

Research on Market Regulation of Online Car-hailing Travel Based on Tripartite Game

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Abstract. With the rapid development of the Internet, a new business model emerged as the times require, that is, online car appointment. The Internet platform acts as a transaction intermediary to match passengers and drivers reasonably, which saves time cost and achieves decision-making autonomy to a great extent. The purpose of this study is to solve the inevitable travel problems in the online car market and actively regulate the online car market. The research method of this paper is to construct a three-party evolutionary game, and build an evolutionary model by the government, the platform of online car contracting and the driver, and analyze its stability. The conclusion shows that the best strategy is that the government evolves from loose regulation to strict regulation. The platform of online car contracting gradually changes from passive regulation to active regulation, and the drivers of online car contracting operate legally and regularly. The government, the online car-booking platform and the driver are the interaction of various factors, and put forward relevant countermeasures and suggestions.

Introduction

In recent years, China's traffic situation is particularly severe, especially in the first and second-tier cities. Urban traffic congestion is serious, and the weather conditions, especially the fog and haze, deteriorate. Many cities have chosen to restrict the purchase of private cars, which has led to restrictions on self-driving travel of many citizens. However, in the course of the operation of the online car market, some problems inevitably arise, such as the lag of government legislation, the unclear subject of responsibility after the infringement of consumers' rights and interests, and the disconnection between the platform and government supervision^[1]. These problems have seriously affected the development of the online car-booking market, the government management and the normal operation of the online car-booking platform are affected, causing irreparable damage to some passengers. Therefore, it is particularly important to study the regulation of the online car-booking market and how to achieve healthy travel.

The government's regulation of online car booking is influenced by various factors, which has roughly gone through three stages: policy relaxation, restriction and caution^[2]. On July 27, 2016, the Ministry of Communications, the Ministry of Industry and Information Technology, the Ministry of Public Security, the Ministry of Commerce, the General Administration of Industry and Commerce, the General Administration of Quality Supervision and Inspection, and the State Network Information Office jointly issued the Interim Measures for the Management of Business Services of Taxis by Internet Reservation. On July 28, the General Office of the State Council issued the Guiding Opinions on Deepening Reform and Promoting Healthy Development of Taxi Industry. The two documents issued by the government officially acknowledge the legitimacy of the existence of online car booking, but they are not really implemented in accordance with the actual situation in the local area. The control effect is very obvious, and the existing regulations are different in different places. Therefore, in different backgrounds, it is worthwhile to explore the regulation strategies from the government, the online car registration platform and the driver respectively.

The research on the market regulation strategy of online car-booking refers to the tripartite subjects involved in the regulation of online car-booking, including the degree of government

supervision of online car-booking, the attitude of online car-booking platform to drivers'supervision and whether the operation of online car-booking drivers is legal and compliant. On this basis, the evolutionary game model of the three parties is constructed.

Construction of Tripartite Game Evolution Model for the Regulation of Online Round-trip Market

Problem Description

If the government has two strategies, they are "strict supervision" and "loose supervision". Under the background of relaxed government supervision, the number of illegal operators is increasing and the profits are increasing. For the platform of online car booking, the number of online car booking will increase sharply, the efficiency of platform operation is low and the scheduling is difficult, and the market of online car booking is chaotic, which seriously affects the image of the government. Under the strict supervision of the government, the number of contract car drivers decreases, and the government and law increase their efforts to punish and crack down on illegal network car drivers, but the number of legitimate business increases, the government will give them positive incentives and subsidies to encourage the legitimate operation of drivers; for the network car platform is to maintain the normal operation of the network car market, the platform order is stable, the government will actively reward and encourage support. Develop and maintain the image of the government.

If there are two strategies for the platform, they are "active control" and "passive control". If the network contract vehicle platform is actively regulated, the number of legitimate and compliant drivers will increase, and the platform will have a better corporate image, but the corresponding control costs will arise, such as improving the access threshold of drivers and strengthening positioning services for drivers, the government will also give positive incentives to the platform. However, if the network car-booking platform is passively regulated, the number of network car-booking drivers will increase, including illegal and illegal drivers, which will greatly damage the interests of users, but to a certain extent, the benefits of the platform will increase; the government will take certain measures to attack and punish the platform and drivers, which will damage the image of the network car platform.

If there are two kinds of strategies for online car drivers, they are "legal operation" and "illegal operation". If the net-appointed drivers operate legally, there will be maintenance costs and time costs, such as regular maintenance and cleaning maintenance. However, the number of drivers held by the corresponding platform will be reduced, dispatching efficiency will be improved, and the government will also give positive incentives to legitimate drivers, such as subsidies and various forms of incentives. If the network contract driver violates the rules, the interests of the driver will increase because there is no excessive additional cost, but correspondingly, the platform will never be hired by this user after supervision and inspection, and the government will severely punish it.

Basic Hypothesis of Evolutionary Game

Assuming that the proportion of government departments adopting "regulation" strategy is x , and the proportion of "irregularity" strategy is $1-x$; the proportion of "active control" strategy is y , the proportion of "passive control" strategy is $1-y$; the proportion of drivers adopting "compliance" strategy is z , and the proportion of "irregularity" strategy is $1-z$. The dynamic replication equation of government, platform and driver can be obtained, and the evolution path and stability of the three parties can be analyzed.

Hypothesis 1: When the government regulates, the image of the government is improved to U . W/K is the increase/decrease of social welfare in the case of compliance/irregularity of net contract drivers. When the platform actively regulates the drivers, the government's reward for the platform is set to S_1 ; when the platform is legally operated, the government's reward for the drivers is set to S_2 ; The management cost generated by the government is set to C_g ; when the platform or driver is passively operating, the penalty for the platform or driver is set to C_{gp1}/C_{gd1} ; When the government

carries out negative control, the loss caused by the decline of government image is U_1 .

Hypothesis 2: When the platform is under active control, the basic cost of platform management is C_{p1} , but the operating cost is increased to C_{p0} because of driver loss caused by active control. When the platform is not regulated, there is no cost; when the platform is actively regulated, the corporate image will increase to F_1 , and vice versa to F_2 ; the basic revenue of the platform is R_p , and the loss of users is C_p when the platform is under passive supervision.

Hypothesis 3: When the driver is legally operating, the additional cost incurred by the driver is C_{d1} , and some normal basic costs are C_{d0} . On the contrary, drivers who operate illegally have no extra cost; when drivers operate illegally, the loss of users is C_d , the punishment for drivers by platform is C_{pd1} , and the basic benefit of drivers is R_d .

According to the above assumptions and related parameters, the profit matrix of both players is shown in Table 1.

Table 1. Revenue matrix of relevant government departments, netbook platform and driver

Government and Platform		Driver Compliance (z)	Driver Violation (1-z)
Government's Strict Regulation (x)	Platform Active (y)	$U-C_g-S_1-S_2$ $R_p+S_1-C_{p1}+F_1$ $R_d-C_{d0}-C_{d1}+S_2$	$U-C_g-S_1+C_{gd1}$ $R_p-C_{p1}+F_1-C_{p0}+S_1-F_2+C_{gd1}$ $R_d-C_{d0}-C_{gd1}-C_d-C_{pd1}$
	Platform Negative (1-y)	$U-C_g-C_{gp1}$ $R_p-C_p-C_{gp1}$ $R_d-C_p-C_{d0}-C_{d1}+S_2$	$U-C_g+C_{gp1}+C_{gd1}$ $R_p-F_2-C_d-C_p-C_{gp1}$ $R_d-C_p-C_d-C_{gd1}$
	Platform Active (y)	$W-U_1$ $R_p-C_{p1}-C_{p0}+F_1$ $R_d-C_{d0}-C_{d1}$	$-K-U_1$ $R_p-C_{p1}-C_p+F_1-C_{p0}-F_2+C_{pd}$ $R_d-C_d-C_{pd}$
	Platform Negative (1-y)	$W-U_1$ R_p-C_p R_d-C_p	$-K-U_1$ $R_p-C_p-C_d-F_2$ $R_d-C_p-C_d$

Evolution Path and Stability Analysis of Tripartite Travel Regulation Market

Dynamic Equations of Government, Platform and Driver

For the government management, the expected return and the average return of choosing strict regulation and loose regulation are respectively: E_0^1, E_0^2, \bar{E}_0

$$E_0^1 = yz(U - C_g - S_1 - S_2) + y(1-z)(U - C_g - S_1 + C_{gd1}) + (1-y)z(U - C_g - C_{gp1}) + (1-y)(1-z)(U - C_g + C_{gp1} + C_{gd1})$$

$$E_0^2 = yz(W - U_1) + y(1-z)(-K - U_1) + (1-y)z(W - U_1) + (1-y)(1-z)(-K - U_1)$$

$$\bar{E}_0 = xE_0^1 + (1-x)E_0^2$$

According to Malthusian dynamic equation, the growth rate of the number of active government regulatory strategies is minus the average return, where t is time, and the dynamic equation obtained by sorting out is as follows:

$$F(x) = \frac{dx}{dt} = x(E_0^1 - \bar{E}_0) = x(1-x)(E_0^1 - E_0^2)$$

$$F(x) = (1-x)x[(2y - yz + 1)(U - C_g) - yS_1 - yS_2 - C_{gp1} + (2y - yz)C_{gd1} - zW - (zy - 2y - 1)U_1 - (z - 1)K]$$

Similarly, the dynamic equations of the platform and the driver are obtained as follows:

$$F(y) = y(1-y) \left[\begin{aligned} &xS_1 - C_{p1} + F_1 + (xz-1)C_{p0} + (x-xz)C_{gd1} + (z-xz)C_p \\ &+ (xz-x-z-1)C_{pd} - xC_{gp1} - (z+1)C_d \end{aligned} \right]$$

$$F(z) = z(1-z) \left[\begin{aligned} &(2-2x-2y)Rd + (2xy-x-y)C_{d0} + (xy-y-x)C_{d1} + xS_2 \\ &+ (x+y-2)C_p + (x+xy)C_{d1} - (2xy-2x-2y+1)C_d - (xy-y)C_{pd} \end{aligned} \right]$$

Tripartite Evolution Path and Stability Analysis

According to the stability principle of differential equation, that is, when the proportion of the three parties in the game is relatively balanced, there will be no change, so that a strategy is in a relatively stable state, then the conditions to be satisfied are as follows:

$$F(x) = \frac{d(x)}{d(t)} = 0; F(y) = \frac{d(y)}{d(t)} = 0; F(z) = \frac{d(z)}{d(t)} = 0$$

Because of the stability principle of differential equation, relevant stability analysis can be carried out for government departments, networking platforms and networking drivers respectively. Mathematica is used to calculate the relevant equations, and the steady-state solution of the dynamic equation is obtained, and the phase diagram is made according to the steady-state solution of the relevant equation.

Evolution of Government Regulation. When the government carries out passive control, the platform and drivers will be affected accordingly, the image of the government will be reduced, and the management cost of rewards (penalties) for the platform and drivers will be reduced. The platform will passively control its own platform and drivers due to loose government control, affecting the integrity of the platform. Body operation. However, when the online car-booking platform is actively regulated, the image of the government itself will be improved, and obviously has a certain impact on the driver regulation itself, the number of legitimate and compliant drivers is increasing. And through the government-related phase diagram, it can be clearly shown that when the government is relatively relaxed on the platform and driver regulation, the platform and driver will be relatively lax, but when the government is relatively strict, the driver's steady state solution tends to infinitely 1 (Fig. 1), which fully illustrates that the number of drivers who are legally compliant increases, creating a good shape for the travel of network contract vehicles. Elephant. Through the steady-state solution of the government's dynamic equation, it can be concluded that the best strategy for the government to control the platform and drivers is to gradually shift from loose government control to strict control, which is conducive to the healthy development of the platform and the safe travel of people.

$$\left\{ \begin{aligned} x \rightarrow 0, y \rightarrow \frac{2Rd - C_d - 2C_p}{2Rd - 2C_d + C_{d0} + C_{d1} - C_p - C_{pd}}, z \rightarrow \frac{-C_d - C_{p0} - C_{p1} - C_{pd} + F_1}{C_d - C_p + C_{pd}} \\ x \rightarrow 1, y \rightarrow \frac{-C_d + C_{d0} + C_p - S_2}{-2Rd + C_{d0} + C_{d1} + C_p}, z \rightarrow \frac{-C_d + C_{gd1} - C_{gp1} - C_{p0} - C_{p1} - 2C_{pd} + F_1 + S_1}{C_d + C_{gd1} - C_{p0}} \end{aligned} \right\}$$

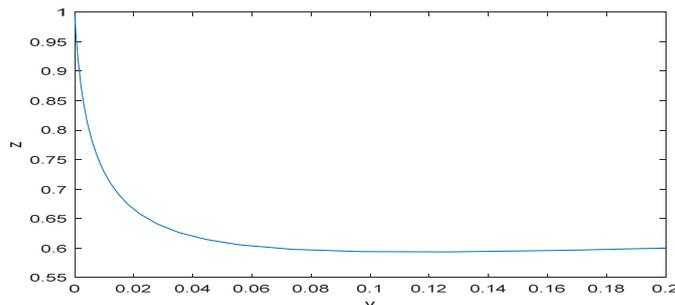


Figure 1. Phase diagram of evolution of government administration

Evolutionary Game of the Regulation of Online Car Rendering Platform. When the platform

is passively regulated, it will also be affected by the government and the drivers of online car Rendering Platform. When the platform is actively regulated, the cost of management will increase, which will improve the image of the government to a certain extent, thus obtaining government incentives and allowances, and the number of legal compliance of drivers will increase. However, when the platform is passively regulated, the image of the government will be correspondingly reduced, and the platform will be punished to a certain extent. Besides the basic operating costs, the management costs of the platform will be correspondingly reduced. From the steady-state solution Y 1 (Fig. 2), we can draw a conclusion that the best strategy of the online car-booking platform is to gradually evolve from passive control to active control and create a safe and reasonable online car-booking travel environment.

$$\{x \rightarrow \frac{2Rd - C_d - 2C_p}{2Rd - 2C_d + C_{d0} - C_p - S_2}, y \rightarrow 0, z \rightarrow \frac{K + U - C_g - C_{gp1} + U_1}{K + W}\}$$

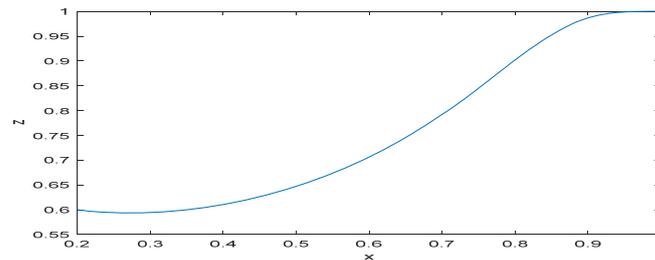


Figure 2. Phase diagram of evolution of network rental platform

Evolutionary Game of Online Appointment Drivers. when analyzing online Appointment Drivers, they will also be affected by the regulatory attitude adopted by the government and online Appointment Platform. When the net car driver is approaching infinitely to 1 (Fig. 3), when the net car driver is operating legally, the government and platform will encourage and support and reward the net car platform. The net car platform will have a good business atmosphere and the government's image will be improved, but the net car driver will increase some additional costs (example). Such as time management costs, maintenance and nutrition protection costs. Therefore, according to the phase diagram analysis of the dynamic equation of the net-appointed car driver, it is concluded that when the net-appointed car driver chooses to operate legally, the infinite trend is close to 1, which has a positive impact on the improvement of the government image and the reasonable and legal normal operation of the net-appointed car platform. According to the steady-state solution of the evolutionary game of the dynamic equation of the networked car driver and the related phase diagram, it is concluded that the best strategy is that the networked car driver chooses the legitimate operation.

$$\{x \rightarrow \frac{-2C_d + C_p - C_{p0} - C_{p1} - 2C_{pd} + F_1}{C_{gp1} + C_p - C_{p0} - S_1}, y \rightarrow \frac{-U + W + C_g + C_{gp1} - U_1}{U - C_g + C_{gd1} - S_1 - S_2 + U_1}, z \rightarrow 1\}$$

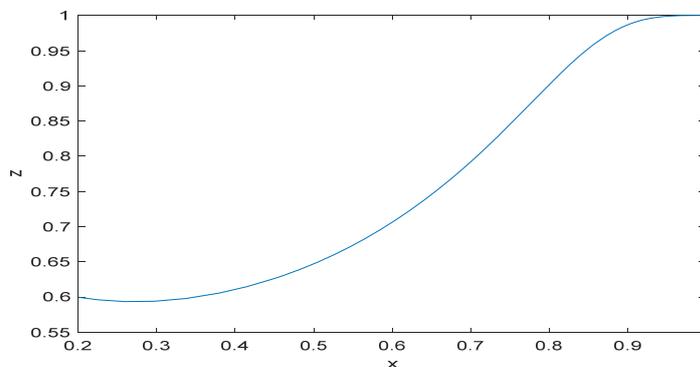


Figure 3. Evolutionary phase diagram of round-trip drivers

In summary, the best strategy for the steady-state solution of dynamic equation can be concluded as follows: x infinitely approaches 1, y infinitely approaches 1, Z infinitely approaches 1. The phase

diagram of the three-party evolutionary game can also be shown, especially the phase diagram of the three-dimensional dynamic equation in Fig. 5 is also infinitely close to 1. Therefore, it is concluded that the best strategy for the government is to choose strict regulation, active regulation and lawful and compliant operation for the drivers of online car booking platforms.

When the government chooses strict regulation, the factors affected include the image of the government, the basic cost of government management, and the reward (punishment) fees for the platform and drivers of online car appointment. The image of the government will be improved, the basic management costs will increase and the management costs of drivers and platforms will increase. The government is a public operation department, and the basic management costs can be neglected.

When choosing the active control of the online car registration platform, the factors affected include the basic management cost of the online car registration platform, the cost of daily operation and maintenance, the increased user traffic of enterprises and the increased incentive cost of the government.

When the drivers choose to operate legally, the factors affected include the daily operating cost and additional management cost of the drivers, the increased user traffic and the rewards given by the government and the platform.

$$\begin{aligned} &\{x \rightarrow 0, y \rightarrow 1, z \rightarrow 1\}, \\ &\{x \rightarrow 1, y \rightarrow 0, z \rightarrow 1\}, \\ &\{x \rightarrow 1, y \rightarrow 1, z \rightarrow 1\}, \end{aligned}$$

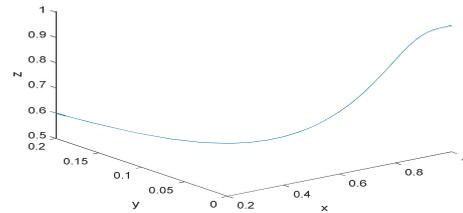
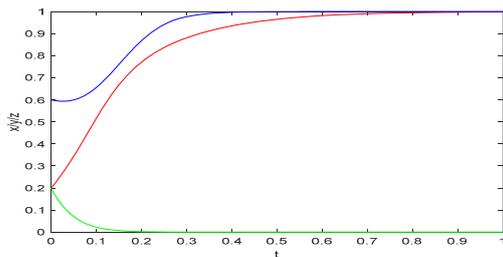


Figure 4. Quadrilateral evolutionary phase diagram Figure 5. Tripartite three-dimensional phase map

Stability Analysis of Tripartite Action

Based on Friedman's conclusion on stability analysis of tripartite dynamic game [3], the stability of tripartite dynamic equation is further analyzed by Jacobian matrix. According to the tripartite dynamic equation, the Jacobian matrix can be obtained (denoted as J):

$$J = \begin{pmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{pmatrix} \text{ one of which:}$$

$$a_{11} = (1-2x)[K+U+2Uy-[-1+y(-2+z)]C_g-C_{gp}+U-1-y[(-2+z)C_{gd}+S_1+S_2+(-2+z)U_1]$$

$$a_{21} = (1-y)y[-(-1+z)C_{gd}-C_{gp}-zC_p+zC_{p0}+(-1+z)C_{pd}+S_1]$$

$$a_{31} = (-1+z)[2R_d+2(-1+y)C_d+C_{d0}-C_p+y[-2(C_{d0}+C_{d1})+C_{pd}]-S_2]$$

$$a_{12} = (-1+x)x[-(-2+z)C_g+(-2+z)C_{gd}+S_1+S_2+(-2+z)(U+U_1)]$$

$$a_{22} = (1-2y)[-(-1+z)C_{gd}-xC_{gp}+(z-xz)C_p+(-1+xz)C_{p0}-C_{p1}+[-1+x(-1+z)-z]C_{pd}+F_1+xS_1]$$

$$a_{32} = (-1+z)z[2R_d+2(-1+x)C_d+(1-2x)C_{d0}+C_{d1}-2xC_{d1}-C_p+(-1+x)C_{pd}]$$

$$a_{13} = (-1+x)x[K+W+Uy+y(-C_g+C_{gd}+U_1)]$$

$$a_{32} = (-1+y)y[C_d+xC_{gd}+(-1+x)C_p+C_{pd}-x(C_{p0}+C_{pd})]$$

$$a_{33} = (1-2z)[-2R_d(-1+x+y)+[-1-2x(-1+y)+2y]C_d+(-x-y+2xy)C_{d0}-yC_{d1}+2xyC_{d1}-2C_p+xC_p+yC_p+yC_{pd}-xyC_{pd}+xS_2]$$

Use relevant parameters:

$U=15, U_1=12, C_g=7.5, C_{gp}=2, C_{gd}=3, C_p=9, C_{p1}=10, C_{p0}=12, C_{pd}=8, C_d=2, C_{d0}=12, C_{pd}=8, C_d=2, C_{d0}=1, C_{d1}=2, S_1=2, S_2=32, W=11, K=10, F_1=9, R_d=5$. In this Jacobian matrix, we analyze the evolutionary game of tripartite regulation of market travel by the government, the platform and the

driver. From this, we can get the Jacobian matrix of correlation coefficient:

$$\begin{pmatrix} 27.5-55.x+11.y+22.z & 21z+42xz-22.5yz+45.xyz & 11.x-11.xz-22.5xz+22.5x'z & -21x+21xz-22.5xy+22.5x'y \\ -5y+5y'+8yz-8y'z & & -23-5x+46y+10xy-z+8xz+2yz-16xyz & -y+8xy+y'-8xy^2 \\ 34z6yz-34z^2+6yz^2 & & 8z-6xz-8z^2+6xz^2 & -10+34x+8y-6xy+20z6xz-16yz+12xyz \end{pmatrix}$$

By introducing the steady-state solutions ($x = 0, y = 1, Z = 1$) into the Jacobian matrix above, the eigenvalues obtained are all real numbers (24., - 5., 2.), which shows that the solutions obtained are stable. Therefore, it can be concluded that the best strategy is when the government takes active control measures, the platform of online car booking takes a positive attitude to carry out relevant control and the drivers of online car booking operate legally and in accordance with regulations.

Countermeasures and Suggestions

According to the above specific analysis and combined with the actual situation of the online car market, this paper gives the following countermeasures and suggestions:

The government should improve relevant laws and regulations and give policy support to the actual development of the market. ^[4] In view of the emerging industry of online taxi booking, the government has not promulgated clear legal provisions to regulate the market at present, but only some simple temporary regulations. It has not fully taken into account the specific implementation of specific issues. If the operation and management costs of local network car-booking platforms are too high, and the state has not given some financial support, it is very easy to cause negative control of local network car-booking platforms. However, if the state promulgates relevant laws and regulations, the compulsory and authoritative characteristics of the Constitution will objectively maintain the normal operation of the online car market, and reasonable policies will also give corresponding help according to the actual situation of the local.

The online car-appointment platform actively establishes information sharing and improves its own management and operation capabilities. In the course of its own operation, the platform should actively make the data information public and provide the data basis for government and social supervision. ^[5] Although there are some problems in data acquisition, that is, if the passengers do not reflect the safety driving or the problems in the driver's operation, the platform can not be fully and accurately grasped, which causes great trouble to the supervision of the online car-booking platform. Therefore, if we need comprehensive and accurate data disclosure, we also need all departments to actively participate in the establishment of information disclosure and sharing platform. ^[6] Not only that, but also the network car-appointment platform should strengthen its own management, improve regularly from vehicle scheduling, control, supervision and rehabilitation, so as to make the operation management adapt to the actual situation of government policies and drivers, so as to create a good operation platform.

To improve the driver's comprehensive accomplishment, we should carry out skill training and quality education. Drivers play an important role as the main body in the online travel market. ^[7] Firstly, there is a close relationship between the legitimate operation of drivers and the control of the government and the online car-booking platform. The government and the online car-booking platform should actively compensate the drivers under the conditions of the legitimate operation of drivers, and on the contrary, punish the drivers. Secondly, it is necessary to train drivers' skills and quality education before they take up their posts. It is not only to train drivers' driving level, but also what measures should drivers take when facing different situations. ^[8] Finally, drivers should carry out routine maintenance and cleaning of the traveling vehicles so that passengers can have a better user experience on the basis of ensuring the safety of the basic facilities of the vehicles.

Summary

Based on the tripartite evolutionary game theory, this paper analyses the regulation of the market of restricted car travel, and constructs an evolutionary game model for the tripartite subjects of

government, platform and driver. The conclusion of the model shows that the best strategy is that the government evolves from loose regulation to strict regulation. The online car-booking platform is gradually changing from passive control to active control. The drivers of online car-booking operate legally and in accordance with the rules. The government, online car-booking platform and drivers are influenced by many factors. Therefore, according to the results of the model analysis, the government perfects relevant laws and regulations, formulates policies according to the actual development of the local market; enhances its own management level, coordinates with various departments to actively manage and improve the information data management; optimizes the driving environment, legitimately and regularly operates, improves its own moral quality, and jointly creates a good travel environment.

References

- [1] Tang Qingli. [J]. Regulation Path of Shared Economy of "Special Vehicle". Chinese Law, 2015 (04): 286-302.
- [2] Cai Lewei. Regulatory Game Space under the New Policy of Internet Appointment [J]. Leadership Science, 2017 (8): 25-27.
- [3] FRIEDMAN A. A simple testable model of double auction markets [J]. Journal of Economic Behavior and Organization, 1991, 15 (1): 47-70.
- [4] Lu Ke, Zhou Jing, Lin Xiaowei. Market Regulation Strategy of Internet Round Car Travel Based on Tripartite Evolutionary Game [J]. Journal of Beijing University of Technology (Social Science Edition), 2018, 20 (05): 97-104.
- [5] Shen Kaiju, Chen Xiaoji. Research on the Government Regulation of Online Car Arrangement from the Perspective of Shared Economy [J]. Hubei Social Science, 2017 (05): 135-143.
- [6] Caoyang. Research on China's Special Train and its Regulation [J]. Social Scientist, 2016 (07): 47-50.
- [7] Li Yongzhong, Wang Renxian. Evolutionary Game-based Research on Vehicle Quality Supervision and Management of Online Appointment [J]. Journal of Fuzhou University (Philosophy and Social Sciences Edition), 2017, 31 (06): 66-71.
- [8] Fang He, Zuo-Jun Max Shen. Modeling taxi services with smartphone-based e-hailing applications [J]. Transportation Research Part C, 2015, 58.