

Research on the Criminal Liability of Manufacturers in Autonomous Vehicle Accidents

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Abstract: With the development of the autonomous vehicle industry, China's criminal law plays an increasingly important role in regulating the criminal liability of participants in autonomous vehicle accidents. However, due to the unique and innovative operating mode of autonomous vehicles, there are many unresolved issues in the criminal law's regulation of traditional automobile traffic accidents through the crime of traffic accident, especially regarding the determination of the criminal liability of manufacturers. Based on the identification and differentiation of the responsible parties in autonomous vehicles, and on the premise that autonomous vehicle systems cannot be criminally liable, this paper analyzes the duty of care of autonomous vehicle manufacturers throughout the production and application process. It emphasizes that manufacturers can be held liable through the perspective of product infringement theory, and examines three different mainstream viewpoints in academia when determining the crime, presenting relevant criticisms from the academic community. Ultimately, it is reasonable to identify the criminal liability of manufacturers in autonomous vehicle accidents as traffic accident crimes, and it is hoped that criminal law can add autonomous vehicle manufacturers as unit subjects of traffic accident crimes, making it feasible both theoretically and practically.

Keywords: Autonomous Vehicle; Manufacturer; Duty of Care; Crime of Causing Traffic Casualties.

1. Introduction

With the development of technology, the field of artificial intelligence is constantly making breakthroughs and innovations. As one of its representatives, autonomous vehicles have gradually emerged as a hot development trend. However, as issues such as frequent accidents involving auto drive systems become increasingly severe, traditional criminal law provisions such as traffic accident crimes are no longer sufficient to regulate negligent crimes in autonomous vehicle accidents and meet the needs and development of society. Due to the unique innovative driving and operation modes of autonomous vehicles, there are many unresolved issues regarding the determination of criminal liability for manufacturers in accidents, which has attracted widespread attention and research both domestically and internationally. Foreign countries are actively regulating autonomous vehicles through a series of measures such as legislation. For example, the UK issued the Autonomous Vehicles Act on May 20, 2024 (AV Act for short), and California, a leading state in autonomous driving technology and law, issued a draft regulation on the operation of autonomous vehicles on highways on August 30, 2024. Domestic L4 autonomous vehicles have also begun to use 5G technology for public demonstration applications. At the same time, the "Guidelines for Safe Service of Autonomous Vehicles Transportation (Implementation)" (Jia Ban Yun [2023] No. 66), issued on December 5, 2023, clearly stipulates that for vehicle dynamic monitoring, the transportation authorities at the operation location shall urge autonomous transportation operators to strengthen the dynamic management of transportation vehicles and safety personnel.

The identification of obligatory subjects and attribution of responsibility in autonomous vehicle accidents is a paramount challenge. This article primarily focuses on manufacturers involved in autonomous vehicle accidents, with an emphasis

on the determination of their criminal liability. It explores the issues of responsibility identification and regulation, clarifies the obligatory subjects as the premise for elaboration, analyzes the duty of care and imputation path of manufacturers from both theoretical and empirical perspectives, summarizes different views in academia on the selection of criminal charges, and provides reasonable legal suggestions for the determination of manufacturers' criminal liability in auto drive system accidents in China.

2. Definition and Characteristics of Autonomous Vehicle

2.1. Definition of Autonomous Vehicle

An autonomous vehicle refers to a motor vehicle equipped with advanced sensors and other devices that utilize artificial intelligence, visual computing, radar, and global positioning systems in a coordinated manner, enabling it to perceive the environment, plan routes, and control autonomously without human active manipulation [1]. The research history of autonomous driving technology in China can be traced back to the 1980s, when China's vision for the modernization and application of autonomous vehicles became very clear. In 1992, China's first truly autonomous test vehicle, ATB-1, was introduced, which was completed through the joint efforts of institutions such as the National University of Defense Technology of the Chinese People's Liberation Army and Beijing Institute of Technology. In December 2015, Baidu's self-developed autonomous vehicle completed autonomous driving tests, marking the beginning of the productization of autonomous driving technology. In recent years, China has emphasized the promotion of research and development as well as application of road autonomous driving technology, and has advocated for a series of advanced technologies to drive the application of autonomous driving and assisted driving. Figure 1-1 below illustrates the research and

development history of autonomous driving technology in China.

According to the national standard "Classification of Automated Driving for Vehicles" (GB/T40429-2021), which came into effect on March 1, 2022, autonomous vehicles can be classified into six levels of automation, namely: Level 0 (Emergency Assistance), Level 1 (Partial Driving Assistance), Level 2 (Combined Driving Assistance), Level 3 (Conditional Automated Driving), Level 4 (Highly Automated Driving),

and Level 5 (Fully Automated Driving). In fact, the first three levels are not strictly autonomous driving. Therefore, this article focuses on Level 3, Level 4, and Level 5 autonomous vehicles and conducts research on the determination of criminal liability of manufacturers in accidents involving autonomous vehicles. The following table shows the classification of autonomous vehicle automation levels.

Table 1. Autonomous vehicle automation level classification

Level	Name	Vehicle lateral and longitudinal motion control	Target and time detection and response	Dynamic driving task takeover	Design operating conditions
Level 0	Emergency Assistance	Driver	Driver and system	Driver	Restricted
Level 1	Partial assisted driving	Driver and system	Driver and system	Driver	Restricted
Level 2	Combined driving assistance	System	Driver and system	Driver	Restricted
Level 3	Conditional autonomous driving	System	System	Dynamic driving task takeover user	Restricted
Level 4	Highly automated driving	System	System	System	Restricted
Level 5	Fully autonomous driving	System	System	System	Unrestricted

2.2. Characteristics of Autonomous Vehicle

Autonomous vehicles are the product of technological development and continuous advancement towards intelligence, exhibiting distinct characteristics compared to traditional cars. This article primarily discusses four aspects: high intelligence, ubiquitous network connectivity, high real-time requirements, and unique safety features[2].

2.2.1. Highly Intelligent

Compared to traditional cars, autonomous vehicles utilize various technologies such as radar, laser, ultrasonic, navigation systems, odometers, and computer vision to perceive the surrounding environment, identify obstacles and various signboards, and exhibit high perception capabilities. Starting from the L3 level, the control of lateral and longitudinal movements, target and time detection and response, and design operating conditions of autonomous vehicles are continuously becoming more intelligent as the level of automation increases. In fully autonomous vehicles, the driver can be equated to the status of a passenger.

2.2.2. Pan-network Connection

The core characteristics of ubiquitous network connectivity are omnipresent, all-encompassing, and omnipotent, aiming to achieve seamless communication between any person and any object at any time and any place. Autonomous vehicles rely on network connectivity and also embody their unique characteristics. Whether it is the operation of the driver during driving or the real-time monitoring of production operators, it is inseparable from the close connection between autonomous vehicles and network connectivity.

2.2.3. High real-time Requirements

Autonomous vehicles are marketed to consumers as offering more convenient and comfortable services. Their high real-time requirements, such as rapid sensor response, real-time data processing, implementation control, and edge computing support, are the basis for consumer trust and application. Autonomous vehicles can respond quickly and accurately in various situations, enhancing driving safety and efficiency.

2.2.4. Safety Specificity

Autonomous vehicles are highly related to people's life and property safety, as well as public safety. Therefore, when criminals use them as tools to launch attacks, the damage caused will be even more severe, and more complex and covert new attack methods will emerge. Autonomous vehicles are equipped with a large number of sensors, providing abundant attack entry points, and rely on technologies such as networking, which significantly increases the risk of data leakage.

Due to its characteristics, autonomous vehicles not only bring convenience to people's daily lives, making travel more convenient and safer, but also bring many unavoidable issues. The regulation of autonomous vehicles in criminal law has also been pending resolution.

3. Criminal Liability Subject of Autonomous Vehicle Accidents

3.1. On the Premise That the Auto Drive System Cannot be the Subject of Criminal Liability for Autonomous Driving

The traditional academic view is to use the existence of free will as the basis for judging whether artificial intelligence can have the status of a criminally responsible subject and bear criminal responsibility. Free will is an essential attribute that distinguishes humans from other species. Humans can make choices independently according to their own will through free will, rather than being determined by external factors. So can the auto drive system (i.e., artificial intelligence) possess free will?

Scholars who support the affirmative view generally explain it from two directions. The first explanation is that robots possess free will, and this free will, like that of humans, is an ability to recognize and control the risks of their own behavior and make choices based on self-determination[3]. Due to the rapid development of artificial intelligence, this ability is entirely feasible in the future. When AI develops to the stage of general AI, it can not only learn, reason, think, and plan through various recognition systems and expert systems, thereby gaining corresponding cognitive abilities

regarding the nature, consequences, and value of its own behavior from a legal perspective, but also learn to think independently like humans through deep learning technology, summarize and solve problems, and draw conclusions from successes and failures, thus exerting autonomous control over behavior[4]. The second explanation is based on social demand theory and social consensus theory. Firstly, social demand theory refers to the inherent conflict that has occurred in our social system regarding illegal behavior in autonomous vehicle accidents. The reason why the damage results of this conflict are attributed to the auto drive system of the vehicle is due to a social demand. By attributing responsibility to the auto drive system, this attribution can resolve social conflicts and contradictions, and the social need to resolve such conflicts exists[5]. Secondly, social consensus theory refers to the fact that a specific subject becomes a subject not because it enjoys a specific identity, but because society recognizes that the specific subject has the ability to meet the expectations of norms as a recipient of norms [6]. In today's society, autonomous vehicles are no longer a novelty. The continuous production, sale, and use of this type of vehicle have become increasingly common in our society. Accidents involving this type of vehicle also occur frequently. Therefore, analogous to the concept of "legal person" which was constructed and gradually recognized by the legal community due to the surge in "illegal and criminal phenomena" of various companies, the auto drive system may also be constructed as a criminal responsibility subject in the exclusive legal concept in the future, becoming a social consensus and existing universally.

Skeptical scholars argue that the ability to understand norms is the prerequisite for all crimes. However, artificial intelligence (AI) does not possess this understanding capability. Whether it is complying with norms, acting in accordance with norms, or violating norms and committing crimes, for AI, it is all a matter of programming. Only when AI has the ability to understand the concept and semantics of norms can its behavior reflect the significance of complying with or violating norms. Some scholars believe that with the deep learning of AI, free will will emerge. However, deep learning actually cannot endow machines with human intelligence, because the so-called "depth" does not refer to the depth of machine understanding of problems, but merely the increased design layers of neural networks. AI benefits from the enormous computing power of computers compared to humans, enabling them to complete massive tasks and computations in a short time. However, this cannot be equated with the reasoning process of the human brain. Because humans can create, AI cannot achieve breakthroughs from scratch. Only on the basis of existing neurons can AI potentially achieve deep learning. For autonomous vehicle systems, even though they can be programmed to avoid collisions with traffic participants, they cannot understand the significance of behavioral norms such as "prohibited killing" or "prohibited harming"[7]. If autonomous vehicle systems cannot understand the content and requirements of behavioral norms and comply with them, let alone how to achieve the legal effects of punishment or prevention through criminal sanctions.

In summary, this article holds a negative view. The autonomous vehicle system cannot become a subject of criminal responsibility and bear criminal liability precisely because it cannot understand the meaning of behavioral norms. Therefore, it is necessary to pursue the criminal

liability of other responsible parties in accidents involving autonomous vehicles. This article is based on the premise that the auto drive system cannot serve as the subject of criminal liability for autonomous driving, and unfolds the following discussion.

3.2. Differentiation of Criminal Responsibility Subjects for Autonomous Vehicles of Different Levels

Due to the different levels of autonomous vehicles, the responsible parties vary. This is mainly reflected through the corresponding relationship between their automatic classification levels and the duty of care and corresponding imputation principles undertaken by each participant. Under different levels, when the obligations of different participants are breached, excluding certain circumstances, whether each participant can become the subject of criminal liability in that situation.

In a fully autonomous vehicle accident, due to its highest level of automation, the autonomous vehicle does not require a driver at this time, with the system fully managing the operation of the vehicle. The driver only bears the obligation to check the vehicle condition beforehand and operate the auto drive system correctly during the accident. Therefore, when the driver performs this obligation and operates correctly, they are equivalent to a passenger, and criminal liability cannot be pursued in this situation. As an obligationist of risk control, automobile manufacturers should bear negligence liability (excluding exclusions). In the production and application stages of autonomous vehicles, manufacturers bear the obligation of risk control throughout the entire process. Regardless of which duty of care is breached, which endangers the protection of legal interests, the resulting damage should be borne by the manufacturer.

In accidents involving conditional autonomous driving and highly autonomous vehicles, it is necessary to determine the obligatory subject of risk management based on the time point of the accident. Firstly, assuming the accident occurs when the auto drive system is controlling the vehicle. After the driver has fulfilled the obligation to check the vehicle condition and correctly use the auto drive system, the manufacturer becomes the primary obligatory subject of risk management, and criminal liability should be imposed on the manufacturer. Secondly, assuming the accident occurs after the autonomous vehicle issues a takeover command but before the driver takes over the vehicle. Since during the operation of Level 3 autonomous vehicles, the driver is obligated to take over the vehicle when the system issues a warning or when necessary, it is generally believed that in conditional autonomous driving mode, the issuance of a takeover request by the autonomous vehicle signifies a transfer of responsibility[8], and the driver should take over the vehicle in a timely manner. If damage occurs due to delayed takeover or failure to take over as required, the driver should bear criminal liability (excluding certain exceptions). During the operation of Level 4 autonomous vehicles, the driver does not have the obligation to respond to the takeover request issued by the autonomous vehicle system, and only the manufacturer is technically responsible for taking minimal risk management measures. If damage occurs due to improper risk management by the manufacturer, the manufacturer should bear criminal liability. Finally, assuming the accident occurs after the driver takes over the vehicle according to the requirements of the auto drive system or

based on their personal judgment. At this point, the driver of an autonomous vehicle is no different from a driver of a regular vehicle, and the driver should bear the duty of care and criminal liability.

4. The Duty of Care and Imputation Principle of the Manufacturer in Autonomous Vehicle Accidents

4.1. Duty of Care of Manufacturers Among Participants of Autonomous Vehicles

In the entire chain of autonomous vehicles, from design and manufacturing to sales and use, there are numerous participants, including designers, manufacturers, sellers, and drivers, each with different obligations. This article focuses on the duty of care of manufacturers.

When manufacturing autonomous vehicles, manufacturers should bear the responsibility for the integrity of the product, ensuring that all components manufactured and integrated during the manufacturing process, as well as the integrated vehicle itself, are functionally flawless. When autonomous vehicles are in operation, manufacturers should fulfill their duty of warning, as autonomous vehicles differ from ordinary vehicles in their use, and different standards for autonomous driving require different operational requirements for drivers. Therefore, manufacturers must clearly inform autonomous vehicle drivers on how to properly operate the autonomous vehicle, and what level of vigilance should be maintained when facing autonomous vehicles with different levels of automation modes during driving. Manufacturers should have the obligation to explicitly inform and notify drivers of the potential safety hazards of autonomous vehicles. During the period when autonomous vehicles are put into use, manufacturers should also bear the obligation to fully test autonomous vehicles and continuously monitor their dangers. Once defects or safety hazards are discovered in autonomous vehicle products that have entered the market, in order to avoid traffic damage, the sale must be stopped and the sold vehicles must be recalled. Otherwise, the resulting damage consequences shall be borne by the manufacturer as criminal liability[9].

4.2. The Liability Path of The Manufacturer in Autonomous Vehicle Accidents

In the current risk society environment, modern criminal law has established the principle of risk responsibility, which stipulates that whoever controls the risk shall bear responsibility for the risk and its consequences[10]. Autonomous vehicles should be distinguished from the criminal liability system established for traditional vehicles in traffic accident crimes, where only the producer during the production stage and the user during the application stage are obligated to avoid traffic accidents. However, in the era of autonomous vehicle operation, the traditional traffic accident crime system has become inadequate for the regulation of this emerging intelligent transportation. Therefore, it is urgent to construct an innovative theoretical system of traffic criminal law. To address the issue of imputation in autonomous vehicle traffic accidents, a new criminal liability system centered on the producer's responsibility for the entire process should be implemented.

There are three theories in academia supporting the principle of imputation of liability for traffic accidents

involving autonomous vehicles. First, the negligence infringement theory. This viewpoint holds that the production and deployment of autonomous vehicles reflect scientific progress and are a convenient tool strongly supported by the government, thus the original intention of users in using autonomous vehicles is to better facilitate daily travel and ensure safety. Given the superior characteristics of autonomous vehicles, such as their high level of intelligence, it is natural that they should reduce the burden on drivers during the driving process. Acts such as making phone calls or sending text messages while driving cannot justify the driver being held liable for negligence. Although in autonomous vehicle accidents, there may only be the vehicle and the driver present at the scene, since the operation of autonomous vehicles relies on their systems, which are controlled and decided by the producers, the producers cannot be excluded from the scope of negligence liability. In fact, only the producers should bear full responsibility for traffic accidents involving autonomous vehicles[11]. Based on the principle of trust, consumers and drivers trust the operation of autonomous vehicles. Therefore, in the event of a traffic accident, it can be understood as the autonomous vehicle failing to live up to the trust of consumers and drivers, and naturally the producers should bear the corresponding civil infringement liability. Second, the product liability theory. This viewpoint holds that in determining liability for autonomous vehicle accidents, the producers should have foreseen potential traffic accidents when producing autonomous vehicles and taken active measures to avoid them. This is the duty of care that producers should have, which is no longer a duty of care in specific cases but an abstract duty of care that producers should fulfill throughout the entire process. In the event of an accident involving an autonomous vehicle, excluding situations where the driver violates the duty of care, when a system malfunction leads to an accident, the producers should bear criminal liability for design defects in the product[12]. Third, the reference to elevator tort liability theory. This viewpoint utilizes the similarities between autonomous vehicles and elevator operations, proposing that the producers of autonomous vehicles can be identified as public carriers and bear tort liability. When an autonomous vehicle loses control, the responsibility should be borne by the producers.

This article supports the theory of product infringement. When designing and producing autonomous vehicles, manufacturers should bear the duty of care for any accidents involving the product, without the need to specify a particular accident. For manufacturers, the benefits brought by autonomous vehicles far outweigh the costs of production. If, due to manufacturing reasons, defects occur in the product, resulting in serious harm during driving, it should be clear that the manufacturer is the responsible party, and such damages should be borne through relatively strict liability for product criminal responsibility[13].

5. Listing and Analysis of Viewpoints on the Choice of Charges for Autonomous Vehicle Manufacturers

5.1. The Crime of Producing and Selling Products That Fail to Meet Safety Standards Should be Selected

This viewpoint primarily pertains to the production phase

of autonomous vehicles, rather than the application phase. If the producer produces and sells autonomous vehicles that fail to meet safety standards, leading to serious consequences, criminal liability should be pursued for the crime of producing and selling products that fail to meet safety standards [10]. However, this viewpoint is difficult to cite as evidence in autonomous vehicle traffic accidents. This is because the subjective aspect of this crime in China's criminal law can only be intentional. Yet, in autonomous vehicle traffic accidents, it is difficult to apply this charge when the responsible party is only negligent.

5.2. The Crime of Major Liability Accident Should be Established

Professor Liu Xianquan analyzed the irrationality of applying the crime of producing inferior products to autonomous vehicle manufacturers, and subsequently proposed that it is more reasonable to identify the manufacturer's negligent crime with the crime of major accident liability. This viewpoint holds that the crime of producing inferior products cannot evaluate the subjective fault of the producer, while the crime of major accident liability is characterized by negligence in its subjective aspect; the crime of producing inferior products cannot evaluate the legal interests infringed by the producer's criminal behavior, while the crime of major accident liability regulates criminal acts that endanger public safety; the subject matter of the crime of producing inferior products cannot cover the responsibility of the producer, while the subject matter of the crime of major accident liability includes all personnel responsible for safety accidents and other personnel engaged in production and operation. Therefore, it is more reasonable to evaluate the manufacturer's negligent criminal behavior in autonomous vehicle accidents with the crime of major accident liability[14]. However, the constituent elements of the crime of major accident liability stipulated in China's criminal law must occur during "production and operation activities". After autonomous vehicles enter the market and are put into use, production activities have already ended, and the vehicles are being used at this time, which does not meet the constituent elements of the crime of major accident liability. Instead of fulfilling the obligation of safe production, the manufacturer should fulfill the obligation of safety supervision, which is unrelated to production and operation activities.

5.3. The Crime of Causing Traffic Accidents Should be Established

This viewpoint is based on the changing driving subject in the "shared autonomy" mode, and therefore the subject of criminal liability should also change. Since the auto drive system cannot be the subject of criminal liability, when the driver has fulfilled relevant duties of care in an accident, non-motorized transportation personnel and pedestrians may become the subject of traffic accident crimes due to their own violations of transportation management regulations. That is to say, the act of violating transportation management regulations by individuals other than the driving subject may constitute the act of committing traffic accident crimes[15]. The traffic accident crimes stipulated in China's criminal law indicate that "violating transportation management regulations" is a necessary element for constituting such crimes. Therefore, it can be inferred from the above that manufacturers can certainly become suitable subjects of

traffic accident crimes.

This viewpoint also faces two critical voices in academia. One viewpoint holds that the duty of care refers to the specific duty of foreseeability of results and the duty to avoid results. When manufacturers apply autonomous vehicles, they cannot foresee a specific traffic accident during the driving or use process, let alone avoid the occurrence of a specific accident, and therefore cannot be held liable for traffic accident crimes. This viewpoint denies that the duty of care of manufacturers is an abstract duty of care, and only when there is a violation of specific duty of care in a specific accident the result can be attributed to the manufacturer[16]. Another viewpoint believes that the manufacturer of autonomous vehicles does not actually drive or use autonomous vehicles, and therefore cannot be a qualified subject for traffic accident crimes. To constitute a traffic accident crime, the behavior must violate transportation regulations and directly endanger public transportation safety [10].

This article agrees that the crime of causing traffic accidents should be established. Firstly, manufacturers should bear the obligation of safety supervision throughout the entire process of autonomous vehicle design, production, sales, and use. This duty of care is an abstract duty of care and does not need to be specific to a particular accident. During the production stage, manufacturers should anticipate the potential accident damage results that may occur during the use of autonomous vehicles and actively design measures to prevent such damage results. This is an essential procedure for autonomous vehicles and the reason why consumers choose them. Otherwise, their criminal regulation will be no different from that of traditional vehicles, and the interests of manufacturers will not match the protection of consumers' rights and interests, making it unable to conform to the development of autonomous vehicles. Secondly, manufacturers can become eligible subjects of the crime of causing traffic accidents. Compared to traditional vehicles, where only the driver controls the steering wheel to drive the vehicle, autonomous vehicles not only have a driver inside but also have a system that plays a non-negligible role in vehicle operation. The system cannot become a subject of criminal liability, so the criminal responsibility of the "person behind" the system, that is, the manufacturer, should be pursued. The driving behavior of the manufacturer is not carried out by holding the steering wheel, but by remotely controlling the auto drive system through algorithms. Especially in fully autonomous driving mode, the driver inside the vehicle is dispensable, equivalent to the status of a passenger. At this time, the manufacturer has absolute influence and control over the auto drive system, and its criminal responsibility cannot be ignored. Therefore, when an accident occurs in an autonomous vehicle, it is reasonable to identify the manufacturer as the true "driver" and charge them with the crime of causing traffic accidents.

6. Conclusion

The autonomous vehicle industry is rapidly developing, and people have strong expectations for it. In the future, autonomous vehicles will undoubtedly be prevalent on the roads. As technology advances, laws should also keep pace with the times. Regarding the criminal liability determination of manufacturers in traffic accidents caused by autonomous vehicles, criminal law should provide more explicit provisions. At the legal level, manufacturers should be held accountable for product liability, and their duty of care

throughout the entire process should be clarified. In terms of criminal law, relevant provisions such as the subjective constitutive elements of the crime of causing traffic accidents should be amended. It is theoretically feasible to regulate the criminal liability of manufacturers in autonomous vehicle accidents using the crime of causing traffic accidents. However, there are still many obstacles in reality. To hold autonomous vehicle manufacturers as the subject of criminal liability for the crime of causing traffic accidents means that it is necessary to amend the current criminal law provisions on the crime of causing traffic accidents, that is, autonomous vehicle manufacturers should be added as the unit subject of the crime of causing traffic accidents. Finally, it is still necessary to advocate for the role of criminal law in reasonably regulating traffic accidents involving autonomous vehicles, so that different types of norms can find their proper place in the criminal law normative system.

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