Exploring the Implications of Autonomous Vehicles on Urban Social Inequality

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction:

Throughout mankind's storied history, there have been many technological innovations that have transformed the way humans interact with the world around them. Examples include the invention of the wheel, the printing press, light bulbs, and telephones (Gormley, 2000). Such inventions went beyond simply boosting productivity. Instead, they revolutionized the human experience and altered the course of civilization. They transformed economies, shifted power dynamics, and expanded the realm of what was thought possible. Another such invention is the introduction of the personal car.

Ever since the introduction of the first personal car in the late 1800s (Gormley, 2000), there has been a relentless pursuit of trying to autonomize as many aspects as possible. Autonomous Vehicles (AVs) got their start in the early 1900s, with the introduction of remote-controlled cars. Since then, AVs have come closer and closer to becoming a reality, with companies now testing fully autonomous vehicles (Bimbraw, 2015). AVs make many promises, including increased safety, decreased emissions, and increased productivity. With the impact that personal vehicles have on people's everyday lives, these claims carry significant merit (Wallace, 2017).

However, amid the optimism regarding AVs, there is a downside. As with many previously maladapted technologies, there is potential for AVs to not only fail to deliver on the promises they make, but instead exacerbate current socio-economic issues (Bills, 2020). Studies of historical revolutionary technologies show that without careful consideration, restrictions, and guardrails, technologies can end up doing a lot more harm than intended, such as the negative mental health effects of social media (Berryman et al., 2018) and the environmental damage caused by pesticides (Aktar et al., 2009). Another such example is the invention of the K-cup.

The K-cup (Keurig coffee cup) are small coffee pods that inadvertently led to environmental issues due to them indirectly promoting the use of single use, disposable plastic cups (Webb, 2016).

Regarding AVs, this issue becomes even more pressing since, as Bills (2020) notes, there are not enough studies done on the impact of AVs on different socio-economic groups. This research dives into the impact of AVs on urban social inequality, and ways of mitigating the negative impacts. Doing so necessitates a complete map of all actors including government regulators (of all sizes), AV manufactures, non-AV manufacturers, public transit companies, and different socio-economic groups of riders. Without adequate guardrails and regulations AVs will only serve to exacerbate urban social inequality, increasing both the geographical and economic differences between different economic classes. It will also serve to place millions of Americans out of jobs. However, with strategic regulations, all parties stand to benefit. AV manufactures can capitalize on business opportunities both in private and public spaces, and social inequality can decrease across all groups by promoting a shared model of ownership.

Background and Significance:

Although the thought of AVs seems like something that has only recently become a reality, they have been a long time in the making. The first sight of an unmanned vehicle was seen in New York City when Houdina Radio Control showed a radio-controlled car (Bimraw, 2015). The first truly autonomous vehicles were seen in the late 1960s and early 1970s, producing small carts and cars going at slow speeds (Stanchev & Geske, 2016). Progress in AVs really started to pick up in the mid to late 1980s, when the Defense Advanced Research Projects Agency (DARPA) – an agency of the Department of Defense – started giving grants and funding research regarding the development of AVs for military purposes. This resulted in the development of the DARPA Autonomous Land Vehicle, which could drive completely unmanned from predetermined points (DARPA, 1986). Development started to spew into the private sector when DARPA hosted its first Cyber Grand Challenge, which challenged teams to complete an unmanned drive from Barstow, CA to Primm, NV. Although no team was able to complete this challenge in the first year, this challenge continued into the next year where the winning team won $2 million (The Grand Challenge, n.d.).

Initial interest in AVs were mainly focused on military projects, partly because computer systems were not as advanced, and the resources needed to research AVs were not possible without military funding (Stanchev & Geske, 2016). As time passed, a combination of public interest in AVs along with the technology related to AVs (such as sensors, compute infrastructure, software capabilities, and production) becoming cheaper caused private companies to develop their own vehicles. Products like Google's Waymo, Cruise, and Tesla autopilot have paved the way for major automobile corporations to create their own AV divisions (Greenwood, 2022).

AVs will have a significant impact on the economy. Around 1 in every 9 jobs are in some way impacted by the transportation industry. This includes public transit officials (like light rail systems and busses), taxi and rideshare drivers, pilots, and truckers. This also includes people not directly in the transportation industry but are impacted by their business such as gas station and traveling lodges for truckers and long-distance travelers (Wallace, 2017). The introduction of personal autonomous cars means the introduction of autonomous trucks, public transit, and flights (Helfrich, 2022). With such a vast economic impact, it is important to carefully consider the socio-economic ramifications of AVs before they are put into the market. Studies need to be done on the current skills these workers possess, what types of new jobs can be created in the

AV ecosystem, and how to create programs and structures to help develop and transfer their skills into a new job.

There is also not enough research regarding the social impact of AVs (Bills, 2020). Current AV research is extremely technological heavy, and even the ones that are socially focused are flawed. Fewer than 20% of AV social research fail to thoroughly consider all social groups. The polling samples are simply not diverse enough to get an accurate understanding (Bills, 2020). The few studies that account for all social groups ask biased questions or put participants in unrealistic scenarios (Bills, 2020). A complete map of all stakeholders must be created to fully understand the social implications of AVs.

AVs will come sooner rather than later. Optimists predict that AVs will replace non autonomous cars by the 2030s, and even pessimistic predictions slate the early 2040s as the date when AVs take over (Littman, 2023). With the speed of technology vastly surpassing the speed of regulation, there is only a short amount of time for governments to act. AVs are the future, and it is imperative to be proactive rather than reactive (Helfrich, 2022). The economic and technological impact of AVs combined with their lack of through social research means it becomes increasingly important to study the impact of AVs on urban social inequality. Doing so will identify which aspects of AVs contribute to exacerbating social inequality, and which aspects can help decrease it. This can be used to help generate best practices that government regulators and AV companies can consider when deciding legislation and product strategy respectively (Bills, 2020).

Methedology:

To study the impact of unregulated AVs on urban social inequality, Actor Network Theory (ANT) was used (Law, 1972). The comprehensive study of the social impact of AVs inherently requires mapping out the different social groups and stakeholders involved, how they interact with each other, and what effect each group will have on the other. This defines ANT perfectly, which makes it a great framework to use (Law, 1972). This will be combined with the concept of latent and manifest function / dysfunction, which defines the phenomena of intended (manifests) effects of a system and its unintended (latent) effects (Merton, 1968).

To use ANT, it is necessary to first define all the actors involved. On the side of creating AVs, there are the manufacturers, engineers, and marketers. Since these groups are generally not making individual decisions, only doing what the management tells them to, they can all be grouped into a category called AV companies. There are also traditional, non autonomous vehicle companies, which are either fighting against the adoption of AVs, or are waiting to develop their own in-house AV research lab. Next are public transit companies, most of which are under government supervision. Another important actor is the government. Governments (of all sizes) are responsible for publishing best practices, setting industry standards and guidelines, and regulating what AVs can and cannot do. They will be important in creating and enforcing regulation.

In most other studies, the users of the AVs are classified as one actor or one body (Bills, 2020). However, to conduct comprehensive research on social inequality, it is necessary to split them up into different socio-economic groups. In the economic aspect, users can be split into 3 classes: upper class, middle class, and lower class. Since research is being done in an urban setting, only those in the upper class will be considered to have personal cars. The middle class and lower class are those who rely on ridesharing / taxi services, or those who take public transit.

Although in suburban / rural environments, people across social calsses own cars, in an urban setting, it is extremely expensive and inconvenient to own a car, so only the upper class can afford that luxury (Sorrel, 2015). On the social side, people can be split into areas that have poorly serviced public transit routes, people that have well serviced public transit routes, people that are disabled, and older people. This creates 7 different socio-economic groups (3 economic and 4 social). People can also fall into multiple socio-economic groups (such as older lower-class people, or middle class disabled people). In this situation, the worst case was taken into consideration. ANT data collection was conducted through literature review. This helped to create a map of the different groups involved and how they interacted with each other.

The concept of latent and manifest function / dysfunction is highly relevant to the study of AV social impact. AV manufacturers often make many promises (manifest) such as reduced emissions, decreased traffic, increased productivity, and high levels safety. However, they never talk about the unintended or secondary consequences that may come as a result (latent).

To better understand the secondary consequences of AVs, case studies were conducted on the adoptions of previous technologies (specifically related to the transportation industry). Conducting these studies helped uncover the connections between technologies and their unintended, dysfunctional outcomes. By uncovering these connections and patterns, parallels were drawn with modern day AV systems to construct guardrails that will ensure similar, negative outcomes don't happen again. Policy analysis was also conducted to figure out what the current interests of governments are, and what their plans are for the future. Knowing current policy and plans for future policy can help generate regulations that align with the government's best interest, increases the chances of them getting passed. Finally, ethical analysis and assessments can be made on behalf of the AV manufacturers. Finding out what is morally right for the company to do instead of what makes business sense will help create best practices that ensure society can benefits of AVs without having to suffer from the potential downfalls.

Literature Review:

Litman, T (2023) in “Autonomous Vehicle Implementation Predictions: Implications for Transport Planning” reviews predictions regarding all aspects of AVs. The report starts by giving an AV adoption timeframe. The optimistic predictions indicate that by 2030, holistic and comprehensive AVs will be in mass production and will be adopted at a relatively large scale (Litman, 2023). However, these predictions are made by people with financial interests such as investors in AV companies. Thus, they have interests in expediting the expectations for faster and greater return on their investments. Realistic predictions following historical trends indicate that it will be closer to 2040 (Litman, 2023). However, it could be decades more before level 5 AVs are on the road due to technological challenges. It would take until about 2060 until half of vehicles on the road are level 5 AVs. (Litman, 2023). This gives a timeline of 15 years before AVs hit the road in significant numbers, and 35 years before they become the majority of vehicles on the road.

Initially, costs of AVs will be somewhere in between human operated vehicles and human operated taxi / ridesharing services. They will be more expensive than public transit options but less expensive than services such as Uber and Lyft. This provides a narrow span in the market that would make AV deployment profitable for AV companies and beneficial to the pubic (Litman, 2023).

One of the proposed benefits of AVs is that their efficiency can reduce total net travel by treating them like permanent taxis. This is paired with multiple other benefits such as reduced emission due to optimized routes, reduced parking costs / need for parking infrastructure in urban spaces, and increased road capacity, allowing more people to move on the same amount of existing infrastructure (Litman, 2023). However, with existing infrastructure and government regulations, vehicle travel / sprawl is expected to increase by 10% - 30% (Litman, 2023). This not only effectively negates the aforementioned benefits, but also causes additional harm such as increased traffic, employment reduction (from people that work in the transport industry such as cab drivers and truck drivers) and exacerbated social inequality. Litman predicts that unless a shared model of ownership is taken, the benefits of AVs will be marginal, since most costs offset by AVs (such as increased safety and potential productivity) will be negated by the economic and environmental costs of not adopting a shared model.

Another study was conducted by Garrick & Atkinson-Palombo (2019) titled “What do we want from Autonomous Vehicles (AVs)?”. This paper looks at the consequences of AVs, and surveyed people at a national forum in Bloomfield, CT to get the public’s opinions, as well as to promote safety, human control, and economic prosperity as it relates to AVs. The article starts by showing government interest in the development and the regulation of AVs from the federal level with people like former Transportation Secretary Anthony Foxx to the local level such as city planner Jeff Speck (Garrick & Atkinson-Palombo, 2019).

The participants came away with three general conclusions. The first is that they always want some form of human control in AVs. They believed that no technology could cover 100% of the edge cases so it is always important for a human to be able to come into the loop and take over if needed. This also takes away some of the ethical challenges with a 100% technological model relating to the trolley problem (Garrick & Atkinson-Palombo,2019). Most participants (80%) voted to implement AVs in a public transport context even if it is more expensive than current transit options (Garrick & Atkinson-Palombo, 2019). Participants were split when it came to the reallocation of jobs relating to the transport industry, with people agreeing that humas, not technology should be at the center of this transportation revolution but split on whether the burden of training the existing job force to other jobs should come on the government or current transport companies / unions.

Weng & Fiol (2022) wrote about how "Shared Autonomous Vehicles Could Improve Transit Access for People with Disabilities If Regulated Appropriately". They talk about how current personal vehicles are not made for those with disabilities, effectively making it so that they do not have the freedom of personal transit. AVs can be made to accommodate all kinds of disabilities since the human does not need to drive, giving everyone the freedom of personal transit. (Weng & Fiol, 2022).

Results and Discussion:

Without proper government regulation, AVs will only serve to exacerbate urban social inequalit. It will reduce up to 1 out of every 9 jobs (Wallace, 2017) and can lead to further physical and economical separation between the wealthy and the not wealthy (Litman, 2023). Many of the promises made by AV companies such as the increased safety and decreased pollution will not be realized (Litman, 2023), and the only people that stand to gain are those that rank high in the socio-economic ladder. However, with proper government oversight, people from all socio-economic classes stand to benefit, and the promises made by AV companies will come to fruition.

Using ANT, we can first classify the AV companies and how they will act. The best way to do this is to see how companies have acted in the past. Companies like Uber and Lyft have revolutionized taxi and ride sharing services across the world, but in doing so, have left certain socio-economic groups behind. Before Uber and Lyft, local governments used to oversee taxi and public transit services. Because of this, they had to ensure all people could be served, including those with disabilities. Companies like Uber and Lyft were able to skirt these regulations by calling themselves tech companies instead of what they are: transit infrastructure (Weng & Fiol, 2022). Without proper regulation, AV companies will act in their interests to maximize profits, not maximize social equality.

The next set of actors are government organizations. Government organizations are clearly interested in helping, but they usually cannot keep up with the fast pace of AV research and development (Garrick & Atkinson-Palombo, 2019). They also deal with lobbying forces from vehicle companies, both AV ones which have interest in pushing towards acceptance of AVs as quick as possible, and non-AV companies (another ANT set of actors), which have in interest in making sure they do not get accepted (Grossmann & Pyle, 2013).

The next set of actors are non-organizational powers. These are the 7 different socio-economic groups. Along the three different economic lines, AVs without regulations stand to benefit the upper class the most. They would have the most disposable income to afford their own AVs, which would allow them to live further away from urban centers and boost their productivity, making urban inequality worse. The lower-class citizens, without this disposable income and under a private ownership model would not be able to afford and thus reap the benefits of AVs (Garrick, & Atkinson-Palombo, 2019).

Moving to social classes, the elderly and those with disabilities stand the most to gain if they can afford the cost of AVs in a private ownership model. It provides them the freedom of personal transit. However, this comes with the large caveat that AVs are made with accessibility features in mind (Weng & Fiol, 2022). When looking at social lines between those well serviced by public transit routes and those not well serviced, a stark difference can be seen in situations of non-government intervention. As AV cost will fall somewhere in between public transit costs and human operated rideshare costs (Litman, T., 2023), those currently well serviced have more to lose and those currently not well serviced have more to gain. ANT analysis shows that without government interference, the only people that stand to gain are the wealthy, which only serves to exacerbate urban social inequality.

Government regulation is needed, as it not only allows all groups of people to experience the benefits of AVs, but solves many problems of urban social inequality. Pushing towards a shared model of ownership means everyone benefits. AV companies benefit because it means large scale contracts and increased initial usage. Without a shared model, AV companies will lose out on most buyers (middle and lower class) anyway, which means a shared model is beneficial to them as well. This immediately provides all economic classes with access to AVs. Although upper class people might still buy their own AVs, the inequality gap has significantly decreased. In social classes, both those serviced by public transit and those not serviced by public transit stand to benefit, as AV shared ownership is cheaper than rideshare, and government subsidies can bring the cost to as low as current public transit fares. All economic ranges of disabled and elderly people can also benefit from the benefit of personal transport.

Conclusion:

The scene of Autonomous Vehicles is a rapidly evolving field that promises to revolutionize travel and transport. However, AVs are not only a technical challenge, but a large social challenge as well. Vehicles and transport are large dictators and correlators of wealth prosperity (Fu et al., 2023). Actor Network Theory (ANT) was used to model four organizational groups (AV manufacturers, non-AV manufacturers, government organization, and public transit companies) and seven socio-economic groups (financial upper class, financial middle class, financial lower class, disabled, elderly, well serviced by public transit and poorly served by public transit). The actor / actor groups were selected to model the different forces in introducing AVs in an urban environment.

Without proper government regulation, the introduction of AVs will only serve to help the already financially well off while exacerbating urban social inequality issues. However, with government regulations promoting a shared model of ownership, all socio-economic groups can reap the benefits of AVs creating a safter, greener, and more equitable transportation future. The recommendations and best practices produced by this research can be used when governments of all sized are implementing legislature and regulations. It can also be used by AV stakeholders to ensure the most optimal deployment and adoption of AVs.

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