Research on the Evolutionary Game and Dynamic Equilibrium of Service Standards of Online Ride-Hailing Platforms Driven by User Complaints

Yan Chen*

School of Information Management and Mathematics, Jiangxi University of Finance and Economics, Nanchang, Jiangxi, China

*2202204790@stu.jxufe.edu.cn

Abstract. The game relationship between service standards of ride-hailing platforms and user complaints profoundly impacts the sustainable development of the industry. This paper constructs a duopoly evolutionary game model to analyze the interaction mechanism between service standards and user complaints, and explores the impact of key variables on equilibrium through numerical simulation. The findings reveal that when the industry benchmark falls below user expectations, high-standard services form a "cost savings-repurchase growth" cycle by reducing complaint rates, with their effect modulated by user rights-awareness and platform response efficiency. Under the user "voting with their feet" mechanism, high-quality sensitivity and efficient complaint handling can suppress the "bad money drives out good money" phenomenon. The dynamic parameter adjustment model can identify the inflection point of marginal returns from service investment, optimizing the equilibrium path. The study provides a basis for constructing a service quality internal control system driven by user feedback, and suggests guiding high-quality equilibrium through differentiated pricing and transparent regulation.

Keywords: Ride-hailing platforms; Service standards; User complaints; Evolutionary game; Simulation analysis; Cost-benefit mechanism

1 Introduction

The rapid development of shared travel mode, but the lack of implementation of platform responsibilities and frequent service quality problems have led to a high rate of user complaints (for example, "poor service attitude" accounted for more than 37% of online car-hailing complaints in a city). Based on the duopoly evolutionary game model, this paper explores how high-standard services can achieve cost savings and word-of-mouth premium by reducing the complaint rate, the reconstruction mechanism of differentiated service standards on market share, and the service optimization path of dynamic parameter tuning. The results show that when the industry benchmark is lower than user expectations, although the cost of high-standard services increases in

© The Author(s) 2025
B. Siuta-Tokarska et al. (eds.), *Proceedings of the 2025 3rd International Academic Conference on Management Innovation and Economic Development (MIED 2025)*, Advances in Economics, Business and Management Research 348,
https://doi.org/10.2991/978-94-6463-835-6_77

the short term, the long-term benefits are formed through the cycle of "low complaints → high repurchases", and its effect is regulated by users' awareness of rights protection and platform response efficiency. The differentiated service standard inhibits "bad money drives out good money" through users' "voting with their feet", and the dynamic parameter adjustment model can identify the marginal return inflection point of service investment to achieve balanced optimization of cost and reputation. This study provides theoretical support for the construction of an internal control system of service quality driven by user feedback.

2 Literature Review

Existing studies focus on the pricing strategy and market structure optimization of shared mobility platforms (such as Stackelberg game and two-sided market theory), but they are limited by static assumptions (exogenous service quality), short-term single-period game framework and price-led competition analysis, which are difficult to reveal the long-term interaction mechanism between dynamic adjustment of service standards and user complaint behavior. This paper breaks through the above limitations, constructs a closed-loop feedback model of "service standard-user appeal-cost benefit" through the evolutionary game framework, introduces user rights protection awareness and platform response efficiency as dynamic adjustment variables, quantifies the cost compensation threshold of high-standard services, and verifies the symbiotic evolution path of "complaint rate-market share". The simulation results show that high user quality sensitivity can inhibit the "bad money drives out good money", drive the market to converge to high-quality equilibrium, and provide theoretical support for the differentiated competition strategy of service quality.

3 Assumptions and Construction of Evolutionary Game Models

3.1 Basic Assumptions

Assuming a duopoly market where the decision-makers are Platform 1 and Platform 2. Users choose the platform based on utility maximization, and the market share is allocated through a dynamic adjustment mechanism. The platform and passengers learn to modify the strategy step by step through trial and error, and finally converge to an equilibrium state [1]. In order to simplify the model and facilitate analysis, the ride-hailing platform $i(i = 1,2)$ charges passengers p_i, with service quality v_i, and the cost per unit of service during the process is c_i. Platform i selects service standard $s_i \in [0,1]$, reflecting the intensity of investment in driver vetting, trip monitoring, complaint response, and other aspects. When $s_i = 0$, it only meets the minimum regulatory requirements.

Based on the consumer utility theory and the quality elasticity theory[2], the service quality of the platform is $v_i(s_i) = v_0 + \beta s_i^{\theta}, \theta < 1$, where the v_0 benchmark utility reflects the rigid needs such as convenience and basic pricing. β indicates the marginal

contribution of service standards to utility; θ is the quality elasticity coefficient, and when $\theta < 1$, the marginal utility of high-standard investments diminishes.

According to quality cost theory, the unit service cost of Platform i and service standards exhibit a nonlinear increasing relationship. Assuming the unit service cost is $c_i(s_i) = \mu_i {s_i}^2 + \delta_i s_i + c_0$, where $\mu_i > 0$ reflects the marginal cost increase effect of service quality investment, δ_i is the fixed cost coefficient, c_0 represents fixed operational costs, and it reflects cost differentiation design, indicating asymmetric competition.

Introducing the "saturation effect" concept from the Logit (McFadden, 1973) model, combined with the practice of the ride-hailing industry —— when the complaint rate significantly decreases as the service standard upgrades from low to medium, but the improvement effect slows down after reaching high standards, we assume its complaint rate function as $r_i(s_i) = r_0 e^{-\lambda s_i}$, where r_0 represents the baseline complaint rate.

Based on the evolutionary game model and the Hotelling framework[3], the platform pricing i in the market equilibrium under duopoly competition is the utility function of p_i users choosing platform i:

$$u_i = \alpha_q v_i - p_i - \gamma r_i - t|x - l_i| \tag{1}$$

α_q represents the coefficient of users' willingness to pay for quality; γ_i is the negative utility caused by the complaint rate r_i. l_i and t respectively represent the platform's position and user preference sensitivity, $l_1 = 0, l_2 = 1$ and x represent the position of users in the unit interval market, and $t|x - l_i|$ represents the cost of user preference mismatch.

Users only choose a service and a platform when the platform utility is $u_i > u_{min}$; If all platforms offer the same utility, users will exit the market. When the utility of platform 1 and platform 2 is indifferent to users, the critical position can be derived:

$$\varepsilon = \varepsilon^* = \frac{1}{2} + \frac{\alpha_q(v_1 - v_2) - (p_1 - p_2) + \gamma(r_1 - r_2)}{2t} \tag{2}$$

At this point $\varepsilon^* = d_1$, $d_2 = 1 - d_1$, we obtain d_1 and d_2:

$$d_1 = \frac{1}{2} + \frac{\alpha_q(v_1 - v_2) - (p_1 - p_2) + \gamma(r_1 - r_2)}{2t} \tag{3}$$

$$d_2 = \frac{1}{2} - \frac{\alpha_q(v_1 - v_2) - (p_1 - p_2) + \gamma(r_1 - r_2)}{2t} \tag{4}$$

The profit of Platform i includes operational income and complaint handling costs, hence the profit function for platform i can be expressed as:

$$\pi_i = (p_i - c_i - k_i \gamma r_i) \times d_i \tag{5}$$

where the complaint handling cost coefficient k_i reflects the complaint response efficiency of Platform i.

3.2 Evolutionary Dynamic Equations

Under the bounded rationality assumption, ride-hailing platform 1 and platform 2 constitute a dynamic evolutionary game system. The strategy adjustment of platform i depends on its sensitivity to s_i and the influence of the opponent's strategy s_j. Traditional evolutionary games usually assume that participants are "myopic" and only adjust strategies based on current utility gradients. However, in real competition, platforms can predict changes in opponent strategies through learning and respond in advance [4]. This influence can be quantified by the cross partial derivative $\frac{\partial^2 \pi_i}{\partial s_i \partial s_j}$, which represents the sensitivity of platform i 's gain gradient $\frac{\partial \pi_i}{\partial s_i}$ when the opponent's strategy s_j changes. If $\frac{\partial^2 \pi_i}{\partial s_i \partial s_j} > 0$, it indicates that an opponent's improvement in service standard s will enhance the marginal benefit of platform i in raising its own standards; conversely, it will weaken it.

In the evolutionary game on a continuous strategy space, the service standard selection is dynamically adjusted through gradient [5]:

$$\frac{ds_i}{dt} = \eta_i \left(\frac{\partial \pi_i}{\partial s_i} + \phi_i \frac{\partial^2 \pi_i}{\partial s_i \partial s_j} \frac{ds_j}{dt} \right), i, j = 1,2; i \neq j \tag{6}$$

Among them, $\eta_i > 0$ is the learning rate coefficient, $\phi_i \in [-1,1]$ is the strategy interaction coefficient, reflecting the platform's sensitivity to changes in the opponent's strategy, $\frac{ds_j}{dt}$ is the evolution rate of the opponent's strategy.

Assuming the platform adopts a Nash equilibrium pricing strategy, solving $\frac{\partial \pi_1}{\partial p_1} = 0$ and $\frac{\partial \pi_2}{\partial p_2} = 0$, we obtain:

$$\frac{\partial \pi_i}{\partial s_i} = \left(\frac{\alpha_q \beta \theta s^{\theta-1} + \gamma \lambda r_0 e^{-\lambda s}(1 - k_i)}{2} - 2\mu_i s_i + \delta_i \right) d_i \tag{7}$$

For evolutionary stable analysis, the equilibrium condition of the system requires that the equilibrium point (s_1^*, s_2^*) satisfies $\frac{\partial \pi_1}{\partial s_1} = 0$ and $\frac{\partial \pi_2}{\partial s_2} = 0$, and the Jacobian matrix is calculated the eigenvalues of J.

$$\mathrm{J} = \begin{bmatrix} \left(\frac{\partial^2 \pi_1}{\partial s_1^2} + \phi_1 \frac{\partial^2 \pi_1}{\partial s_1 \partial s_2} \frac{ds_2}{dt} \right) \eta_1 & \eta_1 \frac{\partial^2 \pi_1}{\partial s_1 \partial s_2} \\ \frac{\partial^2 \pi_2}{\partial s_1 \partial s_2} \eta_2 & \eta_2 \left(\frac{\partial^2 \pi_2}{\partial s_2^2} + \phi_2 \frac{\partial^2 \pi_2}{\partial s_1 \partial s_2} \frac{ds_1}{dt} \right) \end{bmatrix} \tag{8}$$

The value of the Jacobian matrix at that point is calculated for each equilibrium point, if the real part of all eigenvalues is negative, the equilibrium point is the evolutionary stability strategy (ESS), and if there are positive eigenvalues of the real part, the equilibrium point is unstable. When the Jacobian matrix determinant $\det(\mathrm{J}) < 0$, the equilibrium point is the saddle point.

3.3 Numerical Simulation

In this section, MATLAB software is used to simulate the situation of the continuous policy set determining the evolutionary game of the ride-hailing platform, and the influence of the initial game state and the value of the game variable on the decision-making result is mainly studied.

Start by keeping the parameters shared $v_0 = 1.0$, $\beta = 0.8$, $\theta = 0.6$, $c_0 = 0.05$, $r_0 = 0.5$, $\lambda = 2.0$, $\alpha_q = 0.7$, $\gamma = 0.3$, $t = 0.5$; platform differentiation parameters $\eta_1 = 0.1$, $\eta_2 = 0.15$, $\mu_1 = 0.2$, $\mu_2 = 0.25$, $\delta_1 = 0.1$, $\delta_2 = 0.12$, $\phi_1 = 0.4$, $\phi_2 = -0.2$, $k_1 = 0.6$, $k_2 = 0.4$; initial condition setting $s_1 = 0.3$, $s_2 = 0.6$. The data in this section refer to the actual data disclosed in the relevant literature [6-8].

As can be seen from Figure 1, Platform 1 improves service standards and reduces the complaint rate, thereby reducing the cost of customer complaint processing, attracting more quality-sensitive users (α_q with higher settings), and forming a positive cycle of "low complaints → high repurchase →scale effect". However, the high standard of platform 2 in the early stage leads to high operating costs, and when the price sensitivity of users is superior, it is necessary to lower the standard to reduce costs and avoid the loss of market share.

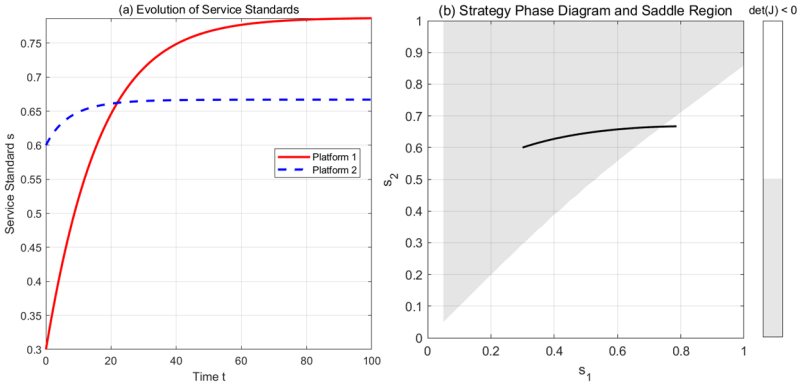

Fig. 1. The evolution path of the evolutionary stabilization strategy

Secondly, change the initial game state, set $s_1 = s_2 = 0.3$ (as shown on the left of Figure 2) and $s_1 = s_2 = 0.6$ (as shown on the right of Figure 2). It shows that the initial service standard significantly affects the evolution path through the saddle point effect and the difference in learning rate, and the convergence or differentiation of the dual-platform competition equilibrium depends on the parameter symmetry and user behavior preference. Platforms with higher initial service levels may have more advantages in market competition, and can improve service standards and attract users faster, which means that the starting point of the platform in the market competition is different, which will affect its revenue expectation, user selection probability, and relative advantage over competitors in the subsequent evolution process, which will have an impact on the strategy outcome.

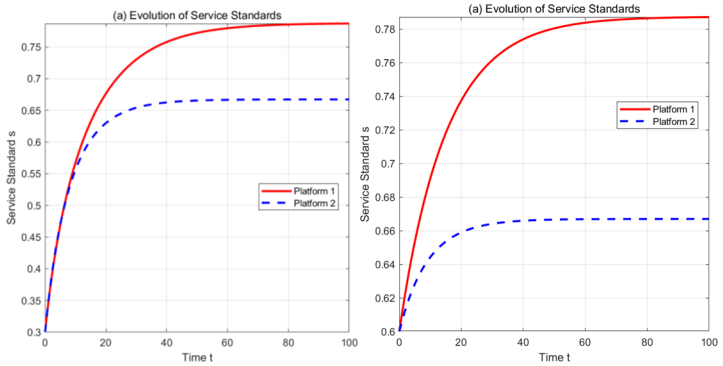

Fig. 2. The impact of initial conditions on the strategy results

Again, change the mass-sensitive parameters $\alpha_q = 0.3$ (as shown on the left of Figure 3) and $\alpha_q = 0.5$ (as shown on the right of Figure 3). When the quality-sensitive parameters are high, the user's willingness to pay for service quality increases, and the platform attracts more quality-sensitive users by improving the service standard, so as to obtain a higher market share and revenue, which will prompt the platform to actively improve the service standard. When the quality-sensitive parameters are low, the platform's motivation to improve service standards is relatively weak, because users are more sensitive to factors such as price, and the platform is more inclined to reduce costs by lowering service standards, and even the adverse selection of "bad money drives out good money".

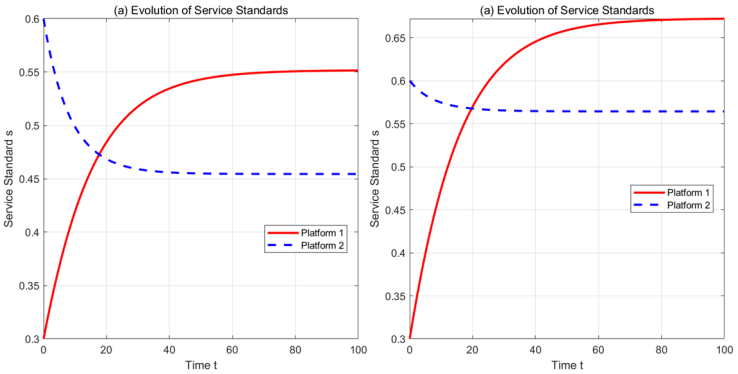

Fig. 3. The impact of quality-sensitive parameters α_q on the strategy results

Reduce the cost of complaint handling $k_1 = 0.3$, $k_2 = 0.2$ (as shown on the left of Figure 4) and $k_1 = 0.6$, $k_2 = 0.4$ (as shown on the right of Figure 4). When the processing cost is reduced, the platform suffers less losses due to service quality problems, and the revenue expectation changes, prompting the platform to re-evaluate the input-output ratio of service standards. This makes the platform have more room to balance

service quality and operating costs when formulating service standard strategies, and the convergence speed of dual-platform competition and equilibrium is accelerated.

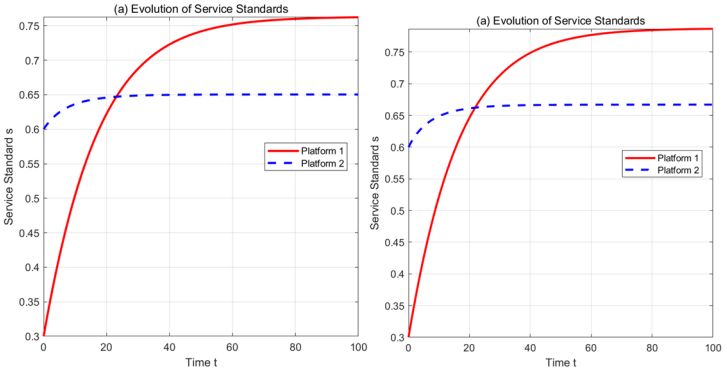

Fig. 4. The impact of complaint processing costs k on the outcome of the strategy

4 Conclusions and Implications

Online ride-hailing platforms face a dynamic game between short-term cost input and long-term revenue compensation in the selection of service standards. When the industry benchmark service level is lower than user expectations, improving service standards will increase unit service costs, but can reduce customer complaint handling costs by reducing the complaint rate and improve user repurchase rate. The key to this revenue compensation effect depends on the interaction between the sensitivity of user rights protection and the efficiency of the platform's complaint response: when the user has a strong perception of the negative utility of the complaint and the platform has a low processing cost, the cost-benefit ratio of high-standard services is better, which promotes the platform to form a positive cycle of "low complaint rate→ high user stickiness → scale effect".

Differentiated service standard selection reshapes market share through the user's "voting with feet" mechanism. The difference in initial service standards and the asymmetry of cost structure will lead to the differentiation of platform strategies: when the quality sensitivity of users is high, high-quality platforms will attract more demand by improving user utility, forming the advantage of "quality premium-order growth"; However, if a low-quality platform relies on cost compression, it may fall into the dilemma of "bad money driving out good money" due to user loss. Numerical simulations further show that the combination of low user quality sensitivity and high complaint handling cost is easy to lead to adverse selection, while high user quality sensitivity and high-efficiency response support the stable evolution of high-quality equilibrium.

The conclusions of this paper have the following implications:

Build differentiated service tiers and dynamic pricing. Referring to the hot spots of user complaints, the service standards are divided into basic compliance and high-qual-

ity services, and differentiated pricing strategies are matched. Based on real-time complaint rates and user rating data, the government can implement dynamic subsidies for high-quality service platforms, and impose compliance cost surcharges on long-term low-standard platforms to incentivize service upgrades through price leverage.

Acknowledgements

2025 Innovation and Entrepreneurship Training Programme for Undergraduates "Evolutionary Game and Simulation Research on the Operation Mode of Shared Mobility Platforms" (Project No.: 202410102244469613)

References

1. Zhang, X.P., Zhang, Z.Y., Li, H.B., et al. (2024) Will Integrity be Market-rewarded? Game Analysis of Agricultural Machinery Enterprise Behavior under Subsidy Ratio Restriction System. Systems Engineering Theory & Practice, 1–22. http://kns.cnki.net/kcms/detail/11.2267.N.20241211.1001.006.html.
2. Peng, X., Hu, T.Y., Sun, J.F., et al. (2021) Research on Pricing Model of Ride-Hailing Platforms Based on Social Welfare Maximization. Systems Engineering Theory & Practice, 41(7): 1806–1818.
3. Yan, S., Guo, Q., Nie, J.J., et al. (2025) Research on Aggregation Strategy of Ride-Hailing Platforms Based on Compatibility in Two-Sided Markets. Industrial Engineering and Management, 1–19. http://kns.cnki.net/kcms/detail/31.1738.t.20250226.1744.016.html.
4. Fershtman, C., Kamien, M.I. (1987) Dynamic duopolistic competition with sticky prices. Econometrica: Journal of the Econometric Society, 1151–1164.
5. Lee, W. (2012) Evolutionary stability in games with continuous strategy space: Recent developments. Journal of Economic Theory and Econometrics, 23(1): 63–78.
6. Zheng, Q., Pan, X.A., Carrillo, J.E. (2019) Probabilistic selling for vertically differentiated products with salient thinkers. Marketing Science, 38(3): 442–460.
7. Chen, X.M., Zheng, H., Ke, J., et al. (2020) Dynamic optimization strategies for on-demand ride services plat-form: Surge pricing, commission rate, and incentives. Transportation Research Part B: Methodological, 138: 23–45.
8. Benjaafar, S., Kong, G., Li, X., et al. (2019) Peer-to-peer product sharing: Implications for ownership, usage, and social welfare in the sharing economy. Management Science, 65(2): 477–493.

Open Access This chapter is licensed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License (http://creativecommons.org/licenses/by-nc/4.0/), which permits any noncommercial use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license and indicate if changes were made.

The images or other third party material in this chapter are included in the chapter's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the chapter's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder.