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# Disruptive transformation in the transport industry: Autonomous vehicles and transportation-as-a-service

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## Abstract

This paper seeks to explore the varying degrees of impact that Autonomous Vehicles and Transportation-as-a-Service will have on several key industries, and how players in those industries might adapt their business strategies to prepare for this revolution. Systematic literature review. Transportation-as-a-Service is still in its infancy when it comes to commercial trucking. The concurrent developments in the autonomous vehicle technologies opens up additional opportunities for disruptive transformations. The scholarly literature is lagging behind trade reports and the current review is an attempt to claim this space. New players might take birth to cater to the emerging needs and opportunities. There are losers and gainers among the existing players. Also, overall, these changes will contribute to greater sustainability in transportation. Implications for Auto Manufacturers, Auto Dealerships, Oil and Energy Companies, Battery Manufacturers, Tech Companies, Insurance Firms, and National Governments are discussed. One specific implication is an overriding message for adaptability to fully leverage the benefits of these disruptive innovations.

**Keywords:**
*Autonomous vehicles*
*Green economy*
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## 1. Introduction

Global concerns regarding the negative environmental impacts of fossil fuels have sparked changes in several global industries. As oil prices become increasingly volatile, the push towards renewable energy sources will become overwhelming. The pressure to reduce greenhouse gas emissions and decrease oil dependence are driving forces behind the current electric-vehicle (EV) transformation in the personal transportation industry (Iglińskia & Babiakb, 2017). The revolution was kicked off in 1997 with the release of the first mass-produced hybrid vehicle, Toyota's Prius (Koppelaar & Middelkoop, 2017). 20 years later, more than a million EVs are sold per year, and EV maker Tesla has successfully launched a variety of fully electric cars (Harper et al., 2019).

Electric vehicles have broken into the mainstream, quickly taking over roadways around the globe. There is an added attraction for these – especially for serving in difficult and dangerous terrains (Chen, Demir, Huang, & Qiu, 2021). EV owners can now drive easily across the country, stopping only a handful of times to charge at one of a growing number of charging stations along the way (Koppelaar & Middelkoop, 2017). It will not be long before fully autonomous passenger vehicles arrive to the same scale (Hancock, Nourbakhsh, & Stewart, 2019). Using cameras, sensors and highly complex machine learning algorithms, fully autonomous vehicles (AVs) will drive significant change in several industries. AVs have the potential to completely transform personal transportation through increased ridesharing, which would lead to a decreased need for personal vehicles. The attitudinal antecedents and the behavioural consequences are not entirely predictable (César, 2021; Sestino, Peluso, Amatulli, & Guido, 2022). It is estimated that one autonomous vehicle could replace 7-9 conventional cars (Waymo is first to ditch drivers: Autonomous vehicles go hands-free in an Arizona suburb, 2018). With AVs on the horizon, several cities are preparing to benefit from the technology early. In fact, AVs are already operating in select cities in the United States. Chandler, Arizona, for example, has been testing self-driving vehicles with AV company Waymo (Insurance Journal, 2019).

In the near future, Transportation-as-a-Service (TaaS) or Mobility-as-a-Service (MaaS) could dominate passenger transportation (Butler, Yigitcanlar, & Paz, 2021). By 2035, one out of every four vehicles on the road might be an AV (Mirzaeian, Cho, & Scheller-Wolf, 2021). More than half of the largest U.S. cities are already preparing for AVs in their long-range transportation plans, and the federal government has announced its commitment to enabling AV technology (Mirzaeian et al., 2021). The impact of this new technology will be felt across a variety of interconnected industries and such impact will not be a simple addition of impacts in the contributory sectors (Lawlor, 2022). Affected industries must consider these widespread impacts to strategically position themselves for long term success.

This paper identifies certain central gaps in the literature: one, most of the extant literature on self-driving vehicles do not refer to transportation-as-a-service, and vice versa. The interactions of these two factors may have unexpected strategic consequences. Taking one step further, this paper discusses the impacts of transportation-as-a-service employing self-driving vehicles upon specific industries and their responses to these new dynamics. The ethical dimensions of this combination are also not elaborated sufficiently in the recent literature and the present authors highlight these.

In the following sections, we will discuss the impacts of this transformation upon various stakeholders. We will examine how each of them will be affected and the associated strategic recourses.

## 2. Impacted Industrial Sectors and Strategic Implications

### *2.1. Auto Manufacturers*

The most obvious businesses to be affected will be vehicle manufacturers (Litman, 2017). The automotive industry is a significant force in the U.S. and global economy. In 2017, the global market size for passenger vehicles was around 85 million units, and output of the automotive industry equalled nearly 3% of the U.S. Gross Domestic Product (GDP) (Tang, 2017). According to Harper et al. (2019) "electrification of only 2% of the current global car fleet would represent a line of cars that could stretch around the Earth." This astonishing fact highlights just how much work still needs to be done before full AV can be attained, and underscores how large the impact will be when achieved. The industry is made up of over 100 automakers worldwide and is characterized as "having features of both an oligopoly and monopolistic competition" (Tang, 2017). Of the hundred-plus manufacturers in the market, 70% of the total vehicle production in 2017 came from the top 10 producers (Tang, 2017).

### *2.2. Impact*

Total vehicle sales in the United States have been increasing since 2012 but have leveled off and decreased since hitting its highest point of nearly 18.5 million units in 2016 (Auto Industry Prospects, 2018). Auto manufacturers will face a decline in demand for traditional gas-powered vehicles. With demand quickly shifting, manufacturers will need to adapt their manufacturing processes to produce more EVs. Failing to respond to the changing needs of consumers will inevitably lead to dwindling profits (Auto Industry Prospects, 2018). In response to the increasing prominence of EVs, their production will substantially ramp up. Soon, all major vehicle manufacturers could be producing more EVs than gas powered vehicles, and the EVs produced will become rapidly more advanced.

EV dominance will dominate roadways and AVs will follow quickly after. Once substantial AV quantities are achieved, demand for personally owned vehicles might wane. With the ability to summon a vehicle on command, consumers will show less desire to purchase a personal vehicle. In addition, if vehicles last longer, there is less need for them to be replaced or repaired. These changing dynamics are of critical consideration for the automotive industry, an industry that, prior to the COVID-19 pandemic, had seen an average annual growth rate of 2 to 3% since 1975 (Tang, 2017).

### *2.3. Strategies*

Automakers will need to consider several strategic elements to best position themselves for success in a future of AVs. First, they must consider what they produce, how they produce their products, and where they locate their operations. As mentioned previously, manufacturing of EVs will substantially increase. Newer companies have an advantage in the fact that they can design their manufacturing processes with AVs in mind.

More established companies, however, will need to leverage their market dominance and capital positions to alter their already established processes. For example, a company such as Ford will need to either repurpose current assembly lines or develop new ones to produce higher quantities of EVs. They should also consider the developing market for EV batteries. Securing batteries will be critical to successful EV production and, as discussed later in this work, processes of recycling and reusing these batteries may "provide a valuable secondary source of materials" for EV manufacturers (Harper et al., 2019).

The way EVs are produced will be another key component. As will be discussed later, there are certain environmental concerns that should factor into which suppliers are chosen. In addition, production sites might need to be reconsidered. Automakers, who have historically maintained production sites close to their consumers, may need to consider the possibility of reduced demand for personally owned vehicles (Tang, 2017). Certain factors, such as technical, political, and transportation factors, may impact the quantity of locally built vehicles (Tang, 2017). When it comes to Research and Development (R&D), a blend of closed and open innovation strategies might be appropriate for autonomous vehicle development, according to Blankesteijn, Jong, and Bossink (2019). Next, manufacturers should seek to capitalize on significant government support in producing EVs and exploring AVs.

The "AV 4.0" report outlines the United States government's approach to the development and deployment of autonomous vehicles (AVs). The report was released by the United States Department of Transportation and the National Science and Technology Council in January 2020.

The report focuses on four main areas:

- Ensuring the safety of AVs: The report emphasizes the need for robust safety standards and practices to ensure that AVs are safe for passengers and other road users.
- Promoting innovation: The report encourages the development of new AV technologies and encourages collaboration between industry, academia, and government to accelerate the deployment of AVs.
- Enhancing accessibility and affordability: The report recognizes the potential for AVs to improve mobility for people with disabilities and to reduce the cost of transportation for everyone.
- Preparing for the future: The report discusses the need for infrastructure and regulatory frameworks to support the deployment of AVs, as well as the importance of educating the public about AVs and addressing concerns about their deployment.
- Overall, the "AV 4.0" report presents a comprehensive vision for the future of autonomous vehicles in the United States and outlines the steps that need to be taken to ensure their safe and successful deployment.

The report outlines the federal government's commitment to making the United States the leader in AI technology. The expansive plan highlights several ways the government is incentivizing manufacturers to pursue AVs, including the ability to expense R&D costs, costs of purchasing manufacturing equipment, and costs of acquiring or developing computer hardware and software (National Science & Technology Council and the United States Department of Transportation, 2020). Manufacturers are also offered a federal income tax credit for up to 20% of AV production costs (National Science & Technology Council and the United States Department of Transportation, 2020). Established and new companies alike should seek to take advantage of these programs. Elon Musk, for instance, has been the recipient of almost $5 billion in government support in the form of grants, tax breaks, factory construction, and discounted loans (Koppelaar & Middelkoop, 2017).

## 3. Auto Dealerships

Dealerships have historically held a key position in the distribution network, connecting customers and representing vehicle brands (Dealerships Must Win Their Place in the Mobility Future, 2017). Fully Autonomous Vehicles have the potential to completely change the business model for auto dealerships (Arentz, 2017). Already, technology has made it possible to complete the entire vehicle purchasing process online. Several platforms exist to digitize the auto-buying process from browsing to selling vehicles. In 2016, e-commerce giant Amazon launched their own online car research and review service (Coppola, 2021). Some brands are skipping the dealership altogether, opting for a made-to-order model, such as EV maker Tesla (Coppola, 2021).

### *3.1. Impact*

Dealers do not quite have to worry about going out of business overnight, but the future of AV dominance does present an existential threat. A survey conducted in Texas revealed that older drivers are less willing to accept or adopt new vehicle technologies, suggesting that there will still remain demand for the traditional business model (Bansal & Kockelman, 2018). Still, auto dealers will quickly see changes in their business due to EV and AVs. One major change is the growing data-ecosystem that can be used to track consumer buying trends (Dealerships Must Win Their Place in the Mobility Future, 2017). Dealerships will soon find themselves handling significant amounts of consumer data. By some estimates, AVs could generate up to 4,000 gigabytes of data per hour (Dealerships Must Win Their Place in the Mobility Future, 2017). Dealerships might find themselves struggling to use this large amount of data and seek to partner with tech companies more digitally capable. One such dealership, Lithia Motors Inc, has partnered with tech company Shift to collect and share data (Coppola, 2021). The partnership helps Shift offer app-driven shopping and test-drivers, while Lithia Motors leverages the collected data that could not be gained from traditional shopping processes (Coppola, 2021).

### *3.2. Strategies*

When AVs dominate the roadways, visiting the dealership will become a rare occurrence. Dealerships should alter their service offerings as demand changes. Upgrading vehicles by adding AV features such as Lane Assist is one possibility. According to a 2018 study, one of the top concerns among Texans regarding AVs is affordability (Bansal & Kockelman, 2018). Equipping vehicles with AV features may be difficult early on, but as these upgrades become more affordable, a wider audience may be reached. Dealers might want to tailor to high income individuals to upgrade their cars, as higher income individuals are more likely to outfit their vehicles with AV technologies (Bansal & Kockelman, 2018).

Massive amounts of data will be created from AVs. Dealerships should seek to use collected data to their advantage. Insights from sales trends, driving patterns, and servicing frequency can all be used to improve the dealership experience. To be able to do so, they will need to develop strategic partnerships with multiple parties that give them access to this data (Dealerships Must Win Their Place in the Mobility Future, 2017). Recognizing that increased data pools will lead to greater cyber security risks, dealerships should be diligent in their assessment of cyber security measures both of themselves and their partners.

## 4. Oil and Energy Companies

In recent years an enormous amount of pressure has been placed on the need to reduce the world's dependence on fossil fuels (Mack et al., 2021). Prominent celebrities, business leaders, and government officials have been outspoken in their views on fossil fuels and climate change. The public recognition of climate change has led to a global focus on renewable energy sources. Despite several years of this movement, crude oil remains as the world's most prominent energy source. In 2016, 36.9% of global primary energy consumption came from Crude oil (Kyritsis & Serletis, 2019). The first 'supergiant' oil field was discovered in Texas in 1901, and the United States Geological Survey estimates over 90% to 95% of all discoverable oil has since been found (Koppelaar & Middelkoop, 2017). The rapidly depleting oil reserves is a cause for concern for oil-dependent industries. Oil discovery has slowed to an alarming rate, and Big Oil companies are not funding as much in the search for oil as they were in the past (Koppelaar & Middelkoop, 2017).

### *4.1. Impact*

According to Koppelaar and Middelkoop (2017) "the key issue is not so much the actual quantity of oil underground but the ability to obtain sufficient oil at an affordable cost." Increasing costs of discovering and extracting oil in combination with increases in oil price volatility has led to great uncertainty in the crude oil market. This has only quickened the transition to renewable energy (Kyritsis & Serletis, 2019).

Kyritsis and Serletis (2019) analysed the relationship between oil prices and stock returns for clean energy and technology companies using monthly data from 1983 to 2016. They discovered that oil price uncertainty had a positive impact on renewable energy and technology stock returns, but this effect was not statistically significant. These findings indicate that renewable energy stock returns are resilient to oil price uncertainty. While the market for Crude Oil is shrinking, other fossil fuels such as coal and natural gas still dominate in electricity generation (Kyritsis & Serletis, 2019). The increasing demand for EVs will contribute to the shrinking demand for Crude Oil, though electricity demand for public and home charging stations will rise substantially. This trend will increase until AVs begin to replace personal vehicles, at which point several AVs can serve multiple people, thereby reducing demand for electricity.

### *4.2. Strategies*

The investment in the oil supply will continue to shrink as EVs gain prominence. With the public adoption of AVs on the horizon, less oil will come to market and oil companies will find the market is no longer driven by rising oil demand (Koppelaar & Middelkoop, 2017). Big Oil companies will need to rethink their strategies to ensure long-term success. The first action to take is to invest in renewable energy technologies. Over time, these investments will become bigger revenue streams, replacing decreasing revenue from crude oil, and companies should rebrand themselves as energy companies rather than oil companies.

Acquisitions will play a crucial role in the survival of big oil companies during this transition. Acquiring other oil companies will increase the oil production capacity, allowing them to save on oil discovery expenses. They should also acquire renewable energy companies and battery manufacturing companies. These investments will allow the companies to adapt to the changing demand without spending years of research and development.

## 5. Battery Manufacturers

Key to AV success is the availability of high-powered batteries and this has been recognized even in the very early phases of the development of autonomous vehicle systems (Wall, Bennett, & Eis, 2002). Batteries determine the range and reliability to a great extent. Tesla's Roadster was the first production vehicle to use lithium-ion batteries instead of lead-acid batteries (Koppelaar & Middelkoop, 2017). Lithium-ion batteries (LIBs) are expected to last three times longer than lead-acid batteries. Electric vehicle manufacturers, including Tesla, rely heavily on lithium-ion batteries to power their vehicles. To meet this demand, Tesla is constructing a lithium-ion battery factory in Nevada that is expected to have the capacity to produce batteries for 500,000 EVs, which would double the global production of lithium-ion batteries. The factory is expected to cost $5 billion to build. Battery production is currently dominated in Asia, with market share for core components as high as 80% (Koppelaar & Middelkoop, 2017).

Ironically, the current LIB manufacturing process is very harmful for the environment, particularly for its high carbon emissions (Wang, Yu, Huang, & Tang, 2019). In fact, Kawamoto, et al. claim that EVs could have higher carbon emissions than gas powered vehicles if the battery production phase maintains these significantly large emission levels. A major proponent of the higher emissions is the extraction of raw materials such as Cobalt (Harper et al., 2019). Cobalt, a crucial ingredient for LIBs, is geographically concentrated in the Democratic Republic of the Congo. The region is politically unstable, and, as a result, cobalt is subject to sudden price fluctuations. Additionally, there are social, ethical and environmental concerns, including the use of child labor in mining operations (Harper et al., 2019).

### *5.1. Impact*

The rapidly increasing demand for batteries, driven by the EV and AV revolutions, will present a serious environmental challenge (Harper et al., 2019). Storing batteries, for starters, is extremely difficult. Given the highly reactive nature of LIBs, accumulating end-of-life LIBs presents great dangers, including the risk of fires (Harper et al., 2019). Innovative storage and recycling solutions will be required to minimize the environmental impact of increased battery usage. During production, the processing of large amounts of raw materials like spodumene and brine can also have serious effects on the environment (Harper et al., 2019). Mining processes use a substantial amount of water, and a ton of lithium requires almost 2,000 tons of water be used (Harper et al., 2019). Given the rapid pace of innovation in the industry, and the awareness of environmental impacts from LIBs, new battery technologies will soon be revolutionizing EV production.

### *5.2. Strategies*

Manufacturers should seek to increase production ethically and investigate innovative battery technologies and recycling solutions. Enhancing environmental quality through cleaner production processes will enhance the public acceptance of AVs. Seeking new, more environmentally friendly battery technologies should be a high priority among battery manufacturers.

In addition, the required mineral extraction and the resulting environmental impact can be reduced through effective recycling and reuse techniques (Harper et al., 2019). However, manufacturers face a serious hurdle in the current design of batteries, which are not designed for easy repurposing (Harper et al., 2019). A survey found that only 2% of motor technicians in the UK were qualified to handle the specialized tools necessary to dismantle and repurpose these batteries (Harper et al., 2019) Disassembly of batteries is potentially very dangerous to human workers. Robotic disassembly processes are currently being explored but will be extremely complex and expensive to implement (Harper et al., 2019). However, the benefits of recycling will be more than just the reduced environmental impact. Recycled batteries can provide valuable materials needed for further production, helping to offset some of the upfront costs of recycling (Harper et al., 2019).

## 6. Technology Companies

Tech companies are another key industry to be affected by AVs. It is up to these players to develop the technology required to make AVs a reality. AVs are not possible without AI software, high-tech cameras and sensors, and an enormous amount of data. The Alphabet-owned company Waymo is already in the process of testing their self-driving vehicles in Arizona (Insurance Journal, 2019).

### *6.1. Impact*

Tech companies will play a crucial role in developing advanced software and ensuring the systems are safe from cyber threats. Most importantly, they will be the ones responsible for making the technology accessible to the public. Companies that specialize in AI technology will be the most successful. Partnerships will be needed to bring AI tech to EVs successfully. Waymo, for instance, has partnerships with Fiat-Chrysler, Lyft, and Avis, allowing the brand to focus their efforts on developing the AI technology while their partners provide the missing pieces (Waymo is first to ditch drivers: Autonomous vehicles go hands-free in an Arizona suburb, 2018). Local infrastructure improvements such as increased 5G and broadband connectivity will enable AVs to communicate with their surroundings, increasing the accuracy and feasibility of their product (National Science & Technology Council and the United States Department of Transportation, 2020).

The increased demand for batteries will drive up prices. Other products that use LIB batteries, including smart phones, may see an increase in price as well. Electronic device makers that utilize LIB may raise their prices or seek alternatives to LIB technology.

### *6.2. Strategies*

Tech companies are already working quickly to bring AVs to the public. The U.S. government is supporting this endeavour, stating in the AV 4.0 report, The US administration places a priority on wireless technologies that enhance the capabilities of automated vehicle technologies (National Science & Technology Council and the United States Department of Transportation, 2020). If technology companies wish to beat competitors to market, they will need to maintain a quick pace of product development. Given the government's commitment to supporting AV development, technology companies should be able to pour more money into their development process. The technology will need to be good enough to instil more confidence in people. Only 36% of respondents in the previously mentioned survey of Texans reported that they would feel comfortable with AVs on congested streets (Bansal & Kockelman, 2018).

Partnerships will be necessary for many companies. Partnering with auto manufacturers, such as Waymo and Fiat's partnership, will allow tech companies to focus on their strengths and might add a degree of brand recognition to further adoption. Established vehicle manufacturers who already have production capacity and large amounts of capital to invest will allow AVs to come to market faster. As with battery producers, tech companies should be careful to ensure sourcing of labour and components is ethical for themselves and their partners. For example, silicon chips sourced from a country that is known for utilizing child labour could result in negative publicity and even government sanctions.

It will also be critical for companies to consider the sense of ownership that is achieved from possessing a personal vehicle. As AVs hit the roads, the need for a personal vehicle will decline. Many current vehicle owners will choose to hold onto their vehicles, simply as a "just in case." Tech companies should think creatively to deliver this feeling through their services. Ride sharing apps with personalized memberships is one potential way of achieving this.

## 7. Insurance Companies

The auto insurance industry, which collects around $200 billion in premium per year, will see a radical change in the business for auto-insurance (Preston, 2016). One of the main advantages of AVs is to eliminate human error from the driving process, reducing the likelihood of accidents. A declining frequency of accidents will inevitably lead to a decreased demand for insurance (Chittley, 2016). It is predicted that by as early as 2035, 25% of vehicles on the road could be AVs (Mirzaeian et al., 2021). The risk of an accident will be greatly reduced, causing insurers to adjust their rating and policy structures. Soon, liability will begin to shift away from individual policyholders to the AV manufacturers and partners (Self-Driving Cars to Transform Motor Insurance in Liability Shift: Fitch, 2021). The 'sue my car, not me" era will inaugurate a fundamentally different perspective on auto insurance (Gurney, 2013). The legal system may take years to come up with a comprehensive plan of action to deal with the complexities of this Carp (2018); however, law trailing technology is nothing new in the radical innovation space.

### *7.1. Impact*

AVs are able to avoid accidents because they are able to communicate with other AVs on the road. This back-and-forth communication allows AVs to safely maintain larger groupings of vehicles with less space between clusters (Mirzaeian et al., 2021). As the number of AVs on the roadway increases, accidents could decrease by as much as 90% (Bansal & Kockelman, 2018). The first impact of this shift will be reduced claims, which will drive insurance premiums downward. This is already happening with EVs that are equipped with Advanced Driver Assistance Systems (Self-Driving Cars to Transform Motor Insurance in Liability Shift: Fitch, 2021). Global consulting firm Klynveld Peat Marwick Goerdeler (KPMG) estimates that auto insurers could expect a 60% reduction in auto premiums within 20 years (Preston, 2016). The available data after an accident will also assist in determining liability (Self-Driving Cars to Transform Motor Insurance in Liability Shift: Fitch, 2021). This will allow insurers to assess risk more accurately and appropriately adjust premiums.

These dynamics have caught the attention of local regulators. In the UK for example, a proposal established a "single insurer mode" in which insurers would be able to reclaim costs from manufacturers if a crash is determined to be caused by a technology failure (Self-Driving Cars to Transform Motor Insurance in Liability Shift: Fitch, 2021). The regulation would also stop insurers from excluding cyber-attacks, which exposes insurers to large losses, and could lead to a higher demand for cyber reinsurance (Self-Driving Cars to Transform Motor Insurance in Liability Shift: Fitch, 2021).

### *7.2. Strategies*

Insurers should prepare for this future by drafting policy terms and structure for more commercial accounts. Insurers should be prepared for insurance policies to be concentrated to a handful of large accounts as individual policyholders decline (Preston, 2016). Insurers who are slow to change their business models will most likely face insolvency (Self-Driving Cars to Transform Motor Insurance in Liability Shift: Fitch, 2021).

In addition, insurers should prepare for cyber security risks. AV manufacturers, TaaS providers, and governments face heightened vulnerability to cyber-attacks such as personal data leaks and terrorist attacks. Insurers should adequately re-insure themselves to avoid insolvency. Lastly, insurance companies should diversify their product offerings. By expanding into other markets, the lost income from auto premiums can eventually be replaced.

## 8. Local Government

Local and federal bodies will also be impacted by this future. Federal agencies such as the Department of Transportation, National Highway Traffic Safety Administration, Department of Energy, and even the U.S. Postal Service have all committed to supporting the development of AVs (National Science & Technology Council and the United States Department of Transportation, 2020). The U.S. Government is supporting AV research and development within the country. Investments have already been made in "safety, mobility, security, infrastructure, and connectivity" in an effort to ensure the U.S. is a global leader in AV technology (National Science & Technology Council and the United States Department of Transportation, 2020).

### *8.1. Impact*

AVs may have many benefits for state and federal governments, including reducing highway congestion. If implemented properly, AVs do have the potential to reduce time spent in congestion and highway throughput several times over (Mirzaeian et al., 2021). In their study on the effectiveness of AVs at reducing highway congestion, (Mirzaeian et al., 2021). Examined a separated and an integrated policy for a mixed fleet of Human-driven Vehicles and AVs. Their findings showed that traffic congestion is most improved when AVs constitute a high portion of vehicles and are not separated into their own lanes (Mirzaeian et al., 2021). Under both policies, the impact on congested highways improves as the percentage of AVs on the road increases, with throughput increased by as much as 400% when all vehicles are AVs (Mirzaeian et al., 2021).

Adaptive Cruise Control features, seen on many vehicles today, can likewise significantly increase highway capacity when implemented widely (Mirzaeian et al., 2021). Traffic congestion will continue to decline as driver assistance features improve and as the number of AVs on the road increases. In addition to better traffic flow, AVs will benefit the public through safer travel, greater mobility, lower energy usage, more efficient supply chains, and an improved quality of life (National Science & Technology Council and the United States Department of Transportation, 2020).

### *8.2. Strategies*

Many countries have already incorporated AV technologies into their long-term plans. The United States and other countries should begin by recognizing the wide-spread impact of the AV introduction. Changes in key industries can have significant top-down effects, all of which should be carefully considered and mapped out. Governmental agencies should collaborate with domestic businesses in a range of industries to understand the potential effects and any current limitations. Creating open dialogues with AV exploring companies will provide the government critical insights for how to prepare for the future technology.

Being the first country to successfully implement wide-spread AV transportation will have substantial benefits (Fagnant & Kockelman, 2015). The United States has been open about their intent to be the world leader in AI technology but major moves are not happening, at least partially due to pressure groups with vested interest in the fossil fuel economy. Companies in the U.S. will gain a competitive advantage by receiving large amounts of support from the federal government. Incentivizing product development, domestic manufacturing, and ethical sourcing will be key to capturing early market share.

National security should be a top priority for countries. The highly interconnected infrastructures of the future present a potential target for hackers and terrorist attacks (Self-Driving Cars to Transform Motor Insurance in Liability Shift: Fitch, 2021). An attack that halts AV operations could be detrimental to an economy that is dependent on AV transportation. National security measures should be taken to mitigate this growing cyber security risk.

Table 1 summarizes the some of the key themes:

**Table 1.** Key themes in TaaS, AVs, and their interactions.

| Transportation as a service (TaaS) | Autonomous vehicles (AVs) | Using AVs for TaaS |
|---|---|---|
| Ownership costs | Future of work in trucking | Co-existence of smart and dumb sub-systems making realization of synergies difficult |
| Efficient utilization of fleet | New players in the associated network | Different kinds of AIs powering different autonomous vehicles may be informed by different "philosophies" of success. |
| Sustainability | Sustainability | Hacking systems to create havoc and / or advantage for competitors |
| New uses with existing fleet | Inter-modal transportation issues | Lack of ownership coupled with less human control may exacerbate the complexity. |
| Regulatory issues | Legal and ethical issues | In the absence of an open-source platform for TaaS AI, there is no interoperability and can cause traffic accidents and also issues with fixing liability. |
| Industrial (re)organization | Need for new infrastructure | Big corporations may control and even greater piece of the transportation pie. |
| Reliability and quality control | Cultural consequences upon the economy | Technology adoption may take time. |

## 9. Conclusion

Digital technologies are fundamentally altering our personal lives, economies, and societies (George & Paul, 2020). The ethical blueprints that the deployment of these technologies assume for their success are often alarming (Stilgoe, 2021; Ziyan & Shiguo, 2021). The digital transformation that we are witnessing currently is unmatched and Covid-19 just accelerated it. Transportation is an area where technological infusion has made tremendous impacts (Flämig, 2016). Artificial intelligence is going to play and increasingly greater role in the future of transportation (Bartolini, Tettamanti, & Varga, 2017).

In this paper, we charted out possible strategic directions for stakeholders involved in the autonomous vehicle space, especially those participate the "transportation as a service" economy. The strategies are not always clear, given the uncertainties about how the space is evolving. Also, the space may further be nuanced with the presence of exogenous actors. In a way, this observation is true for most areas undergoing AI driven transformation (Yang, Henthorne, & George, 2020).

Several industries that are not explored in this paper will be affected as well. Such an industry is the real estate market, which will be impacted by the changing use of land and infrastructure needs. AI technology is not limited to road vehicles, and transformations will occur in several other industries such as airlines, logistics, and more. Global supply chains will be transformed, and daily lives will be impacted. Individuals and companies alike should be prepared to embrace the coming technology and its accompanying challenges.

Since the current efforts are largely aimed at attaining effectiveness, massive level deployments and efficiency from the same may have to wait a bit longer (Bellone et al., 2021). Also, while news items about autonomous cars and trucks fill more of the popular media, revolutionary changes are happening in mass public transportation as well. In a way, this is where governments and public policy makers ought to stress more. If it proceeds further, there are important benefits to everyone, especially from a sustainable development perspective. Alongside, the legal framework for a fully autonomous and self-sustained transport system needs to be developed as well.

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