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Research on the Security Problem of Online Car-Hailing Based on Evolutionary Game

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Abstract: *In recent years, online car-hailing has become the preferred method for many people to travel. Car hailing industry integrates the idle resources of the society. To some extent, it has solved the problem of difficulty in taxi taking, but it also brings about a lot of security issues. Online car-hailing platforms and drivers are two important subjects for regulating the online car-hailing market, this article establishes an evolutionary game model of the online car-hailing platforms and the drivers, analysis of the impact of changes in parameters on the decision-making of both sides of the game, and using Matlab software for simulation. The result shows that it is helpful to regulate the online car-hailing market order by adopting the following methods: online car-hailing platforms increasing penalties for illegal operation of platform drivers, improve the driver's good external environmental benefits, online car-hailing platforms reducing regulatory costs, and strengthening public supervision of online car-hailing platforms and drivers.*

Keywords: *online car-hailing platforms; drivers; evolutionary game*

1. INTRODUCTION

The online car-hailing platform uses Internet technology to build a taxi service platform for passengers. Eligible vehicles and drivers can register on the platform. Passengers use the service platform to make vehicle reservations. The service platform receives and dispatches orders to realize peer-to-peer services. In 2013, the online car-hailing started to rise in China, and various taxi softwares began to appear in major cities in China, such as Didi taxis and Shenzhou buses.[1]As of December 2017, the number of users of online taxis reached 285.51 million, and the usage rate of netizens reached 37.1%, an increase of 61.88 million compared with 2016, with a growth rate of 27.5%. The number of online or express train users reached 236.23 million, and the usage rate of netizens reached 30.6%, an increase of 68.24 million compared with 2016, with a growth rate of 40.6%.[2]In the first half of 2018, the usage rates of booking taxis and booking special buses/expresses among netizens were 43.2% and 37.3%, respectively, which was 20.8% and 26.5% higher than the user size at the end of 2017.[3](Aiping Zhang, 2017)With its business model different from traditional taxis the online car-hailing has formed a new form with high efficiency, open consumption and subversiveness to the existing market, its new model is mainly reflected in the low-end taxi market. Reshaping, opening up new markets for "special car" and opening up new markets for "carpooling".[4](Jing Wang,2016)In the short period of time that the online car-hailing has appeared, it has been widely used. The emergence of the online car-hailing not only solves the urban traffic problem, but also satisfies the passenger travel demand, and greatly improves the utilization efficiency of the motor vehicle, but the social problems, legal conflicts and regulatory issues it brings cannot be ignored. In recent years, the government has issued a series of policies for online car-hailing rentals, such as the "Interim Measures for the Administration of Network Appointment Taxi Operation Services",which was promulgated on July 27, 2016 and implemented on November 1, 2016;on December 21, 2016, Beijing and Shanghai both issued their own new rules for the online car-hailing. On May 24, 2018, the Ministry of Transport announced the newly revised "Measures for the Assessment of the Quality of Taxi Service" and so on. The promulgation of a series of regulatory rules is enough to show the government's emphasis on the healthy development of the online car-hailing industry. Although the relevant policies have been issued in the central and local management of the online car-hailing, the implementation effect is not satisfactory, In recent years, safety accidents about the nonline car-hailing have appeared repeatedly, the passengers' information is disclosed, the drivers' information is falsified, the registered driver is inconsistent with himself, etc. This series of violations are caused by the management loopholes of the online car-hailing platform.

At present, some literatures have applied the evolutionary game to the research of online car-hailing. [5]Lu Ke et al.(2018) constructed a three-way evolutionary game model of online car-hailing market regulation based on evolutionary game theory, and analyze the evolution paths and stationary policies of the governmental authorities, online car-hailing platforms and drivers by Model derivation and numerical simulation.[6] Yongzhong Li(2017)constructed an evolutionary game model between the online car-hailing platform and the driver, and analyzed the selection and stability of the platform supervision strategy and driver operation strategy.[7]Yongfang Zhao (2017) used the evolutionary game theory to establish the evolutionary game model of the online car-hailing and the traditional taxi, and the three-way evolutionary game model of the government, the online car-hailing and the traditional taxi. Proposing corresponding development proposals for the government, online car-hailing and traditional taxi companies. Based on the bounded rationality hypothesis, this paper establishes an evolutionary game model, analyzes the equilibrium point and stability of the game model, uses Matlab to simulate, analyzes the influence of parameter changes on the decision-making of both sides of the game. Finally, through the results of the model and the impact of parameter changes on decision-making, proposing corresponding development proposals for the online car-hailing platform tend to be actively regulated and the driver's behavior tends to be compliant.

2. Constructing and analyzing the evolutionary game model of the online car-hailing platform and drivers

2.1Game Participation Subject and Behavior

The participating parties are two bounded rational players, namely the online car-hailing platform(T) and the platform driver(D).As an intermediary service provider, the online car-hailing platform provides information for passengers and drivers. Drivers can register information on the online car-hailing platform to undertake business. Assume that the online car-hailing platform has two strategic spaces ST = (positive, negative).Driver's strategic space SD = (compliance, violation).The "positive" strategy of the online car-hailing platform refers to its very active implementation of various rules and regulations when supervising the platform drivers, and strictly supervising according to the relevant laws and regulations of the state; The "negative" strategy of the online car-hailing platform refers to its passive supervision attitude when it supervises the platform. The "compliance" strategy of the platform driver means that the driver registers the information strictly in accordance with the requirements of the national and online car-hailing platform, and requires himself to meet the high standards in the process of serving the passengers; The "violation" strategy refers to the platform driver's neglect of the policies formulated by the state and the online car-hailing platform, and poor service level to passengers.

2.2Propose hypotheses and establish the game payment matrix

Hypothesis 1: The online car-hailing platform and drivers are all bounded rational participants, who are fully aware of the income level, game rules and game process of their respective participants.

Hypothesis 2: The probability that the online car-hailing platform chooses to positively supervise is $x(0 \leq x \leq 1)$, the probability of choosing negative supervision is 1-x.The probability that the driver chooses to operate in compliance is $y(0 \leq y \leq 1)$,and the probability of selecting the illegal operation is 1-y.

Hypothesis 3 : When the online car-hailing platform adopts positive supervision, it will win the recognition of the society and the higher authorities, and have a positive effect on the influence of the platform. Assume that when the online car-hailing platform completes the expected goal of positive supervision, it is recognized by the passengers, society and superiors. The return is Rt.

Hypothesis 4: The regulatory goal of the online car-hailing platform is that the platform driver provides the application materials as required, and operates in accordance with the rules and regulations. When the online car-hailing platform implements the "positive" strategy, the online car-hailing platform achieves the implementation goal of the supervision target of 1, and implements "negative" strategy, the degree of achievement of the regulatory objectives is α $(0<\alpha<1)$.When the platform driver adopts the "compliance" strategy, the degree of realization of the regulatory target is 1 for the online car-hailing platform, and the degree of realization of the regulatory target is β $(0<\beta<1)$ when the "violation" strategy is implemented.

Hypothesis 5: When the online car-hailing platform chooses to positively supervise, it needs to pay the supervision cost Ct, including the salary of the supervisors and the hardware facilities invested.

Hypothesis 6:The driver's income is Rd. Drivers need to have the relevant qualifications for the "compliance" strategy. They need to meet the relevant requirements and improve their own quality in the process of serving passengers. Achieving these standards requires input costs. It is assumed that these additional costs are Cd. Because of these extra costs, the driver are more inclined to choose the "violation" strategy. However, if the driver chooses the "compliance" strategy, the passengers will praise the driver in the system, the driver's credibility will increase, the passenger's willingness to choose the driver will increase, form a good external environment for the driver, this income will be recorded as e.

Hypothesis 7: When the driver adopts the "violation" strategy, if the online car-hailing platform adopts the "positive" supervision strategy, the illegal operation of the driver must be discovered. At this point, the driver needs to pay a penalty amount of P;if the online car-hailing platform adopts the "negative" supervision strategy, the probability that the driver's illegal operation is publicized is θ $(0\leq\theta\leq1)$,at this time, the online car-hailing platform and the driver are facing losses Lt and Ld respectively.

According to the above assumptions and the set parameters, the payment income matrix under different strategies of the two players can be obtained, as shown in Table 1.

Table 1

Online car-hailing platform(T)	*The driver(D)*	
	Compliance(y)	*Violation(1-y)*
Positive(x)	*Rt-Ct;Rd-Cd+e*	*βRt-Ct+P;Rd-P*
Negative(1-x)	*αRt;Rd-Cd*	*αβRt-θLt;Rd-θLd*

2.3 Constructing the replication dynamic equation

According to the hypothesis, the expected return Et1 when the online car-hailing platform(T) selects the "positive" strategy is:

$$Et1=y(Rt-Ct)+(1-y)(\beta Rt-Ct+P)=(Rt-\beta Rt-P)y+\beta Rt-Ct+P$$

The expected return Et2 when the online car-hailing platform(T) selects the "negative" strategy is:

$$Et2=y\alpha Rt+(1-y)[\alpha\beta Rt-\theta Lt]=(\alpha Rt-\alpha\beta Rt+\theta Lt)y+\alpha\beta Rt-\theta Lt$$

The average revenue of the "active" and "negative" hybrid strategies for the online car-hailing platform(T) is:

$$\bar{Et}=xEt1+(1-x)Et2$$

The expected return Ed1 of the driver(D) when selecting the "compliance" strategy is:

$$Ed1=x(Rd-Cd+e)+(1-x)(Rd-Cd)=ex+Rd-Cd$$

The expected return Ed2 of the driver(D) when selecting the "violation" strategy is:

$$Ed2=x(Rd-P)+(1-x)(Rd-\theta Ld)=(\theta Ld-P)x+Rd-\theta Ld$$

The average revenue of the "compliance" and "violation" hybrid strategies for the driver(D) is:

$\bar{E}d=yEd1+(1-y)Ed2$

According to the Malthusian equation (Friedman, 1991), the replication dynamic equation F(x) for selecting the "positive" strategy for the online car-hailing platform and the replication dynamic equation G(y) for the driver to select the "compliance" strategy are:

$$F(x)=\frac{dx}{dt}=x(1-x)\{[(1-\alpha)\beta Rt-Ct+P+\theta Lt]+[(1-\beta)(1-\alpha)Rt-P-\theta Lt]y\}$$

$$G(y)=\frac{dy}{dt}=y(1-y)[(e+P-\theta Ld)x-Cd+\theta Ld]$$

2.4 Equilibrium point and stability analysis of evolution process

According to the stability theorem of differential equations, the equilibrium dynamic equations of the two sides of the game can be equal to 0 to find the equilibrium point of the evolutionary system, as follows:

$$\begin{cases} F(x)=\frac{dx}{dt}=0 \\ G(y)=\frac{dy}{dt}=0 \end{cases}$$

The five partial equilibrium points of the game between the online car-hailing platform and the driver are(0,0),(0,1),(1,0),(1,1),(x*, y*),among which,

$x^*=(Cd-\theta Ld)/(e+P-\theta Ld)$

$y^*=[(\alpha-1)\beta Rt+Ct-P-\theta Lt]/[(1-\alpha)(1-\beta)Rt-P-\theta Lt]$

According to the method proposed by Friedman (1991), the stability of the equilibrium point can be analyzed according to the Jacobian matrix of the game system. Let the Jacobian matrix be J, and the equilibrium point is the evolution stability strategy (ESS). The condition is that the determinant value(|J|) of the Jacobian matrix is positive and the trace(TrJ) is negative. Next we will analyze the stability of the five equilibrium points of the game system.

The Jacobian matrix J of this system is:

$$J=\begin{bmatrix} \frac{\partial F(x)}{\partial x} & \frac{\partial F(x)}{\partial y} \\ \frac{\partial G(x)}{\partial x} & \frac{\partial G(x)}{\partial y} \end{bmatrix}=\begin{bmatrix} A & B \\ C & D \end{bmatrix}$$

among which,

$A=(1-2x)\{[(1-\alpha)\beta Rt-Ct+P+\theta Lt]+[(1-\beta)(1-\alpha)Rt-P-\theta Lt]y\}$

$B=x(1-x)[(1-\beta)(1-\alpha)Rt-P-\theta Lt)]$

$C=y(1-y)(e+P-\theta Ld)$

$D=(1-2y)[(e+P-\theta Ld)x-Cd+\theta Ld]$

Thus, the values of A、B、C、D in the Jacobian matrix corresponding to the five partial equilibrium points are as shown in Table 2.

Table 2

Equilibrium point	*A*	*B*	*C*	*D*
(0,0)	*(1-α)βRt-Ct+P+θLt*	*0*	*0*	*-Cd+θLd*
(0,1)	*(1-α)Rt-Ct*	*0*	*0*	*Cd-θLd*
(1,0)	*(α-1)βRt+Ct-P-θLt*	*0*	*0*	*e+P-Cd*
(1,1)	*(α-1)Rt+Ct*	*0*	*0*	*-e-P+Cd*
(x, y*)*	*0*	*B**	*C**	*0*

among which,

$B^*=[(Cd-\theta Ld)/(e+P-\theta Ld)][1-(Cd-\theta Ld)/(e+P-\theta Ld)][(1-\beta)(1-\alpha)Rt-P-\theta Lt]$

$C^*=\{[(\alpha-1)\beta Rt+Ct-P-\theta Lt]/[(1-\alpha)(1-\beta)Rt-P-\theta Lt]\}\{1-[(\alpha-1)\beta Rt+Ct-P-\theta Lt]/[(1-\alpha)(1-\beta)Rt-P-\theta Lt]\}(e+P-\theta Ld)$

The values and traces of the determinant of the Jacobian matrix are:

$|J|=AD-BC$

$TrJ=A+D$

The values and traces of the determinant of the Jacobian matrix corresponding to each equilibrium point are shown in Table 3.

Table 3

Equilibrium point	/J/	TrJ
(0,0)	(Cd-θLd)[(α-1)βRt+Ct-P-θLt]	-[(α-1)βRt+Ct-P-θLt+Cd-θLd]
(0,1)	[(1-α)Rt-Ct](Cd-θLd)	Cd-θLd+[(1-α)Rt-Ct]
(1,0)	(e+P-Cd)[(α-1)βRt+Ct-P-θLt]	(e+P-Cd)+[(α-1)βRt+Ct-P-θLt]
(1,1)	(e+P-Cd)[(1-α)Rt-Ct]	-{(e+P-Cd)+[(1-α)Rt-Ct]}
(x*, y*)	/J/*	0

among which,

|J|*=-

$$\frac{[(\alpha-1)\beta)\beta+Ct-P-\theta Lt][(1-\alpha)Rt-Ct](e+P-Cd)(Cd-\theta Ld)}{[(1-\alpha)(1-\beta)Rt-P-\theta Lt](e+P-\theta Ld)}$$

It can be seen from Table 3 that the trace of the Jacobian matrix of the equilibrium point (x*, y*) is equal to zero, which is obviously not an evolutionary stability strategy. The conditional analysis of the stability results of the four equilibrium points (0,0), (0,1), (1,0), and (1,1) is shown in Table 4.

Table 4

Equilibrium point	Stable state	|J| symbol	TrJ symbol	Condition 1	Condition 2
(0,0)	ESS	+	-	Ct>P+(1-α)βRt+θLt	Cd>θLd
(0,1)	ESS	+	-	αRt-Ct<αRt	Cd<θLd
(1,0)	ESS	+	-	Ct<P+(1-α)βRt+θLt	Rd-P>Rd-Cd+e
(1,1)	ESS	+	-	αRt-Ct>αRt	Rd-P<Rd-Cd+e

2.5 Analysis of the conditions for the establishment of equilibrium point stability results

Situation 1:Ct>P+(1-α)βRt+θLt and Cd>θLd

At this point, the equilibrium point (0,0) satisfies the condition of the evolutionary stability strategy, that is,the online car-hailing platform adopts the "negative" supervision strategy, and the driver takes the "violation" operational strategy is the Evolution Stable Strategy (ESS) combination. Further analysis, Ct>P+(1-α)βRt+θLt indicates that the supervision cost of the online car-hailing platform is greater than the penalty for the driver. At this time, for the online car-hailing platform, "negative" become a dominant strategy; Cd>θLd indicates that when the driver pays more for the "compliance" operation than the loss of the reputation of the driver caused by the "violation" operation, the "violation" becomes the dominant strategy of the driver.

Situation 2 : αRt-Ct<αRt and Cd<θLd

At this point, the equilibrium point (0,1) satisfies the condition of the evolutionary stability strategy, that is,the online car-hailing platform adopts the "negative" strategy, and the driver adopts "compliance" operational strategy is the Evolution Stable Strategy (ESS) combination. Further analysis, αRt-Ct<αRt means that when the revenue of the online car-hailing platform adopts the "negative" strategy is greater than the income of the "positive" strategy, "negative" becomes a dominant strategy for the online car-hailing platform; Cd<θLd indicates that "compliance" becomes a dominant strategy for the driver when the driver pays more for "compliance" operations than the loss of credit for the driver caused by "violation" operations.

Situation 3 : Ct<P+(1-α)βRt+θLtand Rd-P>Rd-Cd+e

At this point, the equilibrium point (1,0) satisfies the condition of the evolutionary stability strategy, that is, the online car-hailing platform selects "positive", and the driver selects "violation" operational strategy is the Evolution Stable Strategy (ESS) combination. Further analysis, Ct<P+(1-α)βRt+θLt is βRt-Ct+P>αβRt-θLt, and the gain from the "positive" strategy of the online car-hailing is greater than The benefits of the "negative" strategy, at this time, "positive" strategy has become the dominant strategy for the online car-hailing platform; when the driver's "violation" net income is greater than the net benefit of his choice of "compliance" strategy, that is, when Rd-P>Rd-Cd+e, "violation" becomes the driver's dominant strategy.

Situation 4 : α Rt-Ct> α Rt and Rd-P<Rd-Cd+e

At this point, the equilibrium point (1,1) satisfies the condition of the evolutionary stability strategy, that is, the online car-hailing platform selects the "positive" strategy, and the driver selects the "compliance" strategy is an evolutionary stability strategy(ESS) combination. α Rt-Ct> α Rt indicates that when the revenue of the online car-hailing platform adopts the "positive" strategy is greater than the benefit of adopting the "negative" strategy, "positive" becomes a dominant strategy for the online car-hailing platform; when the driver chooses the "compliance" strategy, the net benefit is greater than the net benefit when he chooses the "violation" strategy. That is, when Rd-P<Rd-Cd+e, "compliance" becomes the driver's dominant strategy.

3. The influence of parameter changes on the decision of the online car-hailing platform and the driver's decision

In the process of the game between the online car-hailing platform and the driver, the value of the payment function of both sides of the game changes with the change of the parameters, and the evolution system will converge to different equilibrium points with the initial values of some parameters and their changes. Next, the changes in the parameters will be analyzed in detail. First assign values to the parameters, assume

α,β,θ=0.5;Rt=2000;Rd=2000;Ct=860;Cd=850;P=250; Lt=100;Ld=100;e=800.At this time, the replication dynamic equation F(x) of the "positive" strategy for the online car-hailing platform and the replication dynamic equation G(y) for the driver to select the "compliance" strategy are:

$$F(x)=\frac{dx}{dt}=x(1-x)(200y-60);$$

$$G(y)=\frac{dy}{dt}=y(1-y)(900x-800).$$

Let F(x) and G(y) be equal to 0,and get the five partial equilibrium points of the game system, namely (0,0),(0,1),(1,0),(1,1),(0.89,0.3).By analyzing the stability of the local equilibrium point, we can see that (0,0) and (1,1) are evolutionary stability strategies, and (0.89,0.3) is the saddle point. The initial dynamic evolution map of the online car-hailing and the driver can be obtained, as shown in Fig-1.

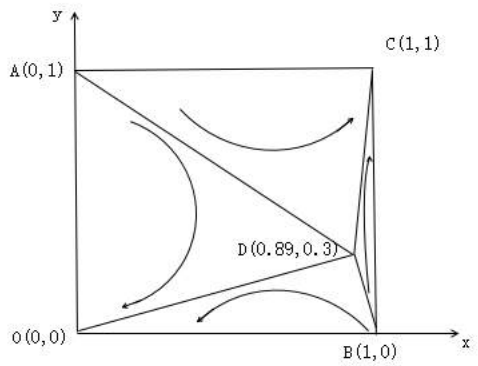

Fig-1: *Initial dynamic evolution diagram of the online car-hailing platform and driver*

3.1Influence of parameter P on evolution path of online car-hailing platform and driver

Fig-2 calculates the effect of the increase of the parameter P on the saddle point coordinates. With the positive supervision of the online car-hailing platform, the penalties for the driver violation strategy P increased from 250 to 310, and the saddle point coordinates eventually changed from D(0.89,0.3) to D ´ (0.8,0.3). Thus, the area ADBC that evolved toward (positive, compliance) has become AD ´ BC, the area has increased ADBD ´ , and the area ADBO that has evolved toward (negative, illegal) has become AD ´ O, and the area has decreased by ADBD ´ . The probability that the game system converges to the equilibrium point C increases, the probability of convergence to the equilibrium point O decreases, and the online car-hailing platform and drivers evolve toward (positive, compliance) direction.

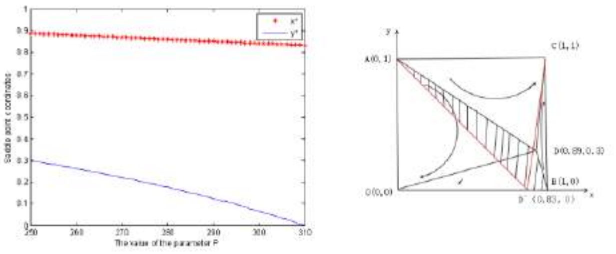

Fig-2: *The influence of the change of parameter P on the evolution path of the online car-hailing platform and the driver*

3.2Influence of parameter e on evolution path of online car-hailing platform and driver

Fig-3 calculates the influence of the growth of the parameter e on the saddle point coordinates. As the good external environment benefit e for the driver increases from 700 to 800, the saddle point coordinates eventually change from D (0.89, 0.3) to D(0.8, 0.3). Thus, the area ADBC that evolved toward (positive, compliance) has become AD ´ BC, the area has increased ADBD ´ ,and the area ADBO that has evolved toward (negative, violation) has become AD ´ BO, and the area has decreased by ADBD ´ .The probability that the game system converges to the equilibrium point C increases, the probability of convergence to the equilibrium point O decreases, and the online car-hailingplatform and the driver evolve toward the direction of (positive, compliance).

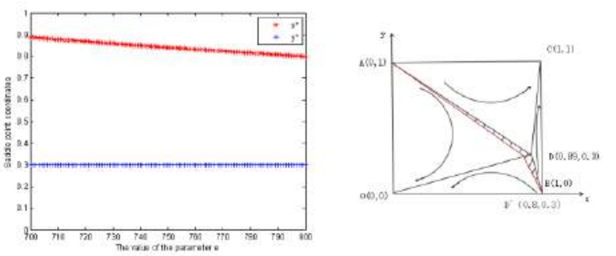

Fig-3: *Influence of the change of parameter e on the evolution path of the online car-hailing platform and drivers*

3.3Influence of parameter Ct on evolution path of online car-hailing platform and driver

Fig-4 calculates the influence of the increase of the parameter Ct on the saddle point coordinates. As the supervision cost Ct of the online car-hailing platform increases from 860 to 1000,the saddle point coordinates eventually change from D(0.89, 0.3) to D ´ (0.89, 1).At this time, the area of the game system that evolved toward(positive, compliance) ADBC became D ´ CO, the area decreased by ADBD ´ ,and the area ADBO that evolved toward (negative, violation) direction became AD ´ BO, and the area increased ADBD ´ ,the probability that the game system converges to the equilibrium point C decreases, the probability of convergence to the equilibrium point O increases, and the online car-hailing platform and drivers evolve toward (negative, violation) directions.

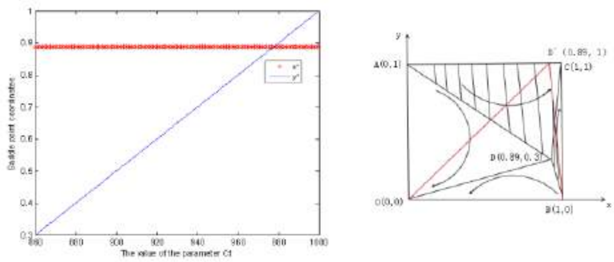

Fig-4: *Influence of the change of parameter Ct on the evolution path of the online car-hailing platform and drivers*

3.4Influence of parameter θ on evolution path of online car-hailing platform and driver

Fig-5 calculates the influence of the increase of the parameter θ on the saddle point coordinates. As the public's supervisory coefficient θ for the online car-hailing platform and the driver increases from 0.5 to 0.8,the saddle point coordinates eventually change from D(0.89, 0.3) to D ´ (0.88,0.25),At this time, the area of the game system that evolved toward (positive, compliance) ADBC became AD ´ BC, the area increased by ADBD ´ ,and the area ADBO that evolved toward (negative, violation) direction became AD ´ BO, and the area decreased ADBD ´ ,the probability that the game system converges to the equilibrium point C increases, the probability of convergence to the equilibrium point O decreases, and the online car-hailing platform and the driver evolve toward the direction of (positive, compliance).

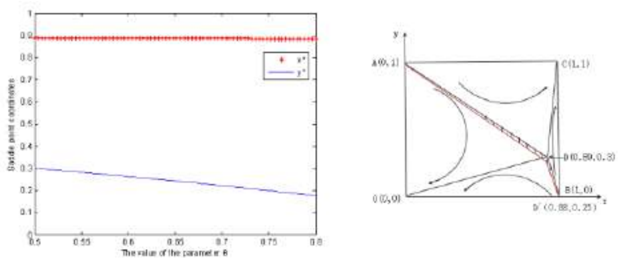

Fig-5: *Influence of the change of parameter θ on the evolution path of the online car-hailing platform and drivers*

4. SUGGESTIONS AND MEASURES

In this paper, the evolutionary game is applied to the driver's supervision process in the online car-hailing platform, and through the establishment of the evolutionary game model of the online car-hailing platform and the driver, solve the replication dynamic equation, analyze the stability of the equilibrium point, and then solve the evolutionary stability strategy, using matlab to simulate and analyze the evolution of the supervision behavior of the online car-hailing platform and the driver's operational behavior, analyze the impact of changes in parameters on the strategies of both players. According to the research results, in order to actively monitor the online car-hailing platform and the platform driver to choose compliance operation, the following suggestions are proposed:

4.1 Online car-hailing platform increases penalties for drivers' illegal operation

Increasing the punishment of the online car-hailing platform for the illegal operation of the driver will help to promote the formation of the “positive” strategy of the online car-hailing platform and the “compliance” strategy of the platform driver. Increasing the punishment of the driver's illegal operation of the online car-hailing platform can impose high economic penalties on drivers who operate illegally. In addition, it is necessary to re-qualify the violating driver's qualifications. For those who have serious circumstances, they should refuse to pay the bill within a certain period of time or for a long time. In addition, a penalty level system can be established. For drivers who violate the rules repeatedly, the punishment is higher than once, and the limit of the number of violations can be set. If this limit is exceeded, the offending driver will always join the platform blacklist.

4.2Improve the driver's good external environmental benefits

Improving the driver's good external environmental benefits will help to create the “positive” strategy for the online car-hailing platform and the “compliance” strategy for the driver. The main measures are as follows: The first is that the online car-hailing platform can set a rating system for driver compliance behavior. When the driver's favorable rate reaches a certain amount, the driver's credit rating can be upgraded, and the driver with a high reputation level receives more passenger information. The second is to provide a good environment for the operation of the online car-hailing, such as providing a professional parking place for passengers to get on and off. The third is to send more tasks to the driver with high praise rate, increase the direct economic benefits of the driver, and improve the enthusiasm of the driver to choose “compliance” strategy.

4.3 Reduce the cost of supervision of the online car-hailing platform

Reducing the cost of supervision of the online car-hailing platform will help to promote the formation of the “positive” strategy for the online car-hailing platform and the “compliance” strategy for the driver. There are two main points in reducing the cost of supervision of the online car-hailing platform. First, the online car-hailing platform utilizes advanced regulatory equipment, makes full use of the Internet platform, encourages passengers to conduct real-time feedback, and actively handles negative evaluations of passengers. The second is to establish a margin system for drivers' compliance operations. If the driver evaluates well and conducts compliance operations, the deposit can be returned in installments. If the driver violates the regulations, a certain amount of deposit can be deducted. The amount can be increased according to the number of violations, and the deducted margin will be used for related work such as online car-hailing supervision.

4.4 The general public increased the supervision of the online car-hailing platform and drivers

The online car-hailing is closely related to the lives of the people. The safety of the passengers is the focus of public attention. After the driver's violations are made public, the impact of the online car-hailing platform and the driver in the public's mind is impaired, and the online car-hailing platform and the driver will suffer corresponding losses. Studies have shown that the higher the probability that the driver's violations are discovered by the public, the more helpful it is to promote the formation of the "positive" strategy for the online car-hailing platform and the "compliance" strategy for the driver. Specifically, a special regulatory team can be set up in the private sector. The supervision team can be composed of users of the online car-hailing, news media, etc. This supervision team regularly collects the feelings and evaluations of the online car-hailing users after they take the online car-hailing. For the drivers with violation records. The news media in the supervision team should publicize the drivers with violation records. In view of the loss pressure caused by the damage of reputation, the online car-hailing platform will impose penalties on the corresponding drivers. The online car-hailing platform can also cooperate with the civil supervision team. Fully utilizing the civil supervision team to supervise the driver can greatly reduce the supervision cost of the online car-hailing platform. The reduction of supervision costs will also help to promote the "positive" strategy for the online car-hailing platform and the "compliance" strategy for the driver.

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