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Research Article

Research on Local Government Governance and Enterprise Social Responsibility Behaviors under the Perspective of Cournot Duopoly Competition: Analyzing Taxi Companies and Online Car-Hailing Service Companies

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Clarifying the rational choice strategy of local governments and enterprises is crucial for promoting control on the failure of taxis and online car-hailing service companies to fulfill their social responsibilities. The local government can reduce the negative externalities and irresponsibility of such companies by improving the regulatory system; thus, it is important to build a governance model that bridges tradition and modernity. This paper, on the basis of summarizing the achievements of the predecessors, builds a mixed dynamic game model among the local government, online car-hailing service companies, and taxi companies; analyzes the relationship between local government preference, execution, and governance of irresponsible enterprise behaviors; and analyzes the equilibrium solution between local government and duopoly enterprises behavior game deeply. The results show that the key to governance irresponsible companies is to make the punishment cost higher than the cost savings for irresponsible behaviors; no matter what the preference of the local government no-governance of online car-hailing service companies' irresponsible behaviors may persist; and local government ambivalence when regulating irresponsible companies is derived from the complex relationship between social benefits and company interests. Finally, through the analysis of the equilibrium results for the above model, this paper provides suggestions on regulatory policies so as to provide theoretical support and a decision-making basis for establishing scientific, universal, and feasible governance policies and offering responsible methods of urban transportation.

1. Introduction

Recently, online car-hailing services such as Uber and Didi Chuxing have been on the rise, with their low-price, high-quality model, convenience, and other advantages impacting the traditional taxi market. This has underlined the poor service and refusal to take passengers among some taxi drivers; however, taxi drivers have maintained pressure against local governments by interest struggle [1]. In addition, the rapid development of online car-hailing services has caused a number of problems related to a lack of supervision, hidden crime, disturbance to the taxi market, and allowing taxis to operate unlicensed, which has triggered in the public transport industry a new round of competition and game [2]. On July 28, 2016, the Ministry of Transport and six other ministries issued the "Guidance on Deepening Reform to Advance the Healthy Development of the Taxi Industry" and "Interim Measures for Online Car-Hailing Business Service Management" (hereafter referred to collectively as the "New Deal"). For the first time, the Interim Measures made the legal status of online car-hailing services clear at national level, defining them as taxi companies and referring to both traditional taxis and online car-hailing services collectively as taxis. By January 2, 2018, the consultation opinions for local taxi regulations had been introduced in Beijing, Tianjin, Shanghai, Shenzhen, etc. with more than 100 cities around the whole nation, which aims at supervising the online car-hailing service companies and making them

take social responsibility by traditional methods, in order to obtain balance of the two market subjects' interests for taxi enterprises and online car-hailing service companies. While traditional methods of supervision only disturb the market, the online car-hailing service market has gradually formed strategies by which to cope with these supervision methods and has incorporated them into its market operating costs [3]; however, this has exacerbated certain social problems. At the second collective learning meeting of the Political Bureau of the CPC (the Communist Party of China) Central Committee, General Secretary Xi Jin-ping emphasized that we should have a deep understanding of the current situation and big data trends, along with their impact on economic and social development, in order to make the community of shared future in cyberspace better serve China's economic and social development and improve people's lives. Therefore, questions of how to make the government provide differentiated traffic governance policies to balance the two market subjects' (online car-hailing service companies and taxi companies) interests and ensure fair competition, and ensure they are fulfilling their social responsibility, have become urgent problems to be solved.

2. Literature Review

Without social responsibility, enterprises and the local government supervision departments both probably take a profiteering attitude, which leads to the illegal operation of enterprises, etc. to a certain degree [4, 5]. As the local government has inherent advantages in the external institutional mechanism and can institute policies regarding enterprises' social responsibility, it has played a positive role in promoting the social responsibility of enterprises [6–8]. Over the past two years, new policies in each city have lacked a common basis for laws and specific measures, and the effects of these policies are not yet clear, which makes governance and law enforcement difficult. Online car-hailing service companies have not yet established a sound management system, safety management system, passenger complaint mechanism, or service quality assurance system [9]. For example, drivers are not specially trained or certified; many foreign vehicles have begun to operate in the market; the platforms do not track the vehicle's status following registration; and the platforms can temporarily increase prices at random. In addition, the no-governance of taxis and related services have caused driver to arbitrarily choose the order on the platform and decreased overall turnover, leading to a lack of passenger safety, high travel costs, difficulties with car-hailing, and other issues [10, 11]. The irresponsible behaviors of taxi and online car-hailing service companies face positively impact network externalities and negatively externality of traffic safety and public trust, making the design of governance policies particularly complicated. Irresponsible behaviors of taxi and online car-hailing service companies are restricted by local government control and market competition simultaneously [12]. The local government can reduce the negative externality of taxi and online car-hailing service companies and the irresponsible behaviors of enterprises by improving governance policies so as to establish a regulatory model that balances tradition with modernity [13].

Many domestic and foreign scholars have discussed the influence of government governance on the social responsibility of taxi enterprises from different angles and in different fields. Calo and Rosenblat [14] built an end-to-end framework called deep supply-demand (SD) to study how sharing-economy firms such as Uber and Airbnb facilitate trusted transactions between strangers on digital platforms. Hall and Krueger provided [15] the first comprehensive analysis of the labor market for Uber's driver-partners according to both survey and administrative data. Kim, Kibum, and others [16] built a time-series regression model, controlling for various factors that may affect taxi trips, and found that taxi drivers have been forced to change their means of conducting business in order to retain their market position, such that the sharing economy has transformed the existing market in a positive and welfare-enhancing way. Fan Lizeng and KoIllSang [17] employed a conceptual framework on the determinants of adopting car sharing services based on information processing and literature on collaborative consumption and found, after studying the responses from 599 Chinese Didi mobile application users, several factors that have a positive influence on user adoption of car sharing services. Wang and Zhao [18] analyzed the competitive strategies of Didi and the challenges brought by regulation and provided several suggestions for Didi, such as improving the interface design of the platform and the order allocation process, so as to increase user engagement and loyalty. Posen [19] studied regulation trends in the taxi industry and the growing challenges faced by Uber and suggested that Uber should not be forced to comply with outdated regulations but rather that experimental governances could allow consumers to make the consumer' choice. Regarding "Internet accelerated speed," Zhang and Zhang [20] highlighted the relatively high safety risk for passenger transportation regarding online car-hailing services in China based on government regulations for such services, stating that the government should improve and complete the related supervision legislation and pattern, management approach. Zhang Ruixue [21] discussed, using a multiple-streams framework that included a problem stream, policy stream, and political stream, how the "New Deal" entered decision-makers' awareness and was promoted to the policy agenda. Sal-man and Cruz [22] studied the influence of the government's strategy of guiding the duopoly market on consumer welfare by constructing the duopoly Stackelberg game model. Yu and Yu [23] applied complex oligopoly dynamics theory in games of incomplete information, analyzed dynamic behaviors of Bayesian games, and proposed a dynamic Cournot model with asymmetric information. Zheng and Zhang [24] studied duopoly manufacturers' decision-making considering green technology investment and under a cap-and-trade system, finding a relationship between the carbon emission of unit products and the market share of an enterprise. Zhang and Wang [25] analyzed how the introduction of rail transport services affects port competition, building a two-stage game model based on the Hotelling Model, which consists of two ports

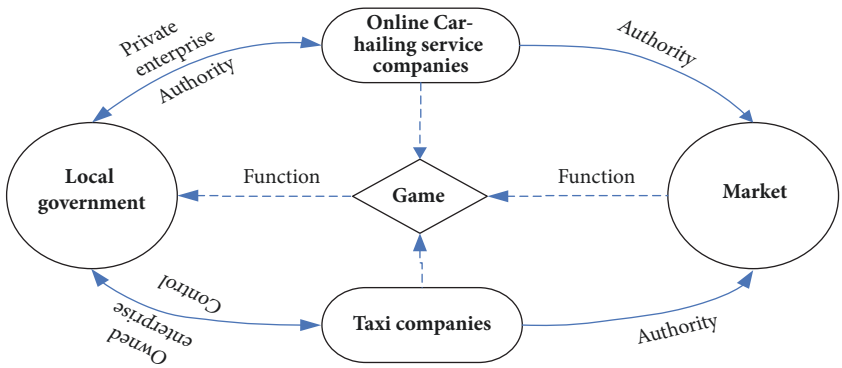

Figure 1: Tripartite interaction between local government and duopoly enterprises.

and one rail operator, thus offering support for decision-making towards comprehensive transportation management in coastal zones. Ning [26] suggested that the paradox of government preference results from the duality of irresponsible corporate behaviors. But they did not apply the Cournot duopoly theory model to the actual problem. Chen Yifeng [27] studied the group buying pricing strategy for duopoly merchants based on the Bertrand model with a static pricing mechanism and used an example to analyze the sensitivities of main factors on the key parameters.

These studies have pointed out that local governments could reduce transaction costs of companies by reducing the initial emission rights of monopolies and increasing the verification probability or introduce an emission auction mechanism or similar thing to promote social welfare. Some of the above studies focused on local government-specific issues that affect corporate responsibility for consumers, employees, and the environment, and qualitative analysis is more; on the lack of local government participation in decision-making regarding online car-hailing services; on local government participation therein, but without considering tracking and cooperation mechanisms; and on the game model used in the duopoly market (while the Cournot model has rarely been used); and some studies without game analysis focused on the price between the online car-hailing service companies and the local government [7, 28]. In addition, prior studies have not taken into account the impact of local government preferences and local government enforcement on regulatory policies. In reality, the purpose of government governance is to restrict the irresponsible behaviors of enterprises through governance measures. When faced with the governance measures of local governments, these two enterprises will be resistant to local government governance driven by the goal of maximizing profits; and the number of oligopolies is an important factor influencing the competition strategy of the oligopolistic market. The local government has to reconcile differences in terms of not only social and corporate interests but also implementation. Because of the inadequacy of the existing literature and the number of oligopolies is less, in this paper, on the basis of summarizing the achievements of the predecessors, the Cournot duopoly game model is extended and applied to the practice of such a situation, combines local government governance and service product competition, and introduces local government preferences and local government execution factors [26]. Through the construction of a mixed Cournot duopoly game model of the local government and enterprise, the relationships among local government preferences, local government executive ability, and local government governance of enterprises' irresponsible behavior are considered. Accordingly, a governance program is proposed to balance companies' interests while ensuring they fulfill their social responsibility.

3. Model Building

3.1. Problem Description. To manage the irresponsible behavior of online car-hailing service and taxi companies, the local government has promulgated certain policies (e.g., the "New Policy") [29]. However, online car-hailing service and taxi companies together constitute an oligopoly under such policies. Taxi companies are more responsible, and they manage and serve in accordance with social expectations, while online car-hailing service companies act irresponsibly as they take to production that is lower than the social expectations [30, 31]. In the tripartite interaction between local government, taxi companies, and irresponsible online car-hailing service companies are subject to two direct constraints: one is the market pressure from taxi companies' competition; the other is the mandatory pressure from local government. The local government impacts the network of car companies indirectly through the transmission of the product service market (as illustrated in Figure 1). Irresponsible behaviors of the local government-controlled enterprises can be divided into three stages: (1) local government promulgates the management policy of irresponsible enterprises—that is, compensates the victim (stakeholders) k times the loss caused by irresponsible enterprises; (2) a production decision is made by online car-hailing service and taxi companies; and (3) the local government implements regulatory policies in accordance with the loss caused to stakeholders by the irresponsible behavior of online car-hailing service companies.

3.2. Model Construction

Definition 1. The taxi companies and online car-hailing service companies provide travel services of equal quality—i.e.,

the two modes consume the same expenses for the same traveled distance—thus, the price competition of the two enterprises depends mainly on passenger traffic. Set passenger traffic as q_1 and q_2, respectively, and they face a common price function $F_p(q)$ as follows:

$$F_p(q) = a - q \tag{1}$$

where $q = q_1 + q_2$ is total passenger traffic and $q_1 \geq 0,\ q_2 \geq 0$; $a(a > 0)$ is the peak value of passenger traffic; if exceeded, the enterprise will make no profit, and $a \geq q_1 + q_2$.

Assumption 2. The taxi companies and online car-hailing service companies have no fixed payment cost, while all expenses paid to stakeholders change with changes in passenger traffic. Taxi companies run completely responsibly, so their short-term cost function $F_c(q_1)$ can be expressed as

$$F_c(q_1) = cq_1 \quad (c > 0) \tag{2}$$

where c $(0 < c < a)$ represents the marginal expenses payable to stakeholders by the enterprise that runs responsibly. While the online car-hailing service companies are not run fully responsibly and fail to adjust their irresponsible behaviors in a short time period after the local government promulgates policies, their short-term cost function $F_c(q_2)$ is

$$F_c(q_2) = (c - \Delta c) \cdot q_2 + \eta k \Delta c q_2 \quad (c > 0) \tag{3}$$

where Δc $(0 < \Delta c \leq c)$ represents the marginal expenses saved by the online car-hailing service companies being run in an irresponsible way from the stakeholders. The larger this cost, the more severe the enterprise's irresponsible behavior; $\eta \in (0, 1]$ represents the local governmental executive ability, which embodies the extent to which the local government can execute the promulgated policies, and is known by society. The local governmental executive ability is not influenced by the local government's efficiency, but by its work efficiency, social pressure, etc. $k(k \geq 0)$ represents the regulatory policies of local government regarding punishment for irresponsible behaviors of online car-hailing service companies—i.e., the first item in (3) represents the total payments of online car-hailing service companies to stakeholders, which are significantly lower than the total sum payable for running responsibly, implying the existence of irresponsible behaviors; the second item represents the total punitive cost imposed by the local government for irresponsible behaviors of online car-hailing service companies.

According to the above assumptions, the benefit functions for taxi and online car-hailing service companies can be derived, respectively, as follows:

$$F_{r1}(q_1) = F_p(q) \cdot q_1 - F_c(q_1) = (a - q_1 - q_2 - c) \cdot q_1 \tag{4}$$

$$\begin{aligned} F_{r2}(q_2) &= F_p(q) \cdot q_2 - F_c(q_2) \\ &= [a - q_1 - q_2 - c - (\eta k - 1) \cdot \Delta c] \cdot q_2 \end{aligned} \tag{5}$$

Assumption 3. The local government is rational and only focuses on the short-term effect of enterprises' behaviors, while the local government utility function is not only influenced by consumers' surplus and all payment by the enterprises to other stakeholders, but also by the benefit objective of enterprises [32]. The local government shows different preferences for social benefit objectives composed of consumers' surplus and payment by enterprises to stakeholders and the enterprises' benefit objectives composed of the enterprises' benefit. The local government's preference for the above objectives is represented by weight, $\mu \in [0, 1]$, such that the local government utility function can be expressed as follows:

$$\begin{aligned} F_G = \mu &\left[\frac{(q_1 + q_2)^2}{2} + c(q_1 + q_2) + (\eta k - 1) \Delta c q_2 \right] \\ &+ (1 - \mu)(F_r(q_1) + F_r(q_2)) \end{aligned} \tag{6}$$

4. Equilibrium Analysis

According to the above analysis and assuming the model established is a mixed Cournot duopoly dynamic game model under perfect information [33], as η is an exogenous variable, the local government makes no decision in the stage, only systematically imposing a fine $\eta k \Delta c q_2$ on online car-hailing service companies according to policy k and the stakeholders' loss $\Delta c q_2$, caused by online car-hailing service companies.

4.1. Benefit Decision in Duopolistic Market. Premised on the predicted punishment cost in the third stage of $\eta k \Delta c q_2$, the taxi and online car-hailing service companies are in Cournot competition during the second stage. According to (4) and (5), the first-order partial derivative of the benefit F_{ri} of taxi and online car-hailing service companies relative to their own passenger traffic q_i can be derived, respectively, as

$$\begin{aligned} \frac{\partial F_{r1}(q_1)}{\partial q_1} &= a - 2q_1 - q_2 - c \\ \frac{\partial F_{r2}(q_2)}{\partial q_2} &= a - q_1 - 2q_2 - c - (\eta k - 1) \cdot \Delta c \end{aligned} \tag{7}$$

Equations (4) and (5) show that the benefit functions of taxi and online car-hailing service companies are strict convex functions, thus solving q_1 and q_2 when the above first-order derivative is 0 and can realize the maximum benefits of the two enterprises—i.e., the Nash equilibrium solution when the taxi and car-hailing enterprises are in Cournot gaming:

$$q_1^* = \frac{a - c + (\eta k - 1) \cdot \Delta c}{3} \tag{8}$$

$$q_2^* = \frac{a - c - 2(\eta k - 1) \cdot \Delta c}{3} \tag{9}$$

Adding (8) and (9) can derive the gross equilibrium passenger traffic q^* of the two enterprises:

$$q^* = q_1^* + q_2^* = \frac{2(a - c) - (\eta k - 1) \cdot \Delta c}{3} \tag{10}$$

If the two enterprises are all responsible, the social benefits are the largest, which implies $\Delta c = 0$, and the gross equilibrium passenger flow q^{**} becomes

$$q^{**} = \frac{2(a-c)}{3} \tag{11}$$

It is clear that the following relation exists when the car-hailing enterprise is irresponsible ($\Delta c > 0$):

$$\begin{aligned} &\eta k < 1, \quad q^{*} > q^{**} \\ &\eta k = 1, \quad q^{*} = q^{**} \\ &\eta k > 1, \quad q^{*} < q^{**} \end{aligned} \tag{12}$$

It can be concluded from the above relation that the enterprise benefits and social benefits are both contrary and unified. When the irresponsible behaviors of online car-hailing service companies are not regulated, the social benefits will be significantly harmed; however, the irresponsible behaviors of online car-hailing service companies stimulate an increase in total social passenger traffic, which can, in turn, promote an increase in social benefits to a certain degree. In practice, the above conclusion can explain the contradiction when local governments regulate the irresponsible behaviors of enterprises.

With other conditions being fixed, the enterprises' competitive edge can be measured by their benefits. If we subtract (4) from (5) to obtain the benefit difference between taxi companies and online car-hailing service companies and substitute (8) and (9), we obtain

$$\begin{aligned} \Delta F_r &= F_{r1}(q_1^*) - F_{r2}(q_2^*) \\ &= \frac{-(\eta k-1)^2 \Delta c^2 + 2(a-c)(\eta k-1)\Delta c}{3} \end{aligned} \tag{13}$$

According to $a > c$, when the online car-hailing service companies are irresponsible ($\Delta c > 0$), there exists the following relation:

$$\begin{aligned} &\eta k - 1 < 0, \quad \Delta F_r < 0 \\ &\eta k - 1 = 0, \quad \Delta F_r = 0 \\ &\eta k - 1 > 0, \quad \Delta F_r\text{-indetermination} \end{aligned} \tag{14}$$

It can be concluded from the above relation that, with other conditions being fixed, when $\eta k - 1 < 0$—i.e., the local government's marginal punishment cost ($\eta k \Delta c$) for irresponsible behaviors of online car-hailing service companies is smaller than the marginal cost (Δc) saved by the enterprises' irresponsible behaviors—the benefit difference of the two enterprises is $\Delta F_r < 0$; that is, the benefit of online car-hailing service companies is more competitive than that of taxi companies ($F_{r1}(q_1^*) < F_{r2}(q_2^*)$).

When $\eta k - 1 > 0$—i.e., the local government's marginal punishment cost ($\eta k \Delta c$) for irresponsible enterprises is greater than the marginal cost (Δc) saved by the enterprises' irresponsible behaviors—the benefit difference between the two enterprises ΔF_r needs to be further discussed, and the following relation exists:

$$\begin{aligned} (a-c) &\geq \frac{(\eta k-1)\cdot \Delta c}{2}, \quad \Delta F_r > 0 \\ (a-c) &\leq \frac{(\eta k-1)\cdot \Delta c}{2}, \quad \Delta F_r < 0 \end{aligned} \tag{15}$$

As the Nash equilibrium solution for the two enterprises represents actual passenger traffic, $q_1^* \geq 0$ and $q_2^* \geq 0$ should also be met; i.e.,

$$\begin{aligned} &q_1^* \geq 0 \Longrightarrow \\ &(a-c) \geq -(\eta k-1)\cdot \Delta c \\ &q_2^* \geq 0 \Longrightarrow \\ &(a-c) \geq 2(\eta k-1)\cdot \Delta c \end{aligned} \tag{16}$$

Considering the relation in (16), it can be derived that when $\eta k - 1 > 0$ and $(a-c) \geq 2(\eta k - 1)\cdot \Delta c$, the benefit of taxi companies is more competitive than that of online car-hailing service companies—i.e., the benefit difference between the two enterprises is $\Delta F_r > 0$. Now, the local government's marginal punishment cost ($\eta k \Delta c$) for online car-hailing service companies and the marginal cost (Δc) saved by online car-hailing service companies' irresponsible behaviors have the following relation: $\Delta c \leq \eta k \Delta c \leq \Delta c + (a - c)/2$.

In sum, the key to reining in the irresponsible behaviors of online car-hailing service companies lies in suppressing the economic motivation for those behaviors. When the irresponsible behaviors are not worthwhile, pressure from market competition will compel them to return to normal practice or weed it out. Thus, increased punishment from local government imposed on online car-hailing service companies to make their irresponsible behaviors submarginal is a powerful measure to propel those enterprises to assume their own social responsibilities.

4.2. Local Government's Regulatory Policies. In the first stage, the local government will select the regulatory policy k^{**} that can maximize own efficiency F_G according to its executive ability η and enterprise passenger traffic q_1 and q_2 analyzed and studied out in the second stage—i.e., to solve the maximum value point of F_G.

Firstly, it is needed to define value range of k, the following can be derived from (16):

$$\frac{-(a-c)+\Delta c}{\Delta c \eta} \leq k \leq \frac{a-c+2\Delta c}{2\Delta c \eta} \tag{17}$$

Meanwhile, $q_1^* + q_2^* \leq a$ should be met as well—i.e.,

$$k \geq \frac{-(a+2c)+\Delta c}{\Delta c \eta} \tag{18}$$

As $a > c \geq \Delta c > 0$ and $\eta > 0$, it is known that $(-(a-c)+\Delta c)/\Delta c\eta > (-(a+2c)+\Delta c)/\Delta c\eta$. In addition, considering $k \geq 0$, so the value range of k is

$$\begin{aligned} &a-c > \Delta c, \quad 0 \leq k \leq \frac{a-c+2\Delta c}{2\Delta c\eta} \\ &a-c \leq \Delta c, \quad \frac{-(a-c)+\Delta c}{\Delta c\eta} \leq k \leq \frac{a-c+2\Delta c}{2\Delta c\eta} \end{aligned} \tag{19}$$

The value range in (19) shows that the upper limit value of governmental regulatory policy is $k_{\max} = (a-c+2\Delta c)/2\Delta c\eta$, to explain its connotation, it is substituted into (8) and (9) to derive that the now passenger traffic of taxi companies is $q_1^1 = (a-c)/2$ and that of the online car-hailing service companies is $q_2^1 = 0$—i.e., when $k = k_{\max}$, the online car-hailing service companies have gone bankrupt exactly, while the taxi companies run by completely monopolistic mode, so $k_{\max}$ represents the local government's regulatory policy of controlling irresponsible behaviors of online car-hailing service companies and making it go bankrupt.

Equation (19) also shows that when $a-c > \Delta c$, the lower limit value of local governmental regulatory policy k is $k_{\min 1} = 0$, whose connotation is that when $k = k_{\min 1}$, the local government adopts laissez-faire policy. When $a-c \leq \Delta c$, the lower limit value of local governmental regulatory policy k is $k_{\min 2} = (-(a-c)+\Delta c)/\Delta c\eta$, which is also substituted into (8) and (9) to explain its connotation, and it is derived that the passenger traffic of taxi companies now is $q_1^2 = 0$ and that of online car-hailing service companies is $q_2^2 = a-c$, i.e., when $k = k_{\min 2}$, the taxi companies have gone bankrupt exactly, while the online car-hailing service companies entirely monopolistically run, so $k_{\min 2}$ represents the local government's regulatory policy of controlling irresponsible behaviors of online car-hailing service companies and making it monopolize.

Solve the maximum value point of F_G based on the above analysis, and substitute Nash equilibrium solution q^* solved in Section 4.1 into (6) to obtain

$$\begin{aligned} F_G = &\frac{(10-21\mu)}{18}X^2 - \frac{[(2-3\mu)a+2(3\mu-1)c]}{9}X \\ &+ \frac{2(a-c)[a+(3\mu-1)c]}{9} \end{aligned} \tag{20}$$

where $X = (\eta k - 1)\cdot \Delta c$.

Solve first derivative of F_G to k to obtain

$$\begin{aligned} \frac{dF_G}{dk} = &\frac{(10-21\mu)}{9}\Delta c^2\eta^2\left[k \right. \\ &\left. - \frac{(2-3\mu)a+2(3\mu-1)c+(10-21\mu)\Delta c}{(10-21\mu)\Delta c\eta}\right] \end{aligned} \tag{21}$$

Let k^* be the point where the first derivative of F_G to k is 0, and then it is obtained according to (21):

$$k^* = \frac{(2-3\mu)a+2(3\mu-1)c+(10-21\mu)\Delta c}{(10-21\mu)\Delta c\eta} \tag{22}$$

Solve second derivative of F_G to k to obtain

$$\frac{d^2F_G}{dk^2} = \frac{(10-21\mu)}{9}\Delta c^2\eta^2 \tag{23}$$

As $\Delta c > 0$, $\eta > 0$, obviously the following relation exists:

$$\begin{aligned} &0 \leq \mu < \frac{10}{21}, \quad \frac{d^2F_G}{dk^2} > 0 \\ &\mu = \frac{10}{21}, \quad \frac{d^2F_G}{dk^2} = 0 \\ &\frac{10}{21} < \mu \leq 1, \quad \frac{d^2F_G}{dk^2} < 0 \end{aligned} \tag{24}$$

According to the above relation, the maximum value point of F_G is discussed separately when μ is set as different values.

(1) When $0 \leq \mu < 10/21$, as $d^2F_G/dk^2 > 0$, F_G is a strict concave function relative to k in this interval, so the optimal regulatory policy k^{**} that makes F_G the largest must be among terminal values of the interval. The previously mentioned defined value range of k shows that now there are three possible terminal values, so k^{**} value may be $k_{\min 1}$, $k_{\min 2}$, and $k_{\max}$. Combining previously mentioned defined range of k value, it is known that

$$\begin{aligned} &a-c > \Delta c, \quad k^{**} = k_{\min 1} \text{ or } k_{\max} \\ &a-c \leq \Delta c, \quad k^{**} = k_{\min 2} \text{ or } k_{\max} \end{aligned} \tag{25}$$

Thus it is concluded that when $0 \leq \mu < 10/21$, the local government adopts laissez-faire policy, or the policy of letting online car-hailing service companies monopolize, or the policy of bankrupting online car-hailing service companies.

(2) When $\mu = 10/21$, substitute it into F_G to obtain

$$\begin{aligned} F_G\big|_{\mu=10/21} = &-\frac{2(2a+3c)\Delta c\eta}{63}k \\ &+ \frac{2(a-c)(7a+3c)+2(2a+3c)\Delta c}{63} \end{aligned} \tag{26}$$

As a result of $a, c, \Delta c, \eta > 0$, F_G and k are inversely proportional; thus the minimum value of k corresponds to maximum value of F_G. It is concluded from range of k value defined by combining the previously mentioned that

$$\begin{aligned} &a-c > \Delta c, \quad k^{**} = k_{\min 1} \\ &a-c \leq \Delta c, \quad k^{**} = k_{\min 2} \end{aligned} \tag{27}$$

Thus the following conclusion can be drawn—i.e., when $\mu = 10/21$, the local government adopts either laissez-faire policy or the policy of letting online car-hailing service companies monopolize.

(3) When $10/21 < \mu \leq 1$, as $d^2F_G/dk^2 < 0$, F_G is a strict convex function relative to k in this interval, so the optimal regulatory policy k^{**} making F_G the largest may exist among the maximum value and terminal values of this interval.

Combining the above relations, it is known that k^* is maximum value point of F_G. To show the regulatory strength of local government for irresponsible behaviors of online car-hailing service companies when $k = k^*$, it is needed to compare the magnitude of k^* and $k_{\max}$. As k^* changes with change of μ, the first derivative of k^* relative to μ is solved according to (22) as follows:

$$\frac{dk^*}{d\mu} = \frac{12a + 18c}{(10 - 21\mu)^2 \Delta c\eta} \tag{28}$$

As $a, c, \Delta c, \eta > 0$, obviously $dk^*/d\mu > 0$—i.e., k^* monotonically increases with μ. Substitute $\mu = 1$ into (22), and $k^*_{\max} = (a - 4c + 11\Delta c)/11\Delta c\eta$ is derived. Compare magnitude of $k_{\max}$ and $k^*{}_{\max}$ to obtain $k_{\max} - k^*_{\max} = (9a - 3c)/22\Delta c\eta > 0$, so their relation of magnitude is $k^* \le k^*_{\max} < k_{\max}$—i.e., k^* certainly meets the conditions for value range of upper limit of k.

① When k^* also meets the conditions for value range of lower limit of k, k^* is maximum value point of F_G—i.e., k^* is equilibrium solution k^{**} of local government's optimal regulatory policies, indicating that the more preferences the local government shows for social benefits, the larger punishment strength of local government for irresponsible enterprises, yet it does not bankrupt them.

② When k^* does not meet the conditions for value range of lower limit of k, the following relation certainly exists:

$$\begin{aligned} &a - c > \Delta c, \quad k^* < 0 \\ &a - c \le \Delta c, \quad k^* < \frac{-(a - c) + \Delta c}{\Delta c\eta} \end{aligned} \tag{29}$$

And, according to (21), when $10/21 < \mu \le 1$, $dF_G/dk < 0$, indicating F_G monotonically decreases with k in this interval. So the left terminal of this interval is just the maximum value point of F_G—i.e., now the value of local government's optimal regulatory policy k^{**} is

$$\begin{aligned} &a - c > \Delta c, \quad k^{**} = k_{\min 1} \\ &a - c \le \Delta c, \quad k^{**} = k_{\min 2} \end{aligned} \tag{30}$$

Thus it is concluded that when $10/21 < \mu \le 1$, the local government adopts laissez-faire policy, or policy of bankrupting the irresponsible enterprises, or $k^{**} = k^*$ policy.

Discussion and analysis by synthesizing the above three cases can well explain the swinging of local government between enhanced governance and no-governance in reality. In addition, the above analysis also shows that no matter what value the local governmental preference μ is in interval $[0, 1]$, the local government may adopt regulatory polices of $k^{**} = k_{\min 1}$ or $k^{**} = k_{\min 2}$ when facing specific a, c, and Δc, while when $k^{**} = k_{\min 1}$, $\eta k^{**}\Delta c = 0 < \Delta c$; when $k^{**} = k_{\min 2}$, $\eta k^{**}\Delta c = \Delta c - (a - c) < \Delta c$. Combining the conclusion in Section 4.1, it is known that when the marginal punishment cost ($\eta k^{**}\Delta c$) of local government for irresponsible behaviors of online car-hailing service companies is less than the marginal cost (Δc) saved by the online car-hailing service companies attribute to irresponsible behaviors, the online car-hailing service companies are competitive compared to the taxi enterprises, leading to "expulsion of good enterprises by the inferior enterprises."

Analysis of the above three cases also reveals that no matter how much the local government values social benefits, it may still deregulate the industry in certain contexts, thereby leading to a rise in irresponsible behaviors of online car-hailing service companies. The key to understanding these illogical behaviors of local government lies in understanding the complex internal relationship between enterprises' benefits and social benefits, as mentioned above [34]. This indicates that if the local government only focuses on current social benefits and ignores long-term social benefits, such as the sustainable development of society, it will fail to effectively suppress enterprises' irresponsible behaviors.

5. Numerical Analysis

To verify the above conclusions, the parameter value of a, c, and η is assumed, and MATLAB analogue simulation is used to analyze the influence of governmental preference μ and irresponsible degree Δc of online car-hailing service companies on the local government's optimal regulatory policy decision, enterprises' benefits, and enterprises' equilibrium passenger traffic.

(1) Assuming the travel service industry has a narrow margin, set $a = 1$, $c = 0.3$, and $\eta = 0.5$, with a, c, and η being unchanged, and we can assess the influence of local government preference μ and degree of irresponsibility Δc of online car-hailing service companies on the local government's optimal regulatory policy k^{**}. The simulation result is shown in Figure 2(a). In addition, analyzing the influence of local government preference μ and degree of irresponsibility Δc of online car-hailing service companies on the local government's optimal regulatory policy k^{**} under different governmental executive abilities, Figure 2(b) shows the simulation results when $\eta = 1$ and $\eta = 0.5$.

Figure 2 shows that governmental preference μ and governmental executive ability η indeed influence its regulatory strength k^{**} on irresponsible behaviors of online car-hailing service companies. This is relatively in line with our expectation for the local government. The following conclusions can be drawn from the results.

① Figure 2(a) shows that sometimes the strength k^{**} of regulatory policies for a local government highly focused on social benefit (μ tends to 1) is obviously lower than the regulatory strength when the local government is highly focused on enterprises' benefits (μ tends to 0), which indicates the existence of a "local government preference paradox": on the one hand, the local government places significant stress on social benefits; on the other hand, it tolerates the existence of irresponsible enterprises. The key to understanding this "paradox" lies in understanding that social benefits, especially socioeconomic benefits, are always attached to enterprises' benefits; even if the local government only considers social benefits, this unavoidably impacts the enterprises' benefits [35].

② Figure 2(a) shows that when $0 \le \mu < 10/21$, the greater the local government's preference for enterprises'

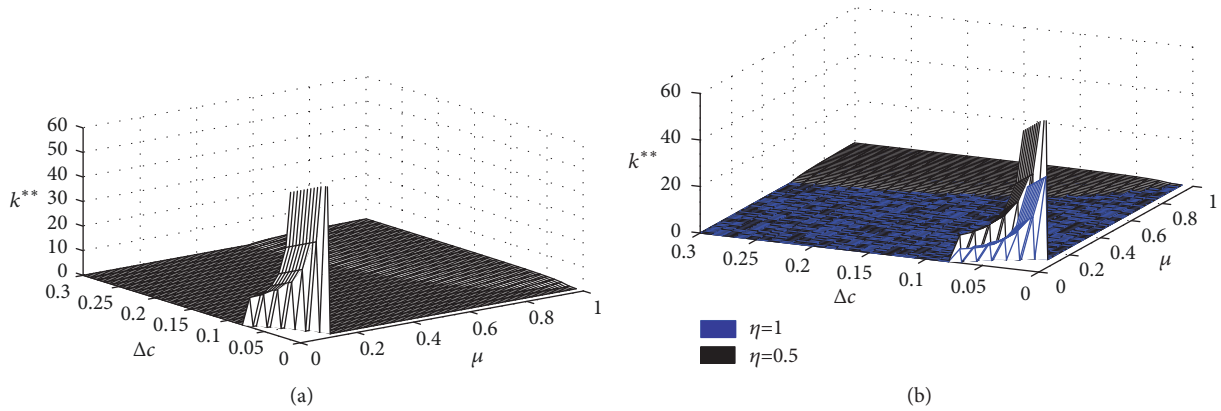

Figure 2: The change of optimal regulatory policy k^{**} with local government preference μ and irresponsible degree Δc of online car-hailing service companies.

benefits (the smaller the μ), the more possible it is to punish the irresponsible behaviors of online car-hailing service companies in the most severe way possible, which will bankrupt those companies—i.e., $k^{**} = k_{\max}$. This conclusion is the same as the previous analysis result.

This phenomenon reveals that, under certain conditions, the monopolistic profit is greater than the duopolistic gross profit. Now, the real motive of the local government is not to protect the benefits of stakeholders, but to eliminate competition via legal paths to obtain monopolistic profit. A similar phenomenon exists objectively in the real world. Some local governments use legal means to expel foreign products for the purpose of protecting local financial revenue, thereby forming local protectionism.

③ Figure 2(a) shows that when $10/21 < \mu \leq 1$, the more the local government values social benefits—i.e., the larger μ—the stronger its punishment k^{**} on irresponsible behaviors of online car-hailing service companies, which can effectively suppress those behaviors to protect social benefits. Besides, now the local government governance does not aim to thoroughly expel online car-hailing service companies from the market—i.e., $k^{**} \neq k_{\max}$. This conclusion is in line with the above analysis result.

④ Figure 2(b) shows that the strength of governance policies of a local government with low executive ability k^{**} is significantly higher than that of a local government with high executive ability. This reveals that, to deliver an equal governance effect, the local government with low executive ability tends to need to create a greater threat momentum compared to the local government with high executive ability.

(2) Assuming that the travel service industry has narrow margin, set $a = 1$, $c = 0.3$, and $\eta = 0.5$, with a, c, and η being unchanged; we can then consider the influence of local government preference μ and degree of irresponsibility Δc of online car-hailing service companies on the benefit functions F_{r1} and F_{r2} of taxi companies and online car-hailing service companies. The simulation result is shown in Figure 3(a). In addition, to analyze the influence of governmental executive ability η on enterprises' benefits, Figure 3(b) shows the simulation results for the benefit function F_{r1} of taxi companies when $\eta = 1$ and $\eta = 0.5$.

The following conclusions can be drawn from the results:

① Figure 3(a) shows that the benefit function F_{r2} of online car-hailing service companies is higher than the benefit function F_{r1} of taxi companies in most cases, indicating that no matter what the local government preference, the online car-hailing service companies are generally more competitive than the taxi companies. Combining this with Figure 2(a), we can see that $\eta k^{**} < 1$ in these regions, which implies that the marginal punishment cost ($\eta k \Delta c$) imposed by the local government for the irresponsible behaviors of online car-hailing service companies is smaller than the marginal cost (Δc) saved by those behaviors—i.e., the local government deregulates the irresponsible behaviors of online car-hailing service companies.

② Figure 3(b) shows that, under different governmental executive abilities η, the benefit function F_{r1} of taxi companies almost never changes, indicating that governmental executive ability does not influence the enterprise benefits, because there exists a tradeoff between governmental executive ability and governmental policies when other conditions are fixed.

(3) Assuming that the travel service industry has a narrow margin, set $a = 1$, $c = 0.3$, and $\eta = 0.5$, with a, c, and η being unchanged; we can then consider the influence of local government preference μ and degree of irresponsibility Δc of online car-hailing service companies on the equilibrium passenger traffic ${q_1}^*$ and ${q_2}^*$ of taxi and online car-hailing service companies. The simulation results are shown in Figure 4(a). In addition, to analyze the influence of different operation modes of duopolistic enterprises on the total equilibrium passenger traffic of the two enterprises, the change in total equilibrium passenger traffic q^{**} when the two enterprises are responsible and the change in total equilibrium passenger traffic q^* when online car-hailing service companies are irresponsible, with the change in governmental preference μ and degree of irresponsibility Δc of online car-hailing service companies, are simulated, respectively, as shown in Figure 4(b).

The following conclusions can be drawn from the results:

① Figure 4(a) shows that the equilibrium passenger traffic ${q_2}^*$ of online car-hailing service companies is higher than the equilibrium passenger traffic ${q_1}^*$ of taxi companies in most

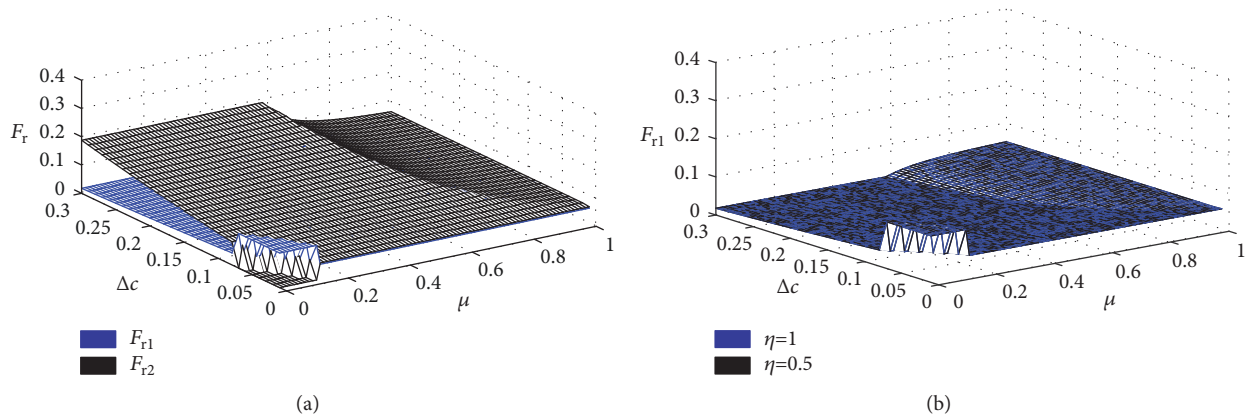

Figure 3: The change in enterprises' benefit function F_r with local government preference μ and degree of irresponsibility Δc of online car-hailing service companies.

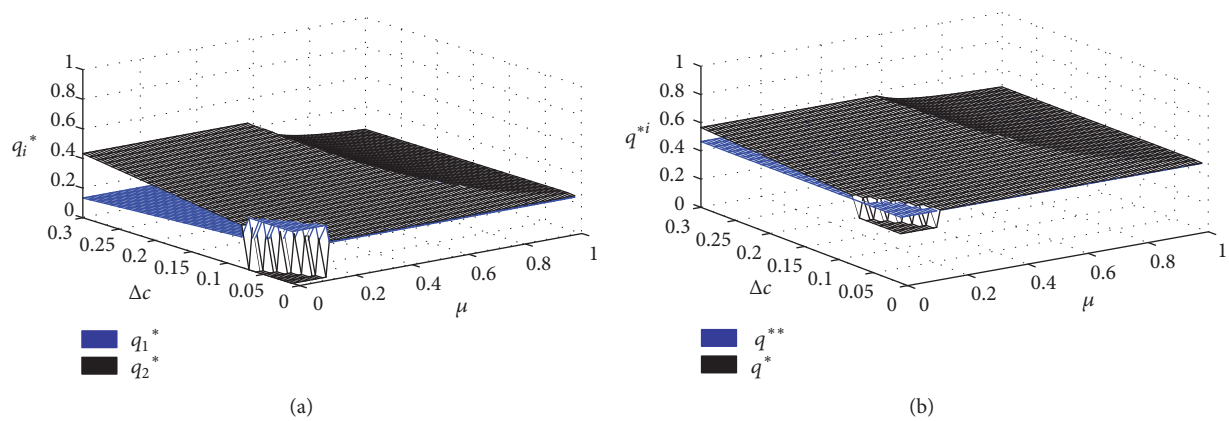

Figure 4: The change in equilibrium passenger traffic q_i^{*i} with governmental preference μ and degree of irresponsibility Δc of online car-hailing service companies.

cases. Combining the analysis with that shown in Figure 3(a), the "expulsion of good enterprises by good enterprises" is shown—i.e., no matter what governmental preference is, the online car-hailing service companies are generally more competitive than the taxi companies.

② Figure 4(b) shows that the gross equilibrium output q^* for the duopolistic market with irresponsible behaviors of online car-hailing service companies is generally higher than the gross equilibrium output q^{**} for the duopolistic market with responsible behaviors of both enterprises, which is also because the local governments with different preferences adopt no-governance policies, thereby making the irresponsible enterprises more competitive than the responsible enterprises. This also speaks volumes for the complex relation between social benefits and enterprise benefits: when the irresponsible behaviors of online car-hailing service companies are not regulated, the social benefits will be significantly harmed, yet the irresponsible behaviors of online car-hailing service companies stimulate an increase in total social passenger traffic, which can, in turn, promote an increase in social benefits to a certain degree.

If this model is applied to the actual decision-making of local governments, the policy-makers may conduct numerical research and analysis before issuing regulatory policies; that is, based on different levels of governmental preference μ and degree of irresponsibility of online car-hailing service companies Δc, corresponding theoretical analysis can be conducted to derive corresponding local government decision-making recommendations. Subsequently, the local government policy-makers can choose the most appropriate management approaches for the current market, as per the above decision-making suggestions and establish a response scheme for the degree of irresponsibility of different online car-hailing service companies to implement these approaches. The specific operations are as follows.

① Considering different actual conditions, determine the reasonable value range and change the step size of governmental preference μ and degree of irresponsibility of online car-hailing service companies Δc, and determine all possible actual situations via permutation and combination as per the different values of μ and Δc. For example, a greater value of μ means that the greater the governmental preference

for regulatory objectives and the greater the value of Δc the more serious the irresponsible behavior of the company.

② According to all of the above-mentioned actual situations, all actual situations and their corresponding decision-making suggestions should be summarized after carrying out corresponding numerical analyses and the optimal decision-making approach selected based on current market conditions. A relatively fair and equitable suggested conclusion can then be put forward [36]. The local government's disposal scheme can be formulated under different Δc circumstances to establish a scientific, universal, and operable local government supervision policy.

③ The mixed Cournot game entails not only confrontation and conflict. Under a clear market mechanism and local government management, it also includes cooperation elements and conflict and cooperation may overlap and coexist [37]. In reality, taxi companies and car-hailing service companies are both bounded rationality, but the two companies can make themselves completely rational by paying certain information costs [38]. Under a situation of mixed rational behavior, the two parties in the Cournot game model usually need to make strategic choices in two areas: rational behavioral decision-making and output decision-making [39]. It is worth mentioning that a series of studies conducted based on the mixed dynamic game model established in this paper. It is found that through solving equilibrium solution and analyzing the stability of the equilibrium solution, under the mixed rational behavior, the two sides of the game will obtain the stable solution consistent with the static Cournot model under completely rational behavior by the dynamic adjustment strategy, which shows that the game mechanism designed in this paper is effective [40]. When the socioeconomic environment and decision-making issues are more complicated, these game subjects could be further integrated in order to increase the actual mixed game research, and we have not considered how end-user (passenger) characteristics influence their game, or the conclusions of this paper can be generalized to the multienterprise Cournot practice, which represents a direction for future study [41].

6. Conclusion and Policy Implications

By bringing in the factors of local government preference, implementation capacity of the local government, and product competition, this paper studies the policies of local government to regulate irresponsible behaviors in a duopolistic market; analyzes the influence of local government preference and local government implementation capacity on the local government governance policy regarding duopoly enterprises; and explains the phenomenon of local government governance in reality. Thus, the following conclusions can be drawn: (1) the key to regulating irresponsible companies is to make the punishment cost higher than the cost savings for irresponsible behaviors; (2) no matter what the preference of the local government no-governance of online car-hailing service companies' irresponsible behaviors may persist; and (3) local government ambivalence when regulating irresponsible companies is derived from the complex relationship between social benefits and company interests.

From the above conclusions, we can understand that balancing social benefits and enterprise interests is a difficult problem when it comes to local governmental governance of the irresponsible behaviors of online car-hailing service companies. The traditional means of "governance" tends to make enterprises gradually deviate from social responsibility. As new technology and new commercial activities emerge, the local government should use Internet technology and web-thinking and change from a single-government control approach to a cooperative governance model [42, 43]. As for online car-hailing services and taxis, the cooperative governance model of "local government + platform + driver + passenger" should be used.

(1) Advocating Cautious Governance by the Local Government and Its Playing a Guiding Role. Local government should focus on formulating fair industry rules for online car-hailing service and taxi companies, clarifying the legal relationship between the parties, improving the risk control of market subjects, improving the overall regulatory framework and system, and establishing a national online car-hailing service monitoring platform so that these companies can fully share and dock with local government departmental data platforms and to protect the all-round development of local government information governance systems [44]. Local governments should also actively listen to and widely solicit views from all parties; research and formulate future development planning and policies under national and local laws and governance; regulate qualifications, document issuance, and filing; organize and conduct the evaluation of service quality among enterprises; help enterprises establish and improve their information security and management systems, registration systems, and comprehensive credit evaluation systems; provide information security, confidentiality responsibility, and punishment systems; standardize information collection, processing, storage, and exchange; and implement dynamic supervision [45].

(2) Clarifying the Responsibility and Market Role of Participants, Playing Their Role in Market. Local governments must give full play to the decisive role of the online car-hailing service market in the allocation of resources; ensure the online car-hailing service market subjects are fully developed and have free competition so as to promote the survival of the fittest; and maximize the elimination of contradictions between supply and demand. In the nature of the use, under the framework of national and local government laws and governance, service qualifications should be acquired. Access conditions regarding the appointment of taxi drivers should be strictly reviewed; drivers and companies should sign a formal labor contract; physical health requirements of drivers should be determined; and drivers should have regular medical examination and training. In terms of cost control, enterprises should also pinpoint the conditions for vehicles to access the enterprise platform; comprehensively calculate the enterprise cost; determine the market price basis; and flexibly adjust the price and the number of vehicles according to the actual market supply and demand. In the meantime, enterprises should complete information registration records

about drivers who apply for entry to the car-hailing platform in police station [46, 47]. Vehicle satellite positioning devices and emergency alarm devices with a driving record function should be installed. In addition, personal data should be subject to multiple encryption, so as to ensure that it is not at risk of being sold or stolen during transmission.

(3) Cultivating Industry Associations and Developing a Social Organization Supervision Function. Local governments must learn from the experience of the development of social organizations, such as traditional taxi industry associations, and actively cultivate industry associations such as online car-hailing service industry associations and other nongovernmental organizations [48]; establish an industry association management mechanism for online car-hailing service companies; organize seminars led by the association for online car-hailing service companies; develop and constantly improve the corresponding self-discipline measures of the industry; and actively cooperate with the local government in completing corresponding public service security work. In terms of ensuring independence of industry associations, the local government should increase support in industry associations initial stage of development, including finance, taxation, and hiring of personnel, to promote its independent development; establish a sound complaints mechanism so that citizens can participate in the collaborative management of online car-hailing service companies; reward whistleblowing with evidence to solve problems such as hiked prices, poor service quality, and other issues. To ensure these issues can be resolved quickly and appropriately, the local government should collect and collate the feedback in a timely manner and use it as a reference source for governance; for instance, for enterprises that have frequently been complained about, issuance of relevant certifications and so on could be refused the following year, or the company could even be removed from the market.

Data Availability

No data were used to support this study. Because this article uses mathematical simulation to study and gets results by formula-derivation, there is no data used in this article.

Conflicts of Interest

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

Authors' Contributions

Xintao Li and Zaisheng Zhang contributed equally to this work.

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