Improvement Strategy of Car-hailing Service Quality Based on System Dynamics

Qi-liang REN*, Ling-ling WU, Zi-han MAO and Zi-yu ZHAO
66 Xuefu Avenue, Nanan District, Chongqing, China
*Corresponding author

Keywords: Car-hailing service quality, System dynamics, Policy simulation, Improvement strategy.

Abstract. In order to improve the car-hailing service quality, this paper adopted system dynamics. Based on the simulation of the system model, the improvement strategy of car-hailing service quality was proposed. The system boundary was determined from the car-hailing service environment quality, service interaction quality, service result quality, and other aspects. Relying on Vensim policy simulation function, this paper simulated the impact of car-hailing service quality changes on the car-hailing about the business income of the vehicle, the number of users of the car-hailing, the size of the car-hailing, and the GDP of the city. Research shows that the improvement of the network service quality of the vehicle service to the network business Revenue, network users, number of vehicles, and urban GDP have a positive effect.

Introduction

The car-hailing service system is a complex system with multi-variables, multi-service subjects and multi-feedback. In the process of development, it is directly affected by the policy, the urban development level and other factors. At the same time, the income level of residents will also have an impact on the car-hailing service system. Because the factors in the car-hailing service system are interrelated and constantly changing, it will affect the dynamic development of the car-hailing service system. In view of the complexity of the car-hailing service system, it is difficult to analyze the relationship among the various elements of the service quality of the car-hailing by simple methods, and it is necessary to analyze the relationship between the different subjects in the car-hailing service system based on the complexity and dynamics of the system, in order to find the best method to improve the service quality. Onesimo Flor et al. [1] discussed the problems and difficulties in the process of the supervision of the car-hailing, and put forward the strategy of improving the service environment of the car-hailing by strengthening the cooperation between the supervision departments. Mingshu Wang et al. [2] studied the influencing factors of the spatial accessibility of the car-hailing by constructing the Autoregressive model. Joshua Paundra et al. [3] studied the influence of passenger psychological factors on the choice of the car-hailing. Li Tang et al. [4] studied the selection behavior of the choice of the car-hailing by combining with the mix-logit model. Wei Cao et al. [5] studied the factors that affect the passenger's choice of the car-hailing service model by constructing the simulation model. The analysis shows that the existing results are not perfect enough for the research on the improvement strategy of the car-hailing service quality, and it is necessary to further study the improvement strategy of the car-hailing service quality with scientific research methods. In this paper, the system dynamics is used to describe the complexity and dynamics of the car-hailing service quality. On the basis of analyzing the relationship and function between the passenger demand and the service subjects, the system dynamics model of the car-hailing service quality is constructed, and the relevant strategies to improve the service quality of the car-hailing are discussed.
Construction of System Dynamics Model of Car-hailing Service Quality

System Boundaries and Model Elements

With the continuous expansion of the scale of car-hailing, some subjects with low service quality seriously affect people's pursuit of high service quality sustainable development of car-hailing. In this paper, the system dynamics method is used to study the improvement strategy of car-hailing service quality, and its feasibility is as follows. Firstly, because there are many factors involved in the service quality of car-hailing, and the relationship between them is complex. The system dynamics method can abstract the factors affecting the service quality of car-hailing. Through structured thinking, the development of car-hailing service quality can be comprehensively understood and analyzed by considering all the factors from a full perspective. Secondly, through the analysis of the relationship and function between the factors of the service quality of car-hailing, the causality diagram and the system flow diagram are constructed, which can clearly describe the effective measures to improve the service quality of the network, and it is helpful to put forward the improvement strategy of the car-hailing service quality.

In this paper, when determining the boundary of the car-hailing service system, the selection of the evaluation index of the car-hailing and the construction of the evaluation model are fully considered in order to determine the important system elements in the car-hailing service system. The service quality level of the car-hailing is affected by the whole service process, including the service environment quality, the service interaction quality and the service result quality. At the same time, each link is controlled by the service subject, including the supervision department, the operator, the driver and the service platform. The interaction relationship between the elements in the car-hailing system and their influence on the behavior of each service subject need to be based on a reasonable analysis model of the whole car-hailing service system. The elements of system dynamics model about the car-hailing quality system are shown in table 1.

Table 1. System boundary.

| System Categories          | Specifically covered variables                                                                 |
|---------------------------|-------------------------------------------------------------------------------------------------|
| Service Environment Quality | The perfection of guarantee mechanism, stability of market order, effectiveness of supervision and management, reliability of driving behavior, reliability of vehicle performance and reliability of service platform |
| Service Interaction Quality | The unimpeded nature of the evaluation system, the feedback nature of complaint handling and the normative nature of service behavior |
| Service Results Quality    | The confidentiality of passenger information, comfort of riding environment and satisfaction of passengers |
| Others                    | The city size, number of car-hailing, government support, passenger travel habits                 |

Causality Analysis of the Car-hailing Service Quality

Through the analysis of the relationship between the elements of car-hailing service system and the influencing transfer chain, the complex and dynamic causality diagram of car-hailing service system can be constructed, as shown in Figure 1.
As shown in Figure 1, the service behaviors of regulatory authorities, operators, drivers, vehicles, service platforms and other service behaviors directly or indirectly affect the car-hailing service quality. The formulation and implementation of the relevant regulations can make car-hailing get reasonable and effective development, and provide a strong basis for the supervision and management of the supervision Department. Effective supervision and management maintain the stability of the market order, and supervise the service behavior of the service subject, and promote the improvement of the car-hailing service quality. Pre-job training is the basis for drivers to enter the car-hailing service market, which is conducive to improving the driver's driving level, thus improving the quality of car-hailing service. Increasing supervision and management is an effective guarantee for the service quality of car-hailing. By collecting passengers' satisfaction with the car-hailing service quality through evaluation system and complaint channels, we can understand the deficiency of service and passengers' demands. In addition, as the product of "Internet +", the car-hailing to promote information level is beneficial to improve service efficiency.

Construction of the Model of Car-hailing Service Quality System

Causality diagram can describe the causes and trends of changes in the system, but this qualitative description can not determine the mechanism of changes in variables in the system, and can not quantify the relationship between variables. Therefore, the introduction of system flow graph based on causality diagram, including stock, flow, auxiliary variables and constants, can more accurately quantify the mechanism of interaction between system elements. In order to clearly analyze the mechanism of action between the factors affecting the car-hailing service quality, the system dynamics model of the car-hailing service quality is constructed on the basis of establishing the causality diagram of car-hailing service system, as shown in Figure 2.

![Figure 2. System dynamic model.](image)

Construction of System Dynamics Equation

The equations in the system dynamics model include: state equation, rate equation and auxiliary equation. Four state variables are set in the model of car-hailing service quality: revenue, user scale, car-hailing scale and urban GDP. The corresponding rate variables are the growth of revenue, the growth of users, the growth of car-hailing number and the growth of urban GDP.

State Equation. The state equation in the system dynamics model of the car-hailing service quality is as follows:

\[
\begin{align*}
L_1.K &= L_1.J + D_1 \times DT \\
L_2.K &= L_2.J + D_2 \times DT \\
L_3.K &= L_3.J + D_3 \times DT \\
L_4.K &= L_4.J + D_4 \times DT
\end{align*}
\]  

(1)

Where \(L_i.K\) is the state quantity of the \(i\) -th state variable at the moment of \(K\) (present-moment), and \(L_i.J\) is the state quantity of the \(i\) -th state variable at the moment of \(J\) (past-moment). \(D_i\) is the...
increment of the \(i\)-th state variable and also is the rate variable, i.e. \(DT\) is the time interval between \(J\) time and \(K\) time, usually in unit time. When \(i=1,2,3,4\), it respectively represents the revenue, user scale, car-hailing scale and the urban GDP.

**Rate Equation.** The rate variable determines the growth rate of state variable, and the rate equation is constructed as follows.

\[
\begin{align*}
D_1JK &= P_m - P_v \\
D_2JK &= M_n - M_q \\
D_3JK &= \min(N_r, N_{ri}) \\
D_4JK &= L_{ri}K \times R_i
\end{align*}
\]  

Where \(D_iJK\) is the growth of the \(i\)-th state variable from the moment of \(J\) to \(K\). \(P_v\) is the operating earnings from the moment of \(J\) to \(K\). \(M_q\) is the increasing number of new users from the moment of \(J\) to \(K\). \(M_r\) is the number of exit users from the moment of \(J\) to \(K\). \(N_{ri}\) is the allowed increasing number of car-hailing from the moment of \(J\) to \(K\). \(R_i\) is the growing rate of urban GDP.

Among them, the formula for calculating the increment and requirement of car-hailing is as follows.

\[
\begin{align*}
N_{ri} &= \text{Integer}(Q_{q_i}, Q_{p_i}) \\
N_d &= N_{ad} - (N_{q_i} - N_q)
\end{align*}
\]  

Where \(Q_{q_i}\) is the total operating profit of car-hailing. \(Q_{p_i}\) is the single car’s price of car-hailing. \(N_{ad}\) is the total requirement of car-hailing. \(N_{q_i}\) is the number of car-hailing at the current stage. \(N_q\) is the number of car-hailing at the initial stage.

The formula for calculating the requirement of car-hailing is as follows.

\[
N_{ad} = \text{Integer}\left[\frac{(M_m - N_q)}{N_{ri}}\right].
\]  

Where \(M_m\) is the total user volume of car-hailing. \(N_q\) is the initial amount of car-hailing users. \(N_{ri}\) is the required increasing number of car-hailing users.

**Auxiliary Equation.** The auxiliary equation can accurately express the rate equation. This paper mainly studies the improvement strategy of the car-hailing service quality. By improving the quality of service, the number of new users can be increased, while the number of withdrawal users can be reduced, and the growth rate of users can be increased. Finally, by increasing the number of users of car-hailing, the scale of car-hailing is expanding, business income is increasing, and urban GDP is raising.

\[
\begin{align*}
M_m &= M_{q_i}^+ \times \alpha^+ + M_i^+ \times \beta^+ \\
M_{re} &= M_{q_i}^- \times \alpha^- + M_i^- \times \beta^-
\end{align*}
\]  

Where \(M_{q_i}^+\) is the increasing or decreasing number of car-hailing users due to the changes of service quality. \(M_{q_i}^-\) is the increasing number as a result of improved service quality. \(M_{re}\) is the decreasing number as a result of deteriorated service quality. \(M_i^+\) is increasing or decreasing number of car-hailing users due to the other factors. The meaning of \(M_i^+\) and \(M_i^-\) is the same as that
mentioned above. \( \alpha \) is the influence coefficient of service quality of the number of users. It takes a value of 0 or 1. If takes a value of 0, it means that the improvement or decrease of service quality has no effect on the increasing or decreasing number of users. If 1 is chosen, the opposite is true. \( \beta \) is the influence coefficient of other factors of the number of users. The value of \( \beta \) is the same as \( \alpha \).

In addition, the service quality of car-hailing is the result of the comprehensive effect of passengers' safety, comfort, convenience, efficiency and other aspects. At the same time, on the basis of obtaining the basic services of car-hailing, there are many important measures to improve the car-hailing service quality such as the formulation and implementation of relevant regulations, the effectiveness of supervision, the reasonable pre-job training, the promotion of information technology and other improvements. The auxiliary equation is expressed as follows.

\[
W_{nu} = \gamma_{saf} + \gamma_{com} + \gamma_{con} + \gamma_{he} + \gamma_{e} = \omega \times (\lambda_{vat} + \lambda_{sup} + \lambda_{tra} + \lambda_{of} + \lambda_{e})
\]  

(6)

Where \( W_{nu} \) is the car-hailing service quality. \( \gamma_{saf} \), \( \gamma_{com} \), \( \gamma_{con} \), \( \gamma_{he} \), \( \gamma_{e} \) respectively represent the safety, comfort, convenience, efficiency and other aspects of car-hailing service. \( \lambda_{vat} \), \( \lambda_{sup} \), \( \lambda_{tra} \), \( \lambda_{of} \), \( \lambda_{e} \) respectively represent the formulation and implementation of relevant regulations, the effectiveness of supervision, reasonable pre-job training, improvement of information technology level and other aspects.

**Simulation and Analysis of Service Quality System Model of Car-hailing**

The improvement of the car-hailing service quality can enhance the passenger's service satisfaction to the car-hailing, so as to increase the number of users of car-hailing, and promote the expansion of car-hailing service scale. The income of car-hailing drivers has increased correspondingly, and the increase of the investment in the car-hailing has further promoted the development of the network, and ultimately contributed to the increase of the contribution rate of urban GDP growth. We use Vensim policy simulation function to simulate the impact of the revenue of drivers, the number of users, the scale and the GDP of the city after changing the car-hailing service quality. By changing the development and implementation variables of the relevant regulation of car-hailing, the variables of supervision force, the variables of pre-job training and the variable of informatization level, the change of service quality of the network is studied. As shown in Figure 3-6, we get the change of revenue, number of users, scale and urban GDP with the car-hailing service quality(\(CHSQ\)) through Vensim policy simulation.

![Figure 3. Commercial revenue impact on CHSQ.](image)

![Figure 4. The number of users impact on CHSQ.](image)
Good car-hailing service quality can effectively increase the income of car-hailing drivers, increase the number of users, expand the scale of car-hailing and improve the contribution rate of car-hailing to urban GDP. Therefore, the level of car-hailing service quality plays an important role in the sustainable development of car-hailing. Its main manifestation is the safety, comfort, convenience and efficiency of passenger. It is influenced by the regulation, supervision, pre-job training quality and informatization level of car-hailing. The degree of influence on the service quality of car-hailing is shown in Figure 7-10.

Analysis on the Improvement Strategy of the Car-hailing Service Quality

Improvement of the Relevant Regulations and Efficiency of Implementation

Perfecting the regulation content, restraining the service behavior of the service subject, and punishing the service subject who violates the regulation can not only guarantee the service quality of passengers, but also stabilize the order of the car-hailing market, which is conducive to the sustainable development of the car-hailing. In the process of formulating and implementing the regulation of car-hailing service, we should change our ideas and concepts. Firstly, we should change the concept of once and for all. At present, the formulation and implementation of the
car-hailing regulation in China is still in the exploratory stage. Its comprehensiveness and rationality need to be further improved. The formulation and implementation of the car-hailing regulation involves all aspects, and should be carried out in practice and constantly adjusted and improved. Secondly, we should avoid copying. There are different characteristics between different cities about the car-hailing development. We should formulate regulation that adapts to the city according to the characteristics of the city itself.

**Strengthening Supervision to Create a Good Service Environment**

The car-hailing is a service mode that integrates of Internet technology and taxi industry. It should be monitored jointly by various departments and managers to promote the standardized development of car-hailing industry. We should take the supervision of service quality as the starting point and promote the daily supervision system of government guidance, car-hailing operators and platform companies. For the car-hailing operation supervision system, it requires not only internal audit management of vehicles on the platform, but also necessary supervision by government departments to form external pressure to prevent the platform from considering only commercial interests and ignoring safety supervision.

**Improving Pre-job Training Mechanism and Raising Access Threshold**

Through pre-job training, drivers can make clear the relevant laws, regulations and basic norms of service, so as to avoid drivers in the process of service irregularities. This mechanism can effectively improve the driver's safe operation and ensure the safety of passengers' travel. In addition, by improving the access mechanism of drivers and other service providers, the reliability of the car-hailing service system can be effectively improved and the service quality can be guaranteed. In the driver's assessment, we should not only examine the knowledge of relevant policies, laws and regulations, knowledge of safe operation, but also consider the driver's familiarity with the city and the ability to judge traffic conditions.

**Improving the Level of Informatization and Strengthening the Intellectualized Service**

Car-hailing has been developed under the promotion and application of "Internet +". With the continuous innovation of technology, the information level of car-hailing should also be improved continuously, so as to promote the efficiency of car-hailing. By improving the informatization level of service platform, the efficiency of passenger appointment has been greatly improved. In addition, innovative regulatory instruments and the application of emerging technologies continue to enrich regulatory means, such as the use of big data analysis, in-vehicle video surveillance and so on. In the aspect of information security, increasing the level of informatization can make the safety system improve continuously, make the passenger's information more secure.

**Conclusions**

The boundary of the car-hailing service quality system is defined from the quality of the service environment, the quality of service interaction, the quality of service results and other aspects, and the causality diagram of the car-hailing service system is drawn, and the system dynamics model is constructed. On this basis, we use Vensim policy simulation function to simulate the impact of the revenue of drivers, the number of users, the scale and the GDP of the city after changing the car-hailing service quality. Through the above analysis, we can get the strategies to improve the quality of service. The following conclusions can be drawn from the study of this paper.

(1) In order to improve the service quality of car-hailing, we should pay attention to strengthening the standardization of the service behavior of relevant service subjects, such as supervisors, operators, drivers, vehicles and service platforms, which have direct or indirect effects on the car-hailing service quality.

(2) Improving the service quality of car-hailing can effectively increase the revenue of drivers and the number of users, expand car-hailing scale and improve the contribution rate of car-hailing to urban GDP.
(3) By formulating and implementing relevant regulations, strengthening supervision and implementing pre-job training, the service quality of car-hailing can be maintained at a higher level. With the continuous improvement of information technology, the service level of car-hailing has been continuously improved.

In order to improve the service quality of car-hailing, it is proposed to perfect the relevant regulations, increase the implementation efficiency, strengthen supervision, create a good service environment, improve pre-job training mechanism, raise access threshold, increase the level of information technology, strengthen intelligent service and other improvement strategies.

References

[1] Onesimo Flores, Lisa Rayle. How cities use regulation for innovation: the case of Uber, Lyft and Sidecar in San Francisco[J]. Transportation Research Procedia, 2017(25):3756-3768.

[2] Mingshu Wang, Lan Mu. Spatial disparities of Uber accessibility: An exploratory analysis in Atlanta, USA[J]. Computers, Environment and Urban Systems, 2018(67):169-175.

[3] Joshua Paundra, Laurens Rook, Janvan Dalen, et al. Preferences for car sharing services: Effects of instrumental attributes and psychological ownership[J]. Journal of Environmental Psychology, 2017, 53:121-130.

[4] Tang L, Zou T, Luo X, Chen S W. Choice Behavior of Taxi-hailing Based on Mixed-Logit Model[J]. Journal of Transportation Systems Engineering and Information Technology, 2018, 18(01):108-114.

[5] Cao W, Li Y J, Luo X. Simulation of Taxi Passenger Travel Mode Considering the Influence of Online Booking Taxi[J]. Journal of System Simulation, 2018, 30(02):505-512.