INNOVATIONS IN VEHICLE TECHNOLOGY: OPPORTUNITIES AND CHALLENGES

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Abstract: *by carrying goods over vast distances, the trucking industry plays a significant role in the global economy. In the past few years, the trucking industry has faced a number of problems, such as a lack of drivers, rising fuel prices, and worries about how the industry affects the environment. The industry has turned to innovation to improve efficiency, sustainability, and safety in response to these issues. This paper investigates how innovations affected the transportation sector, concentrating on two important areas: (1) advances in vehicle technology, such as electric and autonomous trucks; (2) emphasizing the need to carefully assess each innovation's risks and challenges, such as job displacement issues. A detailed literature review in this study shows the possible benefits and challenges connected with each of these developments. Specifically, we address how developments in vehicle technology can lower pollution and fuel costs while also boosting safety and reliability. Lastly, we investigate the potential job losses from automation. Overall, this study argues that innovation is crucial to the future of the trucking industry because it may help address many of the difficulties now affecting the sector. This paper presents a detailed overview of the possible influence of innovation on the trucking industry and identifies critical topics for future study and development by investigating these challenges.*

Keywords: *innovation, Trucking Industry, Sustainability, Safety of Drivers, Vehicle Technology, Job Displacement Issue.*

ИННОВАЦИИ В АВТОМОБИЛЬНЫХ ТЕХНОЛОГИЯХ: ВОЗМОЖНОСТИ И ВЫЗОВЫ

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Аннотация: *перевозя грузы на огромные расстояния, автотранспортная отрасль играет значительную роль в мировой экономике. За последние несколько лет отрасль грузоперевозок столкнулась с рядом проблем, таких как нехватка водителей, рост цен на топливо и опасения по поводу того, как отрасль влияет на окружающую среду. В ответ на эти проблемы отрасль обратилась к инновациям, чтобы повысить эффективность, устойчивость и безопасность. В этой статье исследуется, как инновации повлияли на транспортный сектор, с упором на две важные области: (1) достижения в области автомобильных технологий, таких как электрические и автономные грузовики; (2) подчеркивая необходимость тщательной оценки рисков и проблем, связанных с каждой инновацией, таких как проблемы смещения рабочих мест. Подробный обзор литературы в этом исследовании показывает возможные преимущества и проблемы, связанные с каждой из этих разработок. В частности, мы обращаемся к тому, как разработки в области автомобильных технологий могут снизить загрязнение окружающей среды и затраты на топливо, а также повысить безопасность и надежность. Наконец, мы исследуем потенциальные потери рабочих мест из-за автоматизации. В целом, в этом исследовании утверждается, что инновации имеют решающее значение для будущего отрасли грузоперевозок, поскольку они могут помочь решить многие трудности, с которыми сейчас сталкивается этот сектор. В этом документе представлен подробный обзор возможного влияния инноваций на отрасль грузоперевозок и определены критические темы для будущих исследований и разработок путем изучения этих проблем.*

Ключевые слова: *инновации, автотранспортная отрасль, устойчивое развитие, безопасность водителей, автомобильные технологии, проблема сокращения рабочих мест.*

INTRODUCTION:

Electric vehicles are quickly growing in popularity for consumers as well as for commercial purposes, with companies like Amazon already planning on adding tens of thousands of electric vehicles to their fleets (Coyle. M, 2022). The obvious advantages of reducing fuel consumption and costs pale in comparison to the anticipated savings and safety improvements that autonomous vehicles will eventually bring to the industry. Drivers will be able to relieve their physical and mental stress, reducing the number of accidents and injuries for drivers and consumers alike.

Logistics and supply chain management enhancements have the potential to greatly increase productivity and decrease delivery times. Emerging technology such as predictive analytics, real-time tracking, and route optimization software can assist trucking businesses in managing their fleets more effectively and reducing costs related to idle time, missing deliveries, and inefficient routing (Tan. A, 2019). But these technologies don't come without their limitations. Our findings show that real-time tracking concerns data privacy and cybersecurity, while predictive analytics can be difficult to deploy and are not always correct. As the industry continues to implement new logistics and supply chain management technology, it must carefully consider these possible risks and obstacles.

In the United States, long-haul trucking is a prevalent occupation, especially for males with a high school degree (Wertheim, 2020). On the other side, it has been stated, frequently by the businesses developing this technology, that long-distance trucking is now experiencing a labor crisis and that automation will create new short-distance employment that will compensate more for the lost long-distance positions. As a result of these contradictory assertions and the uncertainty regarding the technology and its limits, there is little clarity regarding the deployment of automated trucking and its economic and political implications, such as the influence on the long-haul trucking labor market. In this study, we examined the technological limitations of automated trucking in order to get more precise estimates of the potential near-term effects of automation on long-haul trucking operators in the United States by analyzing several deployment scenarios. Overall, it will likely be at least ten years until fully autonomous Class 8 trucks displace a significant portion of long-distance truck drivers. Our research indicates that, in less than a decade, automated platooning is expected to replace fewer truck driver positions.

LITERATURE REVIEW:

The literature review provides a thorough overview of the possible benefits and difficulties connected with innovations in the trucking business. Tan. A, (2019) believes that advancements in car technology can lower pollution and fuel costs while also boosting safety and dependability. Electric trucks, for instance, have the potential to reduce pollution and fuel costs, while autonomous trucks could boost safety and efficiency by removing human mistakes. Yet, our findings show that there are considerable obstacles connected with these developments, including high costs, limited infrastructure, and regulatory constraints.

Groshen et al. (2019) investigate the employment effects of the deployment of automation in various areas of the economy using simulations and interviews with industry experts. They believe that 60–65 % of long-haul driver jobs will be destroyed if automation is fully implemented (Groshen et al., 2019).

The paper also discusses future employment losses caused by automation. We recognize that while automation could boost efficiency and cut costs, it could also contribute to job displacement, especially among drivers. The authors contend that rigorous planning and preparedness are required to offset the potential adverse consequences of automation on employment.

Lastly, future work studies concerning the deployment of autonomous trucks have also examined the issue of employment losses in the trucking industry caused by automation. For example, Leonard et al. (2020) estimate that automation would create new professions such as remote truck management, dispatching, and field support while displacing daytime driving occupations.

Overall, the report presents a detailed analysis of the possible influence of innovation on the transportation business. We make a persuasive case for the significance of innovation in tackling the difficulties facing the industry. We emphasize important issues for future research and development, such as infrastructure, regulations, and jobs. The report continues by emphasizing the significance of thoroughly examining the risks and obstacles associated with innovations in the sector to guarantee that they result in favorable outcomes for all stakeholders.

METHODOLOGIES:

1. Impact of Innovation in Vehicle Technology:

The introduction of electric and autonomous trucks is one of the most significant advancements in the transportation sector. Electric trucks provide a number of advantages over diesel-powered trucks, including lower emissions, lower operating costs, and quieter operation. Some of the industry's biggest truck manufacturers, including Tesla and Daimler, are developing electric commercial vehicles. Currently, companies like Uber, Waymo, and TuSimple are testing autonomous trucking technology.

Current work on autonomous vehicles focuses mostly on their possible effects on traffic safety, travel behavior, congestion, and energy consumption. The consequences of partially automated to completely autonomous vehicles on traffic performance and greenhouse gas emissions are still unknown. Many studies examined the effects of the broad implementation of autonomous vehicle technology (Barth, M.; Boriboonsomsin, K. 2009).

a. Statistics of presented research:

The U.S. Environmental Protection Agency (EPA)reported in 2020 that medium and heavy-duty trucks contribute 26% of annual U.S. transportation greenhouse gas emissions. The implications included air pollution and greenhouse gas emissions. The introduction of autonomous vehicles may lead to an increase in ridesharing, traffic flow smoothing, platooning, efficient driving, efficient routing, eco-friendly traffic signals, and reduced parking searches (Pettigrew, S.; Fritschi, L.; Norman, R. 2018). As a result, energy consumption will decrease, so contributing to a decrease in greenhouse gas emissions.

b. *Physical Representation of presented studies:*

The EPA has implemented CO^2 emission rules for medium- and heavy-duty trucks in two distinct phases. Figure 1 depicts the evolution of Phase 2 CO^2 emission regulations from 2021 to 2027, as assessed by the per-ton-mile standard. A "ton mile" indicates that one ton of freight is conveyed in one mile.

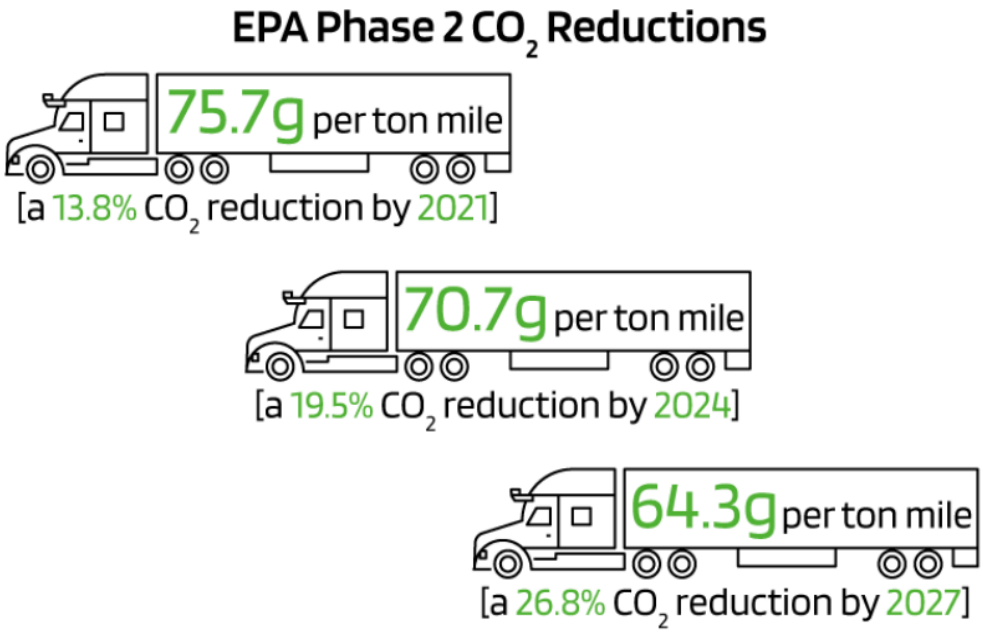

Fig. 1. EPA phase 2 CO2 reductions (Eaton).

c. *Possible outcomes of those findings above:*

TuSimple, a global self-driving truck company tested their autonomous driving system over 160,000 miles in real-world conditions for the UPS North American Air Freight Services, and results showed that they have been able to exceed the already substantial fuel savings data observed in the study conducted by the University of California San Diego. As a result of testing their autonomous driving system with UPS North American Air Freight, TuSimple ADS delivered over 13% fuel savings compared to human drivers when operated in the optimal long-haul operating band from 55 to 68 miles per hour (TuSimple, San Diego Study, 2019).

However, research shows that applying technological advancement to the trucking industry comes with many limits. Currently, autonomous truck demonstrations in the United States, such as Aurora Innovation and TuSimple, run with onboard safety drivers who can intervene in the event of issues. All of these companies say that they will eliminate safety drivers at some time in the future, but none of them have done so as of yet. The goal of autonomous vehicle companies is to achieve level 4 of the five-level autonomy scale developed by the Society of Automotive Engineers:

The vehicle is capable of performing all driving functions under certain conditions. The driver may have the option to control the vehicle. (NHTSA United States Department of Transportation)

In this context, "certain conditions" typically refer to driving autonomously on limited-access highways in regions without rain or snow.

1. Introduced Technological Advancement in the field of Autonomous Trucking:

Inevitably, it will likely take at least a decade until fully autonomous Class 8 trucks displace a substantial number of long-distance truck drivers. However, in less than a decade, our analysis predicts that automated platooning will replace fewer truck driver roles. This section gives a brief overview of various factors that are anticipated to mitigate the reduction in GHG emissions as well as fuel costs while enhancing reliability and safety resulting from vehicle automation.

1. ***Platooning*** – Consumers driving on popular highway routes may be surprised to find a modern version of a “convoy” that offers unique advantages. Research has shown that by equipping trucks with specialized technology – including automated driving systems and vehicle-to-vehicle communication — a fleet can be driven in lockstep (American Transportation Research Institute, 2021). This means that they will speed up, slow down, stop, and drive in an organized way, always in close proximity to one another. Peloton and other startups have developed software, Wi-Fi, and actuators that allow the driver of the lead truck to control the braking and acceleration of the follower truck. The benefit from drafting alone is predicted to result in up to ten

percent fuel savings for trucking companies. For consumers and those who share the highways with the truckers, the result would be far less congestion on the highways, less disruption to traffic patterns, and improvements to safety.

2. ***Smart sensor applications*** – are another exciting innovation introduced in the last few years. The logistics industry has begun to leverage the power of Artificial Intelligence, the Internet of Things, and telematics to create a sea change in vehicle tracking. With the ability to monitor where vehicles are, the condition of the trucking assets themselves, and historical and real-time data including traffic data and route analytics, freight companies will be able to operate more efficiently, ease their burden on America's highways, reduce accidents and breakdowns, and minimize downtime (Cheung, R., & Lee, C. K. M.,2021). Similar technology will be able to monitor the drivers themselves to ensure that they are operating their vehicles safely.

3. Eco Traffic Signaling – Autonomous vehicles can independently communicate with infrastructure, including traffic signals at intersections. This transmission provides information to vehicles that allow them to alter their driving pattern, hence reducing the number of stops at the eco-traffic signal system intersection. The potential to minimize fuel consumption and greenhouse gas emissions at the intersection is particularly high, given that car traveling near intersections at slower speeds tend to consume more gasoline. According to the study, a fully connected protocol can reduce average vehicle emissions by 2 to 6% (Yelchuru, B.; Waller, T. Preliminary, 2020). As previously stated, signalized crossings in metropolitan settings have the enormous potential to cut network-level GHG emissions. AVs are equipped with a variety of advanced sensors for communication with the road environment, which can direct the drivers/vehicles to adapt their driving patterns, reduce stops and speed variations, and optimize fuel efficiency. All of these elements will decrease fuel use and, consequently, vehicle emissions.

2. Job displacement issues caused by Autonomous Vehicles Innovations:

Due to the relative relevancy of technological advancements in automated vehicles, little research has been undertaken on the effects of automation on truck driver jobs. Steve Viscelli, a sociologist at the University of Pennsylvania and former LT driver utilized revenue data from major trucking companies and estimations of average per-driver revenue predict that roughly 300,000 long-haul jobs are under threat (Viscelli, 2018). According to the report, the majority of these at-risk professions are in dry van and refrigerated transportation, which are characterized by high turnover and poor earnings (Viscelli, 2018). However, Viscelli estimates that it will take around a decade to bring the technology to market in order to comply with federal and state safety laws and lower prices sufficiently to make the technology an attractive investment.

Likewise, (Gittleman and Monaco, 2020) have analyzed the probable employment losses caused by automation. Contrary to some media predictions, they also suggest that the top bound on employment losses due to automation is likely to be about 400,000. Their study also indicates that only one part of trucking—long-distance highway driving—is suitable for automation and that operators who execute other jobs or are involved in customer-facing activities, such as those in package delivery, are unlikely to experience job losses (Gittleman and Monaco, 2020).

Automation of highway transportation can have a substantial influence on workers in many industries since it could minimize the necessity for the frequency of truck stops on the highway. However, the establishment of truck ports to allow the transfer-hub model of Autonomous Trucking could result in the creation of new jobs, such as exchanging trailers, providing services to human operators, and performing maintenance and safety checks on sensors and other equipment on automated trucks (Hickman et al., Transport Topics, 2018). It is unknown if current truck stop operators will be interested in or qualified for the new jobs that may be created by the adoption of AT.

CONCLUSION AND POLICY IMPLICATIONS:

Innovation has the ability to transform the trucking sector by tackling the aforementioned difficulties. But the sector will need to carefully assess the possible risks and obstacles connected with each innovation to ensure its continued success in the face of changing economic and environmental challenges. With platooning and data analytics, transportation companies may work more securely and effectively while also making better judgments. When autonomous trucks are widely used, productivity will grow even more while human error is decreased. Despite the fact that these technologies do have the potential to replace truck drivers, digital upskilling technologies can aid in their move to higher-level roles so that workers can still make a contribution to the trucking business.

An initial set of policies should concentrate on the following objectives:

a) Assist workers in advancing into higher-skilled positions that are less susceptible to automation.
b) Applying a Federal Law to compensate the job losses
c) Enhance the safety net for those who are likely to be displaced by automation.

Examples of Implementation of these objectives:

I. ***Digital Upskilling*** – Upskilling becomes increasingly necessary as technology develops. To function effectively in the modern trucking sector, truck mechanics, drivers, and warehouse workers must all be at ease with new technologies. While technological advancements have increased the number of skills that trucking industry workers must learn, they have also in many ways simplified the learning process. You can give employees the resources and knowledge they need to learn remotely by using upskilling technologies like Degreed and Learning Pool (Deloitte, 2020). For in-person training sessions, a specialized teacher is no longer required. Regardless of where they are currently stationed, employees can pick up new skills. An

employee's (especially a new hire's) ability to practice new driving techniques before using them on the road can be aided by the truck driving simulators.

II. ***Implementation of a Federal Vehicle Miles Traveled (VMT) Tax*** – This tax is a sort of tax that is based on the number of miles traveled by a vehicle on public highways. Typically, this tax is used to finance infrastructure projects and road care. A VMT tax on autonomous vehicles has been proposed as a means of generating income and offsetting potential employment losses in the trucking sector caused by automation. A VMT tax imposes a price on autonomous trucks depending on the number of kilometers they travel on public roads (Robert D., 2021). This levy could be modified over time to account for inflation and change in the cost of road maintenance and infrastructure.

However, there are additionally a few problems that could come up with a VMT tax on self-driving trucks. For instance, it may be challenging to adopt and enforce and may demand substantial investments in technology and infrastructure. In addition, there could be worries with privacy and data security, as it would be required to collect data on the number of kilometers driven by vehicles in order to calculate the fee.

Therefore, while a VMT tax on autonomous trucks has the ability to generate income and assist infrastructure initiatives, it would require careful planning and thought to overcome the possible problems and assure its fair and successful implementation.

III. ***Implying on Career Advancement Programs*** – Increasing access to career training for trucking sector personnel can assist people in acquiring new skills and advancing their careers, while simultaneously aiding the industry's march toward automation. Here are some examples to increase access to career training for current trucking industry employees such as; Mentorship Program, Establishing a Training Fund, Partnering with Educational Institutions, and so on.

Examples of companies that provide training programs to help entry-level workers acquire the skills they need for better employment include Amazon's Career Choice for Amazon warehouse associates and Walmart University for Walmart employees. Community colleges also play an essential part in this expansion. Some community colleges have experience instructing on-site courses for businesses, like Amazon's Career Choice program. As the number of youth apprenticeship programs increases, the number of community colleges that have expertise working with employer partnerships is also increasing.

Innovation has the potential to change the transportation sector by tackling rising prices, driver shortages, and environmental issues. Innovations in vehicle technology, logistics and supply chain management, and new business models have the potential to greatly enhance the industry's efficiency, sustainability, and safety. But, the sector will need to carefully assess the possible risks and obstacles connected with each invention to ensure its continued success in the face of changing economic and environmental stresses.

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