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Characteristics and Evolution of Traffic Law Research Methods in Twenty Years: Study of Academic History Based on Multiple Research Paradigm

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Abstract: In the past two decades, with the increasingly weak response of normative law to traffic reality problems, traffic law has experienced a paradigm change from the closed-loop of dogmatics of law to the cross research of legal sociology. The management theory leads to the upgrading and transformation of traffic governance mode, while social collaborative governance and "big traffic" law enforcement mode emerge as required. Information technology, medicine, microelectronics, environmental science, and other natural science research methods developed from the legislative demand of the oriented fragmentation to the legal research methodology level in full. Psychology, comparative law, and feminist law provide abundant theoretical support for the vigorous development of traffic law. The interdisciplinary research advantages of traffic law are fully demonstrated. Traffic law has changed from the standard-oriented "department law" to a problem-oriented "comprehensive law", breaking through the barriers of the legal discipline system, and moving towards a multi-disciplinary research approach. With the rapid development of transportation technology, the demand for the protection of human dignity calls for the return of legal philosophy research methods. **DOI:** 10.13813/j.cn11-5141/u.2021.0302-en

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0   Introduction

In 2004, the development and implementation of the Road Traffic Safety Law in China marked the end of the traffic management era with the Road Traffic Management Regulations as the core. A new traffic management system with key legal norms such as the Road Traffic Safety Law and the Highway Law were formed. With the rapid growth of road traffic capacity, traffic accidents occur frequently; the national traffic management system and mechanism have to evolve day by day to address growing traffic problems and respond to the increasingly complex traffic conditions. In 2019, the CPC Central Committee and the State Council issued the "Outline for Building National Strength in Transportation" and set the achievement goal by 2035. In 2020, the National Transport Work Conference proposed strategies to promote modernization of the national traffic governance system and capacity and enhance the transportation industry reform. Since then, China has entered a new journey from a large transportation country to a strong transportation country.

"Law, as a system of knowledge, is a discourse system formed by human cognition and judgment of legal phenomena. However, because the method of recognizing the same legal phenomenon is different, so as the approach, different systems of understanding results and discourse will form." [1] The complexity and diversity of traffic problems in reality require scholars to carry out interdisciplinary and multi-method exploration of the integrated transportation planning, traffic accidents prevention, and post- responsibility investigation using different research approaches. The integration of law and traffic science has become a new focus for traffic law scholars; the method change in traffic law research is an important perspective to observe the historical process of transportation construction and management, as well as an important starting point to improve the traffic operation ability and the traffic system. The key to future development of transportation law is selection and optimization of research approaches. This paper goes beyond the traditional standard law or legal teaching horizon and aims to analyze the evolution of traffic law research through methods in social science, natural science, and philosophy; the paper also summarizes and evaluates the characteristics of traffic law, and provides insights on its future research methods.

1 Introduce social science research methods

The limitation in studies of normative law makes it difficult to address actual transportation issues; while the social science law can have impacts on judicial adjudication and the whole process of legislation and law enforcement. With the increasingly complex and diversified traffic situation, transportation construction and management cannot be constrained in the logical loop of legal doctrine; the study of interaction between law and society from a broader perspective has become important and necessary. Transportation construction and management involve the developers and operators of administrative subjects, roadways, bridges, and other facilities, as well as daily travelers; they are closely related to the individuals in the society. The social relations contained in transportation are far from being well covered by legal relations. The optimization of the governance ability from management-oriented government to service-oriented government also determines that social governance and public governance in the transportation field are inevitable and practical. Public governance requires the use of social science methods to analyze legal problems, and to reflect on whether the previous understanding of law is too narrow to cover the broader social background behind the legal norms [2]. Traffic law scholars purposely introduce theoretical resources of sociology, psychology, economics, and cognitive science to break the inherent vision of standardized law from the perspective of discipline integration, reflect characteristics of cross disciplines in the research of traffic law, and solve practical traffic problems; such effort has greatly improved the effectiveness of transportation construction and management.

1.1 Transitional study from closed-loop of legal dogmatics to sociology of law

1.1.1 Normative law's limited response to traffic issues

Results of literature search from CNKI suggest that traffic legal documents started with the development of the Maritime Traffic Safety Law in 1983, followed by creation of a logical architecture for a series of traffic laws and regulations. After this period of legislation, loopholes in the legislation were criticized and the period of law revision began with logical deduction as the dominant form. Later, due to the practical difficulty in revising the law and the characteristics of inconsistency between adopting the law and addressing actual needs in reality, scholars gradually realized the limitation of focusing on law revision; they therefore turned to the phase of law interpretation, with the goal of solving traffic problems by explaining the existing laws. This is also a period when scholars established an independent discipline of traffic laws. Scholars had somewhat biased understanding of the theoretical autonomy and independence of traffic laws and emphasized the theoretical self-sufficiency of the discipline; therefore they failed in breaking through the framework of standardizing law, but tried to provide countermeasures to solve traffic problems within the law system.

However, research within a closed legal system becomes increasingly weak in terms of addressing real-world traffic problems. Growing traffic problems suggest that the government control based on traditional law research cannot meet practical requirements. Traffic congestion not only needs government governance and market governance, but also requires coordination and cooperation among various subjects in the social field. All components in legislation, revision of law, and interpretation of law demand new theories to break the closed loop of law development and truly respond to transportation practices. After 10 years since the road traffic safety law was issued, in the Decision of the Central Committee of the Communist Party of China on Several Major Issues of Comprehensively Deepening Reform, an "innovation of social governance system" has been proposed ①. This system requires the change from traditional government-dominated management to government-lead, social governance, and effective organization of participants to modernize management ability. Since then, "social governance" has entered the field of academic research.

1.1.2 Social collaborative governance in the context of traffic law

The traditional legal theory involves limited research on "social governance" and overly focuses on the secondary disciplines of administrative law managed by the government. Without getting theoretical support from the traditional legal theory, social governance needs theoretical foundation to solve practical problems of transportation law through sociological research methods. Social governance emphasizes the coordination and cooperation among society, market, and citizens; it establishes a governance system with multi-party participation and multiple subjects to effectively complete the governance of public affairs and stimulate social vitality to the maximum extent. From the perspective of sociology, social governance is a coordinated social action based on cooperative relations among government, market, and citizens, with the purpose of resolving social contradictions, achieving social justice, stimulating social vitality, and promoting a harmonious social development [3]. In the context of social governance, social public affairs are common affairs of the government, citizens and society; citizens no longer serve as the controlled objects and the governance process is not a one-way government control any more. The governance process of public affairs is a process of consultation and cooperation among multiple subjects [4].

Reducing traffic violations and ensuring travel safety have been the focus and basis of traffic law research. In the study of traditional legal theory, the administrative penalty law played a critical role in the field of transportation. However, traffic violations continue to grow despite the high number of traffic penalties. To address such dilemma in traffic govern-

ance, many innovative governance methods have emerged in the traffic field. For example, under the interaction of the theory of administrative penalties law and the sociology theory, encouraging citizens to take a photo of illegal activities and encouraging drivers to assist in public security management represent methods of "social collaborative governance". The single-subject traffic management mode with spot-check and random feature can be transformed into a multi-directional and comprehensive multi-subject collaborative management mode, which helps share the load of police force and improve the efficiency of discovering illegal travel behaviors. The Heinrich Law indicates that, before a serious accident happens, 29 minor accidents and 300 potential accidents already occurred; such occurrence follows a pyramid-type evolution and suggests that controlling potential accidents could help reduce minor or serious accidents. Therefore, in the transportation field, the prevention of serious accidents with severe injury or death need to be achieved through the regulation of minor traffic violations. The social collaborative governance mode based on sociological research serves as a comprehensive approach to prevent and control minor violations.

At the same time, the transformation from administrative management to social governance also change the potential traffic violators into travelers who can maintain traffic order and discover illegal activities. Traffic management is no longer limited to the penalties and constraints of administrative subjects; instead, it involves every participant in transportation into the common governance system. Such system is not only an extension of the government management, but also a beneficial attempt to encourage all travelers to participate in social governance under the sociological methodology.

1.1.3 Intellectual supply for management: explore the mode of "Big Traffic" law enforcement

Given the strong public attributes of transportation as well as its characteristics as cornerstone and veins of the national economic development, administrative law enforcement has been a solid foundation for traffic safety and stability. The administrative law, with its academic characteristics, has close interactions with management from the very beginning [5]. The management method is an abstract of management phenomena and an extraction of substantial management practices; it guides all management behavior [6]. However, the administrative law in the context of the traffic law lacks research and reference of the method of management. This is largely attributable to the development history of transportation law formed in the early 21st century, when the standardized research of administrative law had been localized. Scholars directly applied the integrated administrative law theory in transportation law and had limited focus on the management theory. However, the excessively differentiated traffic administrative system fails to address growing law enforcement problems in reality. The "multi-lead law en-

forcement" is not only inefficient, but also adds unnecessary burden to the administrative counterparts.

To address problems in traffic law enforcement, some scholars proposed from the management perspectives of administrative efficiency, decentralization, and centralization [7] to grant authority to a single administrative agency in the legislation; for administrative law enforcement power that needs to be centralized, this approach can avoid redundant work and address conflict of power and responsibilities under the "division of law enforcement" of each department. Therefore, under the theoretical guidance of management science, the original parallel multi-lead management mode is changed to a "block-based" comprehensive management mode, which relies on the working mechanism and personnel reorganization, and achieves the maximum efficiency with the minimum personnel resource. The modular operation reform in the field of traffic law enforcement requires the construction of a "big traffic" model at the institutional level; such reform in the current law enforcement system involves effective measures to comprehensively improve overlapping law enforcement, unjustifiable penalties, and self-centered governance.

China is currently in a critical period of COVID-19 pandemic prevention and control. It is also a crucial time for China to extend the comprehensive reform of transportation law enforcement. To complete arduous tasks in preventing and controlling the pandemic and ensuring emergency transportation, the front-line law enforcement teams are facing greater difficulties and pressure; therefore, it is urgent and necessary to improve the ability of comprehensive law enforcement in transportation [8]. Since the first proposal of comprehensive administrative law enforcement, the amount of literature regarding comprehensive law enforcement using management theory grows significantly, while the trend has slowed down in the recent three years. In 2020, a considerable amount of literature were developed by traffic law scholars on the construction of "big transportation" law enforcement model, which is closely associated with the growing demand for improved transportation capacity under the COVID-19 pandemic (see Figure 1).
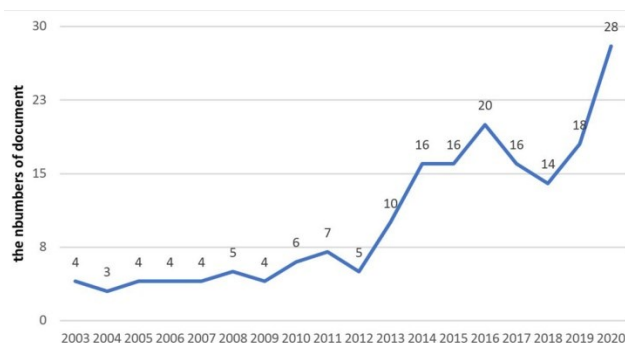
Fig.1 Annual number of comprehensive law enforcement documents since the enactment of the Road Traffic Safety Act

Note: Taking "traffic" and "comprehensive law enforcement" as the theme, the paper screens the literature on comprehensive law enforcement of road traffic using management knowledge in CNKI database.

1.2 Specific application of economic research methods in the context of traffic law

Law and Economics is a marginal discipline that studies legal problems with the method of economics; it applies microeconomics and other empirical methods to investigate and assess the formation, structure, process, effect, efficiency, innovation, and future development of the legal system [9]. In the context of Law and Economics, efficiency value is the basis of fair value, while the fair value is a necessary metric for achieving the efficiency value [10]. In transportation development, efficiency is a fundamental task; fairness serves for the traffic construction management system and mechanism by ensuring that travelers exercise equal traffic rights and interests. Therefore, the pursuit of both efficiency and fairness values is extremely consistent with the development concept of traffic construction and management. With limited ability to standardize the closed loop of law in addressing practical problems, Law and Economics has demonstrated increasing theoretical vitality and interpretation ability.

1.2.1 Economic analysis of the legal system for urban transportation resources distribution

Traffic congestion and environmental pollution have been the difficult problems in traffic system design. For example, some scholars rely on the Eleanor Ostrom's public pond resources theory to perform analysis with the Law and Economics perspective; they believe that urban transportation resources are "public pond resources." With additional cars using the road space, the degree of traffic congestion will increase and result in negative externality; eventually the individual's excess use of transportation resources will lead to a "public tragedy" [11]. Legal system should be used to ensure predictable and fair distribution of urban traffic resources, as well as safety and convenience of people's travel; the sustainable development strategy through restrictions on new and existing vehicles should also be considered.

With respect to specific rules making, local normative documents have been issued in various regions, such as "Shanghai Non-Commercial Bus Quota Auction Management Regulations", "Beijing Passenger Vehicle Number Regulation Interim Regulations", "Guiyang Light-Duty Vehicles Plate Management Interim Regulations", "Guangzhou Regulation of Small- and Medium-sized Passenger Cars Population", "Tianjin Regulation of Small Cars Population", "Hangzhou Regulation of Small Cars Population", and other lottery or auction approaches. Researchers have analyzed a range of regulatory means using Law and Economics methods; they generally believe that existing normative documents restricting the number of new vehicles have the risk of inefficiency and disordered resource allocation. Therefore, in recent years, scholars have gradually shifted their focus on the usage of vehicles, aiming to reasonably limit the use of cars through application of Law and Economics theory.

1.2.2 Usingtravel demand management strategies to control car usage: the theoretical basis of price leverage

Travel demand management was first used in Singapore for traffic congestion control. It combines government regulation, market regulation, and social constraints to reduce unnecessary urban traffic flow.② Travel demand management strategies apply the demand management theory in transportation planning to minimize travel demand, especially the proportion of private cars in the traffic flow.

In the process of studying the travel demand theory, scholars gradually realized that, given the constant and limited roadway space, adjusting the demand for various travel modes and prioritizing the development of resource-saving transportation tools and road area are the only effective approach to reduce roadway occupancy rates. The application of traffic demand theory based on Law and Economics research method discourages the use of transportation tools with high resource consumption cost, scientifically manages, controls and guides the total demand of traffic, encourages people to change traffic modes, effectively relieves traffic congestion, and ensures efficient operation of urban public transportation. Although demand management strategies based on the theoretical support of economics, such as congestion fees and parking fees, are efficient and reasonable, they still need endorsement and protection of legal enforcement in order to achieve practical results. Therefore, through research of the right of way, the principle of legal retention, legal principles of taxation measurement and reconstruction, and academic use of economics methods, scholars have developed a substantial foundation for the optimization of vehicle use.

1.2.3 Legal economics analysis of traffic accidents: distribution of risk and responsibility under the game theory

In the whole traffic accident process of occurrence, responsibility judgment, identification and accountability, the perpetrators of traffic accidents are influenced by complex emotion and interests; their decision making factors cannot be assessed through standard research in the legal system. With the increased frequency of traffic accidents, the qualitative and quantitative needs of accident responsibility identification, attribution, and compensation standards demand research from a legal economics perspective.

With respect to the legal procedure after a traffic accident, legal economics researchers set a principle of maximizing benefits for the whole society; reducing prevention cost, accident cost, and administrative cost, and further minimizing the overall social cost become the legal prevention standard [12]. In the game theory context, people involved in accidents will make rational choices based on their pre-defined strategies. Through studies of relationship between marginal cost and marginal profit, legal economics

scholars asses the impact of strict responsibility rules, no-responsibility rules, negligence responsibility rules on decision-making of people involved in accidents; the assessment provide substantial theoretical support for legislative transition from no-fault responsibility to fault- presumption of responsibility associated with the Article 76 of Road Traffic Safety Law.

The construction of traffic system, with "maintaining road traffic function plus preventing and reducing traffic accidents" as the goal, is not limited to the passive responsibility identification after accidents to regulate traffic violations. There is growing research interest in before-accidents prevention. Motor vehicles hardware replacement is a result of the cost-benefit analysis for a "rational person." With the improved mandatory standard of "motor vehicle operation safety technical conditions", increasing the frequency of annual inspection for motor vehicles of earlier model years is not effective in practice, despite of high safety performance of new vehicles. Therefore, some scholars used the Hand formula to demonstrate the cost-benefit relationship of upgrading vehicle braking systems [13] and proposed to consider both the braking system and the reactive ability when determining liability of negligence in responsibility identification, pressuring vehicle owners to upgrade or replace the braking system. In summary, the review of relevant literature on traffic accidents in the past 20 years has suggested that the whole institutional process from accident prevention to responsibility specification has theoretical support of the legal economics (see Figure 2).

2   Incorporate natural science research methods

The emergence and development of transportation is not associated with the artificial construction of law and other social sciences. Transportation facilities and modes have been originally developed based on the research and improvement of natural science; the connection between transportation and natural science is reflected in the term or concept of "transportation" itself. However, given the independent discipline awareness of transportation law and its discipline status under law, traffic law scholars previously tried to avoid the intervention of natural science methodology with the delay of legal norms. Therefore, with limited understanding of natural science, they only extracted technical segments to address legislative needs.

With the evolvement of natural science as a methodology and knowledge framework settled in the legal filed, traffic law scholars realized that the theoretical knowledge foundation of the Road Traffic Safety Law and other laws or regulations cannot only rely on legal value analysis, logic deduction or research methods of sociological observation and summary. Fragmented technical assessment lacks coherent consideration and cannot be used as a guide for good legislation. Therefore, scholars performed self-reflection and began to pay attention to research methods with natural science discipline; they creatively transformed the natural science framework and knowledge, improved the systematic legal theory, and enhanced the scientific and forward-looking nature of legal judgment. The intellectual supply of natural science has transitioned from the application of fragmented non-systematic nature to the legal system-oriented research methods. The incorporation of natural scientific methods extends the research path of traffic law and leads to more scientific and feasible formulation of traffic laws, regulations, and industry standards.

2.1   Application of big data technology: Improve the legal effectiveness through intelligent transportation

Big data provide accurate and regular data support for the overall traffic management decision-making, laws and regulations formulation, management measures determination, and action plan development. Either static management information (e.g., vehicle management, driver management, traffic accident management, traffic violation management) or dynamic management information (e.g., data generated by investigation control system, urban traffic signal control system, etc) [14], under a strong big data platform with collection, processing, and analysis, the actual effectiveness of laws and regulations has been greatly enhanced and the efficiency scope has also been extended.
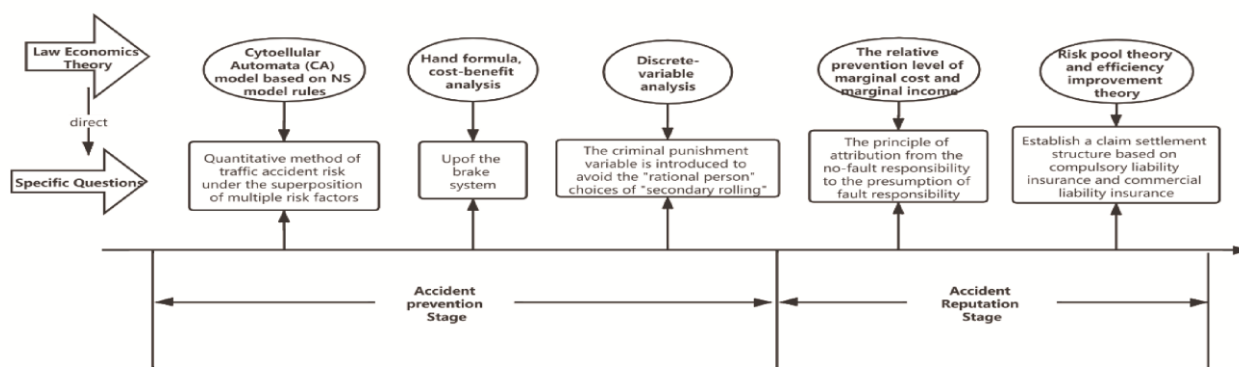

Fig.2   Overview of the whole process law and economics research on traffic accident prevention regulation

Big data technology not only provides scientific and reasonable support for the formulation of laws and regulations, but also greatly enhances the effectiveness of laws and regulations. Based on big data technology, the Ministry of Public Security Institute of Traffic Management Science has developed the highway traffic safety prevention and control platform. The platform is used to collect and transmit road traffic violations information timely, accurately, and effectively; it's also used for data comparison and mining to support drivers with effective reminders and information release, as well as enhancing real-time effect of legal regulation means and improving the actual impact of the law. Data processing ability has become the foundation of traffic law enforcement and implementation.

At the same time, using big data can also provide technical assistance for the development of a case cooperation mechanism. With the strong ability of big data technology in information update and synchronization, all kinds of administrative management and law enforcement information resources, such as administrative licensing and administrative punishment, can be shared among various departments; with the improved efficiency of law enforcement, mutual supervision is also achieved. The "whole process of traces" resulted from using the big data technology protects the rights of administrative counterparts in the transportation field and implements the "file exclusion system" in administrative law enforcement.

2.2 Solve legal value evaluation problems through medical professional judgment

In major traffic accidents, a usual case is that limited medical resources cannot address the injuries and fatalities in time. The treatment sequence becomes crucial for each injured person to minimize the results of accident casualties. When it comes to the value of life, the law aims to actively coordinate people's behavior with "human dignity" through value analysis and value judgment, and provide moral support for giving-up activities. Utilitarianism and other schools thus promoted the controversial and arguable assertion of "the greatest happiness of most people" [15]. If the value analysis of law holds the principle that all lives are equal and no abandonment of critically injured patients is allowed if they demand high labor and material resources to save more lives, it will lead to an unbalanced allocation of medical resources and the loss of lives that can be saved. However, accidents will continue to occur regardless of the lack of legal response. The limitation of medical resources and the conscience of medical workers call for a set of implementable standards.

Clinical medical theory provides a practical solution for the value analysis of law. In the medical context, the wounded can be divided into four categories according to their clinical signs: "minor injury" labeled by green;"noncritical but need emergency care" labeled by yellow; "serious life-threatening injury with recovery possibility" labeled by red; and "death"

labeled by black [16]. There is a wide range of specific medical judgment criteria under each category. While judging the injury severity, medical workers label the four types of "injury classification cards" following the typical international standard; they rank the severity of casualties from high to low in the sequence of black, red, yellow, and green, and then follow the sequence to perform treatment on site.

For the problems that cannot be addressed in the legal system, as another "ancient discipline", the clinical data standard for medical use offer a solution. The legal system's failing to respond does not represent the lack of competence or ability of law; instead, it reflects a necessary avoidance of involvement. After all, law connects the ultimate value philosophy with respect to human nature and human value. When reasonable, rational, and practical solutions are not achieved, it is a valid protection of the legal spirit to solve practical problems using medical knowledge.

2.3 Application of microelectronics: Shift burden of proof with electronic license plate technology

Many Chinese scholars in the administrative law field have argued that the traditional distribution system for burden of proof with "claimers having to prove" is very unfavorable to administrative counterparts in administrative inaction cases. In transportation, the phenomenon of administrative subjects being negligent in performing their duties still exists. For example, the author's hometown has a serious case on October 10, 2019, at the Xigang Road of Xishan District in Wuxi City; where a bridge overturning accident involved three deaths and two injuries. The main cause of the accident was a substantially overloaded truck, which was not caught for inspection while traveling through multiple provinces. This case indicated serious negligence of duty from traffic management departments.

For such cases, the principle of inverted burden of proof in the civil procedure law can be introduced. The administrative subjects with negligence of duties have to prove no direct or indirect causal relationship with the accident outcomes. In transportation, the proof system of administrative subjects can be standardized with assistance from the electronic license plate technology. Using monitors to scan electronic license plates at the road intersection, the government can retrieve the relevant data from the traffic management department [17] and send or archive information in the terminal system in real time. In the subsequent litigation disputes, the road and bridge management department can use these data records as evidence. The "whole process trace" of electronic data enforces administrative subjects to perform their duties; it also provides a better evidence basis for judges to determine the administrative responsibility.

In addition, the promotion and implementation of electronic license plates are of great significance to refine management of urban traffic, improve road traffic efficiency, and reduce congestion. The natural science research of microelectronics, 5G communication technology, and edge compu-

ting technology provide a theoretical basis for promoting electronic license plates. On the one hand, it has enhanced the implementation of existing laws, improved traffic investigation and punishment, and reduced traffic accidents; on the other hand, it has also put forward new legislation requirements to adapt to new systems and technologies.

3 Highlight advantages of interdisciplinary research

In recent years, as the cross-disciplinary fields such as psychology gain increased attention, research of comparative method and feminist law is booming; traffic law scholars not only focus on the methods and theories in natural science and social science, but also actively reference and introduce new theories and disciplines of intellectual factors. The cross-disciplinary advantages of traffic law research has been fully demonstrated.

3.1 Example of the application of psychological analysis method

People, vehicle, and road are three important factors affecting road traffic safety. People are key to functional vehicles and roads, and are also the dependence of all traffic products in the traffic system. Therefore, standardizing people's behavior is the top priority to maintain traffic safety, convenience, and speed. At the macro-level, some scholars analyzed the psychological causes of speeding, driving with poor vehicle conditions, and driving under the influence; they assessed people's tolerance of small probability risk and proposed a solution with combined legal punishment and moral cultivation [18].

At the meso-level, certain scholars studied the psychological deterrence effect of ECG, skin electrical signals, conductance signals, respiratory signals and muscle telecommunications signals to identify the impact of legal deterrence on drivers and further detect their objective real-time response to different law enforcement means and strategies [19]. In the overall academic research context, the most classic psychological theory of studying the influence of law on illegal behavior is the theory of deterrence, which reflects that the law can produce a psychological deterrence effect in the process of formulation and implementation with the effect dependent on the certainty, severity, and immediacy of punishment. Although many domestic laws have been formulated for road safety, only an effective implementation of the law can improve the certainty of punishment and ensure the deterrent effect of the law. Therefore, in the legislative process of determining the range of penalties and the enforcement of implementing specific punishment, psychological theories can be useful on the assessment of deterrence effect.

At the micro-level of a specific legal system or provision, the highlights of psychological research are also fully demonstrated. By analyzing the influence mechanism of the green countdown signal on the psychological and driving behavior, some scholars concluded that the green countdown signal should be limited. Meanwhile, redefining the meaning of yellow light in the Road Traffic Safety Law was also proposed, as well as adding an automatic capture system to reduce the occurrence of speeding at yellow light during the signal transition and improve traffic safety at the intersection [20].

3.2 Rational reference from comparative method studies

"Those who do not know other languages know nothing about their own language" [21]. Goethe is well quoted by the famous German comparative jurist, Kotz, to emphasize that only by studying foreign laws can we understand the characteristics and features of our own national laws [22]. The study of comparative law aims to reflect on the national laws through the comparison and reference of different legal systems, legal culture, and legal regulation. As a latecomer in transportation development, China has become a country with strong transportation including the world's longest highway system (5,013,000 km). The contribution of comparative legal research is substantial.

In order to solve increasingly serious traffic congestion problems, traffic law scholars actively explore the experience of traffic congestion management outside the region, including Singapore's vehicle registration system, London's traffic congestion fee system, and Tokyo's parking fee system [23]. At the end of the 20th century, some scholars pointed out that "when borrowing and transplanting foreign laws, China should thoroughly study the original country or region of the borrowed law with its various social and natural background." [24] In other words, the successful experiences in different countries are based on their own national conditions, and the premise of a successful reference is the complete understanding of their social and natural conditions, as well as a clear recognition of China's national conditions.

In this regard, Chinese traffic law scholars did not blindly apply the experience and practice of comparative law; instead, they took successful examples outside the country as a reference and combined the beneficial experience with China's domestic conditions. Also, they objectively demonstrated its scientific nature, rationality, and feasibility. For example, some scholars have proposed that although Japan's high-priced parking fee system has achieved great results, the parking fees cannot be raised arbitrarily under China's legal system. For cities where parking issues are not significant, parking needs should be met through planning measures, such as gradually adding parking lots, standardizing parking spaces, and building sufficient parking facilities for new projects. For cities with substantial parking needs, increasing parking fees in congested roadway segments can be considered to reduce parking demand.

3.3 Involvement of Feminist law: Transition from liberalism to differential paradigm

The number of female drivers has increased in recent years, while "female drivers" have evolved into a discriminatory word as "road killers" given increasing concerns of women drivers causing traffic accidents. In this regard, traffic law scholars applied empirical research, data analysis, and physiological and psychological theories, analyzed the causes and related factors of traffic accidents that involved female drivers, and proposed measures to address women's differences and protect women's equal driving rights [25].

In the past decade, feminist law researchers realized that women's obtaining equal legal subjectivity as men, or equality before the law, was not sufficient for women to truly achieve equal treatment in the society. Some scholars asked a thought-provoking question: "Why is the law that fully embodies gender equality not enough to bring real equality to women at the social level?" [26] Thus, differential feminist law has gradually entered the field of legal research in China. The liberal legal method and reasoning process itself is believed to be masculine; the legal ideal of liberal and feminist equality of law is illusory. Although current male-dominated norms are expressed in neutral language, they are likely biased to male interests and the equality of legal form masks the bias of the legal norms.

Traffic law scholars who focus on the feminist law research also experienced a transition from "liberal feminist law" to "differential feminist law" paradigm, from the existing legal system for women to characteristics of women, trying to change the existing legal norms for women. The study of improving the traffic accident compensation system based on the physiological characteristics of women is a typical application of differential feminism in traffic law. Some scholars have specifically analyzed the existing traffic accident compensation system that is unreasonable for the bodily injuries and related compensation for female victims; they have also suggested to establish and improve a special compensation system for women, increase mental compensation for pregnant women, and cover nutrition subsidies for pregnant women in the scope of compensation [27].

4 Evolvement and evaluation of traffic law research methods

After the germination of independent consciousness as a discipline, traffic law has experienced the procedure from a closed thought process with standardized legal system to the penetration and integration of research methods in social science, natural science, and other disciplines, and further to the positive response with new research perspectives such as psychology, comparative law, and feminist law. This procedure has highlighted the unique advantages of cross- discipline research of traffic law. In general, the traffic law has transitioned from a standard-oriented "department law" to a problem-oriented "comprehensive law"; with a breakthrough of the closed-loop standard law research method, it has become a multidisciplinary research paradigm. Also, it has been recognized that traffic law development has to rely on the legal system and research principle as foundation to complete the organic integration of multiple research methods.

4.1 From standard-oriented "Department Law" to problem-oriented "Comprehensive Law"

As the social division of labor becomes increasingly detailed and the development of technology becomes refined, a single scholar's research scope in the academic field is constrained while diversified with deep and refined research; a blind spot exists in human's cognition, because no social problems present themselves according to the logic and intention of a single discipline [28]. With the rapid development of transportation technology and the surge of travel demand, the legal knowledge limited to the framework of standardized law is insufficient to respond to the complex needs of transportation reality, and it is difficult to provide both scientific and practical solutions.

The five years after the creation of the Road Traffic Safety Law was the period of traffic law scholars' awakening with discipline consciousness. Traffic law scholars experienced the process from passive attention to relevant legislation, from standardized construction of traffic law system to modified legislation with reality feedback, and further to a pure logic path in response to traffic problems. It was found that the excessive pursuit of discipline independence led to limited and fragmented legal knowledge, despite the use of multidisciplinary research results in the process of legislation and interpretation.

With the "Eleventh Five-Year Plan" proposed in 2006 to prioritize the development of transportation industry, the substantial transportation construction has become an important engine driving the development of transportation law discipline. Since then, traffic law scholars have broken through the secondary discipline restrictions of law. Through the integration of civil law, administrative law, and criminal law, they have analyzed the rationality of regulating traffic violation path with civil responsibility, administrative responsibility, and criminal responsibility, and have broken the traditional department legal system with administrative law as the core or boundary. At the same time, scholars started recognition of the complexity and technology of the real traffic problems and the limitation of "setting boundaries" in the legal discipline; the integrated research has thrived to eliminate the discipline barriers, consolidate the discipline knowledge system, and promote the multidisciplinary research.

"As our knowledge continues to improve, we must strive to form a comprehensive law." [29] In the past 10 years, transportation law has gradually transitioned to a prob-

lem-oriented "comprehensive law", which involves various legal-related phenomena in specific economic and social fields as research objects and includes a research paradigm with a new legal theory system, a discipline system, and a discourse system. This is not only a variant of thought process based on the germination of problem consciousness, but also a paradigm transformation from pre-system research to post-system research. In the same period when the traffic law research paradigm experienced abrupt changes, the legal system with Chinese characteristics had been generally established. The academic defects implied in the legislative research paradigm with functional design and standard construction are increasingly prominent; the transformation to the "post-system research paradigm" to meet the needs of traffic reality became historically unavoidable [30].

4.2　From a closed loop of standardized legal research methods to the multi-disciplinary research path

The application of comprehensive law research method started when value analysis, standard analysis, and social analysis came to an end. Compared with other methods, such integrated research method focuses on the impact of sociological, economic, and psychological factors on the formulation, enforcement, and application of laws [29]. With the problem-oriented "comprehensive law" ideas, the transition of traffic law research paradigm serves as a reminder for us to recognize the relationship between law and other disciplines or fields, rather than seeing law as a closed system. Therefore, sociology, economics, psychology discipline research methods and results have been involved in the traffic law research field in recent years.

First, the application of social analysis method enables the construction of social collaborative governance and large traffic law enforcement mode, and solves the problems of law enforcement in transportation. Different from the methods of value analysis and standard analysis, the social analysis method focuses on the reality problem of the law, especially the reality problem in the dynamic process of the law, which reflects the actual operation, effects, functions, and results of the investigation law [31]. Given the normative analysis of law, the logical loop of legislation, revision and interpretation, and the application of social analysis methods that pay attention to the effectiveness of law, the realistic response ability of traffic law has been greatly improved.

Second, the study of Law and Economics by introducing economic analysis methods is consistent with the paradigm transformation of government macro-control under the market economy and the functional transformation from an all-around type of government to a service type of government. Mitigating traffic congestion and reducing traffic accidents have always been the two focused sides of the traffic law. The Law and Economics research method adjusts the traffic needs in a more efficient way, which can allocate traffic resources and solve the problem of traffic congestion.

At the same time, the risk cost analysis model under the game theory is introduced to reduce the consequence of traffic accidents and balance the interest of both the victims and the perpetrators from the perspective of a "rational person".

In the past 20 years, transportation law has also completed the transformation with respect to the use of natural science research methods, from a fragmented and unsystematic extraction of natural science intelligence supply to a comprehensive entry stage with research methods as the core. In addition, multi-perspective research paradigms such as psychology, feminist position, and comparative law have also provided rich nutrition for the continuous growth of traffic law.

4.3　From legal tool application to legal guideline

With the introduction of social science and natural science research methods and theories, legal research methods in transportation continue to evolve. When the study of traffic law emerged 20 years ago, scholars urgently needed to prove the independent research value of traffic law; therefore, they focused on highlighting the independence of the discipline through legal standard system construction and pure logical deduction, while ignored learning from other disciplines. The "law" at that time was the core of traffic law research. With the substantial development of transportation law, the multi-disciplinary research of sociology, economics, psychology is on the rise. The core position of "law" has moved and even become an endorsement of research results in social science and natural science. Many studies seem to follow legal sociology, legal economics, and legal psychology, but they largely institutionalized the research results of other disciplines in a standard form of "law" in the conclusion stage. With the "law" gradually losing its core position, research achievements of other disciplines seem to be using it simply as a "solidified" tool.

The stagnation and lack of the study of "law" itself lead to failures in following legal disciplines for certain social and economic measures in transportation, and even result in risk of violating the constitutionality and legality. Some scholars have performed self-reflection on this issue. For example, although the nation-wide "casual picture/video shooting" system is regarded as a good approach for social traffic governance by achieving coordination with traffic police to control traffic violations, it easily involves legal disputes given that residents are not the subject of legal law enforcement. Therefore, the importance of research methods in traffic law should be revisited and the "random picture/video shot" traffic governance attempt should be legalized with evidence-clue acquisition system, which can incorporate social governance methods into the legal track based on legal logic and technology.

In addition, other reform measures such as license restrictions, traffic restrictions, transportation taxes were proved efficient, reasonable, and feasible through sociological and economical assessment; they should also be legalized

by standardizing the law to avoid the possibility of violation associated with the principle of proportion, legal retention principle, and tax legal principle. Similar to major reform that relies on law, the transformation of the transportation law from "legal tool" to "legal guideline" is not only a response to the construction of a law-based country, society, and government, but also a reflection of the essential feature of transportation law. Such transformation does not mean the loss of the importance of research methods in natural science, social science, and other disciplines; instead, it represents the development of a traffic law research system that leads and integrates the intellectual achievements of various disciplines under the "rule of law."

4.4 Protection of "Human Dignity" under the rapid development of transportation technology

The establishment of traffic law is designated to solve traffic problems and reduce traffic accidents, which is different from the formation of traditional law. At the beginning of the establishment of traffic law, there was a lack of philosophical and people-oriented consideration. With the rapid growing of research in autonomous driving and AI technology, the expansion and irrationality of technology increase the risk of losing subjectivity of "human"; therefore, it is urgent to regulate the value law of "human dignity."

With the 2016 crash of Tesla Model S electric car in the autonomous driving mode [32], the traffic law community has extensively discussed the management of autonomous vehicles as well as the clarification of responsibility after traffic accidents. The discussion has focused on the formulation of relevant rules for road traffic management of autonomous vehicles, clarification of the responsibility subject and accountability of traffic accidents, and updating the existing mandatory liability insurance system. However, the most difficult problem to solve for autonomous driving is the program setting to avoid choices in distress.

The procedural setting involving life choices should not be determined by the developers. Law must provide standard guidance for the "problem of electric vehicles" conforming to the value law, which is also what the law must respond to [33]. When the algorithm encounters a traffic accident that cannot be avoided, should it prioritize the protection of drivers and passengers or depend on the system for random choices? Is it possible to create an accident emergency algorithm procedure that aims for minimizing casualty of the accident? The answers to these questions cannot be provided by knowledge theories of natural or social sciences; the formulation of legal norms must be applied to metaphysical philosophical judgment.

Currently the research in traffic law with respect to the above issue is rare. From the utilitarian perspective, some scholars supported the procedure setting with minimized casualties as morally reasonable by increasing everyone's safety expectation [34], which is a useful attempt to use philosophy to respond to value judgment problem. However,

this is clearly contrary to the natural legal value law based on "human dignity." "The maximized satisfaction of most people" has the risk to objective people, whose value cannot be measured or compared. It seems to reflect the unquantifiable value of human life if the results are determined by the system itself in a random manner. Addressing the problem of legal value judgment resulted from the vigorous development of technology is exactly an opportunity to leverage the legal philosophy research methods. Traffic law can solve the legal problems brought by emerging technologies and achieve consistency with the Constitution of the basic value to protect "human dignity."

5 Conclusion

In the past 20 years, with the increasingly complex traffic conditions and growing travel demand, traffic law has broken through the boundaries between the second tier of subject in administrative law and first tier of subject in science of law, involved civil law, administrative law, and criminal law, and reflected social science with other research methods and intellectual results. With updated methodology, traffic law has transitioned into a research system with comprehensive disciplines, as well as standard, social, economic, gender, psychological, and value analyses of law. Traffic law has experienced a transformation from a single research method to an overcorrection of legal "tool" under the influence of multidisciplinary subjects, and to the paradigm of multiple research methods to provide social logic, economic logic, and psychological logic for the legal system. On December 23, 2020, the State Council Information Office of China issued a white paper on "Sustainable Development of Traffic in China" and set the goal of building national strength in transportation by 2035. With China's transportation enhancing the supply-side structural reform and entering a new era of high-quality development, transportation law also faces new challenges. Addressing the risk of irrational expansion of technology and implementing legal philosophy research methods regarding "human dignity" could be future research focuses in transportation law.

Anotation

(1) This was the first time for the Chinese Communist Party to propose "social governance" in an official document.
(2) Therefore, the travel demand management strategy serves as an analysis framework based on the economic theory of supply and demand, as well as integrates the characteristics of sociology. Sociological research methods cannot be isolated; instead, an integration with the problem-oriented research methods of various disciplines can play a very important role in finding practical solutions of transportation problems.

References

[1] Li Xiaoxi. 论法学研究方法的多元化趋向[J]. 环球人文地理，2014(20)：142-143. (in Chinese)
[2] You Chenjun. 社科法学的成长与发展[J]. 南开法律评论，2015(00)：6-12. (in Chinese)

[3]Chen Chengwen, Zhao Xingzi. Social Governance:A Coordinate Process of Social Action[J]. Journal of Social Science of Hunan Normal University, 2014, 43(5):11-18.

[4]Zheng Hangsheng. Ideal Type and Local Peculiarity:A Sociological Analysis of Social Governance[J]. Sociological Review of China,2014, 2(3):3-11.

[5]Liu Wenjing. On Relationship Between the Study of Administrative Law and Administrative Management[J]. Journal of Peking University(Humanities and Social Sciences), 2002(3):110-117.

[6] Rao Ai，Zhang Hongtao. 管理学方法在行为法学中的应用[J]. 社会科学研究，2002(01)：88-91. (in Chinese)

[7] Qiu Xin. 行政权运行机制研究：交通大部制改革的视角[J]. 中山大学研究生学刊：社会科学版，2008，29(3)：79-86. (in Chinese)

[8]Zhou Aiyan, Ouyang Bin, Li Yanxia, et al. Improving Comprehensive Capability of Transportation Law Enforcement Under Covid-19[J]. Transport Research, 2020, 6(1):67-72.

[9] Yang Liu，Li Hongchang. 城市交通拥堵治理的法经济学分析[J]. 长春理工大学学报(高教版)，2009，4(8)：39-40. (in Chinese)

[10] Eirik G.Furubotn, Rudolf Richter, Institutions and economic theory[M]. Sun Jingwei, translated. Shanghai: Shanghai University of Finance and Economics Press，2002.

[11]Liu Shuilin. Law and Economics Analysis on Traffic Restriction Regulation[J]. Academic Monthly, 2016, 48(6):76-84.

[12]Liu Feng, Zhang Yan. Discussion of Traffic Accident Liability:Economic Analysis[J].Journal of Southwest Jiaotong University(Social Sciences), 2004(3):63-67.

[13]Ji Mingyu. Legal and Economic Analysis of Traffic Accident Cost[D]. Qingdao:Qingdao University, 2020.

[14] Li Xiujv，Bo An. 科研为交通管理提供强大支撑：访公安部交通管理科学研究所所长王长君[J]. 道路交通管理，2014(5)：18-20. (in Chinese)

[15]Xu Dajian. The Essence and Defect of the Moral Standard of Utilitarianism[J]. Journal of Shanghai University of Finance and Economics, 2009, 11(2):11-18.

[16]Ji Pingping, Shen Xiuqin. First-Aid Nursing of Wounded in Batches[J]. Clinical Medicine&Engineering, 2010, 17(9):108-109.

[17]Chen Jiyang. Development of Identifying System of Electronic License Plate and Its Applied Vistas[J]. Northern Communications, 2007(10):77-78.

[18] Liu Meng. 驾驶员心理素质培养与道路交通安全分析[J]. 智能城市，2017，3(04)：129. (in Chinese)

[19] Yao Jie，Ma Tingj. 道路交通安全法的心理威慑效应[C]//中国心理学会. 第十九届全国心理学学术会议摘要集. 北京：中国心理学会，2016：2. (in Chinese)

[20]Qian Hongbo, Han Hao. Influence of Countdown of Green Signal on Traffic Safety at Crossing[J]. China Safety Science Journal,2010, 20(3):9-13.

[21] Konrad Zweigert, Hein Kotz. An Introduction to Comparative Law[M]. Pan Handian, translated. Beijing: Law Press, 2003.

[22] Gao Hongjun. 比较法研究的反思：当代挑战与范式转换[J]. 中国社会科学，2009(06)：161-170. (in Chinese)

[23] Wang Wenzhong. 世界五大发达城市限车治堵经验[J]. 交通与运输，2014，30(06)：66. (in Chinese)

[24] Shen Zongling. 论法律移植与比较法学[J]. 外国法译评，1995(01)：1-7. (in Chinese)

[25]Cai Na. The Analysis of Factors Influencing Female Drivers'Traffic Accidents[D]. Beijing:Beijing University of Technology, 2010.

[26]Ma Shu. Retrospect and Prospect of China's Feminist Legal Studies[J]. Hebei Law Science, 2012, 30(11):99-106.

[27]Wei Rongping. The Improvement of the Theory of Road Traffic Accident Damage Compensation System:In the Perspective of Women's Rights Protection[D]. Nanchang:Jiangxi University of Finance and Economics, 2016.

[28]Fan Zhiyong. Innovation of Jurisprudential Research Methods from the Perspective of Problem Awareness[J]. Western Law Review, 2019(1): 97-108.

[29]Zhang Zhiwen. Methods on the Construction of Traffic Law Discipline[J]. Journal of Lanzhou Jiaotong University, 2012, 31(5):161-163.

[30]Chen Su. Transformation of the Study Mode After the Formation of the Socialist Legal System[J]. Chinese Journal of Law, 2011, 33(5):3-19.

[31] Hu Yuhong. 西方三大法学流派方法论检讨[J]. 比较法研究，2005(2)：20-32. (in Chinese)

[32]Jia Ping, Wei Huinan. Legal Issues and Solutions Relating to Self-Driving Cars[J]. Journal of Chang'an University(Social Science Edition), 2018, 20(4):36-45.

[33]Chen Jinghui. Autonomous Vehicle and the Priority of Passenger[J]. ECUPL Journal,2020, 23(6):6-19.

[34]Wang Po. Driverless Technology and the Ethics of Algorithm:A Consequential Ethical Framework for Algorithm Designing[J].Studies in Dialectics of Nature, 2018, 34(10):70-75.