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The Influence of Commission Rates on Pricing Strategy of Online Ride-Hailing Platform

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Based on the analysis of the commission model of the online ride-booking platform, this paper establishes a bilateral market model of the platform that charges the transaction amount of bilateral users according to the size of the commission, and analyzes the influence of the proportion of the commission on the platform pricing and platform revenue under the three market structures of platform monopoly, single entry and multiple entry of competitive platform enterprises. The study found that with the increasing commission proportion, monopolistic or competitive platforms tend to attract users to their registered platforms and ride-hailing services by subsidizing consumers. Monopolistic platforms will reduce the price of value-added services and maximize their own profits by increasing the demand for value-added services and off ering higher commission. However, regardless of whether the enterprises are either single or multi-party, competitive platforms tend to lower the service price in order to increase the commission rate and the demand for value-added services, although higher commissions will reduce the total revenue of the platforms.

Keywords: online ride-hailing platform, pricing strategy, commission proportion

1. INTRODUCTION

With the rapid development of new forms of online ride-hailing, the competition within the city taxi industry has intensified. Due to market access control, platform control, and the existence of the traditional contract management mode in the taxi industry, consumers and employees have been debating and disputing the inequities in the income distribution of companies. This issue has been exacerbated by the increasing competition due to the entry of the new format of online ride-hailing into the taxi industry.

As a new form of business, online ride-hailing has been extensively studied by a large number of scholars in the field of industry control. For instance, taking Beijing as an example, Chang Meng and others studied the impact of the marginal entry of online ride-hailing on the current taxi market structure, and examined the impact of online ride-hailing on the profits of traditional rental companies (Meng and Qi, 2017). Zhang Aiping and others found that the changes in ride-hailing in regard to consumers, transportation services, service scope, car use time, charging starting points, payment time and degree of interaction have reshaped the local taxi market and created a new market of value-added services such as the off ering of a“private car” (Zhang et al., 2017). On the issue of income distribution, some researchers have studied the rental industry from the perspective of economic theories. Cao Bin (2019), after studying the distribution of regulated hire prices in the taxi market, proposed that although enterprises obtained most of the regulated income in the early stage of market development, their share of regulated revenue gradually decreased as competition intensified (Cao, 2019). Zong Gang established the model of supply and demand, and concluded that the income of drivers and taxi enterprises depends on the access control, the number of licensed operators and the changes in the driver supply and demand in the labor market (Zong, 2009). Zhang Chaoxia (2015) found that the condition for maximizing the income

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of all parties in the rental industry is whether the other party can choose a strategy that has a greater possibility of benefitting that party. From the perspective of interest games, the management fee is calculated to achieve the balance of benefits and alleviate the conflict of interests between the two parties. In terms of profit distribution of online ride-hailing, Hu Beibei and others calculated the service profit margin under the four service modes of traditional taxi, online ride-hailing, online special ride-hailing and carpooling (Hu et al., 2017). Using game theory and focusing on preferential strategies, Liu Xiang analyzed the game relationship between online ride-hailing drivers and traditional taxi drivers and enterprises, and their changing interests (Liu et al., 2018). Liu Zhen and others used the theory of political economy to analyze the income distribution mode of platform and drivers in online-riding industry in China, and demonstrated that increased exploitation is caused by the monopoly of platforms and the profit-seeking nature of capitalism (Liu and Cai, 2019). In a political economy, exploitation is considered in terms of the amount of commission. Xu Sa and others studied and compared the commission rates off ered by the online ride-hailing platform and those of the traditional taxi services. They found that the online ride-hailing platform was in an absolute dominant position in terms of profit distribution (Xu et al., 2019; Ahmad, 2020; Victor, 2020; Nguyen, 2019).

Based on the analysis of commission drawing model of ride-hailing platforms, and through the establishment of a bilateral market model of the platform that charges the transaction amount of bilateral users in proportionate way, this study investigates the impact of platform pricing and platform revenue under the three market structures of platform monopoly, single entry and multiple entry of competitive platform enterprises.

2. MONOPOLY PLATFORM

Unlike online enterprises that off er only general goods and services to consumers, the platform in this paper not only provides network services enabling the interaction between consumers and established enterprises, but also off ers ride-hailing services. Therefore, the platform not only collects fares from consumers, but also collects charges from the enterprises. In this paper, we assume that there is only one monopoly platform in 0 position in the online ride-hailing market, in which the platform charges a commission in proportion to the price of the online ride-hailing service provided by the enterprises. According to the price set by the platform, the enterprises will consider their own cost factors when choosing whether not to provide value-added services.

2.1 Consumer Users

Consumers who book their ride online are more likely to do so because it is more convenient. Therefore, consumers who do this will obtain intrinsic value y, which is independent of the utility generated by any value-added services. Considering the heterogeneity of consumers' use of ride-hailing services, x is used to indicate consumers' preference for using online ride-hailing service, $x \in [0, 1]$.

Assuming that the utility of consumers who do not use ride-hailing services (and cannot use ride-hailing value-added services) is 0, the utility of consumers who use ride-hailing services is

$$U_b = v - p - tx$$

where p is the price of the online ride-hailing and t is the transportation cost; the smaller the value of x, the greater is the consumers' willingness to use the online ride-hailing service.

The utility of consumers registering with online ride-hailing platforms and using value-added services is

$$U_{bs} = v - p - p_s + \alpha n_s^e - tx$$

where, p_s is the price of online ride-hailing value-added service; α is the marginal utility brought to consumers by each additional value-added service; n_s^e is the type of value-added service expected by consumers. Assume that consumers' expectations of ride-hailing value-added services are rational, which is $n_s^e = n_s$.

It is assumed that the consumer has registered only one account and uses at most one value-added service, and the utility of the indistinguishable consumer x with and without car-hailing service satisfies $U_b = v - p - t\tilde{x} = 0$, that is, the demand for ride-hailing service is $q = \tilde{x} = (v - p)/t$; after registering an account, utility of indistinguishable consumers who do not use value-added services $\overline{x}$ satisfies $U_{bs} = v - p - p_s + \alpha n_s - t\overline{x} = 0$, that is, the demand for online ride-hailing value-added services is $q_s = \overline{x} = (v - p - p_s + \alpha n_s)/t$.

2.2 Enterprises That Settled in The Online Ride-Hailing Appointment Platform

It is assumed that the types of value-added services provided by enterprises are different, such as airport pick-up service, private car driver, chartered car service, etc. In other words, the types of value-added services considered in this paper are equal to the number of registered enterprises providing such services. Assuming that the marginal cost of value-added services provided by the settled enterprises is heterogeneous, y is used to represent the marginal cost of value-added services that provided by the settled enterprises, $y \in [0, 1]$. Therefore, the marginal utility of the value-added services provided by the settled enterprises is $U_s = (1 - \varphi)p_s - \tau y$.

Where φ is the commission proportion of the platform to the price of value-added services, $\varphi \in [0, 1]$; $(1 - \varphi)p_s$ is the marginal revenue of value-added services obtained by the settled enterprises; τ is the transportation cost incurred by the enterprise; the smaller the value of y, the smaller is the marginal cost for the enterprises to develop value-added services for the platform. In order to simplify the study, it is assumed that the fixed cost of value-added services provided by the enterprises is 0. Therefore, the utility of the settled enterprises that provide or do not provide value-added services is equal to $U_s = (1 - \varphi)p_s - \tau\tilde{y} = 0$, and the type of value-added services is $n_s = \tilde{y} = (1 - \varphi)p_s/\tau$.

2.3 Online Ride-Hailing Platform

In this study, the revenue of the platform consists of two streams: the revenue fr om consumers using their own vehicles via the platform, and the revenue from providing enterprise with platform network services. Thus, the total revenue of the platform is $\pi = qp + \varphi q_s p_s$. Here, the costs incurred by the platform operators when establishing the infrastructure and other aspects are fixed costs, which do not affect the partial derivative of the platform revenue function. Hence, the fixed costs of the platform are not considered since they will not affect the main conclusions of this study. Therefore, to facilitate the analysis, the fixed cost and marginal cost of the platform are assumed to be 0.

The platform competition model takes into account the following game sequence: in the first stage, the platform sets the prices of online ride-hailing service and value-added service respectively; in the second stage, consumers and enterprises enter the platform simultaneously, and consumers choose whether to use an online ride-hailing service, and enterprises choose whether to provide value-added services on the platform. In the third stage, consumers who have registered to use the platform decide whether to use value-added services.

The monopoly platform maximizes profits by formulating the fee p for an online ride-hailing service and the fee p_s for a value-added service, so the optimization problem of the monopoly platform is

$$\begin{cases} \max\limits_{p,p_s}(qp + \varphi q_s p_s) \\ s.t. q \geq q_s,\ p_s \geq 0 \end{cases}$$

Here, the demand for online ride-hailing service is not lower than the demand for value-added services, and the value-added services are paid services.

In order to ensure the feasibility and rationality of the equilibrium solution, the following assumptions need to be made:

1) $t < v$, indicates that the intrinsic value of consumers using online ride-hailing service is high enough. When the price of an online ride-hailing service is 0, all consumers choose to use the online ride-hailing service.

2) $\alpha < \tau < 4\alpha$, indicates that the market of value-added services is still in its infancy, and the number of value-added services has a low impact on consumers' utility $\tau > \alpha$. At the same time, the cost of value-added services provided by enterprises will not be much greater than the marginal utility it brings to consumers $\tau > \alpha$. As a result, only a small number of enterprises join the platform network to provide value-added services.

   When the platform is in a monopoly position, the optimal pricing strategy of its service fee is $p^M = v[\tau(2-\varphi) - 2\alpha(1-\varphi)]\psi^M$. The optimal pricing strategy of value-added service fee is $p_S^M = vt\psi^M$. The corresponding service requirements are respectively $q^M = 2v[\tau - \alpha(1-\varphi)]\psi^M/t$ and $q_S^M = v\tau - \alpha(1-\varphi)\psi^M/t$; the types of value-added services is $n_S^M = v(1-\varphi)\psi^M$; the optimal revenue obtained by the platform is $\pi^M = v^2\tau - \alpha(1-\varphi)\psi^M/t$ and $\psi^M = 1/\tau(4-\varphi) - 4\alpha(1-\varphi)$. It can be seen from the above that, under the basic assumption, the equilibrium solution of a monopoly platform is unique.

The price of ride-hailing service and value-added service has nothing to do with the cost of the platform and is directly proportional to the intrinsic value perceived by consumers. Therefore, with the platform's increasing commission for value-added services, the lower the prices of ride-hailing services and value-added services are, the higher the corresponding service demand will be. The fewer the number of value-added services, the higher the total revenue of the platform. With the increase in the number of value-added services in the online ride-hailing market, the platform is more inclined to reduce both the online ride-hailing service fee and the value-added service fee, as this will produce higher service demand. This study considered that the platform should set the price of both the online ride-hailing service and the value-added service. Therefore, when the price is increasing steadily, although the fees for the two services is reduced at the same time, the total revenue obtained by the platform is still increasing because the price is higher and there is greater demand for the service.

3. PLATFORM COMPETITION AND SINGLE ENTRY OF ENTERPRISES

It is assumed that there are two competitive platforms in the ride-hailing market, which are denoted as 1 and 2 respectively. In the case of platform competition, p_i and P_{si} represent the prices of online ride-hailing services and value-added services of platform $i(i = 1, 2)$ respectively. q_j And q_{si} are service requirements of the platform respectively; n_{si} represent the number of settled enterprises providing value-added services to consumers on platform i.

3.1 Consumer User

Due to the different services offered by different ride-hailing platforms, and due to the restrictions regulating the number of vehicles owned by the platforms (such as the number of b-class cars, value-added services such as inter-provincial round-trip chartered cars, etc sensible consumers choose to register their accounts and use the services on only one platform. The endogenous value v obtained by using the online ride-hailing service provided by any platform is the same. Assume the consumers first choose to register platform 1 or 2, and then decide whether to use the value-added service. In this case, competitiveness does not occur in the market of online ride-hailing value-added services. It is assumed that the ride-hailing service market is fully covered; that is, all consumers in the market will use the ride-hailing service. Consumers use ride-hailing service of platform 1 to obtain utility $U_b = v - p_1 - tx$ and use platform 2 to obtain the utility is $U_b = v - p_2 - t(1-x)$. Aft er registration, the consumer preference x is $v - p_1 - \iota\tilde{x} = v - p_2 - t(1-x)$. After using platform 1, the utility of value-added service is selected as $U_{bs} = v - p_1 - p_{s1} + \alpha n_{s1} - tx$, and the utility of using value-added services on platform 2 is

$U_{bs} = v - p_2 - p_{s2} + \alpha n_{s2} - t(1-x)$. Registered platform 1 consumers using or not using value-added services consumer preference $\overline{\chi}_1$ to meet $v - p_1 - p_{s1} + \alpha n_{s1} - \overline{tx}_1 = 0$, namely, the value-added service demand of platform 1 is $q_{s1} = \overline{x}_1 = (v - -p_1 - p_{s1} + \alpha n_{s1})/t$. Registered platform 2 $\overline{x}_2$ satisfies $v - p_2 - p_{s2} + \alpha n_{s2} - t(1 - \overline{x}_2) = 0$. Then the service requirement is $q_{s2} = \overline{x}_2 = (v - p_2 - p_{s2} + \alpha n_{s2})/t$.

3.2 Value-Added Service Providers

Assuming that the enterprises providing value-added services are single companies, the enterprises choose only one platform to provide value-added services for customers through online bookings because of the cost of settlement for the enterprises. The marginal utility of enterprises providing value-added services to enterprise consumers of platform 1 is $U_s = (1-\varphi)p_{s1} - \tau y$. The marginal utility of the service for platform 2 is $U_s = (1-\varphi)p_{s2} - \tau(1-y)$; the marginal cost of undifferentiated enterprises entering platform 1 or 2 is $\tilde{y}$, so $(1-\varphi)p_{s1} - \tau\tilde{y} = (1-\varphi)p_{s2} - \tau(1-\tilde{y})$, then the number of enterprises on platforms 1 and 2 is $n_{s1} = \tilde{y} = [(1-\varphi)(p_{s1} - p_{s2}) + \tau]/(2\tau)$ and $n_{s2} = 1 - n_{s1}$.

3.3 Online Ride-Hailing Platform

In the case of two competing platforms and a single enterprise, the optimization problem of platform $i\,(i = 1, 2)$ is

$$\begin{cases} \max\limits_{p_i, p_s}(q_i p_i + \varphi q_{si} p_{si}) \\ s.t. q_i \geq q_{si},\ p_{si} \geq 0 \end{cases}$$

When considering two symmetrical platform competitions and both consumers and enterprises are single owners, there are the following two equilibrium solutions:

(1) When $\frac{2v+\alpha}{t} < 2 + \frac{(4\tau-\alpha)(1-\varphi)}{2\tau-\alpha(1-\varphi)}$, the optimal price for platform j is $p_i^{DS} = \{-2(2v+\alpha)\tau\varphi + t[4\tau - \alpha(1-\varphi)]\}\psi_i^{SD}$ and $p_{si}^{DS} = \tau(2v + \alpha - 2t)\psi_i^{SD}$; service requirements are $q_i^{DS} = \frac{1}{2}$ and $q_{si}^{DS} = (2v+\alpha-2t)[2\tau - \alpha(1-\varphi)]\psi_i^{SD}/(2t)$, and the number of enterprises providing value-added services is $n_{si}^{DS} = \frac{1}{2}$, and the optimal revenue obtained by the platform is $\pi_i^{DS} = \{(2v+\alpha)^2\tau\varphi[2\tau - \alpha(1-\varphi)] - 2t(2v+\alpha)\tau\varphi[4\tau(2-\varphi) - 3\alpha(1-\varphi)] + t^2[8\tau^2(2-\varphi)] - 8\tau(1-\varphi) + \alpha^2(1-\varphi)^2\}(\psi_i^{DS})^2/(2t)$ and among them, $\psi_i^{DS} = 1/[(4\tau - \alpha)(1-\varphi)]$.

(2) When $\psi_i^{DS} = 1/[(4\tau - \alpha)(1-\varphi)]$, the service requirements of platform j are respectively $p_i^{DS} = -(2v+\alpha)\varphi[2\tau - \alpha(1-\varphi)] + t[4\tau - \alpha(1-\varphi)(2+\varphi)]\}\psi_i^{SD}$ and $p_{si}^{Ds} = \{(2v+\alpha)[2\tau - \alpha(1-\varphi]t(2\tau(3-\varphi) - 3\alpha(1-\varphi)\}\psi_i^{SD}$, and when service demand is saturated, which is $q_i^{DS} = q_{si}^{DS} = \frac{1}{2}$, the number of enterprises providing value-added services is $n_{si}^{DS} = \frac{1}{2}$, and the optimal revenue ofthe platform is $\pi_i^{DS} = \frac{t[\tau(2-\varphi) - \alpha(1-\varphi)]}{4\tau - 2\alpha(1-\varphi)}$.

Since enterprises choose to settle on only one platform, the equilibrium of the market depends on the proportion of the platform. And since $\frac{(4\tau-\alpha)(1-\varphi)}{2\tau-\alpha(1-\varphi)}$ is a minus function of φ, so when $\frac{2v+\alpha}{t} < 2 + \frac{(4\tau-\alpha)(1-\varphi)}{2\tau-\alpha(1-\varphi)}$, which is scaled down, p_i^{DS} is a minus function of v, t is an increase function, p_{si}^{DS} is an increase function of v, and t is a decrease function; when the $\frac{2v+\alpha}{t} \geq 2 + \frac{(4\tau-\alpha)(1-\varphi)}{2\tau-\alpha(1-\varphi)}$, the scaling is high, and the p_i^{DS} is the minus function of v and the increase function of t; the increase function of p_{si}^{DS} is the increase function of v and the increase function of t.

Therefore, when the platform is competitive and the enterprise enters the platform alone, under the two equilibrium solutions, with the increase of the proportion of the platform to value-added service, the price of online ride-hailing service will decrease, and the price of value-added service will increase, but the demand for value-added service will also increase, until saturation, and the total revenue of the platform will decrease. That is, value-added services are becoming more important to the platform in the competitive online ride-hailing market. When the amount of commission increases, the platform is more inclined to seek most of the benefits in the value-added service market, and may issue discount coupons to customers. However, the total value of coupons may be greater than the revenue obtained from value-added services; this means that the total income of the platform will actually decrease with the increase in the amount of commission. In addition, contrary to the belief that demand decreases with the increase of prices in a unilateral market, the demand for value-added services increases with commission increase until it reaches saturation.

The reason for this situation is that when the commission rate is high, the platform will increase the discount to consumers, and even attract consumers to use online ride-hailing services at a below-cost fee.

4. PLATFORM COMPETITION AND MORE ENTERPRISES SETTLED

Assume that two competing platforms provide online ride-hailing services at the same time, and the enterprises are multi-owned; that is, an enterprise can provide value-added services for consumers registered with the two platforms simultaneously.

There is no difference in marginal cost $\tilde{y}_1$ for providing or not providing value-added services for consumers of platform 1 to meet $(1-\varphi)p_{s1} - \tau\tilde{y}_1 = 0$. There is no difference in marginal cost $\tilde{y}_2$ for providing or not providing value-added services for consumers of platform 2 to meet $(1-\varphi)p_{s2} - \tau(1-\tilde{y}_2) = 0$. Therefore, the number of enterprises entering platform 1 is $n_{s1} = \tilde{y}_1 = (1-\varphi)p_{s1}/\tau$, and the number for platform 2 is $n_{s2} = \tilde{y}_2 = (1-\varphi)p_{s2}/\tau$.

When an enterprise can simultaneously provide online ride-hailing value-added services to consumers on competing platforms, the optimization problem of platform $j\,(i = 1, 2)$ is

$$\begin{cases} \max\limits_{p_i, p_s}(q_i p_i + \varphi q_{si} p_{si}) \\ s.t. q_i \geq q_{si},\ p_{si} \geq 0 \end{cases}$$

When settlements for the enterprises are on multi-platforms and consumers register on a single platform, the following solution exists

(1) When $\frac{v}{t} < 1 + \frac{(\tau-\alpha)(1-\varphi)}{\tau-\alpha(1-\varphi)}$, the best pricing for platform i is $p_i^{DM} = 2\{-v\tau\varphi + t[\tau - \alpha(1-\varphi)]\}\psi_i^{DM}$ and $p_{si}^{DM} = \tau(v-t)\psi_i^{DM}$, and the total gain is $\pi_i^{DM} = \{v^2\tau\varphi[\tau - \alpha(1-\varphi)] - 2vt\tau\varphi[\tau(2-\varphi) - 2\alpha(1-\varphi)] + t^2[\tau(2-\varphi)] - 2\alpha(1-\varphi)(\tau - \alpha(1-\varphi)\}_{\psi_i^{DM}}/t$, among them, $\psi_i^{DM} = 1/\{2v[\tau - \alpha(1-\varphi)]\}$.

(2) When $\frac{v}{t} \geq 1 + \frac{(\tau-\alpha)(1-\varphi)}{\tau-\alpha(1-\varphi)}$, the best pricing for platform i is $p_i^{DM} = \frac{-v\tau\varphi + t[\tau-\alpha(1-\varphi)]}{(\tau-\alpha)(1-\varphi)}$ and $p_i^{DM} = \frac{\tau\{2v[\tau-\alpha(1-\varphi)] - t[\tau(3-\varphi) - 3\alpha(1-\varphi)\}\psi_i^{DM}}{2(\tau-\alpha)(1-\varphi)}$. At this point, the service demand reaches saturation $q_i^{DM} = q_{si}^{DM} = \frac{1}{2}$, the number of enterprises settled is $n_{si}^{DM} = \frac{\{2v[\tau-\alpha(1-\varphi)] - t[\tau(3-\varphi) - 3\alpha(1-\varphi)\}\psi_i^{DM}}{2(\tau-\alpha)}$, and the total revenue gained by the platform is $\pi_{si}^{DM} = [\frac{1}{4}t\tau(2-\varphi) - \frac{1}{2}t\alpha(1-\varphi)]\psi_i^{DM}$, among them $\psi_i^{DM} = \frac{1}{\tau-\alpha(1-\varphi)}$.

At this time, the equilibrium of the market still depends on the share of the enterprises' share of the platform. Since $\frac{(\tau-\alpha)(1-\varphi)}{\tau-\alpha(1-\varphi)}$ is a subtraction function of φ, which can be appropriate for conditions (1) when the establishment of the platform commission proportion is relatively low, (2) when the establishment of the platform commission proportion is relatively high. When the enterprise has settled on multiple platforms, no matter in condition (1) or (2), p_i^{DM} is the decreasing function of v and the increasing function of t, and p_{si}^{DM} is the increasing function of v and the decreasing function of t.

Therefore, with the increase of the proportion of the platform to the settled enterprises, when $\frac{v}{t} < 1 + \frac{(\tau-\alpha)(1-\varphi)}{\tau-\alpha(1-\varphi)}$, the price of ride-hailing service decreases, while the price and demand of value-added service increase. The number of value-added services remains unchanged, and the total revenue of the platform decreases; when $\frac{v}{t} \geq 1 + \frac{(\tau-\alpha)(1-\varphi)}{\tau-\alpha(1-\varphi)}$, the price of ride-hailing service decreases accordingly, the price and demand of value-added service increase correspondingly, and the number of value-added services increases until it is saturated, so the total revenue of operators decreases in the long run.

5. CONCLUSION

This paper builds a bilateral platform model by extracting the commission of online ride-hailing services to obtain revenue, and studies the optimal pricing strategy of the platform under three different market structures: platform monopoly, platform competition, and single-entry and multi-entry. The analysis results indicated found that regardless of whether the platform is monopolized or competitive, it tends to subsidize consumers in proportion to the increasing number of sales, that is, by attracting consumers to register on the platform and use an online ride-hiring service that is cheaper. However, when the platform monopolizes, it will suppress the price of value-added services and maximize its own revenue by creating higher demand and commission proportionate to the value-added services. When the platforms compete, no matter whether enterprises enter alone or more, even if the demand for value-added services and the price increase, the high percentage still reduce the total revenue of the platforms. In other words, in terms of platform competition, it is not the case that the higher the proportion of the withdrawal, the higher the total revenue of the platform. The reason is that when there is competition, as the commission proportion of abstraction increases, the market of value-added services becomes more important to consumers. Consumers will have access to value-added services only aft er registering on the platform, which indicates that the platforms' competition for consumers is fierce, resulting in an increase in coupons for complementary faresto consumers as competition intensifies. However, the gains in the value-added service market cannot make up for losses due to discounts, so the total revenue of the platform actually decreases as the commission increases.

The main conclusion drawn in this paper is based on the symmetrical competition platform. In future research, the asymmetric platform competition can be considered. In addition, in-depth research could be conducted on consumer multi-platform registration and enterprise occupancy rate.

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