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The Necessity of Introducing Autonomous Trucks in Logistics 4.0

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Abstract: Autonomous vehicles have become important with the emergence of Logistics 4.0. Moreover, truck-based transport has become the critical means of transport in the logistics market. Thus, to deal with the pending issues of the logistics market, it is not enough to merely expand the workforce. Adopting autonomous trucks will also help change the truck allocation structure. This may enable horizontal and vertical integration based on the new logistics model and help address various problems faced by shipping companies. Thus, adopting autonomous trucks can provide various benefits for the logistics business, society, and consumers. However, adopting autonomous trucks does not only have benefits. Here, this study suggests truck platooning as a method of adopting autonomous trucks more efficiently. Furthermore, we approach the potential issues regarding autonomous truck adoption from various perspectives by demonstrating the efficiency of autonomous trucks as well as their problems.

Keywords: Logistics 4.0; autonomous driving; trucker; CAV; HGV

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1. Introduction

Land transport using trucks is the key transportation mode in the logistics market. Approximately 90% of freight in Japan, and 70% of freight in Australia and the United States is transported by truck. Moreover, such numbers are likely to persist. However, the logistics industry is currently facing a crisis without any significant change or structural transformation for decades.

In particular, truck drivers are becoming older worldwide; furthermore, there is a shortage of manpower. Advanced countries with a high ratio of trucking, such as Japan, the United States, the United Kingdom, and Australia, are already facing a severe shortage of truck drivers due to aging. This has led to an increase in transportation costs and product prices, making it difficult to find carriers to deliver the cargo. This issue directly affects consumers and has resulted in a "logistics crisis".

Similarly, not many job seekers in Korea are entering the trucking market and the average age of carriers is gradually increasing. To address this, efforts are being made to expand the workforce by increasing wages and improving the work environment. However, with the decrease in the working age population with social productivity, it is risky to depend only on expanding the workforce.

Meanwhile, door-to-door delivery has become common in everyday lives in the COVID-19 pandemic. Delivering the goods to consumers quickly at a low cost has become a strategy to survive in the logistics industry. However, with an aging workforce, merely expanding the number of drivers may lead to more accidents as drivers' judgement deteriorates. The "non-face-to-face culture" that has spread after the outbreak of COVID-19 is accelerating "Smart Logistics" that minimizes contact between workers in order to improve the efficiency of logistics operations. It is necessary to develop a smart logistics system that automates the entire process of cargo processing, such as warehousing, storage, and shipment. As demand for non-face-to-face delivery expands, the use of autonomous transportation, such as cargo and ports, is expected to expand even in exclusive environments. In fact, in the early days of the pandemic, companies had no choice but to suspend test services because of the risk of infection, which could rather advance autonomous driving tests without drivers. Currently, the completeness of autonomous driving technology is evaluated as reaching the stage of fully autonomous driving. In particular, as IT companies actively jumped in, technological progress accelerated.

According to a survey on firms by the logistics consulting company EFT, the technologies that will change logistics, in order, are blockchain, followed by artificial intelligence (AI), robots, and autonomous vehicles. In total, 42.01% of the respondents chose autonomous vehicles, which was slightly lower than blockchain at the top [1]. Trucks are a typical means of transport and logistics. Adopting autonomous driving technology (AT) will change the costs, structure, and efficiency of trucking, thereby changing the prime costs of consumer goods. Indeed, logistics has evolved and changed throughout history. Today, Logistics 4.0 has developed over the last few years as a result of the Fourth Industrial Revolution and the technological accomplishments of the 21st century. It has enabled the exchange of new data, and the horizontal and vertical integration of new business models and value chains through the development of Information and Communications Technology (ICT) [2].

However, to the best of our knowledge, there are very few studies applying autonomous driving to logistics. Social approval is necessary to successfully apply autonomous trucks to logistics in a short period of time. In Logistics 4.0, logistics turns into a business model that does not depend on human resources; importantly, trucking is the process that changes first. This study seeks to provide a fundamental solution for the current situation in which it is necessary to expand not the workforce but the logistics according to Logistics 4.0.

2. Theoretical Background

2.1. Logistics 4.0

2.1.1. Evolution of the Logistics System

With the intense competition and accelerated process of technological improvement, some argue that logistics has now entered the era of the Fourth Industrial Revolution [3]. Various product modifications have produced numerous methods to deal with the logistics system, such as modularization [4]. However, there is still a question about whether the logistics system today can handle a much more complicated system without increasing costs or deteriorating quality.

To understand the background of the emergence of Logistics 4.0, chronological milestones and resulting changes in logistics need to be looked into. The first change (Logistics 1.0) was the "mechanization of transportation". Trucks were crucial in bringing the mechanization of transportation. With the advancement in land transport, it became high speed, and involved mass storage due to trucks and railroads. From the late 19th century to early 20th century, carriages disappeared from the streets and many trucking companies were established. In marine transport, steamers and service ships were employed, and mechanization was adopted [5].

The second change (Logistics 2.0) was the discovery of electric power and the introduction of mass production, which led to automation of loading and unloading by the time World War II ended in the mid-20th century. Later, in the 1960s, sea containers contributed greatly to making cargo handling efficient. Before Logistics 2.0, the type of cargo loaded on cargo ships had not been standardized. It required human hands to deal with the entire process of combining different sizes of cargo, as instructed, by workers, and hanging wooden boxes to the cranes on structures installed to easily moor the ship alongside the pier and piling them inside the ship. During this time, large gantry cranes that could lift up sea containers were operated in ports, creating an environment where workers could work without being affected by the weather. In the late 1960s, automated warehouses became popularized, which automated cargo work inside the warehouses such as carrying in and out or storing using material-carrying equipment such as forklifts. Since automated warehouses had low versatility and required high costs, it took some time for wide use; however, they were mostly used in delivery centers close to factories. In the third change (Logistics 3.0), there was systemization of logistics management and the introduction of micro-ICT in the 1980s [5]. Logistics companies adopted Warehouse Management Systems (WMS) to charge storage fees and warehousing/delivery costs to the owners of goods. The use of the WMS and Transportation Management Systems (TMS) was soon generalized after the 1980s. Currently, an integrated management system for all work situations and cargo locations, from inventory to warehousing, housing, delivery, check, and packaging, is widely used. This system manages truck allocation intervals and records information such as the number of trucks, allocation sites, cargo volume, and place of transportation.

The fourth change (Logistics 4.0) was the digitalization of logistics activities and processes, that is, the application of digital logistics [6]. Logistics management includes planning, implementing, and controlling all logistics processes. Meanwhile, product flow includes all activities regarding the movement of goods from the suppliers of materials to end users [7]. Logistics 4.0 is defined as smart logistics, comprising automatic identification, real-time location, automated data collection, connection and integration, data processing and analysis, and business service. As next-generation technologies such as the Internet-of-Things (IoT), AI, and robotics are developed and applied to new avenues, logistics equipment is being industrialized through downsizing (streamlining) and standardization. Downsizing refers to significantly reducing the process that requires manipulation and decision making by humans in each area of logistics. The main operator of logistics is shifted from humans to machines and systems so that the same tasks can be performed by the purchased machines or systems. Another word for this is "streamlining", meaning complete intellectualization in which "human intervention" is unnecessary because of using ICT. Standardization involves various functions and information on logistics being connected, thereby coincidentally operating transport routes or means. Standardization enables multiple owners to share the racks or warehouses, and connecting the information in the supply chain can reduce inventory and opportunity loss as much as possible.

2.1.2. Regulations on Autonomous Driving in Korea

The "Act on the Promotion of and Support for Commercialization of Autonomous Driving Motor Vehicles" was enacted on 30 April 2019, in Korea and enforced on 1 May 2020. The purpose of this law is to promote and support the commercialization of autonomous driving motor vehicles by prescribing matters necessary for introducing and widely selling autonomous driving motor vehicles as well as for establishing, supporting, etc., the foundation for the safe operation of such vehicles, thereby contributing to improving the people's living environment and to developing the national economy. One of the bills currently proposed is the revised bill of the "Guarantee of Automobile Accident Compensation Act (2018)" that determines who is responsible for accidents and the corresponding compensation standards for Level 3 autonomous vehicles. According to this revised bill, the motor vehicle owner is primarily responsible for the accident involving autonomous vehicles, as is the case for current motor vehicle owners. The insurer of the liability insurance policy purchased by the owner is to compensate the victim. If the accident is caused by a vehicle defect, the insurer may exercise the right to indemnity to the autonomous vehicle's manufacturer. The revised bill imposes the duty of recording information on the driving of autonomous vehicles to manufacturer, and views that accidents involving autonomous vehicles have specialized judgment issues different from general car accidents. The key to investigating the cause of autonomous vehicle accidents will be the awareness of the autonomous driving system based on tachograph analysis as well as the analysis and determination of whether the brakes are operating normally. According to this view, tachographs must be mandated when manufacturing and selling autonomous vehicles to obtain data for investigating the cause of the accident. Thus, it suggests establishing an accident investigation board for autonomous vehicles.

The Ministry of Land, Infrastructure, and Transport released the "Ethical Guidelines for Autonomous Vehicles" that define the fundamental values and the main agent that must be considered in the process of manufacturing and operating autonomous vehicles and provide the rules of conduct. An important matter in the guidelines is that the responsibility regarding fully autonomous vehicles is not imposed on the user (consumer) but on the manufacturer. Considering that the aim of fully autonomous vehicles, the final stage of autonomous driving, is to achieve zero accidents, the key issue here is who is ultimately responsible for not ensuring safety as first priority. Regarding this issue, the Ethical Guidelines impose the responsibility about the safety and security of autonomous vehicles on the manufacturer, as well as the responsibility about defects and maintenance issues within service life.

2.1.3. Regulations on Autonomous Driving in USA

When discussing legal regulations on self-driving, it is essential to mention the United States. Legal problems related to autonomous driving cars in the U.S. began in August 2011 when Google crashed an autonomous driving car. In this case, the accident occurred after changing from a person's driving mode to a Jowl driving mode, raising the need for legal regulation.

In the case of the U.S., the federal and state governments are simultaneously trying to legislate for autonomous driving cars, and the legislation is generally centered on the state, and the federal NHTSA is presenting a comprehensive framework.

In the United States, the first federal law on autonomous driving vehicles, the Safely Enforcing Lives Future Deployment and Research in Vehicle Evolution Act, was introduced on 27 July 2017, and was first enacted at the federal level in September 2017.

Previously, 6 states in 2012, 9 states in 2013, 12 states in 2014, 16 states in 2015, 20 states in 2016, and 33 states in 2017 submitted legislation on a state-level basis to permit autonomous vehicles, starting with Nevada. From Nevada to California, Florida, DC, Michigan, Nostakoda, Tennessee, and Utah, the law stipulates the concept of autonomous driving cars and obligations to record operational data, etc. Although slightly different from state to state, it is closely structured and includes definitions of the relevant concepts of autonomous driving cars, test driving requirements for autonomous driving cars, registration requirements, automakers' responsibilities, and regulatory obligations.

In the table below, we would like to present the autonomous driving regulations in Korea and the United States based on four criteria. As shown in the Table 1, Korea lags behind the US in terms of overall autonomous driving.

Table 1. Comparison of laws and regulations related to autonomous driving cars between Korea and the U.S.

	Grounds for Driving	**Responsible Entity Depending on the Level at the Time of an Autonomous Driving Accident**	**Operation Permission Target**	**System for Operation on General Roads**
Korea	Ministry of Land, Infrastructure and Transport	Level 3: Responsibility of the driver who is the temporary driving applicant Level 5: Responsible entity is not determined	Only allowed for testing and research purposes	Legislation regarding test operation in 2016
USA	NHTS each state law	Level 3: Personal or system responsibilities Level 5: Individuals for commercial use are exempt from liability	Fully autonomous vehicle (level 5) allowed	Enacted in 2017 after legislation in 2012 and published NHTSA v.20

Source: Author Created.

2.2. Background of Transport and Logistics Accidents

2.2.1. Causes of Trucking Accidents

Accidents in the trucking industry are caused by safety issues as trucks, which contribute considerably to transport and logistics, are difficult to control, maneuver, and stop quickly due to their size and weight. The risk in truck accidents is more than twice that of car accidents, while the risk of fatal accidents is about six times higher [8]. One-ton trucks, 2.9 million of which are registered in Korea, are the most commonly used vehicles for cargo transportation. Notably, in cases where there is an accident, the risk of death is highest for drivers of one-ton trucks.

Truck accidents have many causes, including general negligence, improper attention, distraction, psychological stress at work, and lack of productivity, which all increase the risk of accidents. A few other factors related to truck accidents include the driver, environment, and weather. Driving a truck when feeling tired during rush hours is another factor that increases accident rates. Foul weather and poor vision due to weather conditions also cause serious accidents for truck drivers. However, 90% of the accidents are caused by drivers, most likely due to errors such as drowsy driving or violation of the duty to keep eyes on the road regardless of the driving skills. Thus, active measures must be taken to solve these problems. Truckers concentrate on driving day and night without enough breaks, which causes many accidents. In particular, truck accidents lead to collateral damage that is likely to result in major incidents, which is why safe and secure driving is necessary. Moreover, heavy goods vehicles have different physical traits and usage patterns than cars as well as different forms of accidents. Thus, it is necessary to establish safe measures that can be applied to heavy goods vehicles.

2.2.2. Accidents by Truckers

Truck accidents, which lead to serious injuries and deaths, are likely to be caused by truckers due to the nature of truck driving. The United States lacked 48,000 cargo truckers in 2015; this number is expected to be 175,000 by 2024. A total of 90% of car crashes involving trucks are caused by driver error. Over the last 30 years, studies have proved the clear relationship between excessive daytime sleepiness (EDS) and motor vehicle accidents (MVAs) [9]. EDS is perceived as a major problem in accidents that occur in road transport. Sleepiness interrupts alertness, reaction time, and psychomotor skills that are considered essential in driving [10]. For example, more than half of the MVAs that occur on the road cause fatal injuries or chronic disabilities, with at least 80% due to truck driver error [11]. There is substantial research on the danger and protection of truck drivers related to MVAs and Near Miss Accidents (NMAs) [12,13]. To prevent crashes and accidents related to sleepiness, the first group to consider are the truckers [14]. Some of the major causes of accidents are characteristics related to truck driving, such as the weight of the truck, long driving distance, level of attention, and monotonousness of driving [15,16].

3. Adoption of Autonomous Trucks

Recently, logistics experts forecast that the age of autonomous trucks may arrive much sooner than expected [17]. For example, autonomous trucks may be supplied more commercially than autonomous cars [18], with the International Bar Association (IBA) arguing for the need to develop autonomous trucks [19]. In total, 95% of cargo in the United Kingdom and 70% of cargo (approximately 10.5 billion tons a year) in the United States is hauled by trucks, but there are not enough carriers.

Autonomous trucks are not just discussed in theory but have been actually developed and are currently in operation. Scania, a subsidiary of Volkswagen, is developing the world's first complete autonomous truck platooning system. Singapore plans to transport containers between port terminals by platooning four trucks on public roads. Korea has also successfully demonstrated platooning of heavy goods vehicles on the highway.

3.1. Truck Platooning

The adoption of autonomous truck platooning is expected to change the highway driving environment. Platooning provides real-time information on the traffic conditions nearby and decisions of the traffic management center. This information improves safety and mobility as well as the efficiency, responsiveness, and work efficiency of carriers. Truck platooning not only affects design and operations but also perfectly automates the process of loading and unloading cargo accurately in transport and logistics. Various sensors are used to stop the truck at precise locations, automate the winch, and dismantle the latch remotely. Management must be handled promptly using software at the control center. Truck platooning will radically reduce major traffic accidents while also positively affecting the environment due to increased fuel efficiency and reduced exhaust gas by minimizing air resistance to the following truck. Truck platooning tests are conducted in two steps. The first step is to design the truck platooning technology, followed by testing and improving it according to local conditions. This experiment was conducted by Scania and Toyota at their research centers located in Sweden and Japan; the second step is to test and improve the technology under real conditions in Singapore.

3.2. Efficiency

Autonomous driving is not a new phenomenon but is likely to be one of the most shocking innovations in the world [20]. Autonomous trucks have environmental, stability, and social benefits.

First, adopting autonomous trucks is likely to significantly improve transport efficiency and reduce pollution. It can also better control vehicle speed and respond more quickly to traffic conditions, which leads to increased fuel efficiency and reduced driver cost, thereby lowering the Total Cost of Ownership (TCO) for truck owners in the long run. Moreover, autonomous trucks can be driven year-round without the need for drivers to take a break, thereby improving driving time [9] (pp. 565–567). These trucks also have high fuel efficiency, thus reducing carbon dioxide emissions [21] and fuel costs, which may lead to lower environmental impacts [22]. For example, Europe tested autonomous trucks in April 2016 and discovered that the leading truck saved 5% of fuel, while the following trucks saved 10–15% [23]. Truck platooning can be an initial example of laying out connected and autonomous vehicles (CAVs) on the road. Moreover, it can provide further benefits regarding fuel efficiency, environment, safety, and combination regarding connected and autonomous heavy goods vehicles used in freight and logistics. This is the method in which one HGV leads the trucks that follow, which is connected wirelessly, to form a train on the road and makes decisions. Two or three trucks move in a single file, with the carrier on the leading truck, which is closely followed by another truck using vehicle-to-vehicle (V2V) communications. One of the major advantages is that the carriers can move closely to one another on the leading truck. The short travel time and less dangerous traffic conditions with high-capacity network leads to increased fuel efficiency. This enables lower cost and higher stability, with an expected cost reduction of up to 28%. The truck following the leading truck also has a substitute carrier to replace the one driving the leading truck to reduce fatigue and time spent in rest areas. If there are no carriers on the following trucks, wages paid to carriers can also be reduced.

Second, autonomous trucks are efficient in terms of stability. They do not require a break time and can be driven regardless of time of the day. Unlike conventional truckers, autonomous trucks do not require drivers to sleep at night and can go farther more quickly than trucks driven by human drivers. According to the National Highway Traffic Safety Administration, in 2012, 333,000 heavy goods vehicles crashed in the United States, killing 3921 people, most of whom were in cars. A total of 3903 people (73%) died in 2014 alone, and over 111,000 people were injured from crashes involving heavy goods vehicles. Approximately 438,000 heavy goods vehicles were involved in traffic accidents reported to the police in 2014. They do not have the uncertainty from human drivers who may call in sick, which is a huge benefit. Another major advantage regarding safety is that they can reduce serious accidents. In particular, autonomous trucks can integrate technologies to increase road safety and reduce human error. According to automotive experts, autonomous trucks equipped with advanced devices, such as automatic emergency braking, lane keeping, and blind spot monitors, may eliminate the impact of human error and reduce accidents. By excluding human drivers from trucks, as suggested by Crandall and Formby, many pending issues in the road transport industry can be resolved, such as shortage of truckers, accidents, and fuel costs.

Third, autonomous trucks have social efficiency. Trucking has been classified and characterized as a male job from the past and even until today. The stereotype in terms of gender roles still widely exists in the trucking business. Despite the effort to break the stereotype by involving women truckers, the industry is still full of masculine culture. There are over 3 million truck drivers in the United States; however, only 5.8% of them are female and this percentage has not changed fundamentally over the last 82 years. In contrast, according to the United States Department of Labor, women account for 47% of all workers in the United States. The percentage of female drivers has remained stagnant since 2000 between 4.5% and 6%. Other studies argue that the percentage of female truck drivers is even lower at 1%. In the United Kingdom, there are 300,000 truck drivers, 1600 (0.5%) of whom are women. By adopting autonomous trucks, the role of cargo truckers can be changed from someone driving one truck at a time to monitoring multiple trucks. Adopting autonomous trucks will change the paradigm of the conventional social and cultural perception of carriers and truckers.

3.3. Problems

There are both advantages and disadvantages in adopting autonomous trucks. Notably, issues regarding law, regulations, and responsibilities are major barriers. Currently, autonomous trucks are not permitted to be driven on public roads. Moreover, most studies note technology barriers and security issues such as hacking. This is closely related to infrastructure that must be compatible with new technology such as highways, communication with other vehicles, and related processes.

The most conflicting issue is the change in labor force. According to a recent report by IBA, the rapid rise of AI will change the labor world of old truckers worldwide who will be ultimately rendered redundant in the future. This means that there will a massive need to retrain and reintegrate the unemployed carriers and truckers into other meaningful jobs. Although autonomous vehicles have been claimed to represent advanced technology that does not require human functions [23], the technology cannot be implemented on autonomous trucks as impeccably as in theory. The road tests of autonomous trucks performed worldwide have included carriers inside the trucks in case of emergency. Thus, to use autonomous trucks in actual transport, human drivers qualified as a carrier must be seated in the driver's seat at all times, even though they can relax and rest.

Social and ethical problems are also major concerns. Autonomous trucks clearly lessen the burden on the driver, but they may also induce new thoughts about the traditional perception of driverless trucks. This affects how carriers accept autonomous trucks; however, once technological feasibility and reliability are proved, the acceptance of carriers, regulations, and infrastructure should follow, thereby solving these issues in the near future. Thus, by overcoming the aforementioned barriers mentioned in adopting autonomous driving, we can provide various benefits for logistics service providers, the society, and consumers.

3.4. Cases of Driving Autonomous Trucks

There are several examples of testing and usage of autonomous trucks globally. For example, in Korea, platooning performed has been performed: when the driver of the following truck approaches the leading vehicle, it switches to platooning mode. Thereafter, the following truck maintains a distance of at least 16.7 m, with real-time control based on the acceleration and deceleration of the car in front. The driver of the lead truck can reduce driving fatigue through semi-autonomous driving. Meanwhile, the driver of the following truck can let go of the steering wheel, thereby being completely free from driving. It is also possible to deal with unforeseen incidents such as another vehicle cutting in between the trucks. If another vehicle cuts in between platooning trucks, the following truck automatically keeps a sufficient distance (at least 25 m) from that vehicle. The test run in Korea successfully implemented the technology for the following truck to operate sudden braking when the leading truck makes a sudden stop or brake in an unexpected situation.

The United States had its first cargo transport by an autonomous truck on 25 October 2016 [24]. The world's first commercial autonomous driving delivery was successful, traveling 120 miles from Colorado in two hours. The track could drive without the assistance of the driver on the highway, validate the traffic conditions, choose acceleration and speed, and keep the lane. In June 2019, USPS also completed a trial run of autonomous driving trucks that can transport mail in cooperation with Tuisimple. USPS tested autonomous driving trucks while moving from Dallas, Texas to Phoenix, Arizona, on a 1000-mile road, but the main goal of this test was to verify safety. Another example is the successful trans-East–West transportation of the U.S. continent in December 2019 with Level 4 autonomous driving trucks. The autonomous truck reached Pennsylvania from California, and as a Level 4 autonomous truck, refrigerated containers full of fresh cargo were the first to cross the U.S. continent during the trial run. In the autonomous system used in the test run, if a multi-modal sensor deep learning visual algorithm and SLAM (parallel processing of self-position estimation and environmental mapping) technology were introduced, the vehicle was accompanied by one driver and one engineer. The route was tested against bad weather such as rain and snow over 11,000 feet above sea level, roads under construction, and long tunnels several miles. In May 2021, the company test-transported freshwater watermelons from Nogales, Arizona, to Oklahoma, Oklahoma, Oklahoma. On the same day, a truck loaded with watermelons from the storage warehouse of Zimara, an agricultural production and distribution company in Nogales, near the Mexican border, arrived at a logistics center in Oklahoma City after passing four states. Usually, it took 24 h and 6 min to drive, but it was reduced by 10 h to 14 h, which was 42 percent less than the transportation time of drivers. Autonomous trucks continued to operate in November 2009. Through a test run of autonomous trucks in the Texas area, two autonomous driving experts were on board, one with a commercial driver's license and one software engineer monitored the truck's operation in autonomous driving mode. In this test run, we learned how autonomous driving technology can help improve safety and efficiency on the I-45 section of the expressway between Dallas and Port Wes and Houston, and conducted a test run to further refine and expand self-driving. In addition to the driving cases mentioned in this paper, autonomous trucks continue to operate, and in some states are allowed to operate not only on test roads but also on general roads. As the demand-driven market trend becomes clearer, the era of autonomous trucks must come to provide uninterrupted supply to meet demand.

4. Conclusions

This study suggested autonomous trucks to reform transportation and promote the adoption of safe and innovative new technology for the benefits of consumers and firms. With its advancement due to intense competition and technological development, Logistics 4.0 enables logistics management, product flow, and information flow by applying digital logistics. In addition, the advancement of future-generation technologies, such as IoT, AI, and autonomous driving, and the expansion of their scope of applications is changing the basic structure of logistics through downsizing and standardization. Accordingly, autonomous driving will become important in future logistics. According to the "2020 KPMG AVRI (Autonomous Vehicles Readiness Index)" released by KPMG, a global accounting and consulting company, Singapore was ranked first, the United States second, and South Korea seventh. It can be seen that technological progress has accelerated as IT companies have actively jumped in.

Trucks, a typical mode of transportation in logistics, are more likely to be involved in accidents caused by truckers. Studies over the last 30 years have proved the clear relationship between sleepiness and MVAs. Under such conditions, depending only on the method of increasing workforce will only increase the number of aged carriers in many aging countries, which may lead to accidents as judgment deteriorates with age.

Notably, the recent increase in public interest in autonomous trucks has changed the cargo transport and logistics business. Adopting autonomous trucks increases efficiency in terms of transportation cost and structure as well as economic efficiency, which then lowers the prime costs of consumer goods, thereby forming a virtuous cycle. Platooning is important for improving the efficiency of autonomous trucks. Platooning can provide real-time information about the traffic conditions and decisions of the traffic management center, which increases stability and mobility as well as efficiency, responsiveness, and comfort of carriers. Moreover, truck platooning can perfectly automate the process of accurately loading and unloading cargo in logistics.

This study also outlines the safety, environmental, and social benefits of autonomous trucking. Autonomous trucks do not require a break, are not exhausted even when they are driven day and night, do not have uncertainty, can increase road safety, control factors that may cause driver-related accidents through technology, control vehicle speed, and quickly respond to traffic conditions. This increases fuel efficiency in the long run and reduces carbon dioxide, thereby benefiting the environment. Furthermore, autonomous trucking can help overcome the stereotype of gender roles in trucking. Trucking has been classified as a male-centered job in the past. Adopting autonomous trucks will change the role of carriers from a person driving one truck at a time to controlling multiple trucks under platooning; this can help transform the conventional masculine image of trucking.

Nevertheless, autonomous trucking also has some problems. First, current regulations only allow autonomous trucks to be driven on public roads with permission. Second, there may also be technological barriers and security issues such as hacking. Third, autonomous trucks are considered a typical technology that does not require human involvement, which may negatively impact employment. However, the road tests of autonomous trucks performed worldwide have had carriers in them in case of emergency. Hence, while running autonomous trucks in actual transport, human drivers qualified as a carrier must be seated in the driver's seat. Thus, realistically, adopting autonomous driving will not necessarily get rid of carriers. Fourth, regarding the social and ethical aspects, driverless trucks are different from conventional trucks. There may be a gap between the two, which might deteriorate reliability. However, once technological feasibility and reliability are proved, carriers should naturally accept and trust autonomous trucks.

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