Deciphering Autonomous Vehicle Regulations with Machine Learning

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1. Introduction

Economic and safety incentives are the primary motivators for autonomous vehicle (AV) deployments. The society of automotive engineers (SAE) categorized vehicles that can always operate without a human driver as level 5 automation [1]. Incentives include significant cost savings from eliminating the human driver, increased efficiency by operating at all hours, and enhanced safety by reducing accidents attributable to human factors such as intoxication and distracted driving [1]. Autonomous trucks can additionally benefit by eliminating driver-related costs like insurance, training, and onboard amenities for human comfort and entertainment. Despite these advantages, concerns about technology readiness and potential negative impacts on traffic safety and congestion have emerged. Such apprehensions have led to state-level legislative actions, including laws mandating a human backup driver, which counteract the core benefits of AVs [2].

Currently, the United States lacks comprehensive federal regulation to uniformly address the safety, design, and operation of AVs. The failure of the 2018 U.S. Senate bill, AV START, due to safety concerns, has left a void filled by individual states introducing their own AV legislation [3]. This has resulted in a fragmented regulatory environment, posing challenges for AV manufacturers and stakeholders who must navigate a patchwork of state-specific laws [4]. Furthermore, existing regulations often do not adequately differentiate between the operation of autonomous trucks and other vehicle types, each with distinct sets of stakeholders.

2. Deciphering Autonomous Vehicle Regulations with Machine Learning

The literature on AVs reveals uncertainties about their impact on traffic, infrastructure, supply chain operations, the environment, and the economy. For instance, some predict that AVs will reduce congestion because they can

smooth out traffic flows by eliminating the accordion effect [2]. Another optimistic expectation is that AVs will be safer because they will eliminate errors due to human factors [4]. Contrary views are that AVs will increase congestion because induced demand from lower costs and greater accessibility to non-drivers will add more vehicles to the road, including empty vehicles [5]. Some researchers posit that AVs will never fully eliminate crashes due to human factors so long as they coexist with human-driven vehicles [6]. Research has also highlighted that AVs can exacerbate inequities if policies do not address access for people with low income, people of color, and rural communities [7].

The regulatory landscape allowing AV operation on U.S. public roads is dynamic and involves a complex interplay between federal and state authorities [3]. There is a growing consensus that the federal government should oversee aspects such as accessibility, safety, design, and manufacturing, whereas state and local governments should retain their traditional roles in regulating titling, registration, traffic laws, and deployments [8]. Toward that end, the National Highway Traffic Safety Administration (NHTSA), a federal agency of the U.S. Department of Transportation (USDOT), updated its safety standard to include aspects of AVs such as not mandating steering wheels and driver's seats [9].

AVs cannot become an affordable and robust form of transportation until the legislative landscape matures [10]. However, ensuring safety, liability, and regulatory compliance in an evolving field often faces hurdles in legislative processes [11]. An exhaustive review of all the recent AV bills that failed revealed a complex interplay of factors. These include a lack of support from legislators, a lack of consensus, safety concerns, opposition from influential stakeholders such as labor unions, competing legislative priorities, and concerns about the practicality of enforcement, technology readiness, and policy implications such as potential economic impact. The literature does not currently offer a comparative analysis between states with differing legislative outcomes to provide more depth in understanding why certain regulations passed or failed, so future work could fill that gap.

There was a limited amount of research that recently explored the association of features in an authority with its propensity to pass supportive AV regulations. Alnajjar et al. (2023) analyzed panel data from 2011 to 2018 and found that an increase in a city's use of electric vehicles, gross domestic product (GDP) per capita, freeway vehicle miles traveled (VMT), and land use score was positively associated with the allowance of AV testing, whereas an increase in fatality cases had a negative association [12]. Bezai et al. (2021) noted that perceived safety issues and public acceptance are predominant barriers to AV adoption [13]. A survey by Freemark et al. (2020) revealed that population size and liberal political ideologies are strongly associated with support for policies that regulate AV use to increase mobility for the low-income and disabled populations, reduce pollution, reduce traffic, increase transit use, and reduce the use of private cars [14]. The study also found no connection between population growth and support for general AV regulations. A survey by Mack et al. (2021) found that, compared with conservative ideologies, moderates and liberals reported higher AV adoption intention based on both higher perceived benefits and lower perceived concerns [15]. A survey by Othman (2021) revealed that the level of fear of AVs increased with an increase in the number of crashes involving AVs [1].

While the literature explores optimistic and pessimistic predictions about AVs, the present research provides a grounded analysis of how legislative actions are translating these expectations. This helps in understanding the practical challenges and considerations, which often go beyond theoretical discussions, that policymakers face. Whereas some research provided a high-level comparison of how other countries approach AV laws [3], there have been no comprehensive and recent studies focused on the dynamic U.S. regulatory landscape. Hence, the present research fills that gap by conducting an exhaustive review of recent AV bills in the United States to uncover the multifaceted factors influencing the success or failure of AV legislation.

While previous studies have explored associations between various socio-economic factors and AV regulation, the present research contributes by employing ML techniques to systematically analyze and rank these factors. This methodological rigor provides a more robust and data-driven foundation for understanding the dynamics of AV regulation. Furthermore, the present research aligns with and expands upon the findings of Freemark et al. (2020) and Mack et al. (2021) by offering empirical evidence on how political ideologies and public perceptions might influence AV legislation. This contribution is crucial in understanding the policy landscape, especially in terms of addressing public concerns and shaping future legislative strategies.

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