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Research Article

Which Factors Affect User Satisfaction with ETC? Evidence from Shanghai and Beijing

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Owing to the current development trend of globalization and informatization, traditional transportation technologies and means can no longer meet the needs of economic and social development. Thus, intelligent transportation will be an inevitable and revolutionary choice for the development of the transportation industry. As a subsystem of the intelligent transportation system, the electronic nonstop toll collection (ETC) system provides a good solution to the problems of traffic congestion, environmental pollution, energy consumption, and low toll operation efficiency caused by expressway toll collection. This high-technology system is utilized in many fields, such as radio communication and computer and automatic control in the transportation field. China's expressway ETC systems have evident effects on congestion reduction at toll stations. Although the advantages of ETC lanes are significant, and China actively implements ETC-handling policies, some drivers are reluctant to install ETC on-board systems or they have negative experiences after handling them. According to a survey, existing literature lacks research on the factors affecting user satisfaction with ETC. On the basis of the questionnaire data of ETC user experience in Shanghai and Beijing, we comprehensively investigate the reasons of banking, ETC equipment, and drivers' personal factors and travel characteristics to establish an ordinal logistics model. Through cluster analysis, drivers in the two cities are divided into three groups, and the significance of related variables is further analyzed. This research can help us understand the degree of influence of different factors on user satisfaction with ETC to a certain extent. Moreover, effective methods and measures can be used to promote the popularity of ETC vehicle equipment and the utilization rate of ETC-dedicated lanes.

1. Introduction

Electronic nonstop toll collection (ETC) systems are on-board units (OBUs) installed on the front windshields of vehicles and are one of the service functions of intelligent transportation systems. A special short-range microwave communication takes place between microwave antennas in the lanes of toll stations and other places, using computer network technology and bank back-end technology, and the distance traveled by vehicles to solve the charging problem. ETC enables vehicles to pay road and bridge tolls through toll stations without stopping. It is one of the most advanced road and bridge toll systems in the world. With the rapid development of China's transportation in recent years, the installation and use of ETC on-board equipment have entered a stage of rapid development. Before the end of December 2020, basically reaching the full coverage of ETC services in railway stations, passenger stations, port terminals, airports, and other large transportation stations was necessary. The market scale of portal systems and roadside units ushers in substantial growth. In addition, the government promotes the application of ETC in residential areas, tourist attractions, and parking lots. Many companies have begun to explore the upgrade of ETC + scene services. According to relevant data, the total number of ETC users nationwide reached 204 million until December 31, 2019,

with approximately 127 million new ETC users. At present, the penetration rate of ETC channels is as high as 90%, which means that manual toll stations will be replaced with ETC channels.

The greatest advantage of ETC is improving traffic efficiency. When using manual toll lanes, vehicles must line up to pay. This inconvenience is heightened during holidays, as the process may take more than an hour. During the period, multiple vehicles decelerating, braking, and accelerating cause congestion and exhaust emissions around toll stations. This condition not only backs the green concept, environmental protection, and low carbon but also consumes manpower and material resources. Unlike traditional manual toll lanes, vehicles do not need to slow down and stop when passing through ETC lanes. When driving on expressways, drivers have accurately measured the distance by using the gantry system covering high-speed sections, and vehicles can pass toll stations and complete toll payments quickly. As a result, exhaust emissions caused by queuing and payments can be reduced. Capital losses caused by employment problems can also be lessened.

Many researchers have analyzed ETC's contribution to transportation development qualitatively and quantitatively. Kovacs gave an overview of ETC in Asia, aiming to learn from the experiences of these countries in road toll collection [1]. Shi pointed out that the application of ETC is a powerful practice of scientific outlook on development and reflects that science makes transportation prosperous. The use of such intelligent systems can solve many of the shortcomings of manual toll collection, such as fare loss and low efficiency [2]. Han revealed that as ETC continues to be accepted by most drivers and passengers, users put forward high requirements for the service quality and service level of ETC, and additional problems may arise in the operation of ETC. For a long period in the future, the passing rate of ETC-dedicated lanes will be continuously provided to give customers convenient and efficient traffic methods [3]. Wang et al. further studied the development trend of ETC, analyzed the current development of smart parking lots, and elaborated on the application of ETC technology in smart parking lots [4].

The application of ETC is beneficial in promoting traffic management in toll plazas and saves fuel for vehicles [5]. Compared with the manual toll collection system, the ETC system has the advantages of speed and convenience [6]. Applying for ETC can indeed bring convenience to drivers and make high-speed traffic smoother, greener, and more environmentally friendly than before. However, limitations remain at this stage. Liang pointed out that the distribution of ETC service outlets is not scientific enough. Some ETC lanes have interference with car following or adjacent lanes causing electronic payment failure. Certain problems also affect ETC user experience, such as narrow expressway toll plazas. In response to these problems, Liang proposed improvement countermeasures, such as establishing a good service management system, strengthening marketing and publicity, and developing and innovating new ideas for operation and management [7]. Qu found that ETC has reduced the operating cost of an expressway to a certain extent. However, if the equipment fails, then the congestion at the toll station can be aggravated, seriously affecting the operating efficiency of the expressway and causing significant economic loss. Moreover, the charged equipment is exposed to the air for a long time, which seriously affects its service life. As a result, normal operation under severe weather conditions cannot be guaranteed. Therefore, increasing research on ETC, innovating toll collection equipment, and handling potential problems in the toll collection system is necessary [8]. Su argued that automatic identification technology is the core technology of ETC, which uses devices with identification functions to obtain vehicle-related information through the induction between microwave antennas and vehicles. However, due to the mutual interference of microwave communication, vehicles passing through adjacent lanes may communicate incorrectly with the ETC lane systems. In this regard, the antenna installation position should be adjusted reasonably to ensure that the installation angle is reasonable to ensure normal microwave communication and to avoid mutual interference [9]. Yan proposed improving the construction of toll station facilities and adopting new toll facilities and methods to improve the vehicle passing rates of lanes by improving the lanes of existing toll stations and exploring new toll collection modes. Doing so can reduce the congestion of toll stations and ensure that their service image is improved while the toll collection works smoothly [10]. Zhang analyzed the problems in expressway toll stations and put forward corresponding solutions to provide a comfortable and safe driving environment for travelers [11]. Sun and Zhang summarized ETC's development bottlenecks and operation difficulties and gave suggestions on this basis [12]. He divided the development of ETC into three stages. First, the problems encountered in the early stage were introduced; second, the midstage was analyzed; finally, the focus was on the current later stage, and solutions to the problems in ETC were provided [13]. Yan et al. summarized the development statuses of domestic standards, technologies, and applications; summarized the problems in the application; analyzed these problems; discussed possible solutions [14]. Li analyzed the factors that affect the efficiency of ETC lanes, aiming to provide a reference standard for the installation and testing of electronic tags [15]. Levinson and Chang developed a model to optimize ETC [16]. The ETC system is an important part of the intelligent transportation system, but the existing ETC system is inefficient and has the problem of escaping fees. Owing to the traceability and tamper resistance of the blockchain, combining the blockchain with the ETC system is a feasible way to solve the above problems [17]. A decentralized ETC architecture based on blockchain technology is proposed, which can effectively run normal ETC services while avoiding most of the attacks that threaten traditional ETC systems. This architecture provides a new idea for the optimization of traditional ETC systems [18].

On the basis of the above-mentioned advantages and disadvantages, exploring the factors that affect drivers' willingness to use ETC, which may contribute to the improvement of the penetration rate of ETC, is meaningful.

Using a questionnaire, Tao and Fan discussed factors that affect the intention to use ETC. Their results showed that adaptability is the most important factor, followed by perceived usefulness and ease of use [19]. Holguin–Veras and Wang used the survey data of freight companies to analyze the reasons and factors that influence the different reactions of users and nonusers to ETC [20]. Holguin–Veras and Preziosi used the discrete choice model on the basis of the data collected in New York City to analyze the factors that determine the use of ETC by car users [21]. Jou et al. confirmed through the structural equation model that the change of impression has a significant direct or an indirect impact on drivers' intention to use electronic toll services; on this basis, they proposed corresponding strategies to increase the adoption rate of ETC [22]. Holguin–Veras et al. discussed the interrelationships among the use of ETC, the choice of travel time, and comprehensive policies that improve the effectiveness of daily pricing [23]. Heras–Molina et al. conducted a nationwide survey of Spanish intercity toll road users and determined the factors that affect drivers' use of ETC [24]. Chang et al. pointed out that the implementation of ETC on expressways can provide more flexible solutions for road pricing, and they developed a road pricing model to promote a win–win situation among stakeholders [25]. Heras–Molina et al. found that free tagging equipment is an effective policy measure to encourage individuals to use ETC and additional toll roads [26]. Al–Deek et al. proposed a microscopic simulation model, which is specifically developed for evaluating the operating performance of toll stations. One of the findings of the study is that for all toll stations that use artificial channels and are overloaded, if only 10% of users switch from manual toll lanes to ETC lanes, then the delay of toll stations can be reduced by half [27]. Through driving simulation experiments, Su et al. found that adding arrows on warning signs can significantly shorten the response time and guide drivers to make lane change decisions in advance, thereby reducing congestion between manual toll lanes ETC lanes and improving traffic capacity and safety [28].

However, with the increase of ETC equipment, many problems have arisen. Although ETC equipment has been significantly more popular than it was in previous years, some drivers have not yet handled related services, and even those who have completed the handling are unwilling to use it.

Existing literature focuses on the development and drivers' acceptability of ETC, but only a few surveys and analyses have been conducted on user satisfaction with ETC on-board equipment. The innovation of this research is that it comprehensively considers 34 independent variables that may affect user satisfaction with ETC under the four categories of banking, ETC equipment, ETC business service, drivers' personal attributes, and travel characteristics. Ordinal logistics regression models are established to analyze quantitatively the impacts of these factors on user satisfaction with ETC. In addition, according to the personal attributes of the respondents, K-means cluster analysis is performed on the samples. This approach allows us to examine the factors that affect the satisfaction of different user groups with ETC.

2. Factor Elaboration

2.1. Positive Factors That May Affect User Satisfaction with ETC. Expressway traffic, as a basic project of China's transportation operation, plays an irreplaceable role in promoting the rapid development of the country's economy [29]. China's current expressway network covers the whole country. However, how to develop and reach a higher level; break the traditional artificial expressway toll station model; and achieve high efficiency, convenience, environmental protection, and the green concept is increasingly gaining the attention of the government and people. The application of ETC breaks the original purely manual toll collection mode. The mast system is installed on the high-speed road section. During the driving process, a vehicle can be recorded in real time without idling; hence, the driver does not need to stop. It can pass through the toll station without stopping, which brings great convenience when traveling. The application of ETC also reduces the toxic and harmful gases emitted by cars due to idling, reduces environmental pollution problems caused by passenger transport services, and contributes to building a green and environmentally friendly modern city. The fully automatic ETC system is a solution to the busy expressway toll collection. The implementation of nationwide networking, automatic bank settlement, and rapid transit is of great benefit to users. The advantages of ETC are given in the next section.

2.1.1. Banking. Banks have strict systems and standardized procedures for applying for ETC OBU equipment. Therefore, when drivers use ETC-dedicated channels on expressways, almost no embezzlement and misuse happen. If relevant situations occur, then they can be ascertained in a relatively short time. In addition, by collecting ETC information at toll stations, narrowing the scope of searching for the whereabouts of vehicles with electronic tags is possible, which is conducive to finding clues in investigations. When necessary, without infringing on customer privacy, consumption records of customers can be tracked on the basis of their bank consumption information. The website interactive service information of ETC is suitable for comprehensive operation information; management information; planning and construction information, such as expressway incident detection, congestion prediction, and running time prediction. It can feed back the current traffic situation and provide information for the Ministry of Transportation to relieve local traffic congestion. The information provided also helps improve drivers' experience.

2.1.2. Expressway Operation Management

(1) Improving Expressway Management and Service Levels. ETC can alleviate traffic congestion in local road sections and road network areas, provide drivers with discounts on tolls, reduce the workload of relevant traffic staff, and improve traffic efficiency. When the scope of ETC and the

number of users reach a certain level, expressway management and operation costs can be greatly reduced.

(2) Promoting the Development of Transportation Informatization. The development of the ETC system in a networked toll collection environment can integrate various information sources to provide services such as congestion prediction and running time prediction, expressway incident detection, and even guidance information publication. The ETC system is conducive to finding clues in the investigation of cases and strengthening the management and service of registered users. Excellent transportation infrastructure is conducive to real-time monitoring and management of traffic conditions and is helpful for the identification of expressway traffic accident risks [30]. The rational use of ETC may comprehensively improve the efficiency and level of expressway transportation management and services, develop China's intelligent transportation system, and promote the development of key technologies in the information transportation system with independent intellectual property rights.

(3) Adapting to the Growth of Traffic Volume. According to estimates, the maximum capacity of the existing closed toll system exits is 180 vehicles per lane per hour. In the case of a large number of vehicles on holidays, bottlenecks are formed in closed toll crossings. Increasing the number of lanes at toll stations is only a temporary solution to traffic congestion. It makes the construction of lanes more difficult, wastes manpower and material resources, and does not meet the growing traffic development needs. At the same time, subject to conditions such as land acquisition and construction, the development of ETC is the most effective solution in the long run.

2.1.3. Green Concept. ETC avoids the frequent deceleration and braking of vehicles when they pass through toll stations, reduces the waiting time for manual payments when vehicles pass through toll stations, reduces fuel consumption, and achieves the effects of saving energy and protecting the environment. ETC can not only improve traffic capacity but also is an effective path to reduce noise levels and exhaust emissions. Specifically, at toll stations, parking, starting, and waiting in line all invisibly increase vehicle exhaust emissions and the surrounding decibel index. ETC is a way to achieve "emission reduction" results by improving the efficiency of transportation operations. The emergence of ETC is conducive to the promotion of energy conservation and emission reduction, a low-carbon and environmentally friendly lifestyle. The economic and social benefits are huge, and an environmentally friendly environment is created by practicing low-carbon travel.

(1) Reducing Energy Waste Caused by Vehicle Parking and Starting Process. ETC enables vehicles to reduce deceleration, idle speed, and number of restarts caused by queuing, thereby achieving the effects of green, low-carbon, energy-saving, and reduced pollutant emissions.

(2) Reducing Toll Station Expansion Costs and Saving Land Resources. The use of ETC improves the traffic efficiency of expressway toll stations, reduces the number of toll lanes and thus reduces the scale of toll stations to achieve the goal of saving infrastructure and management costs. Specifically, the reduction in the scale of toll stations saves costs of land use and toll station construction.

(3) Reducing Personnel and Related Management Costs. Manual lane toll collectors must complete toll collection and change work every day when they are on duty. Sometimes, they need to deal with abnormal situations and answer questions from drivers and passengers. ETC-dedicated lanes require less toll personnel, save costs in hiring related personnel and use talents more effectively. Hence, toll collectors can be assigned to other jobs in road operation and management, which effectively improves the quality of road travel services.

(4) Avoiding the Loss of Access Cards Caused by Receiving and Dispatching Cards. Compared with the past method of sending and receiving cards at expressway toll stations, ETC only needs to install the electronic tag device on the front windshield of a car to pass through toll stations without queuing up and down to get the card. This approach effectively avoids card loss caused by card receiving and issuing.

2.2. Negative Factors That May Affect User Satisfaction with ETC

2.2.1. Banking

(1) ETC Procedures are too Cumbersome, and Many Things Must be Prepared. To go through ETC procedures, one must prepare copies of his/her driver's license, identification card, and insurance policy and bind a credit or debit card [31]. Some banks may require the applicant to reapply for a bank card to increase business volume. Young people may be willing to go through these procedures more than older people who find such steps cumbersome. They would rather line up to go through manual toll lanes.

(2) Capital Misappropriation May Occur in Handling ETC. When going to the bank to apply for an ETC card, a driver is almost always required to pay a deposit, mainly for convenience, and at the same time, to fund the card. If the balance is insufficient, then the deposit will be directly deducted. This situation is troublesome: the margin is also the driver's own, but it is used by the bank. In addition, liquidated damages will be deducted if ETC equipment is cancelled within five years. Five years is a time limit, which means that when the driver revokes the ETC, then liquidated damages will be incurred and the balance will be confiscated. Some drivers do not pay attention to this factor when applying for the card. They only realize it when the money is already confiscated.

(3) Drivers Open Loan Business Unwittingly. When applying for a bank card, the bank may have opened the credit business without the driver's permission. If the card balance is insufficient, then the driver can directly use the credit business and pay directly to the expressway. However, some drivers do not know it, which indirectly affects their future personal credit investigation. Furthermore, Gao found three key factors affecting customer satisfaction with ETC credit cards: ETC information query and change and OBU equipment, ETC credit card security, and employee attitude and business level [32].

(4) The Deduction Message is not Synchronized. ETC bills are not notified until a few days or even weeks later, and the notice of deduction is intermittent. Moreover, understanding the usage of high-speed toll collection in real time is impossible. If the number of passes is large, then even the driver himself cannot remember how many times he has gone. If he deducts a few more money, then he will not be cleared, and determining the overpayment or wrong payment is impossible [33].

2.2.2. ETC Equipment

(1) Quality Problems. After installing the ETC equipment of some banks, identification errors and the inability to lift the pole occur when passing toll stations in about half a year, resulting in the forced use of the manual passage. Some equipment has problems such as nondisplay and black screen. The solar panel can also be damaged for no reason after being overhauled. ETC equipment that relies on solar panel technology is a new product; thus, the probability of problems naturally increases. Once a problem in the equipment occurs, drivers can only return to the factory for inspection and cannot replace other ETC equipment during this period (because a license plate can only be bound to one ETC). Therefore, for drivers who often need to go on high speeds, the quality issues may cause great trouble. As a result, drivers do not enjoy the convenience offered by ETC.

(2) Safety Issues. Installing ETC equipment on the front windshield is necessary. If a driving recorder should be installed in a car, then a corresponding position must be reserved. This case is not only unsightly but also affects a driver's sight. Safety issues arise in addition to driving safety. Drivers may worry about the theft of ETC. After all, electronic products are not human-oriented.

(3) Single Functionality. Currently, China's ETC is mainly used in expressway toll stations. Owing to their single functionality, the ETC is unattractive to drivers. By contrast, some ETC cards abroad have many functions, such as refueling and parking.

(4) ETC Equipment Cannot Pass Through Toll Stations Normally. When taking ETC lanes, one may be unable to pass at one time. It may be caused by the speed of the vehicle, a close distance between vehicles, or insufficient balance. Sometimes, the ETC railing may hit the roof of the car if the driver is careless.

2.2.3. ETC Business Services

(1) Less Recharge Points. Drivers have to queue up every time they recharge their ETC cards, and some provincial expressways do not have recharge points. Although ETC can be recharged online in many areas, it needs to be loaded after being prerecharged. Mobile phones with NFC function can be loaded after the precharge is completed. For users whose mobile phones do not support the NFC function, they need to purchase card readers to write cards. Online recharge is inconvenient for some users; thus, they may opt to recharge at the recharge point.

(2) Difficulties in Obtaining Invoices. Many drivers may often run at high speeds and do not choose ETC because many people travel for official business and require invoices for reimbursements. In general, ETC does not provide invoices and cannot be reimbursed to the company. The ETC invoicing process is cumbersome and requires specialized software or access to the official website. Hence, drivers would rather line up to pay. In addition, in the case of frequent vehicle traffic, inconsistencies in the deducted amount between the bank ETC and the toll invoice amount often occur, thus requiring manpower and time to solve [33].

(3) ETC Portal System Billing Instead of Toll Station Billing. The ETC gantry system replaces the function of the original provincial toll station. It is erected above the expressway similar to a traffic probe. The information of the OBU equipment is read through the radio frequency device to achieve an accurate recording of the vehicle driving path. Drivers do not need to slow down at all. Therefore, the current toll collection method of ETC is based on the actual travel distance instead of the shortest distance from station to station. Although it can ensure accurate billing while cars pass quickly without stopping, drivers who are unfamiliar with the route and road conditions will experience detours. As a result, mast billing may be higher than the previous toll station billing.

2.2.4. Personal Reasons and Travel Characteristics. Many personal reasons are also involved, such as the low frequency of using ETC equipment for people who do not get on high speeds. In general, drivers must go on high speeds only under a few circumstances. Many drivers drive in urban areas and rarely go on high speeds. Moreover, the probability of using them is only high on holidays. Therefore, such drivers may think that ETC equipment is unnecessary.

Applying for ETC can bring convenience to drivers and make high-speed traffic smooth, but using it poses many limitations. No matter how much ETC contributes to the improvement of traffic efficiency, compulsory means must not be used. The rights of the few people who do not want to use ETC should be guaranteed. This factor is not only clarified by the superior authority but is also a sign of social progress.

2.3. Implementation Significance of ETC Systems. Given the current development trend of globalization and informatization, traditional transportation technologies and means can no longer meet the needs of economic and social development. Intelligent transportation will be an inevitable and revolutionary choice for the development of the transportation industry.

Expressways play an important role in promoting economic growth, improving quality of life, reducing energy consumption, reducing environmental pollution, and maintaining national security. In order to build a "people-satisfied, well-secured, and world-leading" transportation power, how to improve expressway traffic capacity and traffic efficiency has become the focus of expressway construction. Furthermore, improving the traffic efficiency of expressway toll stations is an urgent problem to be solved. The popularization and use of ETC has basically realized a safe, convenient, efficient, green, and economical travel mode.

With the introduction of new national requirements and policies, and with the joint assistance of banks and the government, the installation of ETC on-board equipment has increased significantly. In the future, ETC-dedicated channels will increase greatly, and impacts of the implementation and popularization of ETC will be positive and multifaceted. The use of ETC systems improves the efficiency of expressway toll stations, shortens the waiting time of drivers, and reduces the number of manual toll lanes and the resources consumed for personnel management and training. As a result, the scale of toll stations and saving infrastructure and administrative expenses are reduced. Specifically, the reduction of the scale of toll stations saves costs of land use and toll station construction.

However, expressway tolls are still the main means to raise funds to expand the scale of infrastructure construction. These tolls are powerful tools to control traffic flow. Therefore, toll collection systems are indispensable subsystems in the expressway transportation system now and in the future. The current and the following periods will be the main stages of China's road network entering "networked operation." As a subsystem of the intelligent transportation system, ETC provides a good solution to the problems of traffic congestion, environmental pollution, energy consumption, and low toll operation efficiency caused by expressway toll collection. This system is the penetration of high technology in many fields, such as radio communication, computer, and automatic control in the transportation field. It also has a major and irreplaceable positive impact on the stability and continuous operation of the entire road transportation system. However, problems such as traffic congestion and delays, energy waste and environmental pollution, and low toll operation efficiency caused by manual toll lanes hinder the development of road transportation. ETC remains the best answer to this problem. Moreover, as an important subsystem of the intelligent transportation system, ETC is a stepping stone for the informatization and intelligence of China's transportation industry. After nearly 10 years of development, the ETC system has become increasingly mature and perfect in construction, operation, and technology. Its products and technologies have reached standardization under the supervision of the government.

China's recent rapid economic development, rapid expansion of transportation facilities, and rapid popularization of toll roads are conducive to the investment in the construction of ETC systems. In addition, the application of ETC technology has been widely expanded today. In the future, cities must be information-based and intelligent cities that use technology to drive smart construction. The expansion of ETC multiscenario services can help smart transportation and smart city development and can effectively solve market problems such as parking, charging, and refueling. In particular, ETC systems will reflect the infinite value and social benefits in terms of fast payment, smooth traffic, environmental protection, and safety. ETC systems are mainly used in three charging scenarios: expressway, parking lot, and multi-lane. In the post-ETC era, ETC applications can be expanded to smart fueling, smart car washing, smart charging, and smart scenic spots/parks.

Oriented to provide users with convenience, the Ministry of Transport promotes the expansion of ETC multiscenario services combining ETC + smart parking, ETC + smart refueling, ETC + smart car washing, ETC + smart charging, ETC + smart scenic spots/parks through online and offline channels to facilitate the development of smart transportation and smart cities.

Focusing on urban parking needs, the Ministry of Transport instructs all localities to improve ETC parking lots and roadside parking facilities continuously, build a city-level parking management and control platform, and realize unattended parking lots and efficient resource turnover. In this way, the management of urban parking can be refined, and the quality of urban traffic services and environmental order can be improved. The Ministry of Transport continues to promote the expansion of ETC application scenarios to achieve ETC parking in airports, railway stations, bus terminals, and other transportation hubs, as well as large shopping malls, supermarkets, hospitals, universities, residential quarters, roadsides, and other parking scenarios. In this way, it will promote the balanced and coordinated development of urban dynamic and static traffic, optimize the relationship between urban parking supply and demand, and help urban traffic congestion control and green travel. In addition, it is necessary to combine the regional coordinated development strategy, give full play to the leading role of central cities and provincial capitals, drive the coordinated development of surrounding cities, and form a certain regional effect and industrial effect [34].

By the end of 2020, Beijing has realized ETC payment in 300 parking lots including 24 hospitals, 23 hub stations, 95 commercial complexes, 66 residential communities, and 20 scenic parks. The monthly ETC transaction volume exceeds two million vehicles, and the ETC payment proportion exceeds 50%. For example, the payment proportion of the parking lot of Beijing Children's Hospital is 65%, and the payment proportion of the parking lot of Capital International Airport Terminal Three is 51%, which truly realizes fast payment without parking [35].

The "2022 Beijing Municipal Traffic Comprehensive Management Action Plan" further proposes to speed up the construction of smart parking. Formulating and implementing a work plan is necessary to promote the construction of smart parking in Beijing, to revise the management methods for the filing of commercial parking lots, to issue standards and specifications for the construction of smart parking facilities, and promote the upgrading and transformation of the management system of public parking lots. Business districts in the core area and municipal tertiary hospitals should take the lead in expanding the promotion of ETC charging, speed up the construction of "one map" and "one library" of parking resources, strive to realize the full collection of dynamic and static data of the city's road parking spaces and public parking facilities registered for operation, open and share it with map service companies simultaneously, and guide them to provide smart parking services [36].

G15 Shenhai Expressway (Jialiu Section), an expressway in Shanghai with a long congestion time, has been expanded and overhauled for nearly two years. After the reconstruction of this expressway is completed, it will become the first smart expressway in Shanghai. The reconstruction project focuses on "double improvement and double reduction," that is, "improving the efficiency of facility traffic and emergency support, reducing the probability of traffic accidents and the impact of maintenance traffic," and actively explores a new industrial model for smart expressways. Based on the operation and maintenance experience and facility data accumulated for 20 years, the smart expressway digital twin base will be constructed by using big data, artificial intelligence, holographic perception, BIM + GIS (building information model and geographic information system), and other cutting-edge technologies. Unified management of full-life-cycle digital assets such as traffic operation data, facility status data, and construction period data will further realize a smarter and more refined expressway operation and maintenance mode [37].

3. Data Sources

In 2021, Shanghai's expressway mileage has reached 851 km, and the expressway density ranks first among all provinces in China [38], providing good conditions for economic development. The rapid development of expressways in Shanghai has played an important role in enhancing urban agglomeration and radiation capabilities, optimizing urban functional layout, promoting suburban economic development, and building a coordinated urban-rural development pattern.

Beijing, one of the first batches of online charging provinces in China, has a good foundation for ETC development. In addition, as a pilot city, Beijing has carried out ETC smart parking pilot work in advance. In order to promote Beijing's comprehensive transportation management to achieve new results and create a good travel environment, the People's Government of Beijing Municipality formulated the "2020 Beijing Municipal Transportation Comprehensive Management Action Plan." One of the key tasks is to improve traffic information service capabilities, including the realization of ETC charges for 300 large public parking lots.

This research focuses on Beijing and Shanghai, two cities that took the lead in realizing the regional networking of ETC and takes ETC users in these two first-tier cities as the target population of the research.

Despite differences in the popularity and utilization of ETC in various provinces and cities in China, the challenges faced in promoting ETC across China may be similar. The policy recommendations put forward in this paper can be piloted first, and after gaining experience and reaching a consensus, the pilot practice can be promoted. The model of the first pilot and then promotion takes into account the differences in ETC promotion and economics in various regions, which helps reduce reform risks, reduce reform shocks, and frees up time and space for error correction. In the pilot sites with better economic development, the policy effect is more significant, so the policy of the pilot sites is likely to be extended to other regions. Aiming at the bottleneck problems and difficulties in the implementation, use, and management of ETC in Beijing and Shanghai, the formation of countermeasures and prescriptions can expand a "green channel" for the promotion of ETC across China.

3.1. Brief Analysis of Questionnaire Content. The text data are mainly obtained through questionnaire surveys, which were published online from November 5 to 8, 2020. To reduce the relevance of the surveyed individuals, travelers of different age groups, occupations and incomes in Shanghai and Beijing are selected for the random questionnaire surveys; a total of 417 questionnaires were collected. Among them, 351 drivers own private cars and have applied for ETC in-vehicle devices. The subsequent data analysis is based on these 351 samples. The survey subjects are mainly 18–50 years old and are at a suitable driving age, including 175 males and 176 females. The gender ratio is about one to one, which is balanced. Figure 1 shows the distribution of respondents' personal attributes.

The questionnaire data mainly include three aspects of variables: (1) personal attributes, including each traveler's city, gender, age, education level, occupation, monthly income after tax; whether ETC devices have been installed; and satisfaction with ETC; (2) travel characteristics, including the number of trips on expressways each year and the length of time of using the ETC; (3) problems encountered when using ETC lanes; (4) importance of factors that influence the choice of using ETC; (5) concerns about the installation of ETC vehicle equipment; (6) advantages of ETC.

3.2. Variable Definition. Taking user satisfaction with ETC as the dependent variable Y, the questionnaire divides satisfaction into different levels from one to ten. For the convenience of analysis, the satisfaction level from one to four is $Y = 1$, and the satisfaction level from five to seven is $Y = 2$. The satisfaction degree from eight to ten is $Y = 3$. A total of 33 explanatory variables are defined as follows (Table 1).

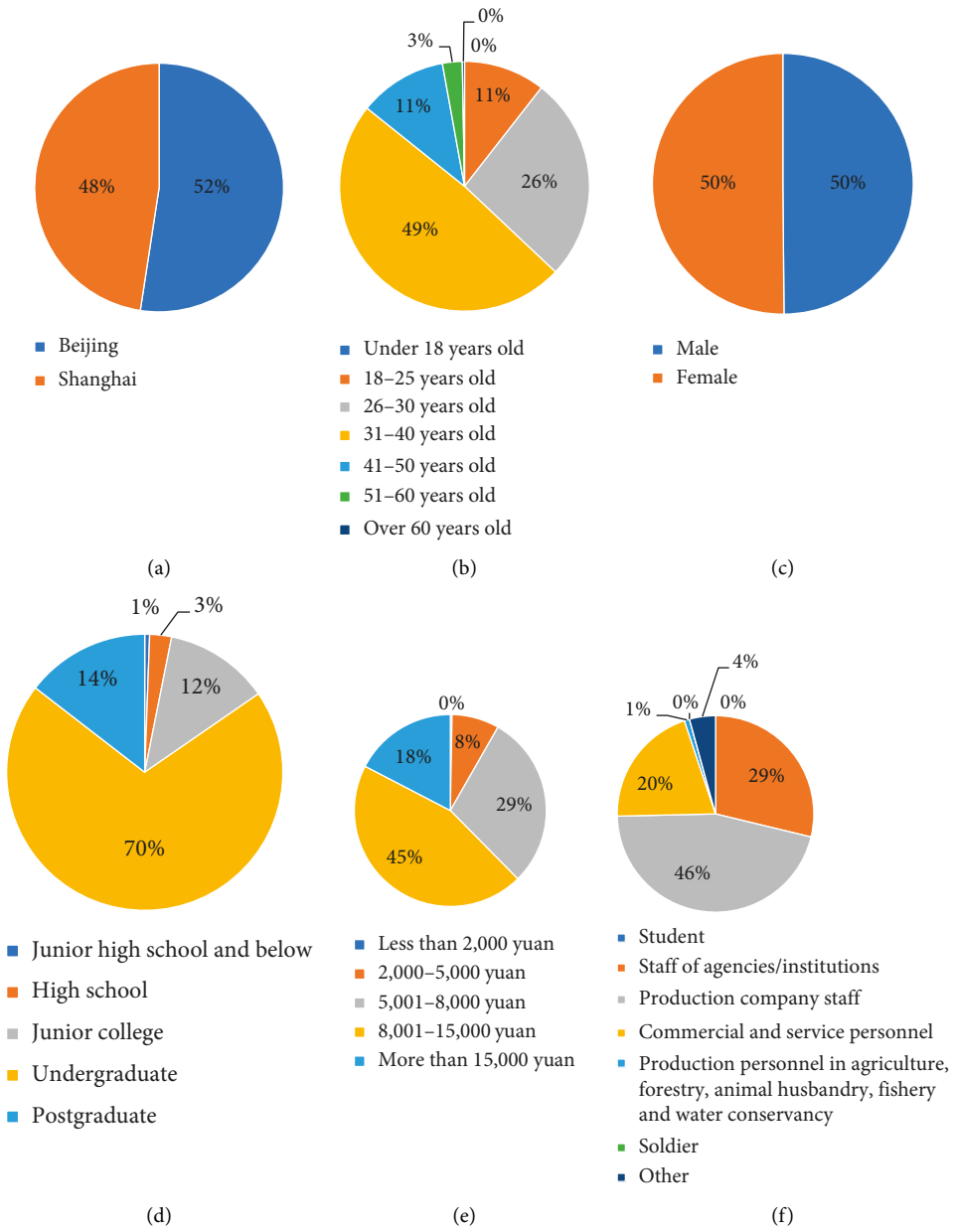

Figure 1: The distributions of respondents' personal attributes. (a) City. (b) Age. (c) Gender. (d) Education level. (e) Monthly income after tax. (f) Occupation.

After the variables are selected, the model parameters can be estimated. The ordinal logistics model is used for estimation, and the SPSS software outputs the estimated value of the model parameters.

4. Methodology

4.1. Ordinal Logistic Regression. Logistic regression analysis is used to study the effect of X on Y. There is no requirement for the data type of X, which can be categorical data or quantitative data. However, Y must be categorical data, and according to the number of options of Y, the corresponding data analysis method must be used. Ordinal logistic regression is suitable for data with different levels or degrees of dependent variables. For example, the dependent variable in this research is divided into three categories, of which one is dissatisfied, two is generally satisfied, and three is very satisfied.

In this research, taking user satisfaction with ETC as the dependent variable Y, the questionnaire divides the satisfaction into different levels from one to ten. For the convenience of analysis, the satisfaction level from one to four is $Y = 1$, the satisfaction level from five to seven is $Y = 2$, and the satisfaction level from eight to ten is $Y = 3$. These three levels have comparative significance: the higher the value, the higher the satisfaction of the sample. Therefore, ordinal logistic regression analysis is suitable for this research.

Table 1: Definition of model variables.

	Variables	Description of variables
Personal attributes	City	1: Beijing; 2: Shanghai
	Gender	1: Male; 2: Female
	Age	1: Under 18 years old; 2: 18–25 years old; 3: 26–30 years old; 4: 31–40 years old; 5: 41–50 years old; 6: 51–60 years old; 7: Over 60 years old
	Education level	1: Junior high school and below; 2: High school; 3: Junior college; 4: Undergraduate; 5: Postgraduate
	Occupation	1: Student (not working); 2: Staff of agencies/institutions; 3: Production company staff; 4: Commercial and service personnel; 5: Production personnel in agriculture, forestry, animal husbandry, fishery and water conservancy; 6: Soldier; 7: Others
	Monthly income after tax	1: Less than 2,000 yuan; 2: 2,000–5,000 yuan; 3: 5,001–8,000 yuan; 4: 8,001–15,000 yuan; 5: More than 15,000 yuan
Travel characteristics	Number of trips on expressways per year	1: 0 times; 2: 1–4 times; 3: 5–10 times; 4: 11–30 times; 5: More than 30 times
	Duration of using ETC	1: Less than 1 year; 2: 1 to 3 years; 3: 3 to 5 years; 4: More than 5 years
Problems encountered when using ETC lanes	Congestion in ETC lanes Inability to synchronize ETC deduction messages in real time Disorderly fee deduction Difficulties invoicing reimbursements Damage to ETC equipment due to quality problems Embezzlement of ETC cards Inconvenience of finding ETC card recharge points	0: No; 1: Yes
The importance of factors that influence the choice of using ETC	Lane congestion Toll level Usage safety (theft and embezzlement) Usage correctness (wrong brushing and missing brushing) Need for invoicing reimbursement Driving information acquisition ETC lane use experience	1: Strongly disagree; 2: Disagree; 3: Neither agree nor disagree; 4: Agree; 5: Strongly agree
Concerns about the installation of ETC vehicle equipment	Cumbersome formalities Hidden dangers of fund security Rarely driving on expressways Don't know about ETC or how to complete the formalities Device effects on driving vision Unsightly appearance	0: No; 1: Yes
Advantages of ETC	Relieve the congestion of expressway toll stations High-tech sense Convenient access No need to take cards Toll reduction Other	0: No; 1: Yes

When user satisfaction with ETC is used as the ordinal dependent variable, the number of logistic regression models to be fitted is one less than the number of dependent variables. Taking a dependent variable with three levels as an example, the rank probabilities p_1, p_2, and p_3; the effect parameter β; and the constant term α are defined.Then, for the two models fitted by n independent variables, as shown in formulas (1) and (2), the corresponding parameters can be directly estimated using SPSS software.

$$\text{Logit}\frac{p_1}{1-p_1} = \text{logit}\frac{p_1}{p_2+p_3} = -\alpha_1 + \beta_1 x_1 + \cdots + \beta_n x_n, \quad (1)$$

$$\text{logit}\frac{p_1+p_2}{1-(p_1+p_2)} = \text{logit}\frac{p_1+p_2}{p_3} = -\alpha_2 + \beta_1 x_1 + \cdots + \beta_n x_n. \quad (2)$$

According to formulas, and (3)–(5), p_1, p_2, and p_3 can be obtained:

$$p_1 = \frac{\exp(-\alpha_1 + \beta_1 x_1 + \cdots + \beta_n x_n)}{1 + \exp(-\alpha_1 + \beta_1 x_1 + \cdots + \beta_n x_n)}, \quad (3)$$

$$p_2 = \frac{\exp(-\alpha_2 + \beta_1 x_1 + \cdots + \beta_n x_n)}{1 + \exp(-\alpha_2 + \beta_1 x_1 + \cdots + \beta_n x_n)}, \quad (4)$$

$$p_3 = 1 - p_1 - p_2. \quad (5)$$

Compared with the rank probability p and the constant term α, we should pay more attention to the effect parameter β to analyze the influence of different factors on user satisfaction with ETC.

4.2. K-Means Clustering Analysis. Many kinds of clustering algorithms can be used, and K-means is one of the most commonly used clustering algorithms. The advantage of this clustering method is that it is simple, easy to understand, and has a fast computing speed. The clustering analysis method can analyze the inherent characteristics of things and group things according to the principle of similarity. It is a commonly used technique in data mining.

When analyzing caregiver travel behavior, Dardas et al. used K-means clustering to identify three relative types of caregiver travel behavior: flexible, between flexible and fixed, and fixed [39]. Akar et al. used K-means clustering analysis and several land-use and built-environment variables to create new neighborhood categories, namely, central urban residential areas, medium-density suburbs, and low density suburbs [40]. Wang et al. applied the K-means clustering algorithm to divide the public into four categories, used the entropy method to evaluate quantitatively the public's haze habituation, and finally chose the ordinal logistic regression model to analyze the factors affecting the public's haze habituation [41]. When studying the time evolution of driving safety efficiency, Tselentis et al. used K-means clustering to identify the main driving characteristics of each cluster, and divided the drivers into three categories: moderate drivers, unstable drivers, and cautious drivers [42]. Zhao et al. applied the K-means clustering algorithm to classify spatial traffic hot spots by camera locations while exploring the weekly travel patterns of private cars [43]. Arian et al. proposed a market segmentation method applied to the field of traffic behavior change, in which 10 personas were generated by using K-means clustering, representing different types of people with different travel patterns and sensitivity to incentives [44, 45]. Eltved et al. used K-means clustering to group passengers according to their travel behavior before and after public transport service closures, allowing them to observe how different passenger groups change their travel behavior after public transport service disruptions [46].

The K-means clustering method requires a given number of clusters k. The n samples to be analyzed are divided into k clusters so that the obtained clusters satisfy the following conditions: samples in the same cluster have high similarity, whereas samples in different clusters have a low similarity. When selecting the k value in cluster analysis, (1) the clusters should be separated as much as possible and (2) the resulting clusters are reasonable and meaningful.

This research uses the K-means clustering method to classify ETC users according to the socioeconomic attributes of respondents. After clustering, the socioeconomic attributes of ETC users in the same cluster are similar, and the socioeconomic attributes of ETC users in different clusters are different. K-means clustering analysis needs to organize data objects into a set of categories $C = \{c_i, i = 1, 2, \ldots, k\}$. Each category represents a data cluster, and each category has a category center c_i. The specific steps of K-means clustering analysis are as follows.

First, k points are randomly selected from the sample set to be studied as the initial cluster centers.

Second, the Euclidean distance $d(x, c_i)$ from each sample to each center is calculated, as shown in formula (6). Then, the samples are assigned to the cluster where the nearest cluster center is located.

$$d(x, c_i) = \left\{ \sum_{j=1}^{J} \left(x_j - c_{ij}\right)^2 \right\}^{1/2}, \quad (6)$$

where x is the data object; c_i is the i th cluster center; J is the data dimension; and x_j and c_{ij} represent the j th attribute value of x and c_i, respectively.

Third, the mean of the data in each cluster is calculated as the new cluster center. The sum of squared error (SSE) for all clusters is calculated as shown in the following formula:

$$\text{SSE} = \sum_{i=1}^{k} \sum_{x \in c_i} \left|\text{d}(x, c_i)\right|^2. \quad (7)$$

Finally, step two is repeated until the SSE does not change, that is, the total sum of squares of the distances of each cluster reaches the minimum.

5. Result Analysis

The ordinal regression results of 167 samples in Shanghai (Table 2) show that the factors that have significant impacts on user satisfaction with ETC include monthly income after tax, the duration of using ETC, embezzlement of ETC cards, lane congestion, toll level, usage safety (theft and embezzlement), need for reimbursement, driving information acquisition, ETC lane use experience, cumbersome formalities, unsightly appearance, and toll reduction. Among them, usage safety (theft and embezzlement), cumbersome formalities, and unsightly appearance have positive impacts on user satisfaction with ETC. The other variables have significant negative impacts on user satisfaction with ETC.

Table 2: Ordinal logistic regression analysis results of Shanghai samples.

Variables	B	SE	Significance	Exp (B)
Threshold				
Dissatisfied	−49.221	22.571	0.029	0.000
Generally satisfied	−34.700	21.443	0.106	0.000
Gender (relative to female)				
Male	0.871	0.877	0.321	2.389
Age (relative to 51–60 years old)				
18–25 years old	−5.816	20.468	0.776	0.003
26–30 years old	−6.463	20.435	0.752	0.002
31–40 years old	−6.668	20.401	0.744	0.001
41–50 years old	−3.411	20.365	0.867	0.033
Education level (relative to postgraduate)				
Junior high school and below	−11.971	33.917	0.724	0.000
High school	6.192	5.900	0.294	488.823
Junior college	−2.014	2.692	0.454	0.133
Undergraduate	0.947	1.818	0.603	2.578
Occupation (relative to others)				
Staff of agencies/institutions	−0.917	3.036	0.763	0.400
Production company staff	−1.103	2.650	0.677	0.332
Commercial and service personnel	−0.313	2.751	0.909	0.731
Monthly income after tax (relative to more than 15,000 yuan)				
2,000–5,000 yuan	−6.196	2.492	0.013	0.002
5,001–8,000 yuan	−1.062	1.440	0.461	0.346
8,001–15,000 yuan	0.986	1.545	0.523	2.680
Number of trips on expressways per year (relative to more than 30 times)				
1–4 times	2.747	2.099	0.191	15.596
5–10 times	2.562	1.962	0.192	12.962
11–30 times	1.624	2.071	0.433	5.073
Duration of using ETC (relative to more than 5 years)				
Less than 1 year	−26.252	2.782	0.000	0.000
1 to 3 years	−20.664	1.792	0.000	0.000
3 to 5 years	−20.196	0.000	—	0.000
Congestion in ETC lanes (relative to yes)				
No	1.887	1.132	0.095	6.600
Inability to synchronize ETC deduction messages in real time (relative to yes)				
No	2.178	1.175	0.064	8.829
Disorderly fee deduction (relative to yes)				
No	0.701	1.178	0.551	2.016
Difficulties invoicing reimbursements (relative to yes)				
No	1.663	1.435	0.246	5.275
Damage to ETC equipment due to quality problems (relative to yes)				
No	0.775	1.161	0.504	2.171
Embezzlement of ETC cards (relative to yes)				
No	−6.357	2.678	0.018	0.002
Inconvenience of finding ETC card recharge points (relative to yes)				
No	0.086	1.250	0.945	1.090
Lane congestion (relative to strongly agree)				
Strongly disagree	−67.366	0.000	—	0.000
Disagree	−0.143	26.948	0.996	0.867
Neither agree nor disagree	−8.093	3.319	0.015	0.000
Agree	0.312	1.135	0.784	1.366
Toll level (relative to strongly agree)				
Strongly disagree	−14.817	0.000	—	0.000
Disagree	33.186	7,372.804	0.996	2.585
Neither agree nor disagree	−8.222	2.681	0.002	0.000
Agree	−2.011	1.26	0.111	0.134
Usage safety (theft and embezzlement) (relative to strongly agree)				
Disagree	26.208	9,731.872	0.998	2.410
Neither agree nor disagree	−0.017	1.819	0.992	0.983
Agree	3.802	1.599	0.017	44.791
Usage correctness (wrong brushing and missing brushing) (relative to strongly agree)				

Table 2: Continued.

Variables	B	SE	Significance	Exp (B)
Disagree	6.298	3.238	0.052	543.484
Neither agree nor disagree	1.208	1.884	0.522	3.347
Agree	0.774	1.113	0.487	2.168
Need for invoicing reimbursement (relative to strongly agree)				
Strongly disagree	−8.234	4.177	0.049	0.000
Disagree	0.631	2.419	0.794	1.879
Neither agree nor disagree	−2.190	1.454	0.132	0.112
Agree	−5.686	1.999	0.004	0.003
Driving information acquisition (relative to strongly agree)				
Strongly disagree	−9.164	4.543	0.044	0.000
Disagree	−5.327	2.252	0.018	0.005
Neither agree nor disagree	−0.060	1.532	0.969	0.942
Agree	−3.100	1.458	0.034	0.045
ETC lane use experience (relative to strongly agree)				
Disagree	17.389	27.561	0.528	35,640,742.730
Neither agree nor disagree	−5.549	2.125	0.009	0.004
Agree	−2.378	1.267	0.061	0.093
Cumbersome formalities (relative to yes)				
No	3.141	1.299	0.016	23.127
Hidden dangers of fund security (relative to yes)				
No	−0.810	1.045	0.438	0.445
Rarely driving on expressways (relative to yes)				
No	0.864	1.102	0.433	2.373
Don't know about ETC or how to complete the formalities (relative to yes)				
No	3.531	1.866	0.058	34.158
Device effects on driving vision (relative to yes)				
No	−3.522	1.799	0.050	0.030
Unsightly appearance (relative to yes)				
No	3.070	1.369	0.025	21.542
Relieve the congestion of expressway toll stations (relative to yes)				
No	−1.725	1.196	0.149	0.178
High-tech sense (relative to yes)				
No	−1.985	1.083	0.067	0.137
Convenient access (relative to yes)				
No	1.523	1.366	0.265	4.586
No need to take cards (relative to yes)				
No	−1.462	0.979	0.135	0.232
Toll reduction (relative to yes)				
No	−2.482	1.259	0.049	0.084

On the one hand, compared with the users who think that usage safety (theft and embezzlement) is very important, users who think that this factor is relatively important are 44.791 times (OR = 44.791) more likely to be very satisfied with ETC. Generally, the security of ETC is guaranteed, but embezzlement is also a risk. Therefore, for users who attach great importance to usage safety, their satisfaction will drop more significantly when they find security risks. Compared with users who feel that the formalities are cumbersome, users who do not worry about cumbersome formalities are 23.127 times (OR = 23.127) more likely to be very satisfied with ETC. The process from application to use of ETC is very long, and some people may need to take a leave from work to apply. More importantly, the application cannot be done all at once, so many people find it complicated. Therefore, users who feel that the processes are cumbersome will reduce the favorability of ETC. Furthermore, users who think that ETC devices are not aesthetically pleasing are naturally less satisfied with ETC.

On the other hand, users with a monthly income of 2,000–5,000 yuan after tax were 99.8% (OR = 0.002) less likely to be very satisfied with ETC than those with a monthly income of more than 15,000 yuan after tax. In most cases, the bank staff will handle the credit card for the car owner, and users with low income may be resistant to this step. The duration of using ETC has a significant negative impact on ETC satisfaction, indicating that user satisfaction with ETC will decrease with the increase of usage time. With the increase of usage time, users feel the defects of ETC more clearly, which worsens the users' experiences of using ETC. Conversely, when users use ETC less frequently and for a shorter period of time, they have fewer negative experiences; thus, their satisfaction with ETC is higher. Compared with users whose ETC has been embezzled, users who have not had their ETC cards embezzled are 99.8% (OR = 0.002) less likely to be very satisfied with ETC. Users may have reported the loss to the bank and applied for compensation as soon as they found out that the ETC was embezzled. They may have

experienced good service in the process, so the negative emotions about the ETC being embezzled were not serious. Users without such experience may be worried about the occurrence of such things, so they have concerns about ETC. Users who felt that lane congestion had a moderate impact on the choice of using ETC were less likely to be very satisfied with ETC. ETC improves the mobility of expressway vehicles so that the congestion of toll stations can be alleviated. However, users who do not pay much attention to lane congestion will not improve their impression of ETC because of this advantage. Need for reimbursement, driving information acquisition, ETC lane use experience have a negative impact on user satisfaction with ETC. Private car drivers generally do not care much about invoice reimbursement. However, invoices are required for the reimbursement of drivers who drive official vehicles. ETC invoices are troublesome, so many drivers would rather queue up at manual toll lanes to pay than apply for ETC. In addition, ETC can check driving track records. For users who value driving information acquisition, their ETC satisfaction will be higher. The impact of ETC lane use experience on user satisfaction with ETC is well understood. People who are not concerned about the experience of using ETC lanes do not pay much attention to the convenience brought by ETC, so their satisfaction with ETC is not very high.

Finally, toll reduction has the same meaning as toll level. The difference between these two factors is that toll reduction is an advantage of ETC in the questionnaire, whereas toll level is one of the factors that users consider when using ETC. Various preferential policies, such as toll reduction and exemption, are implemented on the basis of the ETC system. If it is neither installed nor used, then the preferential policy cannot be enjoyed. Starting from January 1, 2020, cars that do not use ETC will no longer enjoy toll reduction or exemption. Drivers who pay more attention to toll reduction and exemption are, of course, inclined to choose ETC lanes and are more satisfied with ETC.

According to the ordinal regression results of the Beijing sample (184 copies) (Table 3), the education level, the number of trips on expressways per year, difficulties invoicing reimbursements, usage safety (theft and embezzlement), rarely driving on expressways, high-tech sense, and toll reduction have significant impacts on user satisfaction with ETC. Among them, education level, the number of trips on expressways per year, rarely driving on expressways, high-tech sense, and toll reduction have negative impacts on user satisfaction with ETC. By contrast, difficulties invoicing reimbursements and usage safety (theft and embezzlement) have positive impacts on the dependent variable. The possible reasons for usage safety (theft and embezzlement) and toll reduction on user satisfaction with ETC have been analyzed in the results from the Shanghai data. Therefore, we will not repeat them here.

On the one hand, users with only a high school education are less satisfied with ETC than users with a postgraduate degree. Choosing a manual toll lane is reasonable for people with a low frequency of driving on expressways, especially those who hardly drive on expressways, let alone whether to use ETC-dedicated lanes. Therefore, people with a low frequency of driving on expressways are less inclined to choose ETC-dedicated lanes. For users who rarely use ETC because they do not frequently drive on expressways, the lower frequency of use may make them unable to feel the problems of ETC and thus evaluate it highly. In addition, ETC has major technical advantages such as noncontact, long distance, and high precision. At the same time, users are often willing to try new things with a high-tech sense out of curiosity, which is why some users choose the ETC lane.

On the other hand, compared with users who encountered difficulties invoicing reimbursements, users who did not encounter this problem are 4.792 times (OR = 4.792) more likely to be very satisfied with ETC. For office workers with reimbursement needs, the difficulty of issuing reimbursement invoices is especially significant. Invoices are important documents to prove that the business took place. Therefore, the difficulty of issuing invoices may lead to some users' dissatisfaction and resistance to the ETC service. Obtaining an invoice when using ETC is not easy. In the high-speed crowd, many drivers are on business trips. Therefore, the use of ETC may cause difficulties in the reimbursement of tolls. When passing through manual toll lanes, drivers receive an invoice immediately, whereas ETC exits do not issue receipts. If a car owner wants a reimbursement certificate, then he/she needs to download a software and link his/her information to obtain an electronic invoice, which may be troublesome. This factor is an important reason why drivers who need an invoice are reluctant to use the ETC lanes. The difficulties in invoicing reimbursements are particularly significant for office workers with reimbursement needs. Invoices are also important documents to prove the occurrence of business. Therefore, the difficulties in issuing invoices may cause some users to feel dissatisfied and resisted with ETC services. Obtaining invoices when using ETC is not easy. We know that among the people who often drive on expressways, many drivers are on business trips. Thus, using ETC may cause certain difficulties in reimbursing tolls. When passing through manual toll lanes, drivers obtain invoices immediately, but ETC exports cannot. If a car wants a reimbursement voucher, it needs to download other software and bind its own information to obtain the electronic invoice, which may cause more troubles. This factor becomes an important reason why drivers who need invoices do not want to use ETC-dedicated lanes.

To analyze the factors that affect the satisfaction of different groups of ETC, we performed a K-means clustering analysis on the samples of the two cities according to the personal attributes of respondents (i.e., gender, age, education level, and monthly income after tax). Through the analysis of clustering indicators, we found that the clustering effect is the best when the samples are divided into three clusters. The significance of the four variables is less than 0.05, indicating that these four variables can distinguish each cluster well. The 351 samples are divided into three clusters according to their features. According to the characteristics of the clustering variables, the personal attribute

Table 3: Ordinal logistic regression analysis results of Beijing samples.

Variables	B	SE	Significance	Exp (B)
Threshold				
Dissatisfied	−31.077	16,007.873	0.998	0.000
Generally satisfied	−24.848	16,007.873	0.999	0.000
Gender (relative to female)				
Male	−0.557	0.655	0.395	0.573
Age (relative to over 60 years old)				
18–25 years old	−18.838	16,007.873	0.999	0.000
26–30 years old	−16.955	16,007.873	0.999	0.000
31–40 years old	−17.195	16,007.873	0.999	0.000
41–50 years old	−17.843	16,007.873	0.999	0.000
51–60 years old	−19.274	16,007.873	0.999	0.000
Education level (relative to postgraduate)				
Junior high school and below	24.257	0.000	—	34,251,630,282.000
High school	−5.866	2.232	0.009	0.003
Junior college	1.980	1.346	0.141	7.243
Undergraduate	−1.110	0.730	0.128	0.330
Occupation (relative to others)				
Staff of agencies/institutions	−0.055	1.624	0.973	0.946
Production company staff	−0.788	1.625	0.628	0.455
Commercial and service personnel	−0.731	1.683	0.664	0.481
Production personnel in agriculture, forestry, animal husbandry, fishery, and water conservancy	−5.458	4.846	0.260	0.004
Monthly income after tax (relative to more than 15,000 yuan)				
2,000–5,000 yuan	2.365	1.577	0.134	10.644
5,001–8,000 yuan	−1.452	1.027	0.157	0.234
8,001–15,000 yuan	−0.882	0.902	0.328	0.414
Number of trips on expressways per year (relative to more than 30 times)				
0 times	−11.439	4.815	0.018	0.000
1–4 times	−3.286	1.697	0.053	0.037
5–10 times	−3.076	1.541	0.046	0.046
11–30 times	−2.670	1.547	0.084	0.069
Duration of using ETC (relative to more than 5 years)				
Less than 1 year	1.944	1.377	0.158	6.987
1 to 3 years	1.703	1.201	0.156	5.490
3 to 5 years	0.056	1.205	0.963	1.058
Congestion in ETC lanes (relative to yes)				
No	1.204	0.650	0.064	3.333
Inability to synchronize ETC deduction messages in real time (relative to yes)				
No	1.232	0.652	0.059	3.428
Disorderly fee deduction (relative to yes)				
No	0.214	0.756	0.777	1.239
Difficulties invoicing reimbursements (relative to yes)				
No	1.567	0.682	0.022	4.792
Damage to ETC equipment due to quality problems (relative to yes)				
No	0.472	0.659	0.473	1.603
Embezzlement of ETC cards (relative to yes)				
No	−1.271	1.027	0.216	0.281
Inconvenience of finding ETC card recharge points (relative to yes)				
No	0.140	0.965	0.885	1.150
Lane congestion (relative to strongly agree)				
Strongly disagree	−21.321	5,472.259	0.997	0.000
Disagree	−2.89	2.075	0.164	0.056
Neither agree nor disagree	−2.331	1.219	0.056	0.097
Agree	−0.368	0.665	0.580	0.692
Toll level (relative to strongly agree)				
Strongly disagree	−16.379	9,628.021	0.999	0.000
Disagree	3.964	2.457	0.107	52.668
Neither agree nor disagree	0.415	0.876	0.635	1.514
Agree	0.483	0.886	0.585	1.621
Usage safety (theft and embezzlement) (relative to strongly agree)				

Table 3: Continued.

Variables	B	SE	Significance	Exp (B)
Disagree	19.699	5,472.260	0.997	359,059,977.200
Neither agree nor disagree	−1.076	1.003	0.283	0.341
Agree	1.635	0.775	0.035	5.129
Usage correctness (wrong brushing and missing brushing) (relative to strongly agree)				
Disagree	−0.950	2.612	0.716	0.387
Neither agree nor disagree	−0.774	0.988	0.433	0.461
Agree	0.186	0.731	0.799	1.204
Need for invoicing reimbursement (relative to strongly agree)				
Strongly disagree	4.768	2.568	0.063	117.684
Disagree	−0.418	1.411	0.767	0.658
Neither agree nor disagree	−0.891	1.005	0.375	0.410
Agree	−0.150	1.046	0.886	0.861
Driving information acquisition (relative to strongly agree)				
Strongly disagree	12.763	9,628.02	0.999	349,060.312
Disagree	−0.972	1.652	0.556	0.378
Neither agree nor disagree	0.179	0.951	0.851	1.196
Agree	0.775	0.896	0.387	2.171
ETC lane use experience (relative to strongly agree)				
Strongly disagree	18.490	9,628.020	0.998	107,177,832.600
Disagree	0.230	1.883	0.903	1.259
Neither agree nor disagree	−1.757	1.105	0.112	0.173
Agree	−0.010	0.677	0.988	0.990
Cumbersome formalities (relative to yes)				
No	0.680	0.663	0.305	1.974
Hidden dangers of fund security (relative to yes)				
No	−0.834	0.614	0.174	0.434
Rarely driving on expressways (relative to yes)				
No	−2.823	1.030	0.006	0.059
Don't know about ETC or how to complete the formalities (relative to yes)				
No	−0.394	1.080	0.715	0.674
Device effects on driving vision (relative to yes)				
No	0.693	0.779	0.374	2.000
Unsightly appearance (relative to yes)				
No	−0.112	0.797	0.888	0.894
Relieve the congestion of expressway toll stations (relative to yes)				
No	−0.368	0.716	0.607	0.692
High-tech sense (relative to yes)				
No	−1.416	0.660	0.032	0.243
Convenient access (relative to yes)				
No	−0.417	0.756	0.581	0.659
No need to take cards (relative to yes)				
No	0.382	0.627	0.542	1.465
Toll reduction (relative to yes)				
No	−2.738	0.840	0.001	0.065

characteristics of each cluster of ETC users can be obtained as follows:

M1: male ETC users aged 31–40, with higher education level and higher income.

M2: female ETC users aged 41–50, with lower education level and lower income.

M3: female ETC users aged 26–30, with higher education level and higher income.

Table 4 shows the regression results of the sample. The inability to synchronize ETC deduction messages in real time, damage to ETC equipment due to quality problems, embezzlement of ETC cards, usage safety (theft and embezzlement), need for invoicing reimbursement, driving information acquisition, cumbersome formalities, and no need to take cards have significant impacts on user satisfaction with ETC.

Among them, the embezzlement of ETC cards, usage safety (theft and embezzlement), need for invoicing reimbursement, driving information acquisition, and no need to take cards have negative impacts on ETC satisfaction, whereas the inability to synchronize ETC deduction messages in real time, damage to ETC equipment due to quality problems and the cumbersome formalities have positive impacts on ETC satisfaction.

Table 4: Ordinal logistic regression analysis results of the samples of M1.

Variables	B	SE	Significance	Exp (B)
Threshold				
Dissatisfied	−12.280	3.415	0.000	0.000
Generally satisfied	−5.376	2.708	0.047	0.005
Number of trips on expressways per year (relative to more than 30 times)				
1–4 times	−0.719	1.240	0.562	0.487
5–10 times	−1.733	1.241	0.163	0.177
11–30 times	−1.329	1.235	0.282	0.265
Duration of using ETC (relative to more than 5 years)				
Less than 1 year	−1.891	1.404	0.178	0.151
1 to 3 years	−0.934	1.264	0.460	0.393
3 to 5 years	−0.920	1.368	0.501	0.399
Congestion in ETC lanes (relative to yes)				
No	1.213	0.672	0.071	3.364
Inability to synchronize ETC deduction messages in real time (relative to yes)				
No	1.879	0.740	0.011	6.547
Disorderly fee deduction (relative to yes)				
No	−0.348	0.812	0.669	0.706
Difficulties invoicing reimbursements (relative to yes)				
No	0.310	0.655	0.637	1.363
Damage to ETC equipment due to quality problems (relative to yes)				
No	1.989	0.753	0.008	7.308
Embezzlement of ETC cards (relative to yes)				
No	−3.118	1.414	0.027	0.044
Inconvenience of finding ETC card recharge points (relative to yes)				
No	0.873	0.953	0.360	2.394
Lane congestion (relative to strongly agree)				
Strongly disagree	−48.601	12,357.666	0.997	0.000
Disagree	−40.188	12,357.666	0.997	0.000
Neither agree nor disagree	0.020	1.532	0.990	1.020
Agree	0.270	0.754	0.721	1.310
Toll level (relative to strongly agree)				
Strongly disagree	−1.008	0.000	—	0.365
Disagree	24.116	8,072.776	0.998	29,747,174,808.000
Neither agree nor disagree	−0.844	0.842	0.316	0.430
Agree	0.625	0.851	0.463	1.868
Usage safety (theft and embezzlement) (relative to strongly agree)				
Disagree	19.168	6,781.053	0.998	211,133,248.200
Neither agree nor disagree	−2.461	1.163	0.034	0.085
Agree	−0.166	0.749	0.824	0.847
Usage correctness (wrong brushing and missing brushing) (relative to strongly agree)				
Disagree	0.228	2.504	0.927	1.256
Neither agree nor disagree	−0.320	1.089	0.769	0.726
Agree	0.907	0.736	0.217	2.477
Need for invoicing reimbursement (relative to strongly agree)				
Strongly disagree	0.228	2.040	0.911	1.256
Disagree	−2.136	1.272	0.093	0.118
Neither agree nor disagree	−2.682	1.144	0.019	0.068
Agree	−2.017	1.116	0.071	0.133
Driving information acquisition (relative to strongly agree)				
Strongly disagree	−5.749	2.490	0.021	0.003
Disagree	−2.429	1.534	0.113	0.088
Neither agree nor disagree	−1.666	1.280	0.193	0.189
Agree	−0.200	0.965	0.836	0.819
ETC lane use experience (relative to strongly agree)				
Strongly disagree	21.949	9,742.877	0.998	3,406,666,213.000
Disagree	0.746	1.742	0.668	2.109
Neither agree nor disagree	−2.491	0.933	0.008	0.083
Agree	−0.191	0.667	0.774	0.826
Cumbersome formalities (relative to yes)				

Table 4: Continued.

Variables	B	SE	Significance	Exp (B)
No	2.594	0.770	0.001	13.383
Hidden dangers of fund security (relative to yes)				
No	0.543	0.694	0.434	1.721
Rarely driving on expressways (relative to yes)				
No	−1.853	1.055	0.079	0.157
Don't know about ETC or how to complete the formalities (relative to yes)				
No	0.115	1.096	0.916	1.122
Device effects on driving vision (relative to yes)				
No	−0.023	0.864	0.979	0.977
Unsightly appearance (relative to yes)				
No	0.567	0.743	0.445	1.763
Relieve the congestion of expressway toll stations (relative to yes)				
No	−0.874	0.625	0.162	0.417
High-tech sense (relative to yes)				
No	0.729	0.693	0.293	2.073
Convenient access (relative to yes)				
No	−0.456	0.810	0.573	0.634
No need to take cards (relative to yes)				
No	−1.486	0.685	0.030	0.226
Toll reduction (relative to yes)				
No	−1.092	0.710	0.124	0.335

Specifically, the failure to synchronize ETC packets may cause users to miss important information, and the quality of the equipment can directly affect user satisfaction. Users who did not encounter this problem are 6.547 times (OR = 6.547) more likely to be very satisfied with ETC than those who encountered this problem. Common faults of ETC equipment include: the ETC card is in poor contact and needs to be reinserted; the vehicle speed is too fast, resulting in failure to read successfully; OBU equipment failure or internal battery failure makes it impossible to read the information of the ETC card. In general, male drivers drive faster than female drivers, which means that card reading failures are more likely due to excessive speed. In addition, users who pay more attention to usage safety (theft and embezzlement), need for invoicing reimbursement, and driving information acquisition have higher satisfaction with ETC. At the same time, men generally pay attention to convenience; therefore, the impact is high when ETC formalities are too cumbersome. Compared with users who think that the formalities are cumbersome, users who do not agree with this point are 13.383 times (OR = 13.383) more likely to be satisfied with ETC. No need to take cards to a certain extent helps vehicles pass through toll stations quickly and brings a good travel experience for users. Compared with users who believe that ETC has the advantage of not having to take a card, users who do not agree that ETC has this advantage are 77.4% (OR = 0.226) less likely to be very satisfied with ETC.

Table 5 provides the sample regression results of M2. Considering that the sample size of this group is small, adjustments have been made to the independent variables. The congestion in ETC lanes, inability to synchronize ETC deduction messages in real time, disorderly fee deduction, difficulties invoicing reimbursements, damage to ETC equipment due to quality problems, embezzlement of ETC cards, hidden dangers of fund security, device effects on driving vision, relieving the congestion of expressway toll stations, high-tech sense, convenient access, no need to take cards, and toll reduction have significant impacts on user satisfaction with ETC. Many factors affect user satisfaction of this cluster, which shows that this user group has many considerations for ETC.

Among them, user satisfaction varies greatly with lane congestion, indicating that middle-aged women value whether ETC allows them to avoid congestion at toll stations. These users need to juggle family and work, so they pay more attention to time efficiency. Generally, women are concerned about safety, theft, and embezzlement, which may bring unnecessary troubles. Therefore, ETC equipment quality, hidden dangers of fund security, and equipment affecting driving vision are concerns for this group. The direct benefits of ETC, such as convenient access, no need to take cards, and toll reduction are also important aspects that affect middle-aged women's satisfaction with ETC.

Table 6 presents the sample regression results of M3. The number of trips on expressways per year, inability to synchronize ETC deduction messages in real time, toll level, usage safety (theft and embezzlement), driving information acquisition, and unsightly appearance have significant impacts on user satisfaction with ETC. Among them, the number of trips on expressways per year, toll level, and driving information acquisition have negative impacts on ETC satisfaction. By contrast, the inability to synchronize ETC deduction messages in real time, usage safety (theft and embezzlement), and unsightly appearance have positive impacts on ETC satisfaction.

Compared with users who drive on expressways more than 30 times a year, users who drive on expressways 5–10

Table 5: Ordinal logistic regression analysis results of the samples of M2.

Variables	B	SE	Significance	Exp (B)
Threshold				
Dissatisfied	−91.725	70.111	0.191	0.000
Generally satisfied	−8.229	61.228	0.893	0.000
Congestion in ETC lanes (relative to yes)				
No	114.075	45.704	0.013	$3.484E+49$
Inability to synchronize ETC deduction messages in real time (relative to yes)				
No	79.717	32.221	0.013	$4.175E+34$
Disorderly fee deduction (relative to yes)				
No	−45.214	18.651	0.015	0.000
Difficulties invoicing reimbursements (relative to yes)				
No	56.562	23.472	0.016	$3.669E+24$
Damage to ETC equipment due to quality problems (relative to yes)				
No	39.032	16.681	0.019	$8.941E+16$
Embezzlement of ETC cards (relative to yes)				
No	−119.732	72.483	0.099	0.000
Inconvenience of finding ETC card recharge points (relative to yes)				
No	34.36	18.053	0.057	$8.363E+14$
Cumbersome formalities (relative to yes)				
No	3.964	4.613	0.390	52.668
Hidden dangers of fund security (relative to yes)				
No	34.962	13.959	0.012	$1.527E+15$
Rarely driving on expressways (relative to yes)				
No	9.855	7.589	0.194	19,053.384
Don't know about ETC or how to complete the formalities (relative to yes)				
No	75.979	7,484.756	0.992	$9.937E+32$
Device effects on driving vision (relative to yes)				
No	−63.530	26.268	0.016	0.000
Unsightly appearance (relative to yes)				
No	−108.035	7,485.335	0.988	0.000
Relieve the congestion of expressway toll stations (relative to yes)				
No	−9.166	5.586	0.101	0.000
High-tech sense (relative to yes)				
No	−37.756	16.267	0.020	0.000
Convenient access (relative to yes)				
No	38.673	16.011	0.016	$6.244E+16$
No need to take cards (relative to yes)				
No	40.947	18.004	0.023	$6.068E+17$
Toll reduction (relative to yes)				
No	−44.932	18.969	0.018	0.000

Table 6: Ordinal logistic regression analysis results of the samples of M3.

Variables	B	SE	Significance	Exp (B)
Threshold				
Dissatisfied	−24.261	10,051.91	0.998	0.000
Generally satisfied	−17.826	10,051.91	0.999	0.000
Number of trips on expressways per year (relative to more than 30 times)				
0 times	−2.954	4.388	0.501	0.052
1–4 times	−1.734	1.489	0.244	0.177
5–10 times	−2.790	1.393	0.045	0.061
11–30 times	−2.582	1.381	0.062	0.076
Duration of using ETC (relative to more than 5 years)				
Less than 1 year	−17.504	10,051.91	0.999	0.000
1 to 3 years	−14.564	10,051.91	0.999	0.000
3 to 5 years	−13.541	10,051.91	0.999	0.000
Congestion in ETC lanes (relative to yes)				
No	0.793	0.686	0.248	2.210
Inability to synchronize ETC deduction messages in real time (relative to yes)				
No	1.531	0.664	0.021	4.623
Disorderly fee deduction (relative to yes)				
No	−1.186	0.853	0.164	0.305
Difficulties invoicing reimbursements (relative to yes)				
No	1.245	0.718	0.083	3.473
Damage to ETC equipment due to quality problems (relative to yes)				
No	0.460	0.737	0.532	1.584
Embezzlement of ETC cards (relative to yes)				
No	0.373	1.024	0.716	1.452
Inconvenience of finding ETC card recharge points (relative to yes)				
No	−0.497	1.040	0.633	0.608
Lane congestion (relative to strongly agree)				
Strongly disagree	−36.233	14016.454	0.998	0.000
Disagree	−2.306	2.547	0.365	0.100
Neither agree nor disagree	−0.517	1.167	0.658	0.596
Agree	1.311	0.701	0.061	3.710
Toll level (relative to strongly agree)				
Strongly disagree	−0.559	5.168	0.914	0.572
Disagree	16.945	6,382.774	0.998	22,862,304.030
Neither agree nor disagree	−2.141	0.865	0.013	0.118
Agree	−1.486	0.751	0.048	0.226
Usage safety (theft and embezzlement) (relative to strongly agree)				
Disagree	18.334	9,768.32	0.999	91,696,979.710
Neither agree nor disagree	−1.228	1.081	0.256	0.293
Agree	1.639	0.670	0.015	5.150
Usage correctness (wrong brushing and missing brushing) (relative to strongly agree)				
Disagree	19.856	0.000	—	420,098,598.500
Neither agree nor disagree	−0.130	1.173	0.912	0.878
Agree	−0.188	0.732	0.797	0.829
Need for invoicing reimbursement (relative to strongly agree)				
Strongly disagree	2.739	2.340	0.242	15.472
Disagree	1.039	1.234	0.400	2.826
Neither agree nor disagree	−0.074	0.884	0.933	0.929
Agree	−0.525	0.905	0.562	0.592
Driving information acquisition (relative to strongly agree)				
Strongly disagree	−3.073	3.366	0.361	0.046
Disagree	−3.857	1.658	0.020	0.021
Neither agree nor disagree	−1.217	0.897	0.175	0.296
Agree	−1.107	0.807	0.170	0.331
ETC lane use experience (relative to strongly agree)				
Disagree	0.817	2.286	0.721	2.264
Neither agree nor disagree	−0.415	1.252	0.740	0.660
Agree	−0.619	0.699	0.376	0.538
Cumbersome formalities (relative to yes)				
No	−0.312	0.721	0.665	0.732

Table 6: Continued.

Variables	B	SE	Significance	Exp (B)
Hidden dangers of fund security (relative to yes)				
No	−0.465	0.639	0.466	0.628
Rarely driving on expressways (relative to yes)				
No	0.339	0.810	0.676	1.404
Don't know about ETC or how to complete the formalities (relative to yes)				
No	1.481	1.184	0.211	4.397
Device effects on driving vision (relative to yes)				
No	−1.307	0.925	0.158	0.271
Unsightly appearance (relative to yes)				
No	2.455	0.767	0.001	11.646
Relieve the congestion of expressway toll stations (relative to yes)				
No	0.526	0.703	0.454	1.692
High-tech sense (relative to yes)				
No	−1.300	0.697	0.062	0.273
Convenient access (relative to yes)				
No	−0.914	0.785	0.244	0.401
No need to take cards (relative to yes)				
No	−0.454	0.625	0.468	0.635
Toll reduction (relative to yes)				
No	−1.008	0.773	0.192	0.365

times a year are 93.9% (OR = 0.061) less likely to be very satisfied with ETC. This result is understandable, because the more frequently only drives on the expressway, the more intuitively the user can experience the benefits of ETC. Female white-collar workers may care more about ETC's preferential charging policies, and may also attach great importance to driving information.

In the process of using ETC, users who did not encounter this problem were 4.623 times (OR = 4.623) more likely to be very satisfied with ETC than users who encountered the inability to synchronize ETC deduction messages in real time. Usage safety is a concern for every user. Moreover, young women tend to pursue fashion and beauty. Therefore, the unsightly appearance of ETC devices influences their preference for ETC. Users who did not worry about it are 11.646 times (OR = 11.646) more likely to be very satisfied with ETC than users who were worried about the unsightly appearance.

The analysis shows that different user groups have different requirements for the ETC experience. First, the inability to synchronize ETC deduction messages in real time has a significant impact on the satisfaction of the three types of user groups. The expressway ETC system follows the principle of "pass first, then deduct tolls." Therefore, users receive deduction information only after passing. Failure to synchronize the deduction information in real time will create the illusion of "excessive deductions" or "abnormal deductions" for users. Second, male users pay more attention to the quality of ETC equipment, the convenience of using ETC, and the acquisition of driving information. Middle-aged female users pay attention to many aspects, mainly driving efficiency and cost advantages brought by ETC, and especially the safety of ETC. Finally, young white-collar women are more concerned about the toll level, the acquisition of driving information, and the aesthetic of the equipment.

6. Conclusions and Recommendations

The ETC system has effects in saving energy and reducing congestion at toll stations. Although the advantages of ETC lanes are significant, and China actively implements ETC-handling policies, some drivers are reluctant to install ETC on-board systems or they still have negative experiences after handling them. According to a survey, most of the existing research on ETC focuses on the economic benefits brought by ETC, existing equipment problems, and future development trends. However, research on the influencing factors of user satisfaction with ETC from the perspective of utility is lacking. Based on the data from the questionnaire survey of ETC users in Shanghai and Beijing, this research comprehensively considers four categories of variables that may affect user satisfaction with ETC, including banking, ETC equipment, ETC business service, drivers' personal attributes, and travel characteristics. Ordinal logistics regression models are established to analyze quantitatively the impacts of these factors on user satisfaction with ETC.

First, the results are compared. Usage safety has a significant impact on user satisfaction with ETC in both cities. However, ETC users in Shanghai have more factors that affect their satisfaction. In addition to usage safety, monthly income after tax, the duration of using ETC, embezzlement of ETC cards, lane congestion, toll level, need for reimbursement, driving information acquisition, ETC lane use experience, cumbersome formalities, unsightly appearance, and toll reduction have significant impacts on user

satisfaction with ETC. The education level, the number of trips on expressways per year, difficulties invoicing reimbursements, rarely driving on expressways, high-tech sense, and toll reduction have significant impacts on user satisfaction with ETC.

Second, K-means clustering analysis is performed on the samples of the two cities according to the personal attributes of respondents. In this way, the factors that affect the satisfaction of different ETC user groups are further studied. The 351 samples are divided into three categories, namely, male, middle-aged female, and young female groups according to their characteristics. The regression analysis revealed that different user groups have different requirements for ETC experience. First, the inability to synchronize ETC deduction messages in real time has a significant impact on the satisfaction of the three types of user groups. The expressway ETC system follows the principle of "pass first, then deduct tolls." Therefore, users receive deduction information only after passing. Failure to synchronize the deduction information in real time will create the illusion of "excessive deductions" or "abnormal deductions" for users. Second, male users pay more attention to the quality of ETC equipment, the convenience of using ETC, and the acquisition of driving information. Middle-aged female users pay attention to many aspects, mainly driving efficiency and cost advantages brought by ETC, and especially the safety of ETC. Finally, young white-collar women are more concerned about the toll level, the acquisition of driving information, and the aesthetic of the equipment.

On the basis of the above analysis, we propose effective suggestions to increase ETC users, promote the generalization and efficiency of ETC lanes, and increase the willingness of drivers to use ETC.

6.1. Related Preferential Policies. "A basic preferential policy of not less than 5% of vehicle tolls is given to vehicles that have installed ETC on-board equipment. The purpose is to encourage vehicles to install and use ETC, improve traffic efficiency, promote energy conservation and emission reduction, and reduce expressway operating costs. Moreover, starting from January 1, 2020, vehicles without ETC on-board equipment will no longer enjoy the preferential policy of not less than 5% tolls in principle." This part is one of the current government policies to promote the use of ETC lanes among drivers. In view of the current model showing that the favorable conditions of toll reduction and exemption have a great influence on drivers' choice to use ETC-dedicated lanes, we recommend to maintain the toll reduction or exemption for these lanes or slightly increasing the degree of exemption. More attractive preferential activities will be implemented for drivers' newly installed ETC on-board equipment. In addition to the toll reduction or exemption of ETC-dedicated lanes, they can be linked to banks to launch travel-related preferential activities, such as gas station cashback, car cleaning, parking fee deduction, and other convenient activities.

In June 2021, the Ministry of Transport issued the "Implementation Plan for Comprehensively Promoting Differentiated Expressway Toll Collection." The "Implementation Plan" proposes that all localities should, on the basis of an in-depth summary of the pilot work experience of differentiated expressway toll collection, fully consider factors such as the structure and operation characteristics of the local expressway network, select suitable differentiated toll collection methods, innovate service models, and formulate differentiated charging schemes scientifically and accurately. In addition, the preferential mode of ETC electronic payment must be further improved. By increasing the preferential ETC electronic payment, drivers are encouraged and guided to install and use ETC when driving on the expressway without stopping, improve the efficiency of road network traffic, and promote the quality and efficiency of logistics [47].

6.2. Invoice and Reimbursement Process. We must first recognize the existing problems related to the issuance of electronic invoices by ETC. Many irrationalities are observed in the design of the application software of the invoicing platform. Failure to consider the real use environment of most companies has resulted in a large number of printed receipts, increased workload and manpower, and increased company cost. Invoices can be printed multiple times, and reimbursing invoices in the circulation of some large enterprises is possible, thereby increasing the difficulty and workload of enterprise financial personnel during the reimbursement process. Compared with traditional paper invoices, electronic invoices have the advantages of low energy consumption, easy storage, and easy query. However, managing invoices electronically is a difficult problem. The problems to be solved require unified management and reduce the tedious process of invoice printing and review. Therefore, as far as enterprises are concerned, unifying application programs for issuing invoices is necessary to solve the problems of repeated reimbursement and anticounterfeiting. As far as government agencies are concerned, clarifying that the time between the deduction of ETC equipment and the time a driver receives the information should not exceed one week. This duration is a reasonable time frame for a driver's subsequent electronic invoice and reimbursement. Strictly reviewing all kinds of invoicing software in circulation is necessary. Furthermore, enterprises and individuals must comprehensively evaluate and select unified and reasonable invoicing software.

6.3. Delays and Intermittent Issues with Deduction Information. At present, a vehicle that has installed ETC on-board equipment deducts the card fee after passing through the mast to detect the electronic tag OBU on the expressway. Regardless of whether the car owner pulls out the card midway, the ETC system records and restores the driving record of the vehicle and makes subsequent supplementary deductions, which are significant changes from the previous charging method.

Deduction Process of Segmented Billing ETC. When a vehicle passes through a gantry, the cost will be uploaded to

the road section center and then uploaded to the provincial settlement platform from the road section center for settlement. Subsequently, the settlement result is sent to the bank, which deducts the bill and feeds it back to the owner. Interprovincial charges continue to be uploaded to the Ministry of Transport for settlement, and the process takes long. At the exit of the ETC-dedicated channel, only the toll fee of the ramp will be displayed; thus, there will be a phenomenon of less than one yuan. If the toll information can be integrated, then the most ideal solution is to feed back a complete deduction amount of the expressway section to the user. It requires the bank back-end system to process and integrate the intermittent deduction information, recalculate, and send it to the user so that unnecessary trouble caused by the intermittent deduction information can be solved to a large extent.

The survey shows that some car owners reported that they did not travel during their vacation but received ETC deduction information, which was fragmented. Thus, car owners wondered whether they were deducted indiscriminately. The expressway toll collection method has been changed to the gantry segment toll collection mode. Owing to the low quality of the early toll flow and the untimely communication transmission, the current flow of traffic may be settled in batches, and the settlement time will be delayed, causing car owners to be deducted indiscriminately.

Some drivers also reported that after suspecting that they were charged with the wrong fee, they could not reach customer service over the phone and the offline business hall lined up. As the situation of overcharge complaints is more complicated and requires more information from a customer, communication through an operator is not only time consuming but also prone to wrong information. Thus, a customer may need to contact customer service multiple times to confirm the relevant information. For these issues, measures such as increasing the number of operators, setting up complaint handling centers, and optimizing online intelligent robots can be used to improve the abilities of consultation and acceptance. Although a major advantage of implementing ETC lanes is that it can reduce personnel and related management costs, doing so will greatly reduce this advantage. However, from a long-term perspective, only by solving the current problems can the penetration rate of ETC-dedicated lanes be increased and the policy of implementing ETC devices achieve a truly convenient effect. With the rapid development of artificial intelligence, developing intelligent customer service robots is recommended. However, the development cost may be high and options such as increasing telephone staff can be selected. Drivers are also suggested to cooperate with bank outlets to increase service outlets and provide self-service equipment for public use.

To avoid personal troubles, if not for special reasons, drivers should avoid using ETC while driving in artificially mixed lanes to avoid repeated deductions.

At present, the China ETC service applet has undergone a new revision, integrating all ETC services and integrating ETC multi-scenario applications, allowing users to handle ETC-related services and obtain comprehensive services related to the transportation industry conveniently and quickly. In terms of public services, the ETC service applet will provide the following convenient services:

(1) The colorful ETC section provides users with information on user rights, preferential services, and differential charges so that users can keep abreast of preferential policies, charges, and other policies across the country.

(2) The news headlines section regularly publishes the relevant policies of the central and local governments on the transportation industry, answers to hot questions, and the latest developments in the industry, providing users with authoritative and timely information.

(3) According to user needs and industry development needs, intelligent application functions will be added later, such as ETC parking, refueling, and charging, to provide users with high-quality services.

(4) The service applet provides users with the most convenient and fastest service channel by continuously improving the process and business logic of after-sales service.

(5) To create an integrated service mode, users can complete all business transactions related to ETC in the China ETC service applet. There is no need to jump to the entrance of each service, avoiding the inconvenience caused by scattered and inconsistent services.

(6) Intelligent customer service is used to create an ETC knowledge base and hot issues and provide users with convenient and scenario-based problem-solving methods.

Data Availability

Data from the survey-based questionnaire, which were used to support the findings of this research, are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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