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Research on Retailer's Service Level and Pricing Decision under Digital Empowerment

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Abstract: *As the final link of the distribution channel, the retailer directly connects consumers. Therefore, its pricing and service levels directly affect consumers' purchasing decisions and further affect their own profits. Aiming at the phenomenon of e-commerce platform digital empowerment of small retailers, this paper establishes a corresponding mathematical model, conducts research on retailer service level and pricing decision-making under this model. The results found that: (1) The retailer's service decision is quite sensitive to the unit service cost, and the excessively high service cost will make the retailer give up providing high-quality services to reduce costs. (2) With the improvement of consumer service awareness, price strategy is still the most important factor affecting retailers' profits. (3) Contrary to the "free rider" behavior, with the increase in consumer service awareness, even if the higher platform's digital capabilities can ensure service quality to a certain extent, the retailer will still improve its service level accordingly.*

Keywords: *Digital empowerment, Service level decision, Pricing decision*

1. Introduction

As the final link of the distribution channel, retailers directly connect with consumers. Therefore, his pricing and service levels directly affect consumers' purchasing decisions and further affect their own profits.

Nowadays, it has become a reality that daily necessities and medicines can be delivered to your door within 1 hour, and users have been trained to be more and more "lazy" and less "patient". The "2020 JD Daojia Mobile Instant Consumption White Paper" shows that over 90% of users choose JD Daojia because they are attracted by the platform's one-hour delivery service. Compared with the next-day delivery method, users want the delivery time to be as fast as possible [1]. When "instant gratification" has become a habit of users, many e-commerce giants have turned their attention to: how to make "instant gratification" a user's consumption life by empowering small retailers with a full range of products and high contract performance capability’s indispensable part.

According to Kantar retail data, there are currently 7 million small stores in China, of which the stock of mom-and-pop stores is about 6.8 million. In 2019, the shipments of these mom-and-pop stores accounted for 44% of the entire market. Therefore, accessing SaaS systems for these small retailers has become a must for giants. The Haibo system launched by JD Daojia, Aoxiang, and Lexietong released by Alibaba are all SaaS systems or platforms dedicated to providing online and offline integrated product management, service fulfillment and other solutions for merchants [2]. These digitally empowered small supermarkets can not only meet the needs of consumers instantly, but also use the big data capabilities of the system to make the selection of small stores more accurate based on the settlement of surrounding people, and provide consumers with More efficient and high-quality services, thereby improving the shopping experience and efficiency of consumers, and ultimately enabling small stores to obtain better benefits.

Aiming at the phenomenon of the digital empowerment of e-commerce platforms to small retailers, the question studied in this paper is: What impact does the digital empowerment of e-commerce platforms have on the pricing and service provision of small retailers? Whether or under what conditions will small retailers always choose to do this with e-commerce platforms? Based on this, this paper establishes the decision-making model of the supply chain under the digital empowerment, studies the decision-making of retailers in this case to obtain some valuable information provides corresponding management inspiration for retailers.

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2. Literature review

This article focuses on the literature on service level decisions and the provision of services upstream in the supply chain, such as manufacturers or suppliers.

First, with regard to service level decision-making: In the early days, scholars focused on research on issues related to retailer's service decision-making in traditional retail channels. Studies such as Dumrongsiri and others found that when demand depends on price and service, a higher level of retail service or higher consumer service sensitivity can benefit both suppliers and retailers at the same time [3]. Dan et al. found that retail services have a strong impact on the pricing strategies of supply chain members [4]. Girib and Maiti studied the decision-making problem of each subject when a manufacturer provides the same product to two retailers, and the results show that both market demand and retail price depend on the retailer's service level [5]. Over time, the literature on service level decision making has grown in depth. Dan et al. studied the impact of product sales on the pricing strategy of service-oriented supply chains, and based on this, they designed a supply chain coordination contract [6]. Zhang and others found that when the proportion of consumers' services is high, supply chain coordination can be achieved through price adjustment [7]. Pun et al. studied the influence of customer's discretionary behavior on manufacturer's channel strategy. Studies have found that when a channel offers a high level of service, some customers may visit the channel’s store first to take advantage of the service, thereby purchasing the product from a cheaper channel [8]. Liu et al. studied the problem of channel structure selection in the context of omni-channel retailing. The study found that the level of consumer service will have an impact on channel selection [9]. Some scholars studied the extended warranty service under the dual-channel model. The study found that it is more beneficial to provide extended warranty service by itself regardless of the attractiveness of the channel [10]. Yu et al. studied pricing strategies in product and service markets. The study found that the over-pricing in the after-sales market of products is caused by short-sighted customers, and the motivation of enterprises to avoid short-sighted customers depends on their pricing strategies [11]. He et al. studied logistics service sharing and competition in dual-channel e-commerce supply chains. The study found that the sharing of logistics services is beneficial to increase the retail price of the manufacturer, but the retail price of the retailer may increase or decrease at this time [12]. To sum up, the research on service level decision-making has been relatively mature, which has laid a solid foundation for the follow-up research in this paper.

Second, regarding the upstream of the supply chain, such as the provision of services by manufacturers or suppliers: some scholars focus on the establishment of shop-in-shop by manufacturers in retailers, so as to explore their service decisions. For example, Yang et al. studied the service strategy of manufacturers in the shop-in-shop model under the retailer competition environment, and found that: whether in a decentralized supply chain environment or a centralized supply chain environment, manufacturers always choose to provide two competing retailers serve rather than not serve. Further, when the original demand ratio of the two retailers is less than a certain value, the manufacturer will be more inclined to adopt a differentiated service strategy rather than a unified service strategy [13]. Guo Jinsen et al. analyzed and compared the optimal pricing strategy, demand and impact on profits. The study found that no matter under which sales model, although the service can effectively increase the product demand, when the service level exceeds a certain threshold, both manufacturers and retailers no longer have the motivation to improve the service level [14]. There are also some literatures on the phenomenon of manufacturers providing products and services. For example, Bian et al. compared service outsourcing game decisions under different supply chain power structures of a single manufacturer and a single retailer [15]. Li et al. compared the decision-making and benefits of all parties in four product and service situations, and found that when the service cost coefficient is the same, the market demand for the manufacturer's products and services is the largest, and the supply chain system profit is the highest [16]. Tian Wei and Ge Bing studied the sharing of manufacturer service effort and advertising costs in a dual-channel supply chain consisting of two manufacturers and one retailer. The study found that the manufacturer's service effort and advertising cost sharing increase with the intensification of competition, but when the retailer's profit margin is larger, the cost sharing will not be carried out [17].

To sum up, the literature on the provision of services upstream in the supply chain, whether store-in-store or product-attached, has focused on discussing direct-to-consumer services provided by manufacturers, while in this paper, as the upstream platform of the supply chain provides its digital services to retailers, but the ultimate role of digital services is still to improve the shopping experience of consumers, so this kind of service is indirect for consumers. The biggest innovation is that this paper sets a conversion factor of platform digital services to represent the conversion efficiency of digital services, which is also an innovation for the characterization of consumer utility functions.

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3. Symbols and model

3.1. Symbols description

v: Consumer retention of the product.($v \sim U(0,1)$)

α: Sensitivity of consumer utility to price. ($\alpha \epsilon (0,1)$)

β: Sensitivity of consumer utility to service. ($\beta \epsilon (0,1)$)

e: The digital service level of the platform.

η: Conversion factor of platform digital services. ($\eta \epsilon (0,1)$)

f: The cost factor for the service provided by the retailer. ($f \epsilon (0,1)$)

φ: The cost factor for the service provided by the platform. ($\varphi \epsilon (0,1)$)

c: Unit production cost of the product.

p: The retail price of the product.

s: Retailer's service level.

w: The wholesale price of the product.

u: Consumer utility.

d: Consumer demand.

π_p: The profit of platform.

π_R: The profit of retailer.

3.2. Related assumptions

(1) Without loss of generality, assume that the market size is 1.

(2) Referring to the treatment of service cost in the model in the existing literature, this paper also assumes that when a retailer provides a level of service, the cost it spends is $fs^2/2$.

(3) Since the digital construction of the platform is a one-time investment, the digital service level e of the platform is regarded as an exogenous parameter. It is assumed that the platform's digital support for retailers will eventually be converted into a service for consumers, but this conversion cannot be 100%, so we set a conversion factor of the platform's digital services η to represent the conversion efficiency.

(4) Assume that the game sequence between the retailer and the supplier is as follows: the platform, as the leader, decides the wholesale price of the product first, and then the retailer decides the retail price of the product and its own service level.

3.3. Mathematical Model

Consumers make purchasing decisions according to their utility, and their utility will be affected by the negative utility of the retail price of the product, the positive utility of the retailer's service level, and the positive effect of the platform's digital service on the basis of the reserved utility. So the consumer's utility function is:$u = v - \alpha p + \beta(s + \eta e)$.

From this, the consumer demand function can be obtained as: $d = 1 \cdot (1 - \alpha p + \beta s + \beta \eta e)$.

Then, the profit function of the retailer is obtained as: $\pi_R = d \cdot (p - w) - fs^2/2$.

Accordingly, the profit function of the platform is: $\pi_p = d \cdot (w - c) - \varphi e^2/2$.

4. Solution

The pure-strategy Nash equilibria of the Stackelberg dynamic game with complete information are solved by reverse induction:

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Stage 2 Retailers choose the product retail price and service level that maximize their own profits according to the product wholesale price provided by the platform.

For the retailer's profit function, the first-order condition is: $\begin{cases} \frac{\partial \pi_R}{\partial p} = 1 - 2\alpha p + \beta s + \beta\eta e + \alpha w = 0 \\ \frac{\partial \pi_R}{\partial s} = \beta p - \beta w - fs = 0 \end{cases}$

Solving the above system of equations can get the only solution that satisfies the first-order condition as: $\begin{cases} p^* = \frac{f + f\beta\eta e + \alpha f w - w\beta^2}{2\alpha f - \beta^2} \\ s^* = \frac{\beta + \beta^2\eta e - \alpha\beta w}{2\alpha f - \beta^2} \end{cases}$

The Hessian matrix of the above extreme value problem is: $H_0 = \begin{vmatrix} \frac{\partial^2 \pi_R}{\partial p^2} & \frac{\partial^2 \pi_R}{\partial p \partial s_1} \\ \frac{\partial^2 \pi_R}{\partial s_1 \partial p} & \frac{\partial^2 \pi_R}{\partial {s_1}^2} \end{vmatrix} = \begin{vmatrix} -2\alpha & \beta \\ \beta & -f \end{vmatrix}$

Its first-order sequential main subform is $(-1)(-2\alpha) > 0$, when $2\alpha f - \beta^2 > 0$, its second-order sequential main subform is $(-1)^2(2\alpha f - \beta^2) > 0$, and the matrix is a negative definite matrix at this time. That is, when $2\alpha f - \beta^2 > 0$, the retailer's profit function is a strictly concave function with respect to the retail price and service level, so when the platform gives the wholesale price w the retailer's optimal response function about its retail price and service level is: $\begin{cases} p(w) = \frac{f + f\beta\eta e + \alpha f w - w\beta^2}{2\alpha f - \beta^2} \\ s(w) = \frac{\beta + \beta^2\eta e - \alpha\beta w}{2\alpha f - \beta^2} \end{cases}$

Stage 1 The platform selects the wholesale price that maximizes its own profit function according to the expectations of the retailer's sales. Substitute the optimal response function into can get: $\pi_P = (\frac{f + f\beta\eta e + \alpha f w - w\beta^2}{2f\alpha - \beta^2})$.

First-order conditions for platform profits: $\frac{d\pi_P}{dw} = \frac{\alpha f + \alpha\beta f\eta e + \alpha^2 fc}{2f\alpha - \beta^2} - \frac{2\alpha^2 f}{2f\alpha - \beta^2} \cdot w$, the second-order condition is $\frac{d^2\pi_P}{dw^2} = -\frac{2\alpha^2 f}{2f\alpha - \beta^2}$, Since $2\alpha f - \beta^2 > 0$, and $-2\alpha^2 f < 0$, therefore, π_P is a strictly concave function of w. Solving the first-order condition: $\frac{d\pi_P}{dw} = 0$, the optimal wholesale price can be obtained as: $w^* = \frac{\alpha f + \alpha\eta f e\beta + \alpha^2 fc}{2\alpha^2 f}$.

Substitute it back to the retailer's optimal response function about its retail price and service level, and the retailer's optimal product retail price and service level can be obtained as:

$$\begin{cases} p^* = \frac{3\alpha^2 f^2 + 3\alpha^2 f^2\eta\beta e + \alpha^3 f^2 c - \alpha f\beta^2 - \alpha f\eta e\beta^3 - \alpha^2\beta^2 fc}{2\alpha^2 f(2f\alpha - \beta^2)} \\ s^* = \frac{\beta f\alpha + \beta^2\alpha f\eta e - \alpha^2 fc\beta}{2\alpha f(2\alpha f - \beta^2)} \end{cases}.$$

So, the profit function of the retailer is obtained as: $\pi_R^* = (1 - \alpha p^* + \beta s^* + \beta\eta e) \cdot (p^* - w) - fs^{*2}/2$.

The profit function of the platform is: $\pi_P^* = (1 - \alpha p^* + \beta s^* + \beta\eta e) \cdot (w - c) - \varphi e^2/2$.

5. Analysis

In this section, numerical analysis is used to observe the influence of various parameters on the retailer's decision-making to verify the validity of the model and to obtain some management implications. According to the results of theoretical research, in order to ensure that the model has a pure-strategy Nash equilibrium solution, the parameter values need to meet the following conditions: $2\alpha f - \beta^2 > 0$.

5.1. The influence of consumer service sensitivity coefficient on retailer's optimal service level

We study the impact of changes in consumer service sensitivity coefficients on retailers' optimal service levels in different price-sensitive markets and in the presence of differences in platform digital service levels, in order to obtain more valuable conclusions.

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(1) In different price-sensitive markets, the influence of consumer service sensitivity coefficient on the retailer's optimal service level. Let the parameter: $f = 0.5, \eta = 0.6, e = 2, c = 1$, Make $\alpha = 0.3, \alpha = 0.6$ respectively. That is, when $\alpha = 0.3$, consumer is not sensitive to the price, and when $\alpha = 0.6$, the consumer is sensitive to the price. In both cases, the value of the consumer's price sensitivity coefficient is changed separately, resulting in a change in the retailer's optimal service level. The numerical analysis results are shown in Figure 1.

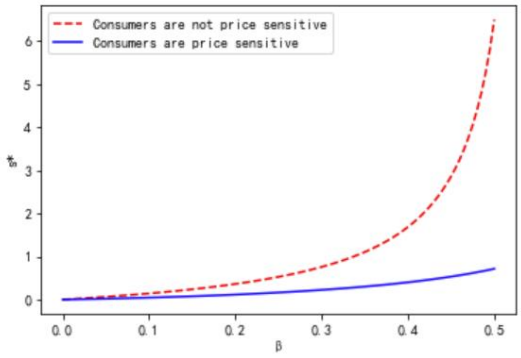

Figure 1: In different price-sensitive markets: β

Looking at Figure 1, it can be found that the impact of consumer service level sensitivity coefficients on the optimal service level of retailers in different price-sensitive markets is not the same. When consumers are not price sensitive, as consumers become more and more sensitive to the service level of retailers, retailers will also improve their service levels accordingly, and the increase will be larger and larger. And when consumers are price sensitive, even if consumers are more sensitive to service levels, retailers are almost unmoved by this change in consumers. This shows to some extent that with the improvement of consumer service awareness, retailers will choose the appropriate service strategy for the improvement of profits, but compared with this, the price strategy is still an important factor affecting their profits.

(2) The impact of consumer service level sensitivity coefficient on the optimal service level of retailers under different digital service levels of platforms. Let the parameter: $f = 0.5, \eta = 0.6, \alpha = 0.5, c = 1$, Make $e = 1, e = 3$ respectively. That is, when $e = 1$, the platform digital service level is low, and when $e = 3$, the platform digital service level is higher. In both cases, the value of the consumer's price sensitivity coefficient is changed separately, resulting in a change in the retailer's optimal service level. The numerical analysis results are shown in Figure 2.

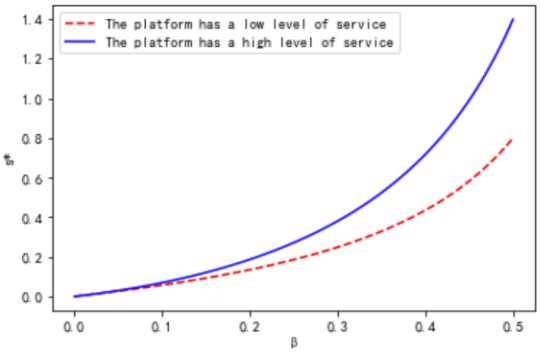

Figure 2: Under different digital service levels of platforms: β

Looking at Figure 2, it can be found that as consumers become more sensitive to the service level of retailers, regardless of the digital service capabilities of the platform, retailers will improve their service levels accordingly. However, it is worth noting that when the service level of the platform is higher, the retailer's improvement of the service level will be more obvious. This is exactly the opposite of the "free-riding" behavior mentioned in some previous literatures, that is, even if the higher service level of the platform is more able to meet the service needs of consumers, retailers will still increase their service investment instead of free-riding on the platform. It can be seen that with the increase of consumer service awareness, even if the digital capabilities of higher platforms can ensure service quality to a certain extent, retailers will still improve their service levels correspondingly.

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5.2. The influence of retailer's service cost coefficient on retailer's service level

In order to obtain more valuable conclusions, the impact of changes in consumer price sensitivity coefficients on retailers' optimal pricing in different service-sensitive markets and platform digital service levels are studied respectively.

(1) In different price-sensitive markets, the effect of retailer service cost coefficient on retailer's optimal service level. Let the parameter: $f = 0.5, \eta = 0.6, e = 2, c = 1$, Make $\alpha = 0.4, \alpha = 0.7$ respectively. That is, when $\alpha = 0.4,$ consumers are not sensitive to the price, and when $\alpha = 0.7$, consumers are more sensitive to the price. In these two cases, the value of the retailer's service cost coefficient is changed respectively, and then the change of the retailer's optimal service level is obtained. The numerical analysis results are shown in Figure 3.

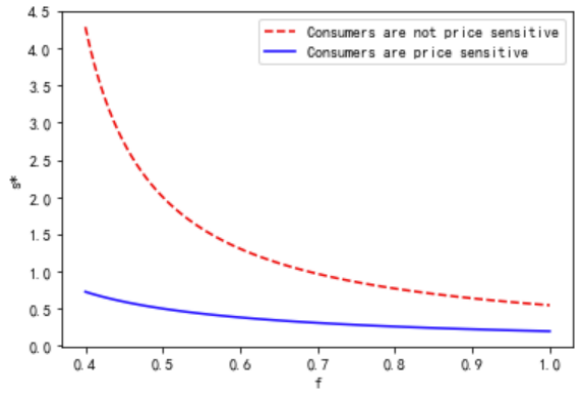

Figure 3: In different price-sensitive markets: f

Looking at Figure 3, we can find that: with the increase of the retailer's service cost coefficient, that is, the retailer's unit service cost increases, the retailer's service level will decrease in both cases. But when consumers are not sensitive to price, the change of retailer's service cost coefficient has a more significant impact on the decision of its service level. This phenomenon is well understood, because when consumers are price-insensitive, service becomes the main factor affecting consumer utility, so service decisions are more important, and when consumers are price-sensitive, price It has become the main factor affecting the utility of consumers. At this time, adopting an appropriate price strategy is more effective in improving profits than a service strategy.

(2) In different service-sensitive markets, the influence of the retailer's service cost coefficient on the retailer's optimal service level. Let the parameter:$\alpha = 0.5, \eta = 0.6, e = 2, c = 1$, Make $\beta = 0.2, \beta = 0.6,$ respectively. That is, when $\beta = 0.2,$ consumers are not sensitive to the retailer's service level, and consumers' service awareness is low at this time, and when $\beta = 0.6,$ consumers are sensitive to the retailer's service level, so consumers' service awareness is high at this time. In these two cases, the value of the retailer's service cost coefficient is changed respectively, and then the change of the retailer's optimal service level is obtained. The numerical analysis results are shown in Figure 4.

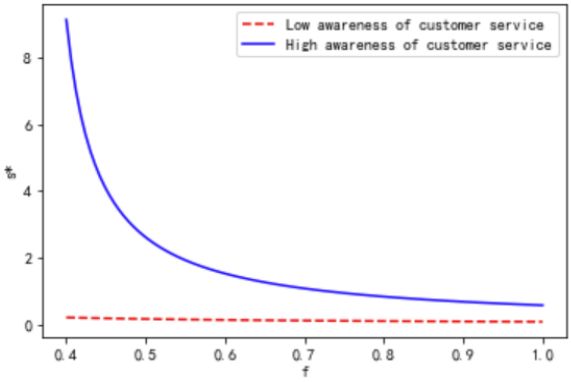

Figure 4: In different service-sensitive markets: f

The results in Figure 4 can verify the model in this paper. Generally speaking, when consumers have low service awareness, retailers are likely to provide a lower service level regardless of the unit service cost; and when consumers have high service awareness and unit service cost is low, retailers will naturally

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choose to provide a higher level of service, and with the increase of this unit cost, it will gradually reduce service input. And this is consistent with the results we got. This shows to a certain extent that the validity of the model built in this paper can be tested.

5.3. The impact of consumer price sensitivity on retailer pricing

In order to obtain more valuable conclusions, the impact of changes in consumer price sensitivity coefficients on retailers' optimal pricing in different service-sensitive markets and platform digital service levels are studied respectively.

(1) In different service-sensitive markets, the impact of consumer price sensitivity on retailers' optimal pricing. Let the parameter: $f = 0.5, \eta = 0.6, e = 2, c = 1$,Make $\beta = 0.2, \beta = 0.6$, respectively. That is, when $\beta = 0.2$, consumers are not sensitive to the retailer's service level, and consumers' service awareness is low at this time, and when $\beta = 0.6$, consumers are sensitive to the retailer's service level, so consumers' service awareness is high at this time. In these two cases, the value of the consumer price sensitivity coefficient is changed respectively, and then the change of the retailer's optimal pricing is obtained. The numerical analysis results are shown in Figure 5.

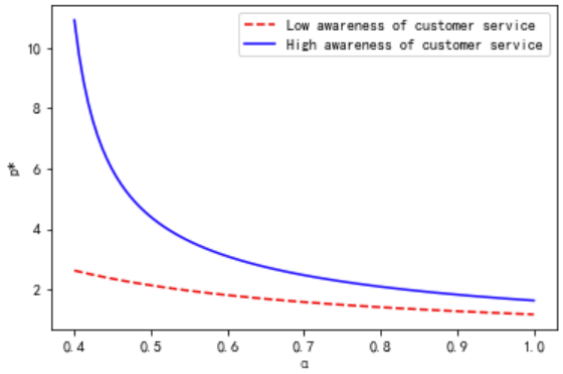

Figure 5: In different service-sensitive markets: α

The results in Figure 5 still show that price strategy is the main means for retailers to increase their profits. This is because, from the results in the figure, we can see that when the consumer's service awareness is low, with the increase of the consumer's price sensitivity coefficient, the retailer will reduce the price to a relatively low level very early, that is, the price reduction strategy was adopted very early. However, when the consumer's service awareness is high, the retailer's pricing has a certain trend of decline, indicating that under the influence of the consumer's service awareness, the retailer will make a certain trade-off between the service strategy and the price strategy.

(2) The impact of consumer price sensitivity on retailers' optimal pricing under different digital service levels of the platform: Let the parameter: $f = 0.5, \beta = 0.5, \eta = 0.6, c = 1$,Make $e = 1, e = 3$, respectively. That is, when $e = 1$, the digital service level of the platform is low, and when $e = 3$, the digital service level of the platform is high. In these two cases, the value of the consumer price sensitivity coefficient is changed respectively, and then the change of the retailer's optimal pricing is obtained. The numerical analysis results are shown in Figure 6.

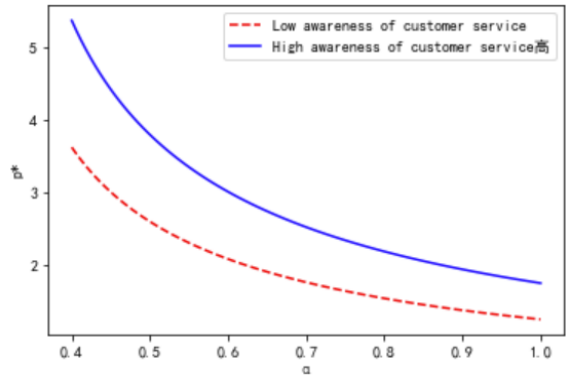

Figure 6: Under different digital service levels of the platform: α

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Looking at Figure 6, it can be found that as consumers become more price sensitive, retailers will reduce their pricing, but when the platform service level is higher, the pricing corresponding to the same price sensitivity coefficient will be higher than when the platform service level is lower. This situation can be explained as follows: the digital empowerment of the platform can alleviate the pressure on retailers in price setting, that is, the positive effect of the digital services of the platform on the consumer utility can offset the negative effect of the retailer's higher pricing.

6. Conclusions

The conclusions reached in this paper are mainly as follows:

(1) The retailer's service decision is quite sensitive to the unit service cost, and the excessive service cost will make the retailer abandon the provision of quality services to reduce the cost, so that it can make up for the loss of demand caused by the lack of service by taking measures to reduce the price, and ultimately ensure the maximization of profits.

(2) With the improvement of consumers' awareness of service, although retailers will also choose the appropriate service strategy for the improvement of profits, compared with it, the price strategy is still the most important factor affecting their profits.

(3) Contrary to the "free-riding" behavior mentioned in some previous literature, with the increase in consumer service awareness, even if the higher platform digital capabilities can ensure service quality to a certain extent, retailers will still improve its service level accordingly.

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