV technology).

153. MUNICIPAL AV PILOTS REPORT, *supra* note 19 at 15; Melissa L. Griffin, *Steering (or Not) Through the Social and Legal Implications of Autonomous Vehicles*, 11 J. BUS. ENTREPRENEURSHIP & L. 81, 95 (2018).

154. MUNICIPAL AV PILOTS REPORT, *supra* note 19 at 27.

155. *See* AV START Act, *supra* note 100 (preempting state and local governments from "adopting, maintaining, or enforcing" AV regulations).

156. *Municipal AV Pilots Report*, *supra* note 19 at 12; AV START Act, *supra* note 100.

157. Edward Graham, *Self-Driving Legislation Sputters in 2018, and 2019 Prospects Aren't Much Better*, MORNING CONSULT (Dec. 20, 2018, 3:00 PM ET), https://morningconsult.com/2018/12/20/self-driving-legislation-sputters-in-2018-and-2019-prospects-arent-much-better.

safety regulations, and critically, *preempt states and lower levels of the government from making or enforcing any regulations* regarding AV "design, construction, or performance" in nine important areas.[158] The bill died in the Senate, primarily as a result of concerns that the legislation "indefinitely preempts state and local safety regulations even in the absence of federal standards,"[159] and rightfully so.

As Part I of the paper has explained, it is essential to adopt an iterative governance model for AV regulation as the technology takes shape.[160] To that end, state and local governments are much better stewards of the AV experiment than the federal government thanks to their flexibility and much more rapid responses to AV technologies.[161]

Compared to the nimble state and local governments, the federal government has been exceedingly slow in waking up to the AV challenge.[162] Entrusting the AV regulatory scheme entirely to Washington will thus likely stifle significant state and local activities. The only federal bill on AV regulation ever introduced to this day is the AV START Act of 2017.[163] Even then, the AV START Act has few substantive rules about AV testing or performance despite attempting to preempt state rules.[164] In contrast, starting from 2011, thirty six states have passed eighty two AV-related laws with another 110 bills currently being considered as of December 2019,[165] and quite a few more (at least ten as of December 2019) have issued executive orders on self-driving cars.[166] At the local level, about 50% of America's largest cities are preparing for a future of self-driving vehicles in their long-range transportation plans,[167] and cities such as Boston, Portland, Pittsburgh, San Jose, Arlington, and Chandler are already

158. *See* AV START Act, *supra* note 100 at § 3.

159. Graham, *supra* note 157.

160. *See* Mandel, *supra* note 16 at 1 (proposing a more flexible government structure for AV regulation).

161. *Municipal AV Pilots Report*, *supra* note 19 at 3 ("Cities have a unique opportunity to reshape urban transportation with the ultimate goal of making it more people-centered, flexible, and responsive."). *See also* Tracy Hresko Pearl, *Hands Off the Wheel: The Role of Law in the Coming Extinction of Human-Driven Vehicles*, 33 HARV. J.L. & TECH. 427, 451 (2020).

162. *Id.* at 7 ("As the federal government continues to deliberate on these matters, the action with autonomous vehicles is decidedly taking place on the ground at the local level."). *See also* Jeremy A. Carp, *Autonomous Vehicles: Problems and Principles for Future Regulation*, 4 U. PA. J.L. & PUB. AFF. 81, 107 (2018).

163. AV START Act, *supra* note 100.

164. Other than saying non-traditional auto manufacturers could also engage in AV testing, the parts of the bill that touch on substantive testing and performance rules essentially only talk about having agencies research into potential legal options and requiring a one-time (or at least not regular, based on the bill's text safety evaluation reports. *See* AV START Act, *supra* note 100, §§ 9, 11, 13–15. Section 10 of the bill, for example, would have "a technical committee of outside experts appointed by the DOT to generate technical recommendations for rulemakings and standards with respect to HAVs" and only provide their recommendations for rulemaking five years of the enactment of the AV START Act.). Senate Committee on Commerce, Science & Transportation, American Vision For Safer Transportation Through Advancement of Revolutionary Technologies Act, S. REP. No. 268 (2017), https://www.congress.gov/115/crpt/srpt187/CRPT-115srpt187.pdf.

165. NATIONAL CONFERENCE OF STATE LEGISLATURES, Autonomous Vehicles State Bill Tracking Database (Dec. 10, 2019), http://www.ncsl.org/research/transportation/autonomous-vehicles-legislative-database.aspx.

166. STATE AV LEGISLATION, *supra* note 55.

167. *Municipal AV Pilots Report*, *supra* note 19 at 2.

running AV pilots[168] often with great results as success stories in Part IV of this paper have demonstrated.[169]

If the AV START Act were passed, many of these laws and the bulk of local AV pilots could grind to a halt before NHTSA could come up with its own set of regulations after going through a lengthy rulemaking process.[170] Much of the current AV experimentation that is critical to the technology's future would also grind to a halt. Specifically, the AV START Act would have prevented states and localities from "adopt[ing], maintain[ing], or enforc[ing] any law, rule, or standard regulating the design, construction, or performance" of AV in areas such as "data recording," "capabilities," and "automation function,"[171] which bear significantly on states' ability to conduct AV pilots.[172] States currently have rules on what AV firms need to report when testing their vehicles as discussed in Section IV.A, including the frequency of disengagements as an important (albeit imperfect) metric of AV safety performance.[173] The AV START Act, however, would explicitly prohibit states from enforcing data recording and other requirements indefinitely even if federal standards are never developed, a concern a group of senators have raised.[174] Without the ability to require up-to-date information on AV safety performance from AV firms, states and localities will be crippled in their attempt to produce iterative regulations that adapt to the fast-changing AV landscape.[175] Two of the three essential elements for state success as detailed in Sections IV.A-B—information reporting and fast-moving regulation—would thus be undermined by federal preemption of "data recording" regulations.[176]

Similarly, federal preemption of state "capabilities" and "automation function" rules without developing its own standards first would leave otherwise vibrant state pilot licensing and testing regimes in limbo.[177]

The AV START Act defines "capabilities" as "the capabilities and limitations of the highly automated vehicle or automated driving system, including its expected SAE level"—that is, how autonomous a vehicle is and to what extent it can do away with drivers.[178] If states were barred from requiring certain levels of automation before permitting firms to conduct pilots, the entire

168. *Id.* at 20–31.

169. *Id*.

170. *See* AV START Act, *supra* note 100 at § 3 (preempting states from "adopting, maintaining, or enforcing" any AV regulation).

171. *See* AV START Act, S.1885, 115th Cong. § 3(a)(3)(A) (2017) ("No State or political subdivision of a State may adopt, maintain, or enforce any law, rule, or standard regulating the design, construction, or performance of a highly automated vehicle or automated driving system with respect to [nine important subject areas]," including data recording, capabilities, and autonomous function).

172. STATE AV LEGISLATION, *supra* note 55.

173. Kang, *supra* note 109.

174. *See* Senator Dianne Feinstein et al., *Letter to Senators Thune and Peters,* U.S. SENATOR FOR CAL. DIANNE FEINSTEIN (Mar. 14, 2018), https://www.feinstein.senate.gov/public/index.cfm/press-releases?ID=46E4DC09-C5AB-4301-98C1-CBB225AE24F8 ("Until new safety standards are put in place, the interim framework must provide the same level of safety as current standards do.").

175. *Id.*

176. AV START Act, S.1885, 115th Cong. §§ 4, 9 (2017).

177. *Id* at § 9; Jesse Woo, *Jan Whittington, Ronald Arkin, Urban Robotics: Achieving Autonomy in Design and Regulation of Robots and Cities*, 52 CONN. L. REV. 319, 389 (2020).

178. AV START Act, S.1885, 115th Cong. § 9(b)(6) (2017).

permit-based regime at the core of many regional pilots would collapse, as a permit without requirements is a free pass after all.[179] For example, California's AV testing program requires an AV manufacturer to have "reasonably determined that [it] is safe to operate the vehicle[s] in each operational design domain" intended for the testing; Boston has similar standards covering "basic driving capabilities, such as staying within a lane" and "emergency braking and emergency stop functionality" for tested AVs; and Arizona demands that driverless AV testing—part of Waymo's offering[180]—must achieve a "minimal risk condition" when the "automated driving system" disengages.[181]

Moreover, the "automation function" element of the AV START Act references an AV's "design domain"—such as the "roadway" and "infrastructure assets" required of AVs to operate.[182] Federal preemption on this front would paralyze states' location and scenario-specific testing rules. State and local licensing requirements for public road testing, closed-route pilot, and pilots limited to certain districts,[183] for example, would be unlawful under the Act, as they allow testing only under specific roadway and infrastructure conditions.[184] This preemption can be particularly problematic given that the technical constraints of AV technologies today often confine meaningful commercialization to limited areas such as ports, highways, and designated neighborhoods.[185] Preventing states from regulating AVs and pilots in these specific areas would obstruct important ongoing developments in AV technology iterations.

While technically the AV START Act would only prohibit states from regulating AV's "design, construction, and performance"[186] and the states would maintain authority over matters such as driver licensing, "[s]tate officials have countered by saying those delineations would be meaningless" when no human

179. *See* Forest Time, *What Will Prevent Me From Getting a Pilot License?*, CHRON, https://work.chron.com/prevent-getting-pilot-license-30770.html (last visited Oct. 21, 2020); Cecilia Kang, *Self-Driving Cars' Prospects Rise with Vote by House*, N.Y. TIMES (Sept. 6, 2017), https://www.nytimes.com/2017/09/06/technology/self-driving-cars-prospects-rise-with-vote-by-congress.html.

180. Daisuke Wakabayashi, *Waymo's Autonomous Cars Cut Out Human Drivers in Road Tests*, N.Y. TIMES (Nov. 7, 2017, 12:11 PM), https://www.nytimes.com/2017/11/07/technology/waymo-autonomous-cars.html#:~:text=SAN%20FRANCISCO%20%E2%80%94%20The%20self%2Ddriving,its%20chief%20executive%20said%20Tuesday.

181. STATE OF CAL. DEP'T OF MOTOR VEHICLES, AUTONOMOUS VEHICLE TESTER (AVT) PROGRAM APPLICATION FOR MANUFACTURER'S TESTING PERMIT § 4(2) (2017); *Autonomous Vehicles: Boston's Approach*, CITY OF BOS., https://www.boston.gov/departments/new-urban-mechanics/ autonomous-vehicles-bostons-approach (last updated June 3, 2020); Ariz. Exec. Order No. 2018-04 (Mar. 1, 2018).

182. AV START Act, S.1885, 115th Cong. § 9(b)(9)(A) (2017).

183. *See* Manufacturer's Permit to Test Autonomous Vehicles That Do Not Require a Driver, CAL. CODE REGS. tit. 13, § 227.38 (2020) (outlining test retirements for autonomous vehicles without a driver).

184. *See* AV START Act, S.1885, 115th Cong. § 9(b)(9)(A) (2017) (stating that vehicle must operate on any roadway or infrastructure asset).

185. *See* TUSIMPLE, *supra* note 7 (explaining that a self-driving trucking company that can navigate different environments); Andrew J. Hawkins, *This Cheerful Waymo Ad Highlights All the Ways We'll Use Self-Driving Cars in Our Daily Lives—It's Also a Stark Comparison to Waymo's Current Situation*, THE VERGE (Mar. 3, 2020, 1:13 PM), https://www.theverge.com/2020/3/3/21162924/waymo-ad-self-driving-car-taxi-delivery-truck-logistics (discussing self-driving technology's "(very) slow-moving march toward commercialization" and Waymo's commercial use within a 100-square-mile zone in a Phoenix, Arizona neighborhood).

186. AV START Act, S.1885, 115th Cong. § 3(a)(3)(A) (2017).

is driving the car—since traditional state licensing requirements governing drivers would now directly affect vehicle operations for AVs.[187] Certain key elements of state regulation of AV testing can also be reasonably interpreted to interact with AV design and operations—for instance, requiring information reporting often means AV providers have to design certain information collection features into their vehicles and ensure the cars operationalize these features accurately and reliably.[188] State regulation over these key elements would thus be prohibited under the law. Moreover, it is impracticable for the federal government to partner with the numerous AV companies out there in conducting pilots, which the state and local governments are doing readily today.[189] Likely substantial interference with vibrant state experimentation therefore strongly militates against federal preemption without substantive federal rules being developed first.

B. Federal Minimum Standards

The problem of federal preemption is two-fold: one is preventing state and local standards; the other is the lack of federal rules to replace them.[190] But it is possible for the federal government to play a role—once it has developed its own rules—without stifling state experimentation: setting minimum standards that can avoid races to the bottom and foster a healthy iterative governance regime even as states compete against each other in attracting AV providers by offering ever lighter regulations. Beyond these minimum standards, states can then set equally or more demanding rules, thereby allowing continued experimentation.

The example of how Uber moved its AV fleets from San Francisco to Arizona is illustrative of this idea.[191] In 2016, California regulators ordered Uber to shut down its AV trials that just started in San Francisco for not having permission from the California Department of Motor Vehicles.[192] Uber quickly contacted the Arizona Governor, who warmly welcomed the company without asking it to first obtain a permit from Arizona, and the company moved a fleet of driverless sport utility vehicles to Arizona and started pilots soon after the incident.[193] Part of the reason why Uber decided to forgo obtaining permit from California can be attributed to California's requirement for disclosing the frequency of a company's AV disengagements—the number of times a driverless car switched from autonomous mode to human-driven mode, a proxy

187. Kang, *supra* 179.

188. *See* CAL. CODE REGS. tit. 13, § 228.06 (requiring information about car performance to be reported).

189. *See* Greg Gardner, *Feds Push Autonomous Vehicle Companies To Report When Things Go Wrong*, FORBES (June 15, 2020), https://www.forbes.com/sites/greggardner/2020/06/15/feds-push-autonomous-vehicle-companies-to-report-when-things-go-wrong/#129f53655838 (listing the states that have partnered with AV companies to share information).

190. *See* TUCKER ELLIS LLP, THE REGULATORY ROAD FOR AUTONOMOUS VEHICLES: ABSENCE OF FEDERAL LAW HAMPERS U.S. DEVELOPMENT (2018), https://www.tuckerellis.com/files/16548_the_regulatory_road_for_autonomous_vehicles_december_2018.pdf (describing the lack of federal regulations in regards to autonomous vehicles).

191. *See* Kang, *supra* note 179 (explaining the move Uber made to Arizona for its self-driving cars).

192. *Id.*

193. *Id.*

for AV technologies' reliability—which irked AV providers who claimed those statistics give misleading impressions of safety.[194]

When states such as Arizona and California compete to attract AV companies, a race to the bottom can happen without external forces setting the floor.[195] In the case of Uber, the company preferred to have less reporting of its AV pilots, and Arizona has few reporting requirements (and certainly no disengagement disclosure rules) compared to California, so the AV provider happily moved to the state with a less stringent regulatory regime.[196] As Section IV of this paper shows, however, information reporting is essential to an iterative governance regime for self-driving cars.[197] Yet to attract AV providers, many states may compete with barely sufficient regulatory requirements similar to what Arizona did and undermine this keystone of iterative governance.[198] Such a regulatory race to the bottom with lackluster requirements can lead to safety hazards—Arizona's lax approach may be one factor behind the fatal 2018 Uber crash in the state.[199] To maintain an iterative governance model that can survive this kind of interstate competition without compromise, it is therefore important to have the federal government establish a limited set of key rules, in particular a minimum reporting standard for AV pilots, that set the boundaries of interstate competition while states develop their respective regulatory experiments.[200]

While many such rules might be useful for iterative AV regulation, this paper focuses on federal minimum information reporting requirements, which is the corner stone of AV's evolutionary governance.[201] To foster iterative AV governance, Congress should authorize an executive branch agency such as NHTSA to promulgate federal minimum reporting requirements for AV pilots.[202] As in the case of California, the information required from AV providers should not be limited to the design and operation of self-driving cars, but also their performance (especially with regard to safety) in order to provide feedback for regulators concerned about AV safety and utility.[203]

Metrics such as frequency of disengagements, or a more detailed version thereof as argued in Section IV.A, should be part of the disclosure from AV pilots.[204] Importantly, AV providers should also equip their vehicles with "black

194. *Id.*

195. *Id.*

196. *Id.*

197. *See* Strickland & McNelis, *supra* note 106 (describing the reason as to why states ask for reports from AV companies).

198. See *id.* (stating that AV companies strongly dislike reporting problems).

199. *See* Andrew J. Hawkins, *Serious Safety Lapses Led to Uber's Fatal Self-Driving Crash, New Documents Suggest*, VERGE (Nov. 6, 2019, 11:45 AM), https://www.theverge.com/2019/11/6/20951385/uber-self-driving-crash-death-reason-ntsb-dcouments (stating the reason as to why Uber's self-driving car crashed).

200. *See* TUCKER ELLIS LLP, *supra* note 186 (expressing the need for federal regulations on AV).

201. *See* AV START Act, S.1885, 115th Cong. § 9 (listing out the minimum federal reporting requirements).

202. *See* Austin Brown et al., *Federal, State, and Local Governance of Automated Vehicles*, UC DAVIS INST. OF TRANSP. STUD. & POL'Y INST. FOR ENERGY, ENV'T, AND THE ECON. (Dec. 2018), at 1, 8, https://policyinstitute.ucdavis.edu/wp-content/uploads/AV-Governance_IssuePaper_1218.pdf (explaining the importance for gathering reporting information).

203. *See id*. at 12 (describing the need for information on safety).

204. *See* CAL. CODE REGS. tit. 13, §227.50 (2020) (requiring the annual report to include disengagement information including the description of the facts causing the disengagement).

boxes" that record accident data similar to the aviation industry—as California's DMV currently requires[205]—so that law enforcement can access the data and investigate accidents, and companies as well as regulators can decide what might be the best strategies to prevent these accidents. Broad industry participation would be helpful in establishing the rules as Section IV.A has explained.[206] States can build upon these rules and require further information as they see fit, but the federal rules serve as the floor of AV regulations that companies have to follow, in order to prevent regulatory races to the bottom as happened in the Uber-Arizona case.[207]

C. Fragmentation, Model AV Code, and Inter-Regional Cooperation

As AV technologies develop, regulators may have an improved understanding of and greater consensus on what sorts of rules are needed.[208] To that end, the federal government could help develop a voluntary model AV code in the meantime to address regulatory fragmentation as states develop different AV standards—a fear of many firms[209]—as a result of strong involvement of state/local governments.[210] To allay this concern, which is valid, it is helpful to have the federal government invest in standard-setting across states as well as to encourage inter-regional cooperation to reduce fragmentation.

For example, Congress could include in its spending bill funding for research into and drafting of a set of model AV regulatory standards which serve as guidance that states could adopt, much like the Universal Commercial Code or Model Penal Code that many states have adopted for their contract law or criminal law regimes.[211] It is true that NHTSA has released voluntary guidance on AV safety and model state policies in the past.[212] But its voluntary guidance

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205. *Compare id.* at § 228.06 ("The manufacturer shall certify in the application that the autonomous vehicles are equipped with an autonomous technology data recorder . . . ."), *with* 49 C.F.R. § 563 (NHTSA not requiring Event Data Recorders but only standardizing the data these recorders capture), *and* Federal Motor Vehicle Safety Standard; Event Data Recorders, 84 Fed. Reg. 2,804 (Feb. 8, 2019), https://www.federalregister.gov/documents/2019/02/08/2019-01651/federal-motor-vehicle-safety-standards-event-data-recorders ("NHTSA withdraws its . . . notice of proposed rulemaking . . . mandating installation of an Event Data Recorder.").

206. Balleisen, *supra* note 112.

207. Hawkins, *supra* note 199.

208. *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, 136–38 (2019) (explaining that new regulatory measures are needed when AV technologies become more widespread).

209. *See, e.g.*, Request for Comment on "Federal Automated Vehicles Policy," 81 Fed. Reg. 65703 (Sept. 23, 2016) (showcasing the anticipations of several commentators growing fear of wildly different AV standards in various states); Mandel, *supra* note 16, at 5–6 (highlighting an example of the federal government's involvement in the AV industry).

210. *See* Mandel, *supra* note 16, at 5–6 (explaining that government regulatory agencies should encourage or require data gathering).

211. *See* AUSTIN BROWN, GREG RODRIGUEZ & TIFFANY HOANG, FEDERAL, STATE, AND LOCAL GOVERNANCE OF AUTOMATED VEHICLES, UC DAVID INST. OF TRANSP. STUD. & POL'Y INST. FOR ENERGY, ENV'T, AND THE ECON. 5 (2018) ("Congress had recently responded to calls for action from the private sector and increased its involvement in AV governance").

212. NAT'L HIGHWAY TRAFFIC SAFETY ADMIN., FEDERAL AUTOMATED VEHICLES POLICY: ACCELERATING THE NEXT REVOLUTION IN ROADWAY SAFETY (2016); NAT'L HIGHWAY TRAFFIC SAFETY ADMIN., FEDERAL AUTOMATED DRIVING SYSTEMS 2.0: A VISION FOR SAFETY (2017); U.S. DEP'T OF TRANSP., AUTOMATED VEHICLES 3.0: PREPARING FOR THE FUTURE OF TRANSPORTATION (2018).

is by definition not mandatory and also explicitly discourages states from codifying its language,[213] which can slow the adoption of relevant rules among states without the support of mandatory legal force (contrary to how UCC and MPC have been adopted, i.e., through statutory codification and mandatory legal authority).[214] NHTSA's model state policies have also been consistently shrinking in size and level of detail—from an 11-page section in 2016 to a one-to-two page overview in 2017, 2018, and 2020—and have never provided for certain key elements of state AV policy that have seen significant divergence among states as the paragraphs below discuss.[215] Other existing efforts, such as the Uniform Law Commission's Automated Operation of Vehicles Act by the National Conference of Commissioners on Uniform State Laws, focus on reforming outdated provisions in existing motor vehicle laws that assumed the presence of human driver, a laudable and important effort, but fall short on providing specific rules for governing AV operations and pilots.[216] A new push from the legislature therefore is needed to reignite the engine of a model AV code that is more specific to AV governance and more effective in achieving wide adoption.

As a starting point, after examining AV legislations from the 36 states that have them on the books, some common issues emerge as to which states tend to have different rules. A model AV code committee could therefore focus onto these issues to reduce fragmentation: (1) conditions under which an AV provider can test and run self-driving cars that do not have human drivers behind the steering wheel;[217] (2) the minimum amount of insurance that AV providers must carry for each of their autonomous vehicles—current requirements range from zero to $2 million to $5 million;[218] (3) whether ride-sharing should be allowed for autonomous vehicles; (4) what, if any, AV firms should be required to do

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213. *See* NAT'L HIGHWAY TRAFFIC SAFETY ADMIN., FEDERAL AUTOMATED DRIVING SYSTEMS 2.0: A VISION FOR SAFETY, at 18 (2017) ("NHTSA strongly encourages States not to codify this Voluntary Guidance (that is, incorporate it into State statutes) as a legal requirement for any phases of development, testing, or deployment of ADSs.").

214. *See id.*

215. NAT'L HIGHWAY TRAFFIC SAFETY ADMIN., FEDERAL AUTOMATED VEHICLES POLICY: ACCELERATING THE NEXT REVOLUTION IN ROADWAY SAFETY (2016); NAT'L HIGHWAY TRAFFIC SAFETY ADMIN., FEDERAL AUTOMATED DRIVING SYSTEMS 2.0: A VISION FOR SAFETY (2017); U.S. DEP'T OF TRANSP., AUTOMATED VEHICLES 3.0: PREPARING FOR THE FUTURE OF TRANSPORTATION (2018); U.S. DEP'T OF TRANSP., ENSURING AMERICAN LEADERSHIP IN AUTOMATED VEHICLE TECHNOLOGIES: AUTOMATED VEHICLES 4.0, at 29–30 (2020).

216. *See generally* NAT'L CONF. OF COMM'RS ON UNIFORM STATE LAW, UNIFORM AUTOMATED OPERATION OF VEHICLES ACT § 5(e) (Dec. 3, 2019), https://www.uniformlaws.org/viewdocument/final-act-no-comments-105 (requiring a vehicle to be "lawfully insured" for testing on public roads, but do not specify any insurance amount, a point of divergence between states as discussed below. Similarly, the Act gives states right to revoke AV license if an AV is not "fit to operate," but does not specify what such fitness entails—in particular neglecting any discussion of an ongoing performance reporting requirement).

217. *See, e.g.*, CAL. CODE REGS. tit. 13, § 227.38 (2020); SB313, 80th Leg. (Nov. 2019) (outlining the requirements of a manufacturer in identifying the conditions in which a vehicle can be driven safety in autonomous mode).

218. *E.g.*, S02005C, 2017 (N.Y. 2017); MICH.DEP'T OF TRANSP. & CTR. FOR AUTOMOTIVE RES., *supra* note 48, at 25.

after an accident (e.g., have human controllers of vehicles remain at the scene or not); and (5) how AVs should interact with law enforcement after an accident.[219]

Scholars have also debated the need for a common state tort liability regime, likely a significant forum for resolving emerging AV accident disputes, with a recent proposal focusing on product liability during the transition into widespread use of highly autonomous vehicles and strict manufacturer liability after the transition.[220] Regardless of which tort or insurance regime states adopt, it would be wise to reach consensus on key questions such as: (1) who should be the principal focus of liability (e.g., manufacturer vs drivers, pedestrians, or other AV component makers); (2) the choice between negligence versus strict liability regime, related insurance coverage requirements; and (3) the AV usage threshold for adopting a new regime[221] through a model AV code in order to resolve the inherent uncertainty of varied state tort regimes.

While states are not required to follow the model code, at least at first, the presence of a common core of standards that take into account the circumstances and industry dynamics of each state could be good guidance that can lead to state law convergence (similar to UCC and MPC) and lay the groundwork for an eventual federally administered national standard.[222] To that end, inter-regional alliance can also help reduce fragmentation as a supplement to the national model code.[223] As the National League of Cities report on municipal pilots points out:

> The greater the testing area that municipalities can offer to piloting entities, often the more robust the argument. For example, Texas hosts a wealth of AV pilots, covering both urban spaces and highways, within its metropolitan triangle between San Antonio, Austin, Dallas and Houston. Regional alliances also help in attracting state and federal funding. Further, coordination between cities provides a streamlined experience for the private sector.[224]

Smaller states/cities can also join larger states or those who have already developed relevant capabilities in conducting their pilots or developing regulations to promote regulatory consistency, save resources, while reaping the benefits of the AV revolution. For instance, Austria joined with Hungary and Slovenia in 2018 in agreeing to establish cross-border development and testing of new vehicle technologies including AVs.[225]

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219. *See* STATE AV LEGISLATION, *supra* note 55 (portraying the common issues across states regarding insurance, ride-sharing, the potential responsibilities of AV firms, and future plans for law enforcement involving AV). Cybersecurity and privacy may also be important issues the committee could study and provide rules on, although currently states have not provided much detail on those fronts, suggesting their relatively lesser significance at this point of the AV technology lifecycle. State tort liability is another area of potential fragmentation, which may benefit from a model rule.

220. *See* Abraham & Rabin, *supra* note 208, at 127 (debating the best liability regime for AV accident disputes).

221. *See id.* at 149–50, 153–55, 161–64 (discussing the significance of these questions).

222. *See* MUNICIPAL AV PILOTS REPORT, *supra* note 19, at 35 (emphasizing the need for collaboration of both the states and their respective local municipalities on AV governance).

223. *Id.*

224. *Id.*

225. INTERNATIONAL AV REPORT, *supra* note 79, at 29.

Of course, the iterative process of AV governance may not always be in a state of constant flux as it often is today. The industry will likely reach a point sometime in the future where AV safety standards and the technology become clearer and more widely understood.[226] At that point, the federal government can promulgate more substantive, mandatory rules regarding AV safety and other aspects of its operations, such as providing for rules regarding physical driver presence, insurance, accident liability, cybersecurity, privacy, etc. It can establish rules for matters that have been well-understood first before moving into less clear territories, but it does not necessarily have to set all rules at once.

Ultimately what is important is that the federal government maintains a healthy environment where states and localities can experiment with their regulatory regimes, ensures that the competition between them can gradually improve AV safety and performance in general without getting into a downward, deregulatory spiral, and helps reach consensus and reduce fragmentation in the process. When the state experiments have produced sufficient regulatory clarity and consensus, the federal government can then step in and build a national regulatory framework for autonomous vehicles without hurting state and local innovations.

VI. CONCLUSION

Clinical trials are essential for a drug to prove its safety and efficacy before the FDA. So are trials critical to autonomous vehicles. As the technology takes a variety of different shapes in the coming decades, it needs a supportive and adaptive environment to thrive.

This paper has discussed AVs' positive externalities and made the case for government support, as well as what forms that support might take. It has also examined over 100 current examples of AV pilots and regulations across America and the world to find key elements for an iterative model of AV governance to work. To safeguard the dynamic and vibrant regulatory experiments, the federal government needs to set the rules of the competition between regions without stifling the innovative spirit and help standardize and coordinate efforts along the way to foster healthy coopetition among states and localities.

The automobile has changed the world and has famously made America a nation on wheels. Another revolution is poised to happen, as long as governments across the country can play the right roles.

226. *See* Abraham & Rabin, *supra* note 208, at 136–38.