

# Research on the supervision mechanism of new energy time-sharing rental Vehicles: An evolutionary game analysis

Wei Zhang (✉ [cqdxzhangwei@163.com](mailto:cqdxzhangwei@163.com))

Chongqing University of Posts and Telecommunications

Yejian Chen

Chongqing University of Posts and Telecommunications

Xiaoyu Wan

Chongqing University of Posts and Telecommunications

---

## Original article

**Keywords:** New energy, Time-sharing leasing, Evolutionary game, Supervision

**Posted Date:** April 7th, 2020

**DOI:** <https://doi.org/10.21203/rs.3.rs-18958/v1>

**License:**  This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

---

---

# Research on the supervision mechanism of new energy time-sharing rental vehicles: An evolutionary game analysis

Wei Zhang<sup>a,b</sup>, Yejian Chen<sup>a</sup>, Xiaoyu Wan<sup>a</sup>

<sup>a</sup>School of Economics and Management, Chongqing University of Posts and Telecommunications,  
Chongqing 400065, China

<sup>b</sup>Research center of network collaborative economy, Chongqing University of Posts and  
Telecommunications, Chongqing 400065, China

**Abstract: Background:** It is difficult to break the “production and marketing dilemma” by relying only on the production enterprises and consumers. This paper introduces the government into market subject and constructs a three-party dynamic evolution game model between government, enterprises, and consumers to reveal the control strategy. This paper makes a concrete analysis and verifies the model with a case study by revealing the game process between the regulation strategy and behavior decision of enterprises and consumers. **Results:** When the key parameters are in different numerical ranges, the system has four evolutionary stability results. By appropriately increasing the amount of subsidies and penalties, increasing the proportion of compensation coefficient to consumers, and urging enterprises to reduce operating costs, the government is conducive to the healthy development of the new energy timesharing automobile industry. **Conclusions:** The subsidy range and punishment intensity have a positive effect on the evolution of the system to the ideal state, the consumer compensation coefficient has a positive effect on the evolution of the system to the ideal state, the effort of operating costs has a negative effect on the evolution of the system to the ideal state. The study can provide a theoretical basis and a reference for policy formulation and decision-making.

**Keywords:** New energy; Time-sharing leasing; Evolutionary game; Supervision

## 1 Introduction

With the booming development of the Internet and the popularity of mobile terminals, the sharing economy, based on the platform created by a third party, adopts a new economic model that makes full use of idle resources, integrates offline resources such as cars, bicycles and labor, and connects the supply and demand sides to maximize social benefits. Time-sharing leasing is a quasi-public transportation mode that has been emerging in China in recent years. It is a combination of the new

---

thinking mode of "Internet +" and new car rental services. The concept of the time-sharing lease first appeared in the Zurich cooperative in Switzerland in 1948, and now the time-sharing lease is a car rental model based on the Internet and Internet of Vehicles' technology (Shaheen et al., 1998; Dimatulac et al., 2018). Time-sharing leases have potential advantages, such as cost savings, improved transportation efficiency, and environmental protection. The cost involved in time-sharing to rent this type of travel is not very expensive compared to that of both carpooling and private car travel. Leasing also provides some private car owners with certain benefits, thereby attracting more private car owners to join and use time-sharing, which reduces vehicle use costs and improves vehicle utilisation (Xiao, 2017; Smallbone et al., 2020). Some scholars use North American time-share leasing as their research object. At the same time, some scholars take time-sharing lease in North America as the research object. The study shows that the increase of time-sharing lease members reduces the average number of vehicles owned by families, and users who use time-sharing lease also use less cars than those who use private cars (Millard et al., 2006; Katzev, 2003). The study on this economic model can be divided into time-sharing lease application mode, scheduling and optimization, and government policy.

The operating model can be divided into an employee-based operating model and a consumer-oriented operating model. The earliest employee operation mode is divided into the shortest time type and the balanced inventory type. Under this premise, some scholars have proposed a new model, which is a time-sharing company called a deployment system that dynamically adjusts the vehicles in the system. The quantity allows the time-sharing leasing company to achieve maximum profit, and it is optimised at the end of a Monte-Carlo simulation based stochastic optimisation (Fan et al., 2008; Duan and Pu, 2017). The second mode can be divided into travel binding and travel splitting. From the perspective of the promotion of time-sharing leases, the current development mode of time-sharing leasing and the particularity of its leasing outlets make this mode of travel more suitable. It is the first to be used in

---

cities with large-scale economies and more developed floating populations. The point is that leasing can alleviate the small number of parking spaces to a certain extent, and it is also an emerging public transportation mode (Levine et al., 2009; Qiu and Wang,2016). Time-sharing lends the theoretical content of the sharing economy, which is an important step in the process of sharing the economic theory. Time-sharing leasing allows car owners and users to achieve a win-win situation, meet the needs of market development, and create new space for their own development (Bardhi et al., 2012; Lü et al,2020).

Regarding the research on time-sharing lease scheduling, some study found that the biggest problem with time-sharing is the lack of number of rental points and coverage (Xu, 2016). In view of the location of the rental points, some scholars have taken the profit of the operating organisation as the target, considering the depreciation of the vehicle and other factors, and have proposed a linear programming model based on the choice of a time-based rental vehicle rental location and the number of parking spaces at the outlet (Correia, 2012; Zhou and Cao,2019). For the time-sharing lease scheduling, the model of dynamic scheduling of a time-sharing lease has been established with the minimum operating cost as the objective function, and the problem of rent pricing has been discussed based on the management idea (Kaplan et al., 2010). Some scholars apply the relevant theories of revenue management to the allocation and scheduling of time-sharing rental vehicles, while others use decision support tools to evaluate the efficiency of the car rental system, aiming to meet users' demands with the minimum number of vehicles to the maximum extent, which is also a scheduling problem(Chen et al., 2005; Fassi et al., 2012). Some scholars have also conducted relevant research on the optimisation of time-sharing leases. Based on the goal of maximising the profit of the operator, a model for the allocation of the leased vehicle has been established, and the maximum benefit of the operator during the peak hours of the car rental and the corresponding optimal user reservation allocation plan have been obtained by solving the model (Wang et al., 2017; Michaelides,2020).

---

In recent years, game research of new energy automobile market has achieved rich results. The results show that current research direction of new energy vehicles focuses on the formulation of government policies, the layout of charging piles, and parking facilities. From their analysis of existing technologies and policies .Yuan et al. (2015) and Liu et al. (2010) proposed that policy guidance and planning play a vital role in the development of the new energy automobile industry.Zhong (2015) and Huang et al(2013) used different methods to analyze the subsidy strategy of new energy vehicles; Huang and Pu(2018)built an evolutionary game model of new energy sources to study competition strategy of time-sharing rental cars in the market. Based on the social–technical transformation theory, Xue et al. (2013) analysed the dynamic linkage and mutual feedback mechanism of various elements in China's current automobile domain from a multi-level perspective. As the research progresses, third-party participation by consumers is also included in the regulatory system. Luo (2014) discussed the impact of government behaviour on the electric vehicle industry from the perspective of industrial chain. Furthermore, Zhong et al. (2015), Fan et al. (2017) used the signal game to analyse the adverse selection problems in the subsidy process and proposed suggestions for improving the efficiency of the subsidy policy. In general, the existing game research involving the development of new energy vehicles has achieved fruitful results and played an important role in the promotion and development of new energy vehicles. Yang et al.(2018) suggested that government support policies, such as subsidies and tariffs, could effectively expand market share for low-tech domestic new energy vehicles. Li et al.(2019) analyzed the dynamic impact of policy and financial support on the relationship between enterprise size and efficiency in the new energy automobile industry, and concluded that it is conducive to improving the efficiency of large new energy enterprises.

In summary, the existing research lacks analysis of the new energy vehicle supervision system in the time-sharing field, and most of the studies are static research. In the regulation of the new energy industry, government, enterprises and consumers form a dynamic multiple game relationship. In light of the particular

---

circumstances of the electric vehicle industry, it is difficult to break the “production and marketing dilemma” using only the game between producers and consumers. Only by including the government as the third party in the game process can stimulate demand growth and promote sustainable development of the industry. How to design the combination of regulatory strategies, so as to give full play to the role of regulatory policies in expanding the scale of electric vehicle market is of great significance for the electric vehicle industry with sluggish market performance. Therefore, this paper draw lessons from the study of the multi-party game of the green supply chain, build evolutionary game model to study strategy choices of three kinds of groups in different periods, find out the control strategy combinations and the relationship between the enterprise and consumer behavior decision-making, finally to meet the new energy car rental industry regulations state of optimal time-sharing, and gives the corresponding policy recommendations.

## **2 Game theory model**

### **2.1 Hypothesis**

Evolutionary game theory originated from Darwin's theory of evolution (Cai et al., 2009). The basic idea is that the decision-makers of bounded rationality constantly adjust the strategy in the process of repeated games, and finally form a stable equilibrium point in the evolution process (Song et al. ,2014). Evolutionary game theory is used widely in the field of regulation by means of replication dynamics (Shen et al.,2017).

Evolutionary game research has become more and more mature under the supervision of many parties. Under the supervision of many parties, the study of evolutionary game has become more and more mature. Some scholars have successfully applied the three-party evolutionary game model to the tourism market (Zhou et al., 2016; Qi et al., 2018), food safety (Zhang et al., 2015), environmental pollution (Cao et al., 2017) and medical treatment (Zhan et al., 2017), and obtained the market evolution conclusions and policy regulatory recommendations.

This paper assumes that the main players involved in the new energy time-sharing

---

car supervision process are the government, enterprises, and consumers. Brief definitions and strategic choices of each of these players are given as follows:

Government: The new energy-time leasing departments of automobile industry supervision and subsidies, including the Ministry of Communications, the Ministry of Communications, the Ministry of Finance, the Ministry of Science and Technology, and the National Development and Reform Commission, play joint roles in supervision and coordinated promotion of governance. As the government is the policy maker and the dominant player in the game, the choice of the game strategy is regulation and non-regulation, that is, the two strategies are adopted to supervise the behaviour of enterprises to achieve the optimal situation of industry governance and let the industry develop freely to achieve a stable state.

Enterprise: A shared automobile enterprise that adopts the characteristics of new energy for automobile power, a time-lease business mode for renting while running, and parking mode for vehicles as "stop and go". Due to either cost constraints or greater benefits, enterprises involved in the production of new energy vehicles will have to deduct the subsidies paid by the government and cut corners. In addition, in the operation process of time-sharing car rental, consumers are not strictly audited, the service is not good, and the number of parking and charging points is too small or the planning is unreasonable. Under the supervision of the government and consumers, enterprises plan to adopt the two strategies of "endeavor" and "don't endeavor".

Consumers: As direct users of this emerging shared economic phenomenon, there will be negative comments on the new energy time-sharing car rental industry in the process of using the new energy timesharing car rental service due to enterprises' bad operation and other behaviors. Weighing the gains and losses of participation in supervision costs and service improvement and compensation gains determines the set of strategies of consumers in the game system, which are to either participate in supervision, report and feedback related bad behaviours, or maintain a wait-and-see attitude. From the above definition of concepts and model assumptions, a three-party game model of government–enterprise–consumer in the new energy-time leasing

period and supervision process is established, as shown in Figure 1.

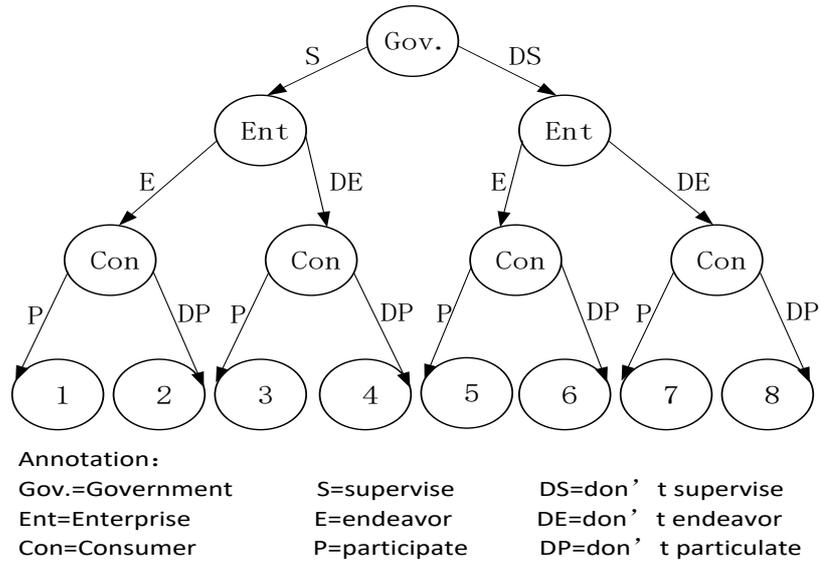


Figure 1. Three-party game theory tree

The following assumptions are made about the model:

Hypothesis 1: In the game between government, enterprises, and consumers, the probability of government choosing supervision is  $x$ , the probability that enterprises choose to work hard is  $y$ , and the probability that consumers choose to participate in supervision is  $z$ , where  $x, y, z \in [0, 1]$ , are functions of time  $t$ .

Hypothesis 2: The total amount of government subsidies provided to enterprises is  $S$ . If the subsidy is issued normally every year, the business status of the enterprise must meet the government's auditing standards. If they are not met, there will be cases where either consumers do not participate or the government supervises. Parameter  $p_1$  is the probability of subsidy cancellation after being discovered.

Hypothesis 3: The cost of the government's choice of regulatory strategy is  $C_1$ . After discovering that the company does not work hard, the government will charge the enterprise a fine of  $F$ . The social benefit obtained after the successful supervision is  $R$ .

Hypothesis 4: Social benefits  $R$  of government regulation include market order correction, road traffic improvement, safety hazard elimination and reduction of adverse public opinion'. If the government chooses not to supervise and the company

chooses not to work hard, the amount of damage caused to the government is  $R$ .

Hypothesis 5: The cost of the business operation phase is divided into fixed cost  $C_2$  and effort cost  $C'$ . The fixed cost is the basic cost when the enterprise maintains normal operation, and the effort cost is paid by an enterprise to achieve the audit requirements and market demands.

Hypothesis 6: When a consumer experiences a substandard product, the loss suffered is  $L_1$ . After the consumer chooses to participate in the supervision and feedback to the government department, the probability that the government supervises the enterprise's ineffective business behaviour is  $p_2(p_2 > p_1)$ , and the cost of consumer participation supervision is  $C_3$ . After the enterprise's inactivity is detected, the consumers are compensated with a value of  $kC'$ ,  $k$  is the compensation coefficient of the enterprise to consumers, and the reputation loss suffered by the enterprise is  $L_2$ .

Hypothesis 7: When consumers choose to participate in the supervision and enterprises do not work hard to operate, if the government's strategy is to choose non-supervision, then consumers' willingness is not responded, leading to a decline in the credibility of the government, and the loss value is  $L_3$ .

Hypothesis 8: When the company chooses not to work hard, the income obtained is  $R_1$ . When the company chooses to work hard, the income obtained is  $R_2(R_2 > R_1)$ .

## 2.2 Function

According to the above assumptions, under the condition that all three parties are bounded rational and the information is asymmetric, the payment matrix is listed as shown in Table 1 and Table 2.

Table 1 The payment matrix of enterprises and consumers when the government regulate

		enterprises	
		Work hard	Not working hard
consumer	Involved	$R - S - C_1,$ $S + R_2 - C_2 - C',$ $-C_3$	$(F + R)p_2 - (1 - p_2)(S + L_3 + R) - C_1,$ $R_1 - C_2 + (1 - p_2)S - p_2(L_2 + kC' + F),$ $p_2kC' - C_3 - L_1$

Not involved	$R - S - C_1,$ $S + R_2 - C_2 - C',$ $0$	$(F + R)p_1 - (1 - p_1)(S + R) - C_1,$ $R_1 - C_2 + (1 - p_1)S - p_1(L_2 + kC' + F),$ $-L_1$
--------------	--	--

Table 2 The payment matrix of enterprises and consumers when the government does not regulate

		enterprises	
		Work hard	Not working hard
consumer	Involved	$R - S,$	$-R - S - L_3,$
		$S + R_2 - C_2 - C',$	$S + R_1 - C_2 - L_2$
	Not involved	$-C_3$	$-C_3 - L_1$
		$R - S,$	$-R - S,$
	$S + R_2 - C_2 - C',$	$R_1 + S - C_2,$	
	$0$	$-L_1$	

Note: In Tables 1 and 2, the first function item in each table represents government revenue, the second function item represents enterprise revenue, and the third function item represents consumer revenue.

### 2.3 Analysis

Before the game analysis, we first analyse the expected returns of the government, enterprises, and consumers.

The expected return of the government's choice of a regulatory strategy is

$$E_{11} = y(R - S) + z(1 - y)[(F + R)p_2 - (1 - p_2)(S + L_3 + R)] + (1 - y)(1 - z)[(F + R)p_1 - (1 - p_1)(S + R)] - C_1$$

The expected return of the government's choice of a non-regulatory strategy is

$$E_{12} = y(R - S) + (1 - y)(-R - S) + z(1 - y)(-L_3)$$

The average expected return of the government is

$$\bar{E}_1 = xE_{11} + (1 - x)E_{12}$$

The expected return of the enterprise's choice of a hard work strategy is

$$E_{21} = (S + R_2 - C_2 - C')$$

The expected return of the company's choice of not working hard is

$$E_{22} = R_1 - C_2 + (1 - x)S - z(1 - x)L_2 + xz[(1 - p_2)S - p_2(L_2 + kC' + F)] + x(1 - z)[(1 - p_1)S - p_1(L_2 + kC' + F)]$$

The average expected return of the company is

$$\bar{E}_2 = yE_{21} + (1 - y)E_{22}$$

The expected return of consumers choosing to participate in the monitoring strategy is

$$E_{31} = x(1 - y)p_2kC' - (1 - y)L_1 - C_3$$

The expected return of consumers choosing not to participate in supervision is

$$E_{32} = (1 - y)(-L_1)$$

The average expected return of consumers is

$$\bar{E}_3 = zE_{31} + (1 - z)E_{32}$$

### 2.3.1 Government regulatory stability strategy

The government's choice of supervision of the replication dynamic equation is

$$\begin{aligned} \frac{dx}{dt} = F(x) &= x(1 - x)(E_{11} - E_{12}) \\ &= x(1 - x) * [z(1 - y)[(F + R)p_2 - (1 - p_2)(S + L_3 + R) + L_3] \\ &\quad + (1 - y)(R + S) + (1 - y)(1 - z)[(F + R)p_1 - (1 - p_1)(S + R)] - C_1] \end{aligned}$$

(1) The effect of  $y$  on  $x$  value

$$X_y = 1 - \frac{C_1}{z[(F+R)p_2 - (1-p_2)(S+L_3+R) + L_3] + (1-z)[(F+R)p_1 - (1-p_1)(S+R)] + R+S}, \text{ if } y =$$

$X_y$ , then  $F(x) \equiv 0$ , it is always in a stable state; if  $y \neq X_y$ , let  $F(x) = 0$ , then  $x = 0$

or  $x = 1$ ; if  $y > X_y$ , when  $x = 0$ , it is in a stable state; if  $y < X_y$ , when  $x = 1$ , it is

in a stable state. Therefore, the conclusion is as follows:

**Conclusion 1: The probability that the government chooses a regulatory strategy will decrease as the probability of the firm choosing to work harder increases.**

$$\text{Prove : } \frac{\partial F(x)}{\partial x} = (1 - 2x)[z(1 - y)[(F + R)p_2 - (1 - p_2)(S + L_3 + R) + L_3] + (1 - y)(R + S) + (1 - y)(1 - z)[(F + R)p_1 - (1 - p_1)(S + R)] - C_1]$$

If  $y > X_y$  and  $x = 0$ ,  $F'(x) < 0$ , when  $x = 0$ , it is in a stable state.

Conclusion 1 is proved.

(2) The effect of  $z$  on  $x$  value

$$X_z = - \frac{[(F+R)p_1 - (1-p_1)(S+R)] + (1-y)(R+S) - C_1}{[(F+R)(p_2 - p_1) + (p_1 - p_2)(S+R) + p_2L_3](1-y)}, \text{ if } z = X_z, \text{ then } F(x) \equiv 0, \text{ it is}$$

always in a stable state; if  $z \neq X_z$ , let  $F(x) = 0$ , then  $x = 0$  or  $x = 1$ ; if  $z > X_z$ ,

when  $x = 1$ , it is in a stable state; if  $z < X_z$ , when  $x = 0$ , it is in a stable state. Therefore, the conclusion is as follows:

**Conclusion 2: The probability that the government chooses a regulatory strategy increases as the probability of consumers choosing to participate in supervision increases.**

**Prove :** 
$$\frac{\partial F(x)}{\partial x} = (1 - 2x)[z(1 - y)[(F + R)p_2 - (1 - p_2)(S + L_3 + R) + L_3] + (1 - y)(R + S) + (1 - y)(1 - z)[(F + R)p_1 - (1 - p_1)(S + L_3 + R)] - C_1]$$

If  $z > X_z$  and  $x = 1, F'(x) < 0$ , when  $x = 1$ , it is in a stable state.

Conclusion 2 is proved.

### 2.3.2 Enterprises strive to operate stable strategies

The replication dynamic equation that the enterprise chooses to work hard is

$$\begin{aligned} \frac{dy}{dt} = F(y) = & y(1 - y)(E_{21} - E_{22}) = y(1 - y)[R_2 - R_1 - C' + xS \\ & + z(1 - x)L_2 - xz[(1 - p_2)S - p_2(L_2 + kC' + F)] - x(1 - z)[(1 - p_1)S \\ & - p_1(L_2 + kC' + F)] \end{aligned}$$

(1) The effect of  $x$  on  $y$  value

$$Y_x = - \frac{R_2 - R_1 - C' + zL_2}{S - zL_2 - z[(1 - p_2)S - p_2(L_2 + kC' + F)] - (1 - z)[(1 - p_1)S - p_1(L_2 + kC' + F)]}, \text{ if } x = Y_x, \text{ then}$$

$F(x) \equiv 0$ , it is always in a stable state; if  $x \neq Y_x$ , let  $F(y) = 0$ , then  $y = 0$  or  $y = 1$ ; if  $x > Y_x$ , when  $y = 1$ , it is in a stable state; if  $x < Y_x$ , when  $y = 0$ , it is in a stable state. Therefore, the conclusion is as follows:

**Conclusion 3: The probability that an enterprise chooses to work hard increases as the probability of the government choosing to monitor increases.**

**Prove :** 
$$\frac{\partial F(y)}{\partial y} = (1 - 2y)[R_2 - R_1 - C' + xS + z(1 - x)L_2 - xz[(1 - p_2)S - p_2(L_2 + kC' + F)] - x(1 - z)[(1 - p_1)S - p_1(L_2 + kC' + F)]]$$

If  $x > Y_x$  and  $y = 1, F'(y) < 0$ , when  $y = 1$ , it is in a stable state.

Conclusion 3 is proved.

(2) The effect of  $z$  on  $y$  value

$$Y_z = - \frac{R_2 - R_1 - C' + xS - x[(1 - p_1)S - p_1(L_2 + kC' + F)]}{(1 - x)L_2 + x[(p_2 - p_1)S + (p_2 - p_1)(L_2 + kC' + F)]}, \text{ if } z = Y_z, \text{ then } F(x) \equiv 0, \text{ it is}$$

always in a stable state; if  $z \neq Y_z$ , let  $F(y) = 0$ , then  $y = 0$  or  $y = 1$ ; if  $z > Y_z$ ,

when  $y = 1$ , it is in a stable state; if  $z < Y_z$ , when  $y = 0$ , it is in a stable state. Therefore, the conclusion is as follows:

**Conclusion 4: The probability that an enterprise chooses to work hard increases as the probability of consumers choosing to participate in supervision increases.**

**Prove :** 
$$\frac{\partial F(y)}{\partial y} = (1 - 2y)[R_2 - R_1 - C' + xS + z(1 - x)L_2 - xz[(1 - p_2)S - p_2(L_2 + kC' + F)] - x(1 - z)[(1 - p_1)S - p_1(L_2 + kC' + F)]$$

If  $z > Y_z$  and  $y = 1, F'(y) < 0$ , when  $y = 1$ , it is in a stable state.

Conclusion 4 is proved.

### 2.3.3 Consumer participation in monitoring and stabilising strategies

The replication dynamic equation that consumers choose to participate in supervision is

$$\frac{dz}{dt} = F(z) = z(1 - z)(E_{31} - E_{32}) = z(1 - z) * [x(1 - y)p_2kC' - C_3]$$

(1) The effect of  $x$  on  $z$  value

$Z_x = \frac{C_3}{(1-y)p_2kC'}$ , if  $x = Z_x$ , then  $F(z) \equiv 0$ , it is always in a stable state; if  $x \neq Z_x$ , let  $F(z) = 0$ , then  $z = 0$  or  $z = 1$ ; if  $x > Z_x$ , when  $z = 1$ , it is in a stable state; if  $x < Z_x$ , when  $y = 0$ , it is in a stable state. Therefore, the conclusion is as follows:

**Conclusion 5: The probability that a consumer chooses to participate in a surveillance strategy increases as the probability of government selection for regulation increases.**

**Prove:** 
$$\frac{\partial F(z)}{\partial z} = (1 - 2z)[x(1 - y)p_2kC' - C_3]$$

If  $x > Z_x$  and  $z = 1, F'(z) < 0$ , when  $z = 1$ , it is in a stable state.

Conclusion 5 is proved.

(2) The effect of  $y$  on  $z$  value

$Z_y = \frac{xp_2kC' - C_3}{p_2kC' + (x-1)(C_3 + L_1)}$ , if  $y = Z_y$ , then  $F(z) \equiv 0$ , it is always in a stable state; if  $y \neq Z_y$ , let  $F(z) = 0$ , then  $z = 0$  or  $z = 1$ ; if  $y > Z_y$ , when  $z = 0$ , it is in a stable state; if  $y < Z_y$ , when  $y = 1$ , it is in a stable state. Therefore, the conclusion is as

---

follows:

**Conclusion 6:**The probability that a consumer chooses to participate in a supervisory strategy decreases as the probability of the firm choosing to work hard increases.

**Prove:**  $\frac{\partial F(z)}{\partial z} = (1 - 2z)[x(1 - y)p_2kC' - C_3]$

If  $y > Z_y$  and  $z = 0$ ,  $F'(z) < 0$ , when  $z = 0$ , it is in a stable state.

Conclusion 6 is proved.

### 2.3.4 Evolutionary game path analysis

In the game analysis above, the probabilities that governments, enterprises, and consumers adopt strategies  $x$ ,  $y$ , and  $z$  are parameters related to time  $t$ . The replication dynamic equations' solution domain is  $[0,1] * [0,1] * [0,1]$ . Let  $F(x) = 0$ ,  $F(y) = 0$ , and  $F(z) = 0$ , then 14 equilibrium points are obtained during the game; these are  $N_1(0,0,0)$ 、 $N_2(1,0,0)$ 、 $N_3(1,1,0)$ 、 $N_4(1,0,1)$ 、 $N_5(0,1,0)$ 、 $N_6(0,1,1)$ 、 $N_7(0,0,1)$ 、 $N_8(1,1,1)$ 、 $N_9(0, Z_y, Y_z)$ 、 $N_{10}(1, Z_y, Y_z)$ 、 $N_{11}(Z_x, 0, X_z)$ 、 $N_{12}(Z_x, 1, X_z)$ 、 $N_{13}(Y_x, X_y, 0)$  and  $N_{14}(Y_x, X_y, 1)$ , The first eight equilibrium points constitute the boundary  $Q$  of the three-party evolutionary game solution domain.  $Q = \{(x, y, z) \mid 0 \leq x \leq 1, 0 \leq y \leq 1, 0 \leq z \leq 1\}$ . The latter six equilibrium points exist within the three-dimensional spatial solution domain, satisfying the situation where the government, enterprise, and consumer policy choices' change rate is zero.

From the analysis of the conclusions 1– 6, we can see that the strategies of the government, enterprises, and consumers in the game process will change with the changes of the other two parties over time, and the result is also the initial game. The size of each parameter set has a close relationship. The partial dynamic derivatives of  $x$ ,  $y$ , and  $z$  are obtained for the replication dynamic equations of the government, enterprises, and consumers, respectively, and the Jacobian matrix  $J$  (Friedman,1991) is obtained.

$$J = \begin{bmatrix} \frac{\partial F(x)}{\partial x} & \frac{\partial F(x)}{\partial y} & \frac{\partial F(x)}{\partial z} \\ \frac{\partial F(y)}{\partial x} & \frac{\partial F(y)}{\partial y} & \frac{\partial F(y)}{\partial z} \\ \frac{\partial F(z)}{\partial x} & \frac{\partial F(z)}{\partial y} & \frac{\partial F(z)}{\partial z} \end{bmatrix}$$

The Jacobian matrix is solved to obtain the eigenvalues corresponding to the respective equalisation points, as shown in Table 3.

Table 3 Characteristic values corresponding to each equilibrium point

Equilibrium point	Eigenvalues		
$N_1(\mathbf{0}, \mathbf{0}, \mathbf{0})$	$p_1(2R + S + F) - C_1$	$R_2 - R_1 - C'$	$-C_3$
$N_2(\mathbf{1}, \mathbf{0}, \mathbf{0})$	$C_1 - p_1(2R + S + F)$	$R_2 - R_1 - C' + p_1S$ $+p_1(L_2 + kC' + F)$	$p_2kC' - C_3$
$N_3(\mathbf{1}, \mathbf{1}, \mathbf{0})$	$C_1$	$-R_2 + R_1 + C' - p_1S$ $-p_1(L_2 + kC' + F)$	$-C_3$
$N_4(\mathbf{1}, \mathbf{0}, \mathbf{1})$	$-[2(1 - p_2)R$ $+ (2 - p_2)(S + L_3) + Fp_2]$	$R_2 - R_1 - (1 + p_2k)C'$ $-p_2(L_2 + F)$	$-(p_2kC' - C_3)$
$N_5(\mathbf{0}, \mathbf{1}, \mathbf{0})$	$-C_1$	$C' - R_2 + R_1$	$-C_3$
$N_6(\mathbf{0}, \mathbf{1}, \mathbf{1})$	$-C_1$	$-(R_2 - R_1 - C' + L_2)$	$C_3$
$N_7(\mathbf{0}, \mathbf{0}, \mathbf{1})$	$[2(1 - p_2)R$ $+ (2 - p_2)(S + L_3) + Fp_2]$	$(R_2 - R_1 - C' + L_2)$	$C_3$
$N_8(\mathbf{1}, \mathbf{1}, \mathbf{1})$	$C_1$	$-[R_2 - R_1 - (1 + p_2k)C'$ $-p_2(L_2 + F)]$	$C_3$
$N_9 \sim N_{14}$	There are eigenvalues with different symbols, no longer detailed		

In the game system, each equilibrium point corresponds to an equilibrium selection. For the eigenvalues of the Jacobian matrix,  $J$ , there are negative real parts, and the corresponding equilibrium point is a stable point, whereas the equilibrium point corresponding to the real part is an unstable point (Friedman, 1998; Di, 2014). In other words, when all eigenvalues are negative, the corresponding equilibrium point is the evolutionary stability strategy of the system; When all eigenvalues are

---

positive, the corresponding equilibrium point is the unstable point; When the eigenvalue is one minus two plus or one plus two minus, the corresponding equilibrium point is the saddle point.

The three eigenvalue symbols for each of the points  $N_9 \sim N_{14}$  are different. It is impossible to have three eigenvalues that are either positive or negative at the same time. Therefore, the six equalisation points must be saddle points. Note that, no matter how the parameter values of the system change, these 6 points will not become the equilibrium point of the system. Then, we analyse the eigenvalues of  $N_1 \sim N_8$  and draw the following conclusions:

**Conclusion 7: (Regulated, hard-working, not involved in supervision), (not regulated, hard-working/not working hard, participating in supervision), (regulation, hard work, participation in supervision). These four strategic options do not exist.**

**Prove:** In  $N_3, N_6, N_7, N_8$ , there are eigenvalues that are not significantly negative. Taking  $N_3(1,1,0)$  as an example, one of the eigenvalues is  $C_1$ . Since the cost parameters are positive in the model hypothesis,  $N_3(1,1,0)$  must not be the equilibrium point. By analogy, the other three boundary points are not stable points of system evolution.

### 2.3.5 Key parameter analysis

The following four boundary equilibrium points of  $N_1, N_2, N_4$ , and  $N_5$  are analysed, and the real-world situation analysis is used to analyse the key parameters affecting government, enterprise, and consumer strategy choices:

#### (1) Key parameters affecting government strategy selection

Among the four boundary equilibrium points, the values of  $\frac{\partial F(x)}{\partial x}$  in  $N_4, N_5$  are significantly less than 0, so they are not analysed in this section.

In the  $N_1$  and  $N_2$  states, the government's strategic choices are not regulation and supervision. If the condition of  $\frac{\partial F(x)}{\partial x} < 0$  is satisfied, the two evolution states tend to be stable. The condition is  $p_1(2R + S + F) - C_1 < 0$  and  $p_1(2R + S + F) -$

---

$C_1 > 0$ . The analysis of the formula shows that the subsidy amount  $S$  and the penalty strength  $F$  are important parameters that influence the choice of government strategy. In the case of a small amount of subsidy and punishment, the government expects that the expected return of supervision is less than zero. Since the government does not participate in the supervision, the probability of successful government supervision is low, and the income obtained is not enough to offset the cost of supervision  $C_1$ . Therefore, changing the government's strategy in the game system to the ideal state requires increasing the amount of subsidies and penalties until the expected return is greater than zero.

### **(2)Key parameters affecting consumer strategy choices**

In the state of  $N_2$  and  $N_4$  in the supervision process of the new energy time-sharing car industry, the participation of consumers in the supervision depends on the positive and negative values of the conditional formula  $p_2kC' - C_3$ . In the  $N_2$  and  $N_4$  states, since the enterprise's effort cost has a high value, the key parameter that determines the establishment of  $p_2kC' - C_3 > 0$  is the compensation coefficient. The larger the compensation coefficient, the larger the value on the left side of the inequality. Therefore, it can be seen from the formula that, in the case of small compensation coefficient, the realistic situation corresponding to state  $N_2$  is that consumers would rather bear the loss of  $L_1$  than pay labor, time and other supervision costs to participate in the supervision of the industry. To change the status of  $N_2$  to  $N_4$ , the government needs to provide complaint channels to reduce the cost of consumer participation in supervision, increase the amount of compensation paid to consumers when penalising problems, and increase consumers' willingness to participate in supervision.

### **(3)Key parameters affecting corporate strategy selection**

The most ideal state for the supervision of new energy time-sharing car companies is  $N_5$  (not regulated, hard-working, not involved in supervision). In this state, the proportion of enterprises' efforts in business strategy selection is relatively high, and the industry has embarked on the road of self-discipline. Comparing state  $N_1$  with

---

state  $N_5$ , it is found that the key condition affecting enterprise policy selection is  $R_2 - R_1 - C'$ . When the cost of efforts to select a company to operate is greater than is the difference between  $R_2$  and  $R_1$ , the strategic choice of the company tends to be not to work hard. As for the enterprise itself, the most important thing is to promote technology upgrades and increase investment in research and development funds in the enterprise's technical department, thereby reducing the cost of efforts to achieve the optimal state of enterprise development.

### 3 Simulation analysis

Based on the above analysis, the evolutionary stability of the system depends on the initial conditions and changes of the relevant parameters. To more intuitively reflect the subject's behavioural evolution path and the influence of parameter values on the evolutionary stability results, this section uses numerical simulation analysis for the above evolutionary game model using *python3.6* software. The key parameters involved are the amount of subsidy,  $S$ , penalty strength,  $F$ , effort cost,  $C'$ , and compensation coefficient,  $k$ , and the initial values of each parameter are  $R = 5$ ,  $R_1 = 17$ ,  $R_2 = 20$ ,  $p_1 = 0.3$ ,  $p_2 = 0.5$ ,  $L_1 = 2$ ,  $L_2 = 5$ ,  $L_3 = 5$ ,  $L_4 = 2$ ,  $k = 0.5$ ,  $S = 1$ ,  $F = 1$ ,  $C_1 = 5$ ,  $C_2 = 5$ ,  $C_3 = 3$ , and  $C' = 10$ .

The initial proportion of government, enterprises, and consumer behaviour decisions is 0.8.

#### 3.1 The impact of subsidy and punishment on system evolution

In the case where the subsidy  $S$  and the penalty force  $F$  are set to (1,1), (1,5), (5,1), (5,5), respectively, the system state evolution simulation diagram is shown in Figures 2–5.

With the subsidy and punishment being small, over time, the government, enterprises, and consumers' strategy choices show a trend of evolution to state  $N_1$ , and the value of subsidy and punishment is increased in a certain range. Excessive subsidies and penalties also slows down the speed at which policy choices evolve toward state  $N_1$ . After the subsidy  $S$  and the penalty force  $F$  are raised to meet the

condition of  $p_1(2R + S + F) - C_1 > 0$ , the policy choices of the government, enterprises, and consumers evolve toward the state  $N_2$  as time progresses. trend. Under the condition that the subsidy and punishment strength values meet the conditions, the rest of the parameter changes are not considered. Only the government's strategic choices change, which proves that only the change of subsidy and punishment cannot promote the evolution of the entire regulatory game system to the ideal state.

Therefore, to make the system evolve to an ideal state, the government departments need to increase the support for new energy-time leasing auto companies and strictly check the actual operation of the subsidised enterprises and the quality of the substandard, fraudulent subsidies. Enterprises with such phenomena charge high fines, and, in severe cases, impose penalties for shutting down the rectification.

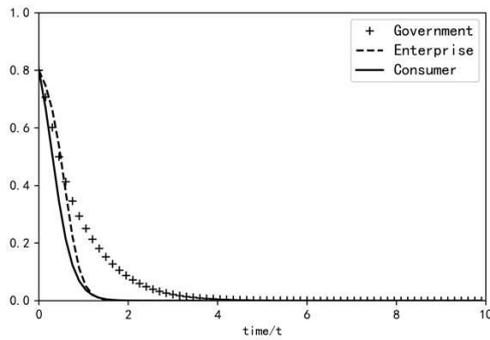


Fig. 2  $S=1$   $F=1$

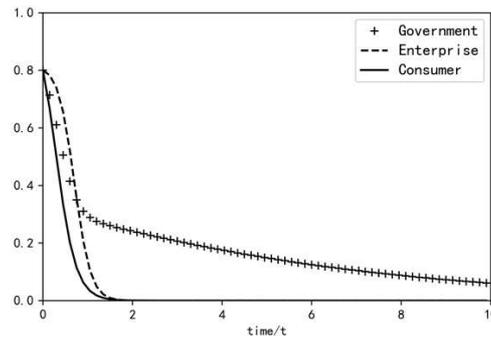


Fig. 3  $S=5$   $F=1$

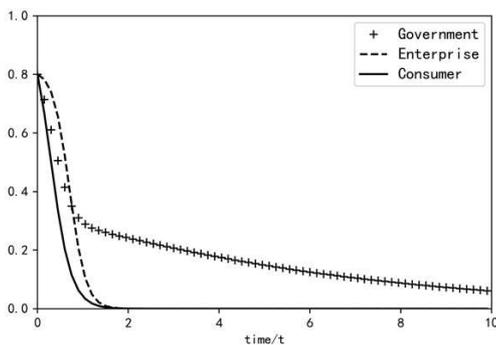


Fig. 4  $S=5$   $F=1$

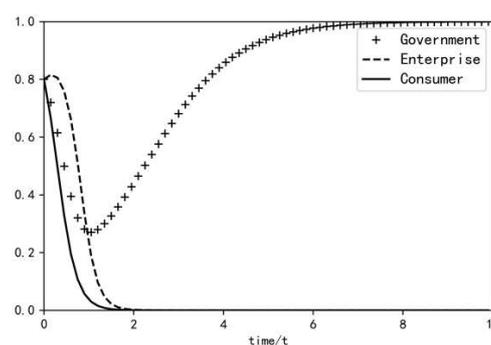


Fig. 5  $S=5$   $F=5$

### 3.2 The influence of compensation coefficient on system evolution

In the simulation analysis of the compensation coefficient, to avoid the influence of the irrelevant variable subsidy  $S$  and the penalty force  $F$ , the amount of the

subsidy  $S$  and the penalty force  $F$ , respectively, are set to 5. The simulation diagram of the system state evolution under the condition that the compensation coefficients are set to 0.5 and 0.9, respectively, is as shown in Fig. 6 and Fig. 7.

In the case where the compensation coefficient is set large, the consumer's strategy choice evolves to participation in the supervision after a certain time node, meaning that the value of the compensation coefficient plays a decisive role in the consumer's strategy choice if the remaining parameters are not changed.

Therefore, as consumers participate in the supervision of the positive promotion of new energy-time leasing vehicle supervision, the government should require enterprises to compensate consumers to a higher degree when they punish the problem enterprise, and improve consumer participation in regulatory willingness.

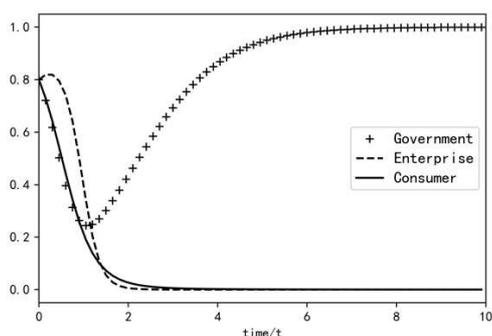


Fig.6  $k = 0.5$

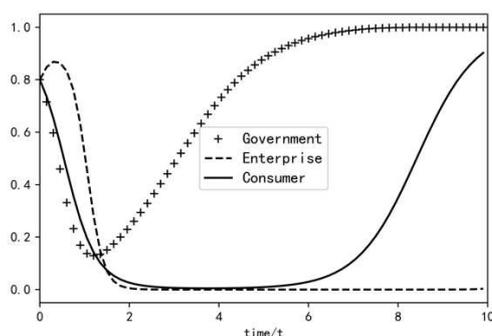


Fig.7  $k = 0.9$

### 3.3 The impact of effort cost on system evolution

Combined with the previous analysis, if the whole system is evolved to the state  $N_5$ , the fundamental condition is  $R_2 - R_1 - C' > 0$ . The effort cost  $C'$  is set to 10 and 3, respectively, and the obtained system state evolution simulation diagram is shown in Fig. 8 and Fig.9.

Under the condition that enterprises are struggling to operate at low cost, the spontaneous choice of enterprises will tend to be work hard, improve the vitality of the industry, and expand the influence of the industry. The changes brought by this series of actions will drive the choices made by government and consumers. Without supervision and non-participation in supervision, companies will also choose to work hard. Currently, the new energy time-sharing car industry is on the right track, and the

necessity of supervision by the government and consumers has declined. To save manpower and material resources, the status  $N_5$  has become a dominant strategy in the regulatory game system. This situation is new. Energy time-sharing leasing is the ideal state of the automotive industry governance.

Therefore, the government should urge enterprises to use subsidies to support and streamline institutions; improve R&D technology and optimise operational planning; reduce the construction costs of facilities, such as parking spots and charging points; reduce operating costs, and achieve new energy-time leasing vehicle governance ideal state.

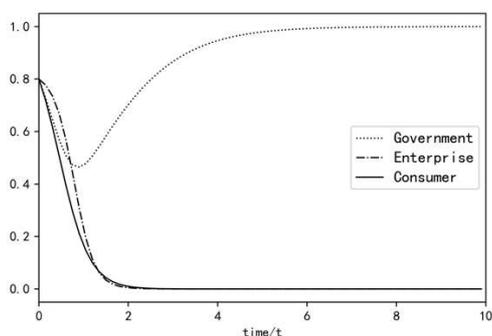


Fig.8  $C' = 10$

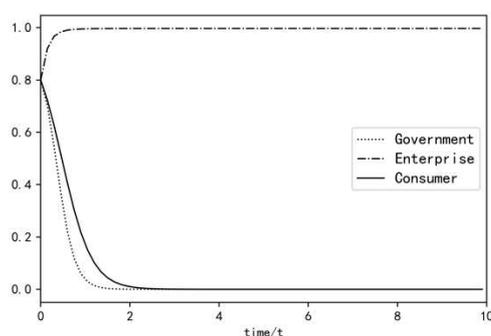


Fig.9  $C' = 3$

#### 4 Conclusion and suggestion

This paper analyzes the regulatory issues in the new energy time-sharing rental automobile industry, establishes a tripartite evolutionary game model for the government, enterprises and consumers, and obtains four key parameters affecting the game process, which are subsidy, penalty intensity, effort cost and compensation coefficient.

From analysis of Figure 2 to Figure 5, the subsidy range and punishment intensity have a positive effect on the evolution of the system to the ideal state. An appropriate increase in the scope of subsidies and penalties is conducive to the supervision of the new energy time-sharing car industry. In the early stage of the development of new energy time-sharing leasing industry, the government should appropriately increase the amount of subsidy for the supportive attitude, and increase the punishment for enterprises with bad business practices. This will accelerate the development of the

---

industry towards a good situation. Because the industry belongs to the form of heavy assets, when the subsidy is too low, the development of the enterprise will die due to capital factors. When the punishment intensity is too low, the enterprise that does not work hard is in the state of low risk and high return, and the enterprise will be inclined to not work hard because of the interest drive. Therefore, it is necessary to raise the threshold for enterprises to receive subsidies, and strictly supervise the requirement that the number of vehicles produced by enterprises reaches a certain level and the quality meets certain standards to receive subsidies. At the same time, industry access rules, security assurance regulations, and commercial competition standards are set up. Enterprises with malicious competition, fraudulent subsidies, infrequent censorship, and poor car quality are subject to high fines. If the circumstances are serious, they will be shut down and rectified.

From the analysis of Figure 6 and Figure 7, the consumer compensation coefficient has a positive effect on the evolution of the system to the ideal state. Increasing the consumer compensation coefficient appropriately is conducive to the supervision of the new energy time-sharing car industry. Since consumers are the direct experiencers of new energy time-sharing cars, they are the first to know whether the business is working hard or not. If consumers are involved in supervision, this can reduce the most inevitable lag in government regulation. To enhance consumers' willingness to participate in supervision, on the one hand, the government information platform should be optimised to provide consumers with more reporting channels. On the other hand, when penalising problem enterprises, the income from illegal and illegal enterprises should be compensated to a certain extent in the consumption process. Consumers who have a bad experience and participate in supervision encourage consumers to participate more in the supervision of new energy time-sharing cars, thereby reducing government supervision costs, and urge enterprises to work hard to improve the user experience.

From the analysis of Figure 8 and Figure 9, the effort of operating costs has a negative effect on the evolution of the system to the ideal state. After subsidies,

---

penalties, and compensation factors are at the desired level, the government should further urge enterprises to improve R&D technology and operating costs. In terms of charging points, the layout of charging pile points should be optimized, construction land coordinated and approval time of enterprises reduced. In terms of the use of subsidies provided, enterprises should be required to give preference to technology research and development and new product production; For specific models of new energy vehicles into the time-sharing rental market after the adoption of tax incentives. The conclusions of this study provide a theoretical basis and reference for policy formulation and decision-making in government departments.

### **Acknowledgement**

The authors gratefully thank the policy-making consulting project of Chongqing university of posts and telecommunications (K2017-112), the project of humanities and social sciences Ministry of Education in China(18YJC790224), the mental theory research project of the 19th CPC National Congress of Chongqing university of posts and telecommunications(K2018-60),the planning project of Chongqing social science (2016BS057).

### **DECLARATION OF INTEREST STATEMENT**

We wish to draw the attention of the Editor to the following facts which may be considered as potential conflicts of interest and to significant financial contributions to this work.

**Ethical Approval and Consent to participate:**We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

**Consent for publication:**We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to

---

intellectual property. In so doing we confirm that we have followed the regulations of our institutions concerning intellectual property.

**Availability of supporting data:** The data used to support the findings of this study are available from the corresponding author upon request.

**Competing interests:** We wish to confirm that there are no known conflicts of interest associated with this publication.

**Funding:** Financial support was provided, please specify below. The project of humanities and social sciences Ministry of Education in China(18YJC790224), the mental theory research project of the 19th CPC National Congress of Chongqing university of posts and telecommunications(K2018-60).

**Authors' contributions:** All authors of this manuscript have directly participated in planning, execution, and/or analysis of this study.

**Acknowledgements:** The authors gratefully thank the policy-making consulting project of Chongqing university of posts and telecommunications (K2017-112), the project of humanities and social sciences Ministry of Education in China(18YJC790224), the mental theory research project of the 19th CPC National Congress of Chongqing university of posts and telecommunications(K2018-60),the planning project of Chongqing social science (2016BS057).

We understand that the Corresponding Author is the sole contact for the Editorial process (including Editorial Manager and direct communications with the office). He is responsible for communicating with the other authors about progress, submissions of revisions and final approval of proofs. We confirm that we have provided a current, correct email address which is accessible by the Corresponding Author and which has been configured to accept email from [cqdxzhangwei@163.com](mailto:cqdxzhangwei@163.com).

Signed by all authors as follows:

Wei Zhang

Yejian Chen

Xiaoyu Wan

## References

- 
- [1] Bardhi F, Eckhardt G M. Access-based consumption: The case of car sharing[J]. *Journal of consumer research*, 2012, 39(4): 881-898.
- [2] Burkhardt J E, Millard-Ball A. Who is attracted to carsharing?[J]. *Transportation research record*, 2006, 1986(1): 98-105.
- [3] Cao X, Zhang L P. The Evolutionary Game Analysis on Green Technological Innovation of Enterprises under the Environmental Regulations——Based on the View of Stakeholder[J]. *Systems Engineering*, 2017.
- [4] Chen X. Car rental pricing and vehicle configuration based on revenue management [J]. *Systems Engineering Theory and Method Application*, 2005,6,14(3): 264-267.
- [5] de Almeida Correia G H, Antunes A P. Optimization approach to depot location and trip selection in one-way carsharing systems[J]. *Transportation Research Part E: Logistics and Transportation Review*, 2012, 48(1): 233-247.
- [6] Di L, Liu Y, Wang J, et al. Research on trust evolutionary game between virtual clusters in software industry. *Chinese Journal of Management Science*, 2014, 22(12): 118–125.
- [7] Dimatulac T, Maoh H, Khan S, et al. Modeling the demand for electric mobility in the Canadian rental vehicle market[J]. *Transportation Research Part D: Transport and Environment*, 2018, 65: 138-150.
- [8] Duan Y, Pu Y. Research on Time-Sharing Leasing Policy and Its Enlightenment to China[J]. *Automobile Industry Research*, 2017(3): 34-40.
- [9] El Fassi A, Awasthi A, Viviani M. Evaluation of carsharing network’s growth strategies through discrete event simulation[J]. *Expert Systems with Applications*, 2012, 39(8): 6692-6705.
- [10] Fan Ruguo, Feng Xiaodan. Research on Local Government New Energy Vehicle Subsidy Strategy in the “Post-Subsidy” Era[J]. *China Population Resources and Environment*, 2017, 27(3): 30-38.
- [11] Fan Y, Leslie D S, Wand M P. Generalised linear mixed model analysis via sequential Monte Carlo sampling[J]. *Electronic Journal of Statistics*, 2008, 2: 916-938.
- [12] Friedman D. Evolutionary Game in Economics [J]. *Econometrica*, 1991, 59(3): 637-666.
- [13] Friedman D. On economic application of evolutionary game theory [J]. *Journal of*

- 
- Evolutionary Economics, 1998, 8(1): 15-43.
- [14] Huang Y, Pu Y. Research on Evolutionary Game Model of New Energy Vehicle Timeshare Rental Market Competition[J]. China Management Science, 2018,26(02):79-85.
- [15] Jian H, Mingming L, Liping L, et al. Promoting electric automobiles: supply chain analysis under a government's subsidy incentive scheme [J]. Iie Transactions, 2013, 45(8): 826-844.
- [16] Levine M. Share my ride[J]. New York Times Magazine, 2009, 5:36-40.
- [17] Li Yawen, Zeng Bohan, Tian Wu, Hao Han. Effects of urban environmental policies on improving firm efficiency: Evidence from Chinese new energy vehicle firms. Journal of Cleaner Production.2019.01:600-610.
- [18] Liu Y, Feng Z. Development of Saving Energy and New Energy Vehicles [J]. Bus Technology & Research, 2010,1:4-7.
- [19] Lü X, Wu Y, Lian J, Zhang Y, Meng L. Energy management of hybrid electric vehicles: A review of energy optimization of fuel cell hybrid power system based on genetic algorithm. Energy Conversion and Management,2020(205): 112474.
- [20] Luo C. Research on Electric Vehicle Supply Chain Strategy Based on Government Subsidy[J]. Management Review, 2014, 26(12): 198-205.
- [21] Michaelides E. Thermodynamics and energy usage of electric vehicles. Energy Conversion and Management,2020(205): 112474.
- [22] Kaplan A M, Haenlein M. Users of the world, unite! The challenges and opportunities of Social Media[J]. Business horizons, 2010, 53(1): 59-68.
- [23] Katzev R. Car sharing: A new approach to urban transportation problems[J]. Analyses of social issues and public policy, 2003, 3(1): 65-86.
- [24] Qi K, Yang Z. Three-party Game Analysis of the Evolution of Tourism Public Crisis with Government Participation[J]. TOURISM TRIBUNE, 2018, 33(4): 46-58.
- [25] Qiu C, Wang G. New evaluation methodology of regenerative braking contribution to energy efficiency improvement of electric vehicles. Energy Conversion and Management,2016(119):389-398.
- [26] Shaheen S, Sperling D, Wagner C. Carsharing in Europe and North American: past, present, and future[J]. 1998.
- [27] Shen L, Wang Y. Research on Collaboration Mechanism in Public Service Outsourcing: An

- 
- Evolutionary Game Analysis[J]. *Management Review*, 2017, 29(3): 219-230.
- [28] Smallbone A, Jia B, Atkins P, Roskilly A. The impact of disruptive powertrain technologies on energy consumption and carbon dioxide emissions from heavy-duty vehicles. *Energy Conversion and Management*, 2020(6): 100030.
- [29] Song Z, Guo Y, Cui D, et al. Local Government Supervision and Evolutionary Game Analysis of Rare Earth Upstream Enterprises[J]. *Research Management*, 2014, 35(8): 145-152.
- [30] Wang Y, Bi J, Sun H. User-assigned allocation model for vehicle time-sharing model during peak hours[J]. *Journal of Beijing Jiaotong University: Natural Science Edition*, 2017.
- [31] Xiao Y. "Internet + Travel" to build a new format Electric car rental will become the main force [J]. *Economic Research Reference*, 2017(12): 34-35.
- [32] Xu C. Interconnection of electric vehicle charging equipment New national standard eradication charging ills[J]. *China Strategic Emerging Industries*, 2016, 1.
- [33] Xue W, Shao L, You J, et al. Social-technical domain analysis and transformation promotion for new energy vehicles[J]. *China Soft Science*, 2013(3):78-88.
- [34] Yang D, Qiu L, Yan J, et al. The government regulation and market behavior of the new energy automotive industry[J]. *Journal of Cleaner Production*, 2019, 210: 1281-1288.
- [35] Yuan X, Liu X, Zuo J. The development of new energy vehicles for a sustainable future: A review[J]. *Renewable & Sustainable Energy Reviews*, 2015, 42(C): 298-305.
- [36] Zhan X, Zhou L, Sun X. Advancement of Telemedicine Services Based on Evolutionary Game[J]. *Systems Engineering*, 2017(2): 95-102.
- [37] Zhang G, Gao X, Guan X. Evolutionary Game Model of Food Safety Supervision Based on Third Party Supervision[J]. *Journal of Systems Engineering*, 2015, 30(2): 153-164.
- [38] Zhong T, Du R. Research on New Energy Vehicle Subsidy Strategy Based on Game Theory[J]. *CMS*, 2015(s1): 817-822.
- [39] Zhou Y, Cao S. Energy flexibility investigation of advanced grid-responsive energy control strategies with the static battery and electric vehicles: A case study of a high-rise office building in Hong Kong. *Energy Conversion and Management*, 2019(199): 111888.
- [40] Zhou H, Chen S, Cui Y. Research on Tourism Market Supervision Mechanism Based on

---

Evolutionary Game[J]. Journal of Systems Engineering, 2016, 31(5): 618-624.

# Figures

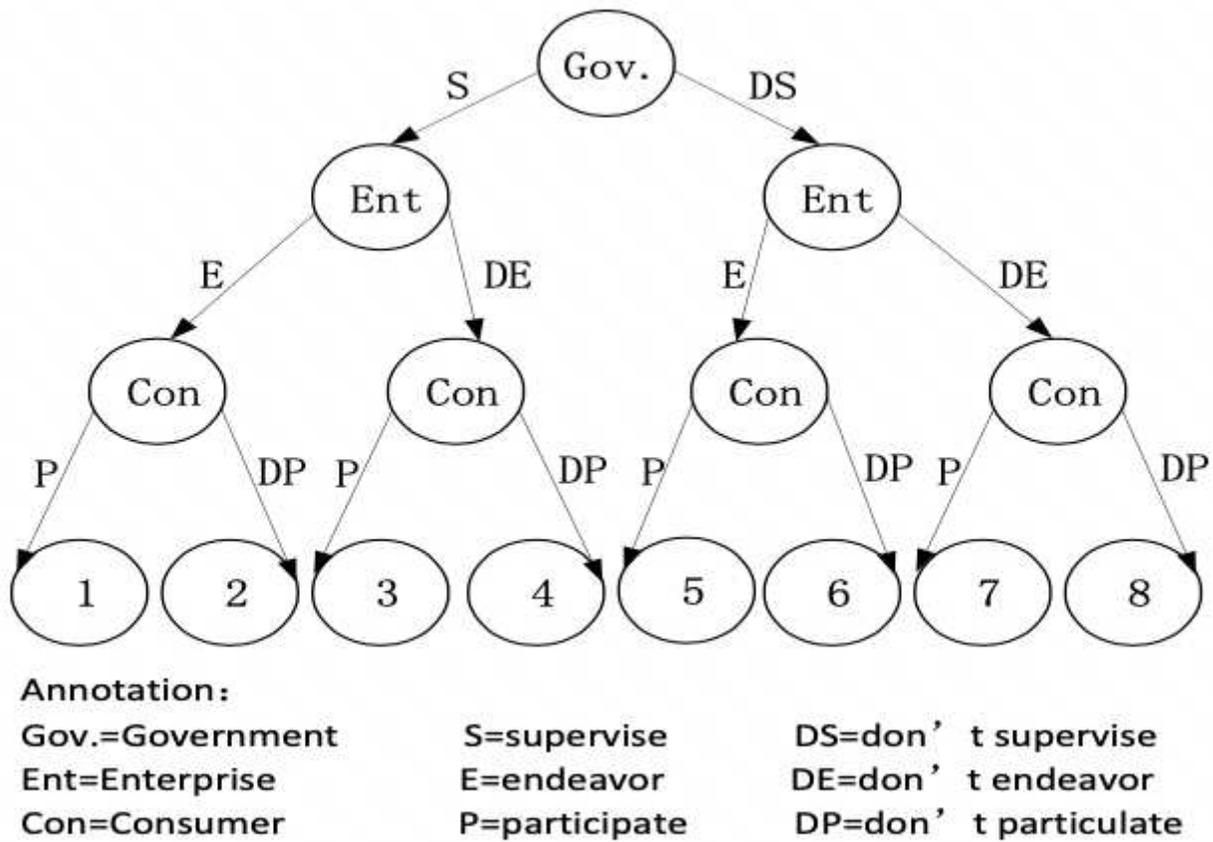


Figure 1

Three-party game theory tree

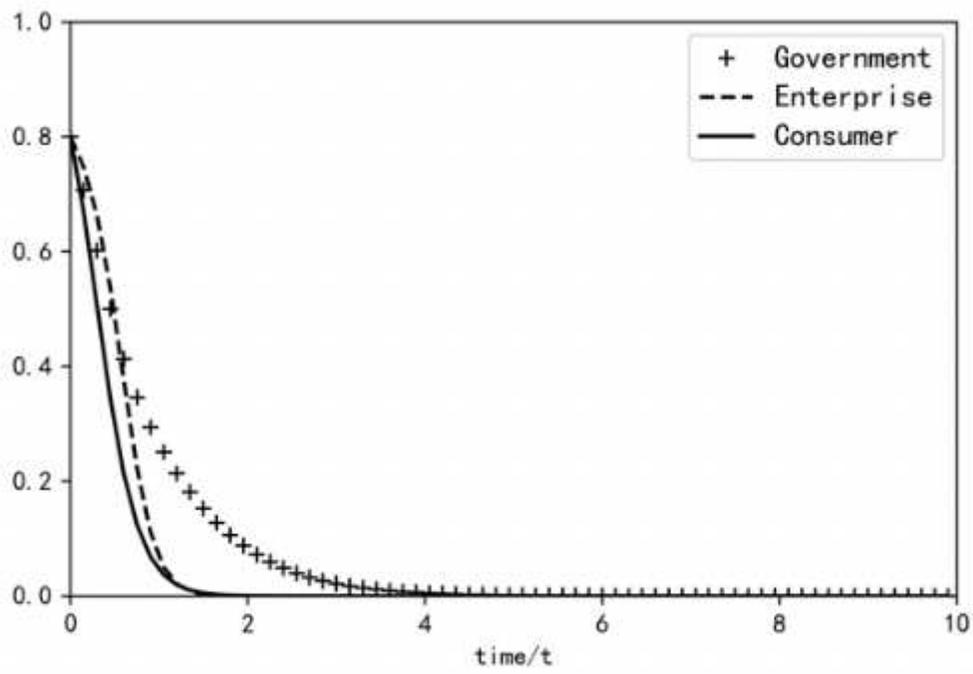


Figure 2

S=1 F=1

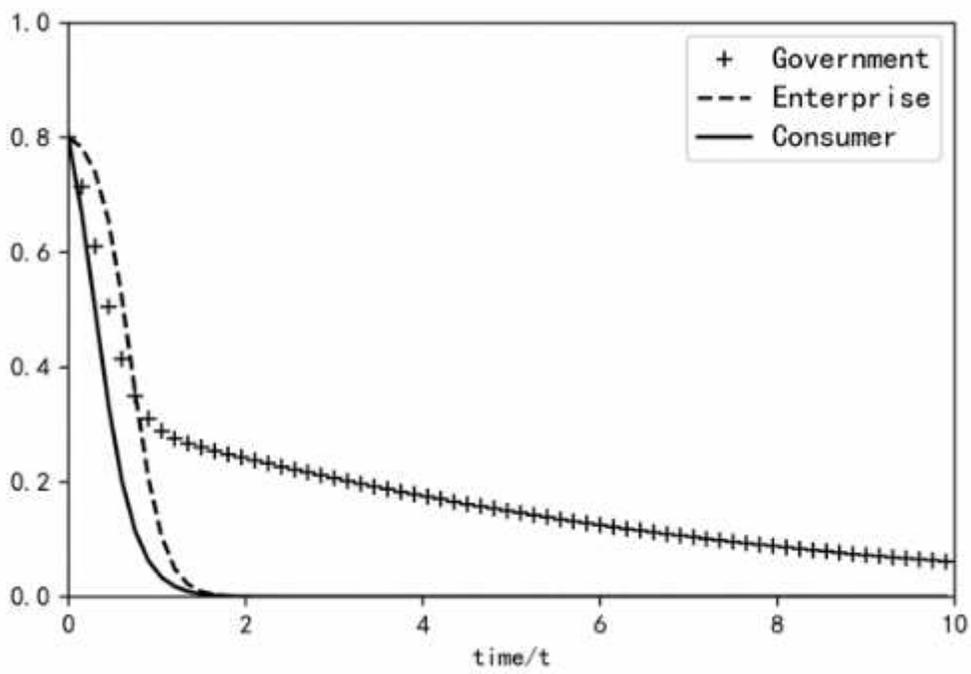


Figure 3

S=5 F=1

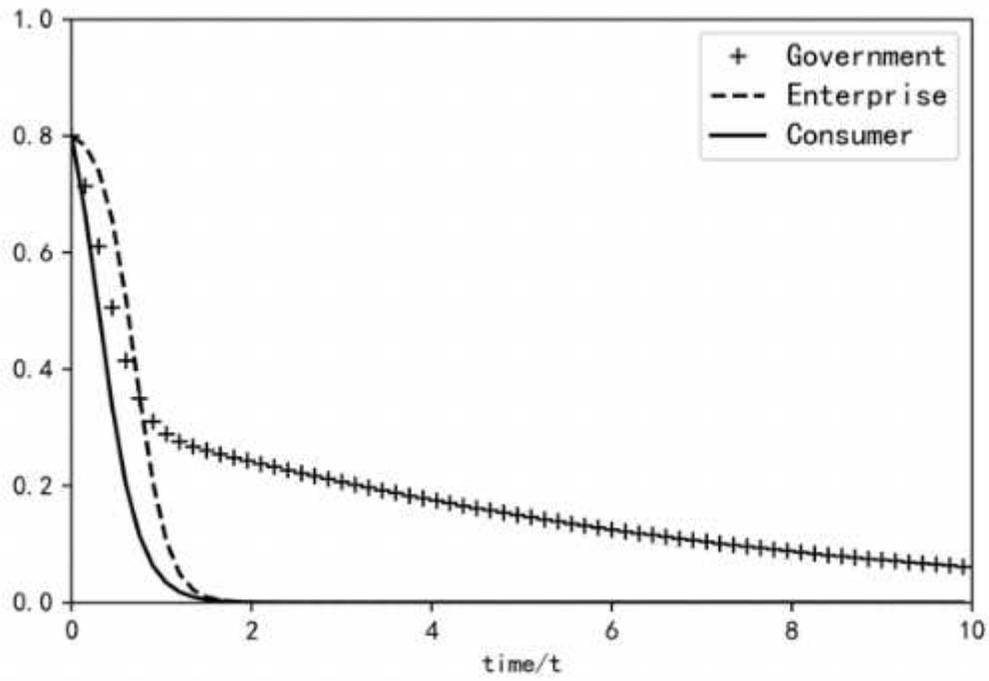


Figure 4

S=5 F=1

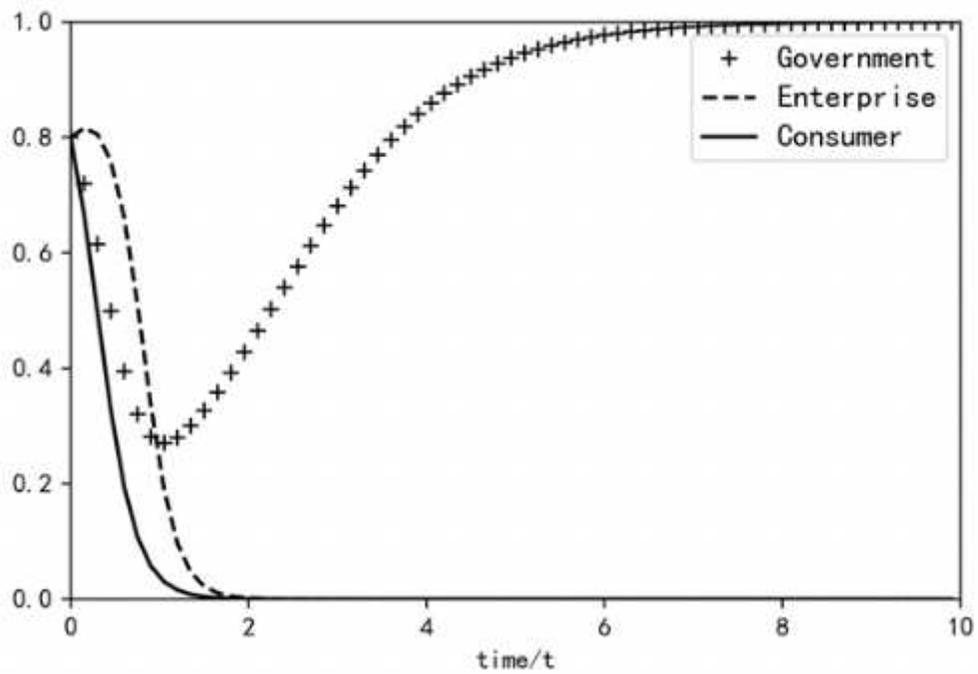


Figure 5

S=5 F=5

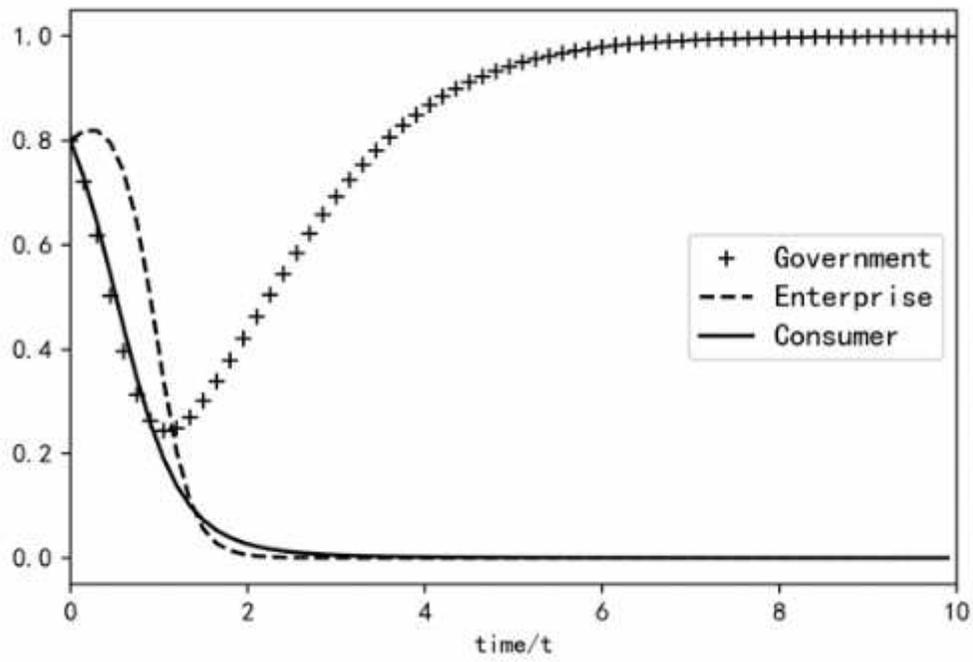


Figure 6

$k = 0.5$

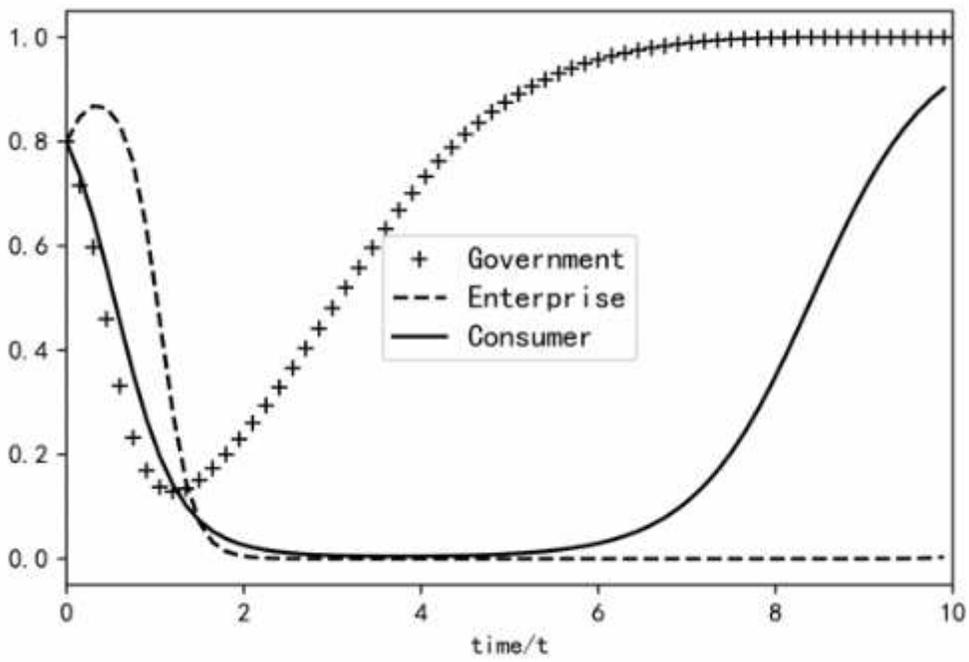


Figure 7

$k = 0.9$

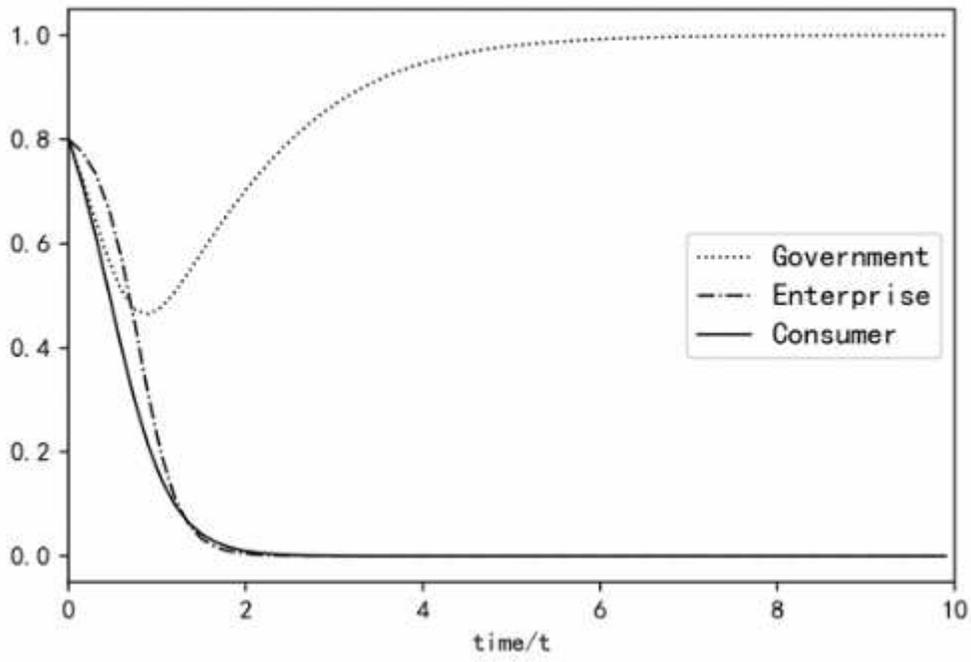


Figure 8

$C' = 10$

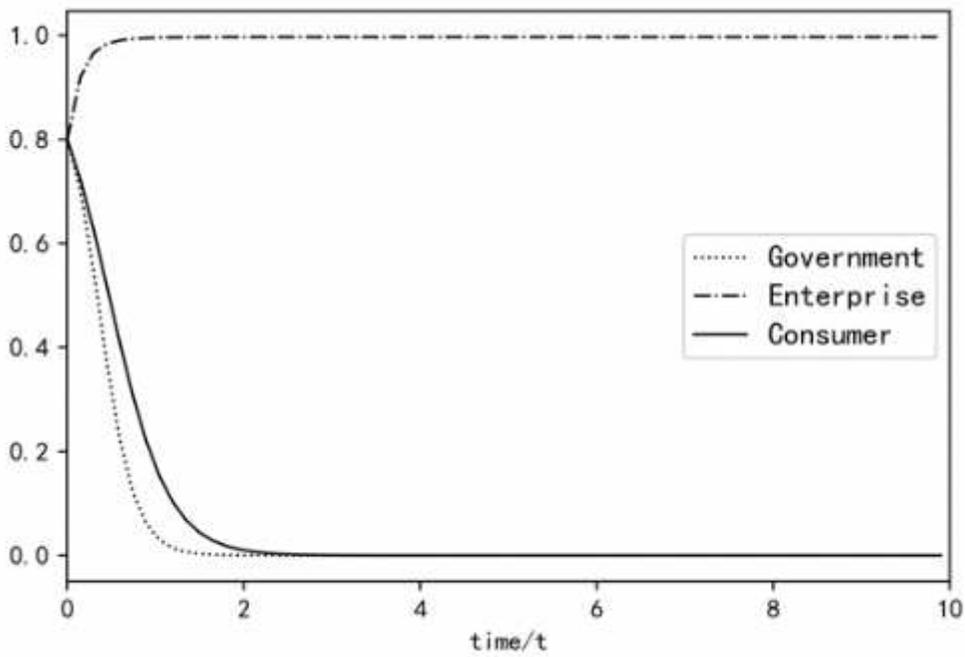


Figure 9

$C' = 3$