

System Analysis of Electric Vehicle Traffic Violations Based on DEMATEL Model

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Abstract. The widespread use of electric vehicles has brought great convenience to people's lives, but at the same time, it is also an indisputable fact that electric vehicle traffic violations occur frequently and the resulting traffic accidents continue to occur, which interferes with normal traffic order and causes certain social conflicts. Only a rational and in-depth analysis of the illegal behavior of electric vehicles can find a reasonable solution. This paper analyzes the traffic violations of electric vehicles through systematic discussion and dimensionality reduction methodology, calculates the logical relationship and direct impact matrix between the elements of electric vehicle traffic violations based on the DEMATEL model, and explores the solution that can solve the problem.

Keywords: Electric vehicles, traffic violations, DEMATEL Model, Systems analysis, countermeasure.

1. Introduction

With the popularization and promotion of electric vehicles, the problem of electric vehicle traffic violations has become increasingly prominent. Electric vehicle traffic violations bring a series of challenges and risks to traffic safety and urban traffic order.

DEMATEL (Decision-Making Trial and Evaluation Laboratory) model is a decision support tool for analyzing complex problems, which can reveal the interrelationship and influence degree of various elements in the problem. In the study of electric vehicle traffic violations, the application of the DEMATEL model can systematically analyze factors such as driver characteristics, road and traffic environment, electric vehicle attributes, and traffic rules and laws to understand their interactions and influences.

The DEMATEL model can reveal the correlation and influence degree of various elements in the electric vehicle traffic violation system, and provide a framework and method for the comprehensive understanding of the problem. The results can help researchers and policymakers gain insight into the connections between different elements, resulting in a more accurate understanding and analytical view of the problem. Through the application of the DEMATEL model, the most significant impact on electric vehicle traffic violations can be identified, which provides a basis for the formulation of traffic management strategies and safety measures. The results can help decision makers understand the priorities and criticality between different elements, so as to rationally allocate resources and formulate effective management strategies. By comprehensively analyzing the elements of the EV traffic violation system, it is helpful to formulate scientific and effective decision-making and management plans. The findings can help government departments and policymakers make informed decisions, improve management efficiency, and reduce the occurrence and harm of electric vehicle traffic violations.

A certain amount of research has been carried out at home and abroad on the systematic analysis of electric vehicle traffic violations based on the DEMATEL model. Domestic research mainly focuses on feature analysis, influencing factor identification and decision support system development, while foreign research pays more attention to violation classification and model construction, influencing factor analysis and correlation evaluation, and traffic safety policy formulation. However, there is still much room for development in this field, and future research can further improve methods and models, deeply explore the relationship between various elements, and strengthen empirical research to provide stronger support for the prevention and control of electric vehicle traffic violations.

2. System theory analysis

2.1. System theory

General system theory believes that a system is composed of interrelated and interacting elements, an organic whole that is affected by the environment and has certain functions. The elements of the system are relative, multiple elements can constitute subsystems, and several systems constitute larger subsystems or systems, and the interrelationships between such subsystems and elements, between subsystems and subsystems, and between systems and subsystems determine that the system has hierarchies.

2.2. Analysis of electric vehicle traffic violations based on systems theory

The analysis method based on systems theory can be used to study electric vehicle traffic violations, by considering the electric vehicle system as a whole, including the interaction of factors such as vehicle, driver, road and traffic environment. The following are the key points of analyzing electric vehicle traffic violations based on systems theory:

System boundary Determine the scope of analysis, including electric vehicles, drivers, roads and traffic environments. These elements interact and collectively influence traffic violations.

Electric vehicle attributes Consider the characteristics of electric vehicles, such as acceleration performance, braking system, vehicle stability, etc. These attributes can affect the driver's actions and compliance with traffic rules.

Driver characteristics: study the behavior and characteristics of drivers, including driving experience, attitude, cognitive ability, etc., cyclists' traffic safety awareness and insufficient knowledge of traffic laws and regulations, and insufficient social popularization of laws and other elements, causing cyclists to illegally drive on the road, violate traffic lights and other behavioral elements, if the management and guidance of these two elements are strengthened, it will reduce the occurrence of cyclists illegally driving on the road, violating traffic lights and other behavioral elements. These factors have an impact on the driver's decision-making and compliance with traffic rules.

Traffic rules and laws Considering the requirements of road traffic rules and laws for driver behavior, violation of traffic rules and laws may lead to electric vehicle traffic violations.

Road and traffic environment Analyze the impact of urban road planning, road conditions, traffic flow, traffic signals and other factors on electric vehicle traffic violations. For example, the chaotic elements of urban road planning will lead to the occurrence of unconscious violation elements of cyclists, cyclists are not familiar with urban road planning, and non-subjective and unconscious traffic violations may occur in the process of driving on the road, if the city strengthens the clarity, rationality and public awareness of road planning, it will greatly reduce the occurrence of unconscious violation elements of cyclists; Congestion can make it easier for drivers to break the rules.

Feedback mechanism Consider the feedback effect of the consequences of traffic violations on the system. Traffic violations can lead to accidents, fines, or other adverse consequences that can affect the behavior of the driver and the system.

By comprehensively considering the above elements, a systematic model framework for electric vehicle traffic violations is established.

Table 1. Model framework of traffic violation system for electric vehicles

factor of system	description
Driver factor	Driver behavior characteristics: including the driver's age, driving age, driving experience, attention level, risk perception ability, etc
	Driver attitude and awareness: including the cognition degree of traffic rules and safety awareness, moral and ethical concepts, etc
	Driver decision-making process: consider the decision-making process of the driver when facing different traffic situations, such as choosing speed, direction, overtaking, etc
Vehicle factors	Technical performance: including the impact of acceleration performance, braking system, stability and other effects on driver behavior
	Vehicle safety equipment: including the existence and state of brake system, airbag, stability control system, etc
Traffic environment factors	Road condition: consider the influence of road type, curve radius, slope, traffic congestion degree on driver behavior
	Traffic flow and density: including traffic flow, speed, vehicle spacing, etc
	Traffic facilities: consider the existence and state of traffic facilities such as traffic signal lights, signs and line marking
Traffic violations	Types of traffic violations: including speeding, running red lights, illegal lane change, retrograde and other common traffic violations
	Reasons and influencing factors of violations: associate the above factors with specific violations, and analyze their influencing factors
	Consequences and penalties: consider the consequences of traffic violations, such as the possibility of an accident, the degree of injury, and the corresponding legal penalties or administrative sanctions
feedback mechanism	The impact of feedback on the system: analyze the impact of consequences and penalties on the behavior of drivers and other traffic participants, including the warning effect, the motivation to change the driving behavior, etc

3. Analysis of system engineering methodology

When analyzing traffic violations of electric vehicles, dimension-enhancing methods can help enrich data features and improve the representation ability of models, while dimensionality-reducing methods can reduce redundant information and noise, improve Model efficiency and explanatory power.

There is a demand curve D1 and a supply curve S1 for the occurrence of electric vehicle traffic violations, and the intersection of the two forms an equilibrium point E1. Later, due to the influence of factors such as the social level and the personal behavior of cyclists, the equilibrium point changed, and traffic violations by electric vehicles occurred.

Cyclist traffic safety awareness is not strong enough, cyclists do not pay enough attention to traffic rules and personal safety, and ride sloppy on the road, resulting in traffic violations, so that the supply of traffic violations increases while the demand remains unchanged, that is, the supply curve moves toward Moving to the right, a new supply curve S2 is formed, which intersects the original demand curve D1 at a new equilibrium point E2.

The country and the society have not popularized the traffic safety norms education to the public, resulting in the lack of traffic safety knowledge of cyclists, resulting in illegal behaviors such as answering and making hand-held phones and listening to music while riding, which makes the supply of traffic violations increase and the demand remains unchanged, that is, the supply curve moves to the right to form a new supply curve S3, which intersects the original demand curve D1 at the new equilibrium point E3.

Many cyclists have the mentality of "following the crowd" and "following the crowd". When they see the behavior of other offenders, they "follow the example", which encourages the occurrence of traffic

violations, increases the supply of traffic violations, and keeps the demand unchanged, that is, supply the curve moves to the right to form a new supply curve S4, which intersects the original demand curve D1 at the new equilibrium point E4.

The road planning in some cities is chaotic and not clear enough, which leads to many cyclists not being familiar with the roads, which leads to non-subjective violations such as unintentional wrong roads and other behaviors, which makes the supply of traffic violations increase and the demand remains unchanged, that is, the supply curve Moving to the right, a new supply curve S5 is formed, which intersects the original demand curve D1 at the new equilibrium point E5.

Some cyclists have a fluke mentality, thinking that a traffic violation will not be photographed or have a greater impact, so they indulge their violations, so that the supply of traffic violations increases and the demand remains unchanged, that is, the supply curve moves to the right, forming the new supply curve S6 intersects the original demand curve D1 at the new equilibrium point E6.

Many novice cyclists are inexperienced and are in a hurry after getting on the road. They are focused on driving safety and have no time to consider road rules, which leads to the occurrence of traffic violations. The supply of traffic violations increases while the demand remains unchanged, that is, the supply curve moves to the right, forming a new the supply curve S7 and the original demand curve D1 intersect at the new equilibrium point E7.

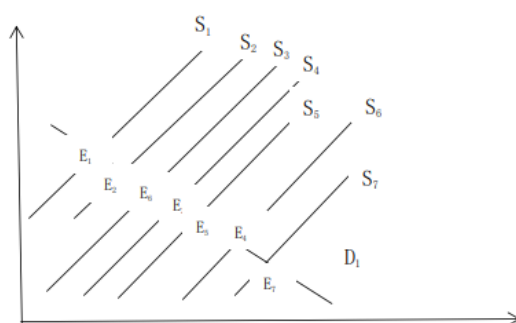


Figure 1. Dimensional reduction analysis

4. Modeling analysis

4.1. Analysis of electric vehicle traffic violations based on DEMATEL model

Using the Likert scale method, the magnitude of the impact degree is set to 0, 1 and 2 from low to high, corresponding to no impact, small impact and large impact, respectively. According to the established index system, the DEMATE model is used to analyze the mutual influence relationship between electric vehicle traffic violations, and the specific steps are as follows.

Table 2. Influencing factor

Electric vehicle traffic violations	a11	Less observation of the rear vehicles
	a12	Did not actively avoid pedestrians and vehicles
	a13	Did not actively avoid pedestrians and vehicles
	a14	Violations of signal lights
	a15	Ride into the motor vehicle lane
	a16	converse
	a17	Listen to music and make phone calls while cycling
	a18	One-handed ride / both hands
	a19	Parking indiscriminately when parking

(1) Construct the direct impact matrix of violations a:

$$a1=(a_{ij}) n \times n \quad (1)$$

Where a_{ij} represents the effect of factor i on factor j ; n is the number of factors.

S	A1	A2	A3	A4	A5	A6	A7	A8	A9	sum
A1	0	2	0	1	0	0	0	0	1	4
A2	1	0	0	1	1	0	0	0	0	3
A3	1	1	0	1	1	1	0	0	1	6
A4	0	2	0	0	2	2	0	0	1	7
A5	1	1	0	2	0	0	0	0	0	4
A6	2	1	1	2	1	0	1	0	0	8
A7	2	2	0	2	1	1	0	1	1	10
A8	1	1	0	1	0	0	0	0	0	3
A9	0	0	0	1	1	0	0	0	0	2

Figure 2. The direct impact matrix

(2) Normalization directly affects matrix a and obtains matrix b:

S	A1	A2	A3	A4	A5	A6	A7	A8	A9
A1	0	0.2	0	0.1	0	0	0	0	0.1
A2	0.1	0	0	0.1	0.1	0	0	0	0
A3	0.1	0.1	0	0.1	0.1	0.1	0	0	0.1
A4	0	0.2	0	0	0.2	0.2	0	0	0.1
A5	0.1	0.1	0	0.2	0	0	0	0	0
A6	0.2	0.1	0.1	0.2	0.1	0	0.1	0	0
A7	0.2	0.2	0	0.2	0.1	0.1	0	0.1	0.1
A8	0.1	0.1	0	0.1	0	0	0	0	0
A9	0	0	0	0.1	0.1	0	0	0	0

Figure 3. Normalization directly affects matrix

(3) The comprehensive influence matrix T is obtained:

$$t=b(E-b)-1$$

(2)

S	A1	A2	A3	A4	A5	A6	A7	A8	A9
A1	1	-0.2	0	-0.1	0	0	0	0	-0.1
A2	-0.1	1	0	-0.1	-0.1	0	0	0	0
A3	-0.1	-0.1	1	-0.1	-0.1	-0.1	0	0	-0.1
A4	0	-0.2	0	1	-0.2	-0.2	0	0	-0.1
A5	-0.1	-0.1	0	-0.2	1	0	0	0	0
A6	-0.2	-0.1	-0.1	-0.2	-0.1	1	-0.1	0	0
A7	-0.2	-0.2	0	-0.2	-0.1	-0.1	1	-0.1	-0.1
A8	-0.1	-0.1	0	-0.1	0	0	0	1	0
A9	0	0	0	-0.1	-0.1	0	0	0	1

Figure 4. The comprehensive influence matrix

S	A1	A2	A3	A4	A5	A6	A7	A8	A9
A1	1.040419	0.252686	0.003347	0.163991	0.074194	0.033468	0.003347	0.000335	0.12111
A2	0.129951	1.077074	0.003277	0.16059	0.146729	0.032773	0.003277	0.000328	0.02971
A3	0.176365	0.2204	1.014864	0.228334	0.199888	0.14864	0.014864	0.001486	0.143443
A4	0.118379	0.320902	0.02397	1.174542	0.309172	0.239703	0.02397	0.002397	0.134086
A5	0.140713	0.197156	0.005456	0.267367	1.083927	0.054565	0.005456	0.000546	0.041899
A6	0.308275	0.304378	0.109646	0.37266	0.245547	1.096461	0.109646	0.010965	0.090023
A7	0.318127	0.401973	0.018229	0.393238	0.258198	0.182293	1.018229	0.101823	0.174782
A8	0.128875	0.165066	0.003059	0.149912	0.053009	0.030594	0.003059	1.000306	0.028491
A9	0.025909	0.051806	0.002943	0.144191	0.13931	0.029427	0.002943	0.000294	1.017599

Figure 5. The comprehensive influence matrix

(4) Calculate the influence degree D_i , affected degree C_i , centrality M_i , and cause degree R_i

D_i is the degree of influence, that is, the combined influence of the i th influencing factor in the system on other influencing factors;

C_i is the degree of influence, that is, the comprehensive influence value of other influencing factors in the system on the i -th influencing factor;

M_i is the centrality, that is, it indicates the importance of the indicator;

R_i is the causal degree, and its value is positive, then the influencing factor i is called the causal factor, and its value is negative, it is called the effect factor.

D_i	0.692896	0.58371	1.148283	1.347121	0.797085	1.647601	1.866893	0.562373	0.414421
C_i	3.120186	4.016435	1.49638	4.903856	3.396222	3.128567	2.21499	0.797182	1.682442
M_i	3.813082	4.600146	2.644663	6.250977	4.193307	4.776168	4.081883	1.359555	2.096863
R_i	-2.42729	-3.43273	-0.3481	-3.55673	-2.59914	-1.48097	-0.3481	-0.23481	-1.26802

Figure 6. D_i , C_i , M_i , R_i

Among them, A2 did not actively avoid pedestrian vehicles and A4 violated the signal light with a low degree of reason, indicating that these two factors are the result of the combined effect of other violations and the risk performance of violations. After analysis, the causes of the above violations are all negative, indicating that the above behaviors are all factors that lead to electric vehicle traffic violations, and electric vehicle traffic violations are the result of the combination of the above behaviors.

Among the outcome factors, A2 did not actively avoid pedestrian vehicles and A4 violated the signal light with a high centrality, indicating that they were key factors affecting the risk of cycling behavior.

In summary, it is recommended that relevant departments strengthen citizens' education on common sense of traffic behavior, strengthen citizens' awareness of traffic behavior norms, and enhance citizens' awareness of traffic laws.

The following measures can be taken in this regard: set up online live classes on the city's more famous social accounts, and invite professionals to teach proper traffic behaviors and what everyone should pay attention to in daily traffic. Information boards on traffic behavior are regularly posted on road billboards.

5. Conclusions and Prospects

5.1. Main research conclusions

In this paper, the DEMATEL model is used to systematically analyze the traffic violations of electric vehicles, revealing the relationship and degree of influence between different elements. In the EV traffic violation system, there are complex interactions and influences among elements such as driver characteristics, road and traffic environment, EV attributes, and traffic rules and laws. Driver characteristics have an important impact on the occurrence of electric vehicle traffic violations, including driver behavior, attitude, and cognitive ability. Road and traffic environment factors, such as road conditions, traffic flow, and traffic signals, also have a significant impact on the occurrence of EV traffic violations. Electric vehicle attributes, including acceleration performance, braking system, and vehicle stability, may have an impact on driver behavior and traffic violations.

Through the system analysis of the DEMATEL model, the relationship between various elements in the electric vehicle traffic violation system can be understood more comprehensively, and guidance and decision support can be provided for improving traffic safety and reducing violations.

5.2. Research suggestions

(1) Improve driver characteristics Strengthen driver education and training, improve drivers' awareness of traffic safety and ability to obey traffic rules. At the same time, pay attention to the driver's attitude and behavior, and enhance the driver's motivation to obey the traffic rules by introducing incentive mechanisms and law enforcement means.

(2) Optimizing road and traffic environment Strengthen road planning and management, improve road conditions, reasonably set traffic signals and signs, and reduce traffic congestion. Through scientific traffic planning and management, provide a good traffic environment and reduce the occurrence of electric vehicle traffic violations.

(3) Improve the properties and technology of electric vehicles Electric vehicle manufacturers should devote themselves to improving the performance and stability of electric vehicles, providing more reliable braking systems and handling performance, so as to reduce traffic violations caused by drivers due to vehicle problems.

(4) Strengthen the enforcement of traffic rules and laws Increase law enforcement, strictly enforce traffic rules and laws, and strengthen drivers' compliance with traffic rules through fines and penalties.

(5) Comprehensively consider the interrelationships of various elements: When formulating traffic management strategies and safety measures, it is necessary to comprehensively consider the interrelationship and influence among elements such as driver characteristics, road and traffic environment, attributes of electric vehicles, traffic rules and laws, to develop a comprehensive solution.

5.3. Research limitations

(1) The model and analysis method used in this study are relatively simple. This study only uses the DEMATEL model for the systematic analysis of electric vehicle traffic violations, and other potential influencing factors may be ignored. Although the DEMATEL model can reveal the interrelationship and influence degree between elements, its results are limited to qualitative correlation analysis and may not be able to provide quantitative weight evaluation.

(2) The selection of various elements in the system is not comprehensive enough. This research may have some subjectivity and limitations when selecting the elements in the system of electric vehicle traffic violations. Certain important elements may be overlooked or under-considered, resulting in an incomplete and inaccurate understanding and analysis of the entire system.

5.4. Research prospect

(1) Comprehensive application of multiple methods Future research can combine other analysis methods, such as AHP, fuzzy comprehensive evaluation, etc., to further make up for the limitation of the singleness of this research method. Through the comprehensive application of multiple methods, the importance and influence of each element can be assessed more accurately, and more specific decision support can be provided.

(2) Introduce more elements in order to comprehensively analyze the electric vehicle traffic violation system, future research can introduce more elements. For example, factors such as driver behavior characteristics, traffic facility conditions, and traffic management policies are considered to more comprehensively reveal aspects that affect EV traffic violations.

(3) Strengthening of empirical research in order to increase the credibility and practicability of research, future research can strengthen empirical research and verify the effectiveness of models and methods by collecting a large amount of real data. At the same time, case studies or field investigations can be carried out to gain an in-depth understanding of the specific circumstances and factors affecting electric vehicle traffic violations, and provide support for the reliability of the research results.

(4) Interdisciplinary cooperation Electric vehicle traffic violations are a complex problem involving multiple disciplines, and future research can strengthen interdisciplinary cooperation. For example, combine the theories and methods of traffic engineering, behavioral science, sociology and other disciplines to form a comprehensive research perspective and promote the in-depth development of this field.

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