OPTIMAL ADD-ON ITEMS RECOMMENDATION SERVICE STRENGTH STRATEGY FOR E-COMMERCE PLATFORM WITH FULL-REDUCTION-PROMOTION

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Abstract. This purpose of the paper is to make an in-depth study on the selection of the optimal shopping add-on items recommendation service strength strategy of the e-commerce platform with full-reduction promotion based on consumers' heterogeneity preferences for discount amount and add-on items recommendation. With respect to the optimal decision problem consisting of an e-commerce platform who maximizes the profits and consumers who make purchase decision based on their utility, we construct a Stackelberg game model that reflects the interaction between platform's recommendation service strength and consumers' purchase willingness. Furthermore, through the derivative function analysis method, we examine the effect of reservation price, recommended commodity price and discount amount on the platform's optimal recommendation service strength strategy. The results show that the discount amount, reservation price and consumer preference have different effects on the optimal add-on items recommendation service strength and the profit of the platform. Additionally, appropriate recommendation services strength is beneficial to enhance consumers' willingness-to-pay and then increase the profits of the platform. Therefore, it is an effective way to improve the performance of the platform to reasonably formulate the basic discount amount, full-reduction promotion threshold and add-on items recommendation service strength.

1. INTRODUCTION

With the increasingly fierce market competition, to gain more market share, e-commerce platforms usually adopt promotion strategy and provide the corresponding shopping add-on items recommendation service to stimulate consumption. Full-reduction promotion is a form of symbiosis promotion strategy in which the platform sets the full-reduction threshold and consumers subsequently make decisions according to the single shopping amount [20]. When consumers' shopping amount achieves the full-reduction threshold, consumers qualify for the price discounts. Otherwise, consumers will face three choices: First, purchase at the original price. Second, to enjoy the price discounts, increase the amount of shopping. Third, give up the shopping because it is difficult to weigh the utility obtained by purchasing at the original price directly or purchasing add-on items [10], which shows that the implementation of full-reduction promotion also has a "dark" side that is unfavorable to the

platform. However, if the platform can provide add-on item recommendation service according to the preferences of consumers and the relationship between products, it will help to maintain and increase the possibility of consumers to purchase [1,7,14]. Take Taobao's double "11" as an example, which is one of China most popular shopping promotion days. Before the promotion day, Taobao platform carries out marketing promotion through advertising and other promotional patterns. As far as the full-reduction promotion is concerned, the most typical combinations in 2020 include: full "300" minus "40", and full "200" minus "25". At the same time, Taobao platform has set up the corresponding personalized add-on items recommendation service, and the additional revenue generated by recommendation is also growing [22].

Therefore, to maximize platform profits and increase the utility of consumers, it is a key problem to explore how to determine the optimal shopping add-on items recommendation service strength and what factors affect the optimal add-on items recommended service strength for e-commerce platform with full-reduction promotion based on consumers' heterogeneity preferences for discount amount and add-on items recommendation. For the purpose, this paper investigates the optimal shopping add-on items recommendation service strength strategy selection problem of the platform when the consumer's shopping amount is less than the full-reduction threshold. It is worth noting that the recommendation set in this paper is different from the recommendation of consumers' usual browsing products. It is a special and frequent time-limited add-on items recommendation service provided by the platform in a promotion Carnival such as "double 11", "618", "double 12" etc.

The main research streams related to this paper are as follows: (i) the impact of sales promotion on consumer and retailer, and (ii) the recommendation service.

Sales promotion has become a widely used marketing strategy in retail industry, which has an important impact on the consumers and the business decision-making of platforms, and has also become a research hotspot. The related researches mainly include two aspects: The first is to study the impact of different promotion patterns on consumer behavior during the promotion days and the reaction of consumers who miss the promotion, mainly based on statistics and questionnaire analysis [8,23]. Such as Büyükda *et al.* [4] studied the influence of a specific promotion mode on consumers' willingness-to-buy based on contextual experiments and statistical studies of data. The study of Van *et al.* [28] analyzed the influence of various promotion patterns on consumers' loyalty to brand. Furthermore, McAlister *et al.* [18] analyzed which types of sales promotion retailers should focus on to improve their store performance. In contrast to above research, Huang and Yang [9] proposed that for consumers who miss sales promotion, previous sales promotion have a negative impact on consumers' current purchase intention. Van *et al.* [27] analyzed the impact of consumers' perceived price unfairness on their negative purchase intention in the context of missed promotion from the perspective of consumers' inaction inertia.

The second is to study the strategic consumers and retailers promotional pricing decisions [6,17,25]. Retailers' frequent sales promotion makes consumers more and more predictable and strategic. When customers strategically choose the purchase time, the factors that affect the pricing strategy increase, which makes the strategy design more complex. In recent years, strategic customer behavior has attracted the attention of operations management researchers, and a lot of research literature has emerged considering strategic customers and retailers promotional pricing decisions. Such as Su and Zhang [26] explored the problem of inventory allocation when retailers face strategic customer behavior by constructing the newsboy model. Li and Yu [12] studied the impact of strategic consumers on retailers' profits from the perspective of the heterogeneity of waiting tolerance. Furthermore, Li *et al.* [15] established two state models to study the discount pricing strategy of a platform based on three different online coupon patterns in the face of strategic consumers. Aviv *et al.* [2] found that when consumers are aware that price discounts are likely to be offered later in the quarter, they will show strategic behavior. Papanastasiou and Savvan [21] studied the influence of social learning on consumers' strategic purchasing behavior and monopoly enterprises' two state optimal pricing strategy. The results show that social learning can stimulate consumers' strategic waiting behavior and improve the profits of enterprises. In the sales promotion literatures, these studies mainly focus on the effect of discount, gift promotion on consumer behavior, as well as strategic consumer and retailer pricing decisions [19]. However, there is a lack of quantitative and mathematical modeling to analyze the impact of the threshold promotion of full-reduction on consumers' willingness. Moreover, there are few studies on the optimal selection of add-on items recommended service strength

strategy that full-reduction-promotion implementers actively provide for consumers to cope with the impact of full-reduction promotion.

With the prevalence of online shopping and the increasing pressure of market competition, platform providers pay more and more attention to the formulation, implementation and optimization of various shopping recommendation service strategies for consumers' shopping behavior, which has also aroused the extensive attention of scholars [11,13]. Xiao and Benbasat [29] found that consumers not only accepted the products recommended by platforms, but also expressed higher trust in them. De keyzer *et al.* [5] studied personalized recommendation advertisements in social media networks. The results show that personalized recommendation improves the perception relevance of consumers, thus improving consumers' click intention and positive attitude towards brands. Based on the iterative factor research method of hidden variable model, Liu and Chen [16] provided real-time dynamic recommendation for consumers, and concluded that the faster the recommendation is updated, the better the prediction of consumers' preferences will be, which further increases the consumer buying behavior. Baier and Stüber [3] proposed that the quality of shopping recommendation service positively influences consumers' online shopping willingness. Sarwar *et al.* [24] believed that the higher the position of a product is, the higher the probability of being browsable will be. For the products that are ranked behind, the platform can use the recommendation system to increase the probability of being browsable, thus increasing the possibility of unplanned consumption by consumers. Different from the above researches on recommendation service, the shopping add-on items recommendation service of platform provider directly targets consumers' personalized demands, the relationship between products and perceived utility brought by purchasing add-on items. Therefore, this paper explores the optimal shopping add-on items recommendation service strength of platform, and further analyzes which factors will affect the optimal shopping add-on items recommendation service strength and its influence trend based on the Stackelberg game model.

This paper has the following contributions: First, different from previous studies on price as an endogenous variable, this study takes product price as an exogenous variable to study the related problems of consumers' purchase willingness and the optimal shopping add-on items recommendation service strength strategy of platform with a full-reduction-promotion policy by constructing a mathematical model.

Second, different from previous studies that only explored the influence of consumer shopping heterogeneity preferences on platform decisions with recommendation service, we further explore how consumers' preferences affect platform recommendation service strength, as well as the influence trends under full-reduction promotion. Specifically, when the consumer purchases a commodity amount less than the full-reduction threshold, based on the consumer's purchase acceptance level at the original price, the discount amount preference and the add-on items preference, this study analyzes how the product reservation price, the add-on recommended commodity price and the discount amount affect consumers' purchasing willingness and the platform' optimal shopping add-on items recommendation service strength and the influence trends, which provides decision-making basis for the effective implementation of full-reduction promotion and the optimal selection of the shopping add-on items recommendation service strength strategy.

Finally, this paper's theoretical contribution is to fill the gap of considering full-reduction promotion and platform recommendation service strength strategy at the same time, as well as the practical contribution is to provide a significant guidance to reasonably formulate the full-reduction threshold, the discount amount and add-on items recommendation service strength for the platform to improve the performance.

2. Model assumptions

Considering the online shopping system composed of a platform that maximizes the profit by implementing a full-reduction-promotion policy and providing add-on items recommendation service, and consumers that make shopping decision based on their utility.

Assume that the original product (the product consumers are trying to buy) price is P and the add-on items price is P_0. In the process of decision, the platform first sets the full-reduction threshold T, the discount amount t and determines the shopping add-on items recommended service strength $r(0 < r < 1)$ according to
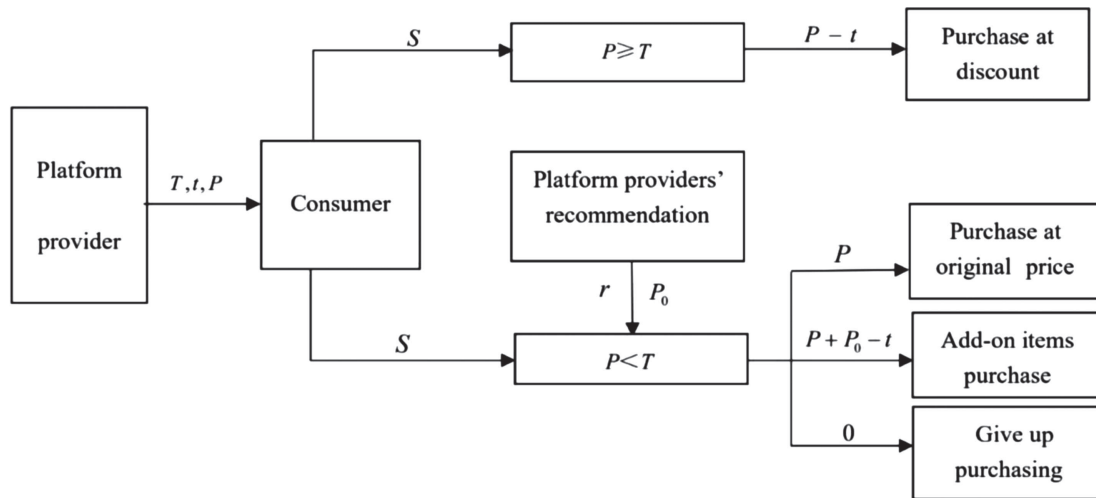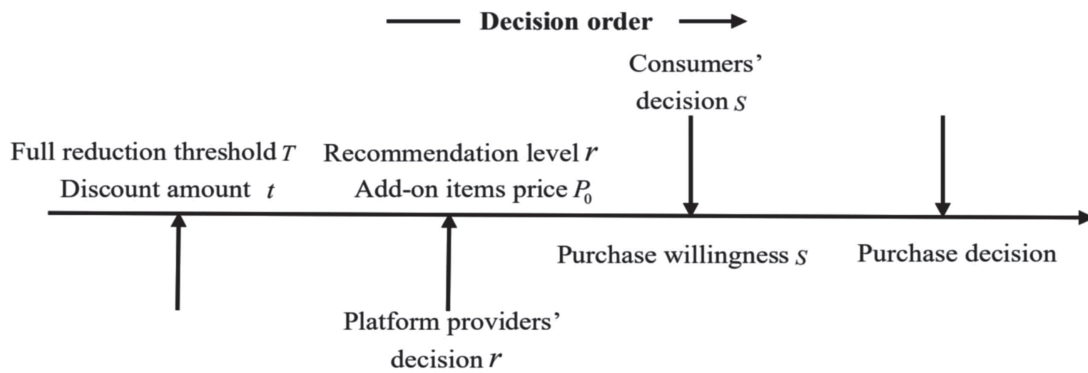
FIGURE 1. Consumer shopping strategy.

FIGURE 2. Decision order between platform and consumer.

original product price P and the add-on items price P_0 and consumers' shopping preferences. Then consumers determine their purchase willingness $S(0 < S < 1)$ based on full-reduction-promotion threshold and the add-on items recommendation service strength (as shown in Fig. 1). Therefore, a game model led by the platform and followed by consumers is formed (as shown in Fig. 2).

After obtaining the platform's full-reduction promotion information, consumers evaluate the product's reservation price V. Assume that consumers' valuation of the product reservation price is heterogeneous and follows the uniform distribution on $\left[0, \widehat{V_0}\right]$, where the larger The $\widehat{V_0}$ is, the larger the consumers' valuation of the product reservation price is. For the sake of generality, we assume that $V \geq P + P_0 - t > 0, V \geq P, P + P_0 \geq T$, and assume that the level of consumers' acceptance of the original price shopping is θ_1 (that is consumers' preference for the original price shopping, $0 < \theta_1 < 1$), the shopping add-on items preference is $\theta_2(0 < \theta_2 < 1)$ and the acceptability of the discount amount is θ_3 (that is consumers' preference for the discount amount, $1 < \theta_3 < 2$). The definitions and related variables are shown in Table 1.

We assume the costs that the platform and consumers need to bear are respectively $\frac{\lambda r^2}{2}$ and $\frac{\delta S^2}{2}$ when the e-commerce platform' shopping add-on items recommendation service strength is r and consumers' shopping

TABLE 1. The definitions and related variables.

Variable name	Variable definitions
T	Full-reduction threshold
t	Discount amount
P	Original commodity price
P_0	Recommended commodity price
S	Consumer's purchase willingness $0 < S < 1$
r	Platform's add-on items recommendation service strength $0 < r < 1$
V	Consumer's valuation of the product's reservation price
	$V \geq P + P_0 - t, V \geq P, P + P_0 \geq T$
θ_1	Consumers' preference at the original price purchase $0 < \theta_1 < 1$
θ_2	The shopping add-on items preference $0 < \theta_2 < 1$
θ_3	The discount amount preference $1 < \theta_3 < 2$
λ	The cost coefficient of the platform to provide the add-on items recommendation service
δ	The shopping cost coefficient of consumers

willingness is $S(\lambda > 0$ is the cost coefficient of the platform within recommendation service, and $\delta > 0$ is shopping cost coefficient of consumers), where the quadratic forms suggest diminishing returns[1]. It is worth noting that in the research of Li *et al.* [13] on add-on item recommended service, they believe that cost of the recommendation service changes linearly. However, in some complex or extreme cases, it is not natural to describe the relationship between recommendation strength and recommendation cost in linear form. Therefore, based on the law of diminishing returns, we use a more reasonable form to reflect the relationship between them, thereby further expanding the research scope and field of application.

When $P \geq T$ (that is, the original product price is greater than or equal to the full-reduction threshold value), the platform provides a price discount to the consumer, then the consumer directly buys the product to enjoy the price discount, and the utility is $(V - P + t)$. But this situation is easy to understand, which is not the scope of our study and will not be discussed in the following paper [13]. When $P < T$, the utility of purchase at the original price, accepting the add-on items recommendation service provided by platform and giving up the shopping are respectively $\theta_1(V - P), \theta_2\theta_3(V - P - P_0 + t)$ and 0.

3. BASIC DECISION MODEL

We construct the basic decision models of consumers and platform respectively when the purchase amounts of consumer are less than the full-reduction threshold value. The details are as follows:

When $P < T$, consumers' purchase decision is determined jointly by their purchase willingness and the add-on items recommendation service strength provided by the e-commerce platform. This expected utility function of consumers is as below:

$$U = \theta_1(V - P)S + \theta_2\theta_3(V - P - P_0 + t)Sr - \frac{\delta S^2}{2}. \tag{3.1}$$

It is worth noting when $P < T$, if consumer buys product at the original price, his purchase decision will not be affected by the add-on items recommended service strength provided by the platform. This is because the consumer, who buys at the original price directly, will not purchase add-on items to qualify for a price discount. In other words, the consumer does not accept the shopping add-on item recommendation service provided by the platform, so the consumer is not affected by the add-on item recommendation service. If consumer purchases add-on items according to the recommendation service provided by the platform that implements a full-reduction-promotion policy to qualify for a price discount, the service strength of the add-on

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[1] Diminishing returns is natural because under the conditions of other factors held constant in amount, when the recommendation strength is increased, the output per unit of the recommendation strength will eventually diminish.

item recommendation will influence the recommended items and non- recommended items purchased together by the consumer.

The decision-making order of Stackelberg game model is that the platform as the leader takes the lead in making decisions, and the consumers in the network as the follower make subsequent decisions according to the leader's strategy. At the same time, to maximize the profits, platform needs to determine the strength of the add-on items recommendation service based on consumers' purchase willingness. Therefore, the profit function of platform can be given as follows:

$$\pi = PS + (P + P_0 - t)Sr - \frac{\lambda r^2}{2}. \tag{3.2}$$

Based on the above analysis, there are the following conclusions about the platform optimal shopping add-on items recommendation service strength and consumers' optimal online shopping willingness.

Proposition 3.1. *Under the full-reduction promotion, when the consumer's shopping amount is less than the full-reduction threshold, based on the Stackelberg game model, the optimal add-on items recommendation service strength of the platform and the optimal online shopping willingness of consumers can be concluded as follows:*

$$r^* = \frac{\theta_2\theta_3 P(V - P - P_0 + t) + \theta_1(V - P)(P + P_0 - t)}{\lambda\delta - 2\theta_2\theta_3(P + P_0 - t)(V - P - P_0 + t)} \tag{3.3}$$

$$S^* = \frac{\theta_1(V - P)}{\delta} + \frac{\theta_2\theta_3(V - P - P_0 + t)}{\delta} \cdot \frac{\theta_2\theta_3 P(V - P - P_0 + t) + \theta_1(V - P)(P + P_0 - t)}{\lambda\delta - 2\theta_2\theta_3(P + P_0 - t)(V - P - P_0 + t)}. \tag{3.4}$$

Proof. According to the decision-making order of Stackelberg game model, the consumer behavior is calculated first. From equation (3.1) we can obtain:

$$\frac{dU}{dS} = \theta_1(V - P) + \theta_2\theta_3(V - P - P_0 + t)r - \delta S = 0. \tag{3.5}$$

And because $\frac{d^2U}{dS^2} = -\delta < 0(0 < \delta < 1)$, we can get that equation (3.5) has a unique solution, which is:

$$S^* = \frac{\theta_1(V - P)}{\delta} + \frac{\theta_2\theta_3(V - P - P_0 + t)}{\delta} \cdot r. \tag{3.6}$$

To guarantee the presence of the optimal shopping add-on items recommendation service strength of the platform r^*, we assume $\lambda > \frac{2\theta_2\theta_3}{\delta}(P + P_0 - t)(V - P - P_0 + t)$ as a prerequisite. Then bring equation (3.6) into equation (3.2), we can get the following result:

$$\pi = P\left(\frac{\theta_1(V - P)}{\delta} + \frac{\theta_2\theta_3(V - P - P_0 + t)}{\delta}r\right) + (P + P_0 - t)r\left(\frac{\theta_1(V - P)}{\delta} + \frac{\theta_2\theta_3(V - P - P_0 + t)}{\delta}r\right) - \frac{\lambda r^2}{2}. \tag{3.7}$$

Then by calculating the first partial derivative of r in the equation (3.7). We can obtain the following equation:

$$\frac{d\pi}{dr} = P\frac{\theta_2\theta_3(V - P - P_0 + t)}{\delta} + (P + P_0 - t)r\frac{\theta_2\theta_3(V - P - P_0 + t)}{\delta}$$
$$+ (P + P_0 - t)\left(\frac{\theta_1(V - P)}{\delta} + \frac{\theta_2\theta_3(V - P - P_0 + t)}{\delta}r\right) - \lambda r$$
$$= 0. \tag{3.8}$$

And because:

$$\frac{d^2\pi}{dr^2} = (P + P_0 - t)\frac{2\theta_2\theta_3(V - P - P_0 + t)}{\delta} - \lambda < 0\left(\lambda > (P + P_0 - t)\frac{2\theta_2\theta_3(V - P - P_0 + t)}{\delta}\right).$$

So, we get that π is a concave function of r. Therefore, the equation (3.8) has a unique value, and the unique value is the optimal solution, which is:

$$r^* = \frac{\theta_2\theta_3 P(V - P - P_0 + t) + \theta_1(V - P)(P + P_0 - t)}{\lambda\delta - 2\theta_2\theta_3(P + P_0 - t)(V - P - P_0 + t)}.$$

Bring equation (3.3) into equation (3.6), we can conclude that:

$$S^* = \frac{\theta_1(V - P)}{\delta} + \frac{\theta_2\theta_3(V - P - P_0 + t)}{\delta} \cdot \frac{\theta_2\theta_3 P(V - P - P_0 + t) + \theta_1(V - P)(P + P_0 - t)}{\lambda\delta - 2\theta_2\theta_3(P + P_0 - t)(V - P - P_0 + t)}.$$

$\square$

Inference 3.2. When the amount of consumer purchase is less than the full-reduction threshold, the profit π of platform first increases and then decreases with the change of the add-on items recommendation service strength r.

From Inference 3.2, we can obtain that the profit of platform π is a concave function of r from $\frac{\mathrm{d}^2\pi}{\mathrm{d}r^2} < 0$. In other words, there is an optimal solution r^* to maximize the profit of the platform. Specifically, when $r < r^*$, the profit of the platform increases with the increase of r. When $r > r^*$, the profit of the platform decreases with the increase of r.

3.1. Analysis of consumers' online shopping decision

According to the theory of consumer utility, rational consumers tend to choose the shopping form with utility greater than 0 and maximum utility when making decisions. Because consumer's utility is affected by the discount amount and the price of recommended add-on items, the following proposition holds:

Proposition 3.3. (a) When $t < \left(\frac{\theta_2\theta_3}{\theta_1} - 1\right)V + \left(1 - \frac{\theta_2\theta_3}{\theta_1}\right)P + P_0$, consumers will choose to buy at original price.

(b) When $P_0 < \left(1 - \frac{\theta_1}{\theta_2\theta_3}\right)V + \left(\frac{\theta_1}{\theta_2\theta_3} - 1\right)P + t$, consumers will accept the shopping add-on items recommendation service provided by platform to purchase.

(c) When $V = P + \frac{\theta_2\theta_3}{\theta_2\theta_3 - \theta_1}(P - t)$, the original price shopping and the add-on items shopping can bring the same utility to consumers, consumers can choose one of the above two ways.

Proof. According to the utility theory, rational consumers always choose the most effective and positive way of shopping. Therefore, the prerequisite that consumers choose the original price to buy is:

$$\theta_1(V - P) > 0 \quad \text{and} \quad \theta_1(V - P) > \theta_2\theta_3(V - P - P_0 + t).$$

Then, we can obtain:

$$t < \left(\frac{\theta_2\theta_3}{\theta_1} - 1\right)V + \left(1 - \frac{\theta_2\theta_3}{\theta_1}\right)P + P_0.$$

According to the same method above, other conclusions can be proved. Proposition 3.3 is supported. $\square$

From Proposition 3.3, we can obtain that: (a) For consumers who prefer to buy at the original price, when the discount amount set by platform is relatively low, they will buy at the original price. When consumers have a higher reservation price for products, even if the discount amount is relatively high, consumers will also buy at the original price, and the probability of consumers' purchasing increases with the increase of the reservation price. When the discount amount is within a specific range, whether consumers with original price shopping preference choose the add-on items purchase will be affected by shopping add-on items recommendation service strength provided by the platform. If the total goods' utilities are higher than that of the original price good,

TABLE 2. The impact of consumers' purchase willingness.

Parameter	Parameter range change	Consumers' purchase willingness change
θ_1	$\theta_1 \in (0,1), \frac{\partial S}{\partial \theta_1} > 0$	Monotonic increase
θ_2	$\theta_2 \in (0,1), \frac{\partial S}{\partial \theta_2} > 0$	Monotonic increase
θ_3	$\theta_3 \in (0,1), \frac{\partial S}{\partial \theta_3} > 0$	Monotonic increase
t	$\theta_1 \in \left(0, \frac{\theta_2\theta_3 P}{V-P}\right), t \in (0,1), \frac{\partial S}{\partial t} > 0$	When θ_1 is relatively small: Monotonic increase
	$\theta_1 \in \left(\frac{\theta_2\theta_3 P}{V-P} > 1\right), t \in (0,\underline{t}), \frac{\partial S}{\partial t} > 0;$ $t \in (\underline{t},1), \frac{\partial S}{\partial t} < 0$	When θ_1 is relatively large: First increase and then decrease
r	$r \in (0,1), \frac{\partial S}{\partial r} > 0$	Monotonic increase
P_0	$\frac{\partial S}{\partial P_0} < 0$	Monotonic decrease

Notes. $\underline{t} = \frac{\theta_2\theta_3 P(V-P-P_0) + \theta_1(V-P)(P+P_0)}{\theta_1(V-P) - \theta_2\theta_3 P}$.

consumers will accept the recommendation service shopping. (b) For consumers who prefer to buy add-on items according to the recommendation service provided by the platform, when the recommended product's price is relatively low, consumers accept the add-on items recommendation service to purchase. When the total goods' utilities are less than that of the add-on items goods, consumers will choose to buy at the original price, otherwise they will choose add-on items to buy. And the greater the utilities of the total goods, the more likely consumers will choose add-on items goods to buy.

Inference 3.4. Table 2 shows the details of the impact of $\theta_1, \theta_2, \theta_3, t, r$ and P_0 on customers shopping willingness under full-reduction promotion.

Proof. We can obtain $\frac{\partial S}{\partial \theta_1} > 0$ and $\frac{\partial S}{\partial r} > 0$ from equations (3.4) and (3.6). Similarly, other conclusions can be proved. □

According to Inference 3.4, there is a significant positive correlation between consumers' purchase preference at original price (add-on items preferences, reduction amount preferences) and their online purchase willingness. The impact of the discount amount on consumers' purchase willingness is related to consumers' purchase preference at the original price, add-on items preferences and reduction amount preferences. Consumers' purchase willingness increases with the improvement of platform' add-on items recommendation service strength. Under the case that the reservation price of commodities remains unchanged, if the platform increases the original product's price and the recommended commodities price at the same time, the utility of consumers will be reduced, thus weakening the consumers' interest and purchase willingness. If the reservation price of the original product increases, the utility that consumers obtain will also increase, thereby increasing the likelihood of consumer purchase.

3.2. Analysis of platform' add-on items recommendation service strength strategy

Under the full-reduction promotion, when the online shopping amount of customer is lower than the full-reduction threshold value, reasonable shopping add-on items recommendation service strength provided by

the platform will improve the possibility of customers' purchase. However, the optimal add-on items recommendation service strength will be affected by customers' purchase preference at original price, add-on items preference, discount amount preference, reservation price, recommended commodity price and discount amount. The influence of these factors will be analyzed in detail below.

We can get the expression of r^* from Proposition 3.1. By calculating the first-order partial derivatives of θ_1, θ_2, θ_3, V, P_0, t in equation (3.3), respectively. The following equations can be concluded:

$$\frac{\partial r^*}{\partial \theta_1} = \frac{(V-P)(P+P_0-t)}{\lambda\delta - 2\theta_2\theta_3(P+P_0-t)(V-P-P_0+t)} \tag{3.9}$$

$$\frac{\partial r^*}{\partial \theta_2} = \frac{\theta_3 P(V-P-P_0+t)}{\lambda\delta - 2\theta_2\theta_3(P+P_0-t)(V-P-P_0+t)}$$
$$+ \frac{2\theta_3(P+P_0-t)(V-P-P_0+t)(\theta_2\theta_3 P(V-P-P_0+t) + \theta_1(V-P)(P+P_0-t))}{(\lambda\delta - 2\theta_2\theta_3(P+P_0-t)(V-P-P_0+t))^2} \tag{3.10}$$

$$\frac{\partial r^*}{\partial \theta_3} = \frac{\theta_2 P(V-P-P_0+t)}{\lambda\delta - 2\theta_2\theta_3(P+P_0-t)(V-P-P_0+t)}$$
$$+ \frac{2\theta_2(P+P_0-t)(V-P-P_0+t)(\theta_2\theta_3 P(V-P-P_0+t) + \theta_1(V-P)(P+P_0-t))}{(\lambda\delta - 2\theta_2\theta_3(P+P_0-t)(V-P-P_0+t))^2} \tag{3.11}$$

$$\frac{\partial r^*}{\partial V} = \frac{\theta_2\theta_3 P + \theta_1(P+P_0-t)}{\lambda\delta - 2\theta_2\theta_3(P+P_0-t)(V-P-P_0+t)}$$
$$+ \frac{2\theta_2\theta_3(P+P_0-t)(\theta_2\theta_3 P(V-P-P_0+t) + \theta_1(V-P)(P+P_0-t))}{(\lambda\delta - 2\theta_2\theta_3(P+P_0-t)(V-P-P_0+t))^2} \tag{3.12}$$

$$\frac{\partial r^*}{\partial P_0} = \frac{-\theta_2\theta_3 P + \theta_1(V-P)}{\lambda\delta - 2\theta_2\theta_3(P+P_0-t)(V-P-P_0+t)}$$
$$+ \frac{2\theta_2\theta_3(V-2P-2P_0+2t)(\theta_2\theta_3 P(V-P-P_0+t) + \theta_1(V-P)(P+P_0-t))}{(\lambda\delta - 2\theta_2\theta_3(P+P_0-t)(V-P-P_0+t))^2} \tag{3.13}$$

$$\frac{\partial r^*}{\partial t} = \frac{\theta_2\theta_3 P - \theta_1(V-P)}{\lambda\delta - 2\theta_2\theta_3(P+P_0-t)(V-P-P_0+t)}$$
$$- \frac{2\theta_2\theta_3(V-2P-2P_0+2t)(\theta_2\theta_3 P(V-P-P_0+t) + \theta_1(V-P)(P+P_0-t))}{(\lambda\delta - 2\theta_2\theta_3(P+P_0-t)(V-P-P_0+t))^2}. \tag{3.14}$$

By analyzing the above function expressions, we can get the conclusions that how the changes of the above factors affect the optimal add-on items recommendation service strength strategy of the platform.

Proposition 3.5. *The optimal shopping add-on items recommendation service strength of the platform r^* is monotonically increasing function of customers' purchase preference at original price θ_1.*

Proof. Based on previous conditions of $V \geq P + P_0 - t > 0, P + P_0 \geq T, V \geq P$, we can deduce that $\frac{\partial r^*}{\partial \theta_1} > 0$ from equation (3.9), further conclude that r^* is a monotonically increasing function of θ_1. Proposition 3.5 is supported. □

Proposition 3.6. (i) *When $0 < \theta_2 < \frac{\lambda\delta}{2\theta_3(V-P-P_0+t)(P+P_0-t)}$, the optimal add-on items recommendation service strength r^* of the platform increases with the increase of customers' add-on items preferences θ_2. When $\frac{\lambda\delta}{2\theta_3(V-P-P_0+t)(P+P_0-t)} < \theta_2$, although the optimal add-on items recommendation service strength r^* of the platform changes with the varies of customers' add-on items preferences θ_2, r^* is less than 0.*

(ii) *When $0 < \theta_3 < \frac{\lambda\delta}{2\theta_2(V-P-P_0+t)(P+P_0-t)}$, the optimal add-on items recommendation service strength r^* of the platform increases with the increase of the acceptability of customer discount amount θ_3. Although the platform optimal add-on items recommendation service strength changes with the acceptability of customer discount amount θ_3 when $\frac{\lambda\delta}{2\theta_2(V-P-P_0+t)(P+P_0-t)} < \theta_3$, r^* is less than 0.*

Proof. From equation (3.10), we assume:

$$F = \theta_3 P(V - P - P_0 + t)(\lambda\delta - 2\theta_2\theta_3(P + P_0 - t)(V - P - P_0 + t))$$
$$+ 2\theta_3(P + P_0 - t)(V - P - P_0 + t)(\theta_2\theta_3 P(V - P - P_0 + t) + \theta_1(V - P)(P + P_0 - t)). \quad (3.15)$$

Calculate the first-order partial derivatives of θ_2 in equation (3.15), then the following equations can be concluded:

$$\frac{\partial F}{\partial \theta_2} = -4\theta_3^2 P(P + P_0 - t)(V - P - P_0 + t)^2.$$

Because P, $P + P_0 - t > 0$, we can get $\frac{\partial F}{\partial \theta_2} < 0$. So, F is a monotone decreasing function of θ_2. And, when $0 < \theta_2 < \frac{\lambda\delta}{2\theta_3(V-P-P_0+t)(P+P_0-t)}$ from the assumptions, we can deduce $F > 0$. So, in this case, r^* is a monotone increasing function of θ_2.

In addition, the prerequisite of $r^* > 0$ is $\theta_2 < \frac{\lambda\delta}{2\theta_3(V-P-P_0+t)(P+P_0-t)}$. When $0 < \theta_2 < \frac{\lambda\delta}{2\theta_3(V-P-P_0+t)(P+P_0-t)}$, we can conclude: $F > 0, \frac{\partial r^*}{\partial \theta_2} > 0$ and $r^* > 0$. When $\theta_2 \in \left(\frac{\lambda\delta}{2\theta_3(V-P-P_0+t)(P+P_0-t)}, 1\right)$, we can conclude $r^* < 0$.
(i) is proved. Similarly, it is easy to prove the conclusion of proposition (ii). □

According to Proposition 3.6, when the customer's add-on items preference (discount amount preference) changes within a specific range, the optimal add-on items recommendation service strength of the platform is a monotonic increasing function of customer's add-on items preference (discount amount preference). In this case, the platform should improve the add-on items recommendation service strength appropriately. However, when the consumers' add-on items preference (discount amount preference) exceeds the specific range, no matter how the optimal add-on items recommendation service strength of the platform changes with customers' add-on items preference (discount amount preference), the optimal add-on items recommendation service strength is always less than 0, which indicates that in the situation, the platform should lower the optimal add-on items recommendation service strength even give up the recommendation service.

Proposition 3.7. (i) *When* $\max\{P + P_0 - t, P\} \leq V < \overline{V}$, *we can calculate* $\frac{\partial r^*}{\partial V} > 0$, *further conclude that the optimal shopping add-on items recommendation service strength* r^* *of the platform increases with the increase of commodity reservation price* V.

(ii) *When* $V > \overline{V}$, *we can obtain* $\frac{\partial r^*}{\partial V} > 0$ *and* $r^* < 0$. *In this case, the optimal add-on items recommendation service strength* r^* *of the platform is a monotonic increasing function of commodity reservation price* V, *where* $\overline{V} = \frac{\lambda\delta + 2\theta_2\theta_3(P+P_0-t)^2}{2\theta_2\theta_3(P+P_0-t)}$.

Proof. Calculate the fist-order partial derivatives of V in equation (3.3). Then we can obtain $\frac{\partial r^*}{\partial V} > 0$. In order to ensure that r^* is greater than 0, the premise is $\max\{P + P_0 - t, P\} \leq V < \overline{V} = \frac{\lambda\delta + 2\theta_2\theta_3(P+P_0-t)^2}{2\theta_2\theta_3(P+P_0-t)}$. So, Proposition 3.7 is supported. □

According to Proposition 3.7, when the commodity reservation price changes within a specific range, the optimal shopping add-on items recommendation service strength of the platform increases with the increase of the commodity reservation price. In order to stimulate consumers to buy, the platform should improve the service strength of recommendation. When the commodity reservation price exceeds the specific range, consumers' purchase decisions are less or not affected by the platform' recommendation service, so the platform should take corresponding measures in this case.

Proposition 3.8. (i) *When* $\theta_2\theta_3 P = \theta_1(V - P)$, *if* $P_0 < \overline{P}_0$, *the optimal add-on items recommendation service strength* r^* *of the platform increases with the increase of the recommended commodity price* P_0. *Otherwise, the optimal add-on items recommendation service strength* r^* *of the platform decreases with the increase of the recommended commodity price* P_0.

(ii) *When $\theta_2\theta_3 P \neq \theta_1(V-P)$, if $P_0 < \overline{\overline{P}}_0$, the optimal add-on items recommendation service strength r^* of the platform increases with the increase of the recommended commodity price P_0. Otherwise, the optimal add-on items recommendation service strength r^* of the platform decreases with the increase of the recommended commodity price P_0, where $\overline{P}_0$ and $\overline{\overline{P}}_0$ are respectively:*

$$\overline{P}_0 = \frac{V}{2} - P + t$$

$$\overline{\overline{P}}_0 = \frac{4\theta_2^2\theta_3^2 P(V-P+t) + 4\theta_1\theta_2\theta_3(V-P)(P-t)}{4(\theta_2^2\theta_3^2 P - \theta_1\theta_2\theta_3(V-P))}$$
$$- \frac{\sqrt{(8\theta_1\theta_2\theta_3(V-P) - 8\theta_2^2\theta_3^2 P)(\theta_1(V-P) - \theta_2\theta_3 P)\lambda\delta + 16\theta_1\theta_2^3\theta_3^3 P(V-P)V^2}}{4(\theta_2^2\theta_3^2 P - \theta_1\theta_2\theta_3(V-P))}.$$

Proof. Make $\frac{\partial r^*}{\partial P_0}$ be equal to 0 and assume:

$$g = -\theta_2\theta_3 P + \theta_1(V-P)(\lambda\delta - 2\theta_2\theta_3(P+P_0-t)(V-P-P_0+t))$$
$$+ 2\theta_2\theta_3(V-2P-2P_0+2t)(\theta_2\theta_3 P(V-P-P_0+t) + \theta_1(V-P)(P+P_0-t)). \qquad (3.16)$$

By calculating first-order partial derivatives of P_0 in equation (3.16), the following equation can be concluded as follows:

$$\frac{\partial g}{\partial P_0} = -4\theta_2^2\theta_3^2 P(V-P-P_0+t) - 4\theta_1\theta_2\theta_3(V-P)(P+P_0-t). \qquad (3.17)$$

Because $P, V-P-P_0+t, \theta_1, \theta_2, \theta_3, V-P, P+P_0-t > 0$, equation (3.17) is less than 0. Therefore, g is a monotone decreasing function of P_0.

Then, make g be equal to 0. There are two situations:

(1) When $\theta_2\theta_3 P = \theta_1(V-P)$, g is n unary linear function of P_0, and the solution of $g = 0$ is $\overline{P}_0 = \frac{V}{2} - P + t$.
(2) When $\theta_2\theta_3 P \neq \theta_1(V-P)$, g is a quadratic function of unary variable of P_0. When $P_0 \in (0, V-P+t)$, g is a monotone decreasing function of P_0. Make g be equal to 0, then we can obtain:

$$\overline{\overline{P}}_0 = \frac{4\theta_2^2\theta_3^2 P(V-P+t) + 4\theta_1\theta_2\theta_3(V-P)(P-t)}{4(\theta_2^2\theta_3^2 P - \theta_1\theta_2\theta_3(V-P))}$$
$$- \frac{\sqrt{(8\theta_1\theta_2\theta_3(V-P) - 8\theta_2^2\theta_3^2 P)(\theta_1(V-P) - \theta_2\theta_3 P)\lambda\delta + 16\theta_1\theta_2^3\theta_3^3 P(V-P)V^2}}{4(\theta_2^2\theta_3^2 P - \theta_1\theta_2\theta_3(V-P))}.$$

Proposition 3.8 is supported. □

According to Proposition 3.8, the impact of the recommended commodity price on the platform' optimal shopping add-on items recommendation service strength generally shows a trend of increasing first and then decreasing. When the recommended commodity price is relatively small, the platform should improve the strength of the recommendation service according to the increase of the recommended commodity price. This is because the recommended commodity price is relatively small, which also means that the price of the original products is close to the full-reduction threshold. In this circumstance, consumers have a greater motivation to make the add-on items shopping. With the increase of the recommended commodity price within a fixed range, the platform should gradually improve the recommendation service strength to further maintain and strengthen the motivation of consumers add-on items shopping. When the recommended commodity price exceeds a certain threshold, the motivation that consumers make the add-on items shopping is relatively weak. In this case, recommendation by the platform will only increase platform costs and reduce profits. Thus, it's better decision for the platform to reduce the recommendation service strength.

Proposition 3.9. (i) *When $\theta_2\theta_3 P = \theta_1(V-P)$, if $t < \bar{t}$, the optimal add-on items recommendation service strength r^* of the platform increases with the increase of discount amount t. Otherwise the optimal add-on items recommendation service strength r^* of the platform decreases with the increase of discount amount t.*

(ii) *When $\theta_2\theta_3 P \neq \theta_1(V-P)$, if $t < \bar{\bar{t}}$, the optimal add-on items recommendation service strength r^* of the platform increases with the increase of discount amount t. Otherwise, the optimal add-on items recommendation service strength r^* of the platform decreases with the increase of discount amount t, where:*

$$\bar{t} = P + P_0 - \frac{V}{2}$$

$$\bar{\bar{t}} = \frac{4\theta_2^2\theta_3^2 P(V - P - P_0) + 4\theta_1\theta_2\theta_3(V - P)(P + P_0)}{4(\theta_1\theta_2\theta_3(V - P) - \theta_2^2\theta_3^2 P)}$$

$$- \frac{\sqrt{(8\theta_1\theta_2\theta_3(V - P) - 8\theta_2^2\theta_3^2 P)(\theta_1(V - P) - \theta_2\theta_3 P)\lambda\delta + 16\theta_1\theta_2^3\theta_3^3 P(V - P)V^2}}{4(\theta_1\theta_2\theta_3(V - P) - \theta_2^2\theta_3^2 P)}.$$

Proof. Similar to the proof of Proposition 3.8, it is easy to prove Proposition 3.9.   □

According to Proposition 3.9, whether $\theta_2\theta_3 P = \theta_1(V - P)$ or $\theta_2\theta_3 P \neq \theta_1(V - P)$, we can conclude that: When the discount amount increases in a specific range, the optimal shopping add-on items recommendation service strength of the platform increases with increase of discount amount. At this time, the platform should appropriately improve the recommendation service strength. But when the discount amount exceeds its specific range, the optimal add-on items recommendation service strength of the platform decreases with the increase of discount amount. In this case, the platform should reduce the recommendation service strength.

4. NUMERICAL ANALYSIS

Let $T = 0.5, P = 0.4, \delta = 0.6, \lambda = 0.6$. Then analyze the interaction among the reservation price, recommended commodity price, discount amount, the optimal shopping add-on items recommendation service strength and the total profit of the platform.

(1) First, this section verifies the relationship between consumers' value of commodity reservation price V and the platform' optimal add-on items recommendation service strength r^*.
Make $t = 0.1, P_0 = 0.2, \theta_1 = \theta_2 = \theta_3 = 0.5$ and Satisfy $\max\{P + P_0 - t, P\} \leq V$. According to the equation (3.3) and the basic parametric values given above, the relationship between the commodity reservation price and the platform's optimal shopping add-on items recommendation service strength is shown in Figure 3. From Figure 3, we can know that when $V \in (0.5, 1.94)$, the optimal recommendation service level of the platform r^* is a monotonic increasing function of the reservation price, and $r^* > 0$. In this circumstance, the platform should improve the optimal add-on items recommendation service strength according to the increase of the reservation price. When $V > 1.94$, the optimal shopping add-on items recommendation service strength of the platform is still a monotonic increasing function of reservation price, but $r^* < 0$, $\lim_{V \to \infty} r^* = 0$. In this case, it is the best decision for the platform to give up providing the add-on items recommendation service. The conclusion verifies the correctness of Proposition 3.7.

(2) Second, this section verifies the relationship between the recommended commodity price P_0 and the platform' optimal shopping add-on items recommendation service strength r^*.
Take $V = 1, \{\theta_1 = 0.2, \theta_2 = 0.5, \theta_3 = 0.6\}, \{\theta_1 = 0.2, \theta_2 = 0.5, \theta_3 = 0.8\}\{\theta_1 = 0.8, \theta_2 = 0.5, \theta_3 = 0.6\}$, $\{t = 0.3, 0.4, 0.5\}$ three sets of data. According to the functional expression of the platform' the optimal shopping add-on items recommendation service strength r^* with respect to P_0 in Proposition 3.1, the relationship between the recommended commodity price P_0 and the the platform's optimal shopping add-on items recommendation service strength r^* is shown in Figure 4.
According to Figure 4, this study finds that either $\theta_2\theta_3 P = \theta_1(V - P)$ or $\theta_2\theta_3 P \neq \theta_1(V - P)$, the trend of the impact of recommended commodity price on the optimal shopping add-on items recommendation service strength of the the platform is the same, which is that when P_0 increases in a fixed range, the optimal add-on items recommendation service strength of the platform r^* increases. When the recommended add-on commodity price is higher than this threshold, the optimal shopping add-on items recommendation service
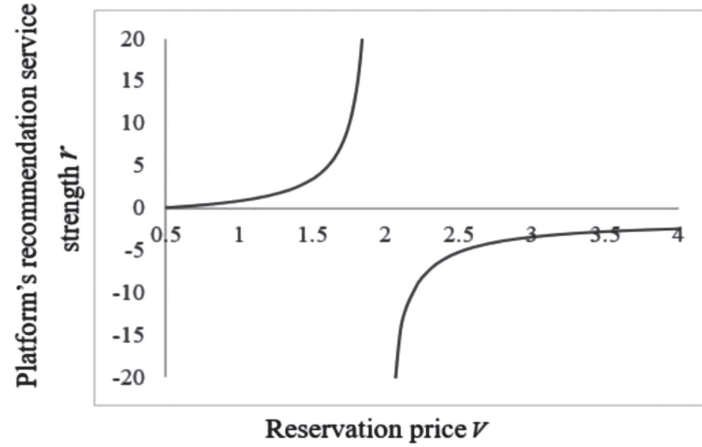
FIGURE 3. The impact of reservation price on the optimal shopping add-on items recommendation service strength of the platform.
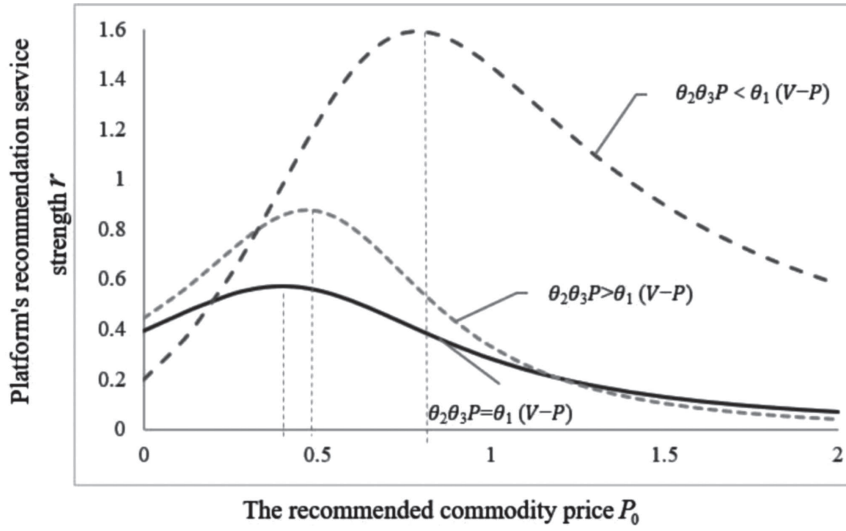

FIGURE 4. The impact of recommended commodity price on the optimal shopping add-on items recommendation service strength of the platform.

strength of the platform r^* decreases with the increase of the recommended commodity price P_0. The relationship between $\theta_2\theta_3P$ and $\theta_1(V-P)$ determines the optimal recommendation service strength, which also means that the optimal add-on items recommendation service strength in each case will be affected by consumer shopping preferences. This conclusion verifies the correctness of Proposition 3.8.

(3) Based on consumers' purchase preference at the original price, add-on items preferences and the discount amount preference, this section analyzes the impact of the change of discount amount t on the optimal add-on items recommendation service strength r^* of the platform.

FIGURE 5. The impact of the discount amount on the optimal shopping add-on items recommendation service strength of the platform.

Take $V = 1, P_0 = 0.5, \{\theta_1 = 0.2, \theta_2 = 0.5, \theta_3 = 0.6\}, \{\theta_1 = 0.2, \theta_2 = 0.5, \theta_3 = 0.8\}, \{\theta_1 = 0.4, \theta_2 = 0.6, \theta_3 = 0.6\}$ three sets of data. The relationship between the discount amount t and the platform's optimal shopping add-on items recommendation service strength r^* is shown in Figure 5.

According to Figure 5, the impact of the discount amount on the optimal shopping add-on items recommendation service strength of the platform shows an overall trend of first increasing and then decreasing. When the discount amount increases within a relatively low fixed range, because the discount amount brings relatively low utility to consumers, the platform should improve the recommendation service strength and strengthen consumers' motivation to make purchase with the increase of the discount amount. When the discount amount exceeds a certain range, the relatively high discount is very attractive to consumers, so relatively low recommendations can bring consumers greater utility. In addition, excessively high discount can cause consumers to doubt the quality of the product, which will reduce consumers' shopping motivation and even cause consumers to give up purchasing. In this case, improving the recommendation service strength can not stimulate consumers' purchase willingness, but will increase the cost of platform recommendation. Therefore, in order to avoid losses, the platform should lower the strength of recommendation service. This conclusion verifies the correctness of Proposition 3.9.

(4) Based on the discount amount, consumers' purchase preference at the original price, add-on items preferences and the discount amount preference, this section analyzes the impact of the reservation price V on the platform' profit π.

Take $P_0 = 0.2, \{t = 0.1, 0.2, 0.3\}, \{\theta_1 = 0.2, \theta_2 = 0.8, \theta_3 = 0.8\}, \{\theta_1 = 0.5, \theta_2 = 0.5, \theta_3 = 0.5\}, \{\theta_1 = 0.8, \theta_2 = 0.2, \theta_3 = 0.2\}$ three sets of data. The relationship between the commodity reservation price V and the profit of platform π is shown in Figure 6.

From Figure 6, we can know that when the platform provides add-on items recommendation service, the profit of platform increases with the increase of reservation price, but has nothing to do with the discount amount, consumers' purchase preference at the original price, add-on items preferences and the discount amount preference. Concretely, when the reservation price is relatively low and $\theta_1 > \theta_2$, the profit of platform is the biggest, which is because although the reservation price of consumers is relatively low, the discount amount is large and the total utility of the final consumers is relatively large, thus improving the consumers' willingness to purchase and then increasing the profits of platform. As the reservation price increases, consumers' expected utility of the product increases. In addition, the higher reservation price
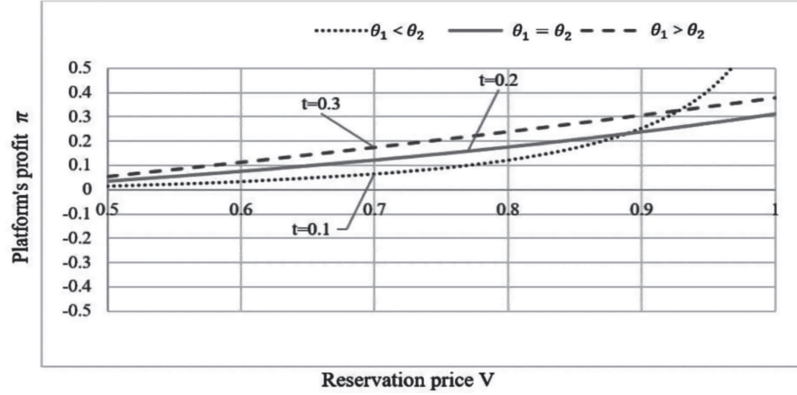
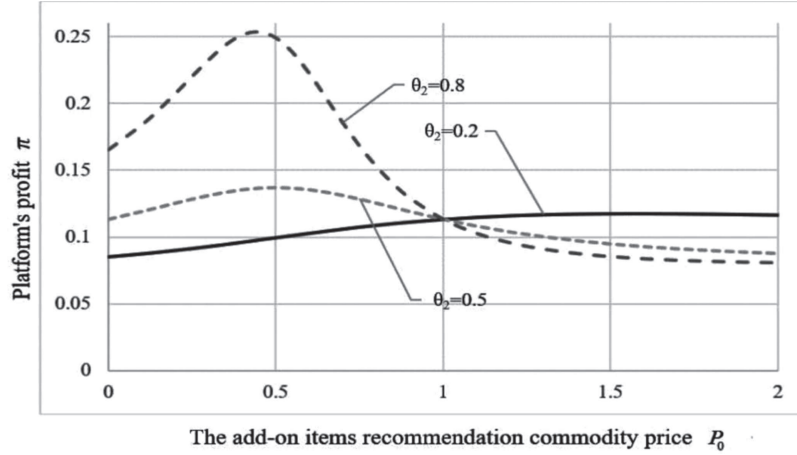FIGURE 6. The impact of reservation price on the profit.

FIGURE 7. The impact of add-on items recommended commodity price on the profit.

and the relatively large discount amount increase the consumer's willingness to buy. In this case, the add-on items recommendation service has played a positive role. However, when the reservation price is higher than a certain amount, the relatively high reservation price enhances the purchase willingness of consumers. Consumers can get great utility by keeping the difference between the reservation price and the price they pay. The higher discount amount set by the platform will make consumers doubt the quality of products. In this circumstance, consumers are more willing to purchase for products with the lower discount amount. Therefore, the profits of platform will show a trend of rapid increase in the relatively low discount.

(5) Based on the consumers' heterogeneity preference for add-on items, this section analyzes the impact of the change of the add-on items recommendation commodity price p_0 on the platform's profit π.

Take $V = 1, t = 0.4, \{\theta_1 = 0.2, \theta_2 = 0.2, \theta_3 = 0.6\}, \{\theta_1 = 0.2, \theta_2 = 0.5, \theta_3 = 0.6\}, \{\theta_1 = 0.2, \theta_2 = 0.8, \theta_3 = 0.6\}$, three sets of data. The relationship between the add-on items recommendation commodity price p_0 and the platform's profit π is shown in Figure 7.

According to Figure 7, when the consumers' add-on items preference is relatively low, the profit of the platform changes very little, which indicates that the recommended commodity price is not the main factor affecting the platform' profit. In this case, platform needs to consider changing other factors to increase
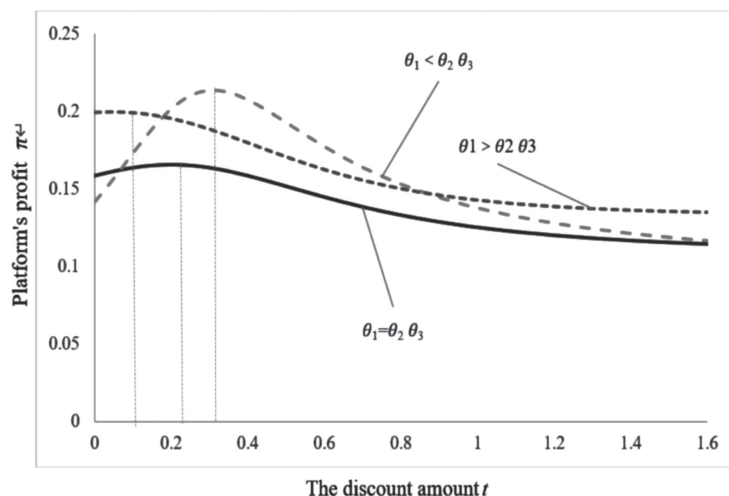
FIGURE 8. The impact of the discount amount on the platform' profit.

profits. With the increase of θ_2, the profit fluctuation of the platform becomes obvious, and presents the trend of first increasing and then decreasing. When $P_0 = 0.45$, the profit of the platform increases with the increase of consumers' add-on items preference. When $P_0 = 1$, the profit of the platform is equal under different consumers' add-on items preferences. When P_0 is greater than 1 and continues to increase, the lower add-on items preference, the greater the profit of the platform. It can be concluded that the higher recommended commodity price will not necessarily increase the platform's profit, and the lower recommended commodity price will not necessarily lower the platform's profit. The optimal strategy of the platform is as follows: when consumers have a higher add-on items preference, recommend lower-priced products as far as possible. Otherwise, recommend higher-priced products appropriately, so as to achieve the goal of maximizing profits for the platform.

(6) Based on consumers' purchase preference at the original price, add-on items preferences and the discount amount preference, this section analyzes the impact of the change of discount amount t on the profit of the platform provider π.

Take $V = 0.8, P_0 = 0.2, \{\theta_1 = 0.3, \theta_2 = 0.8, \theta_3 = 0.8\}, \{\theta_1 = 0.4, \theta_2 = 0.5, \theta_3 = 0.8\}, \{\theta_1 = 0.5, \theta_2 = 0.5, \theta_3 = 0.7\}$ three sets of data to verify the relationship between the profit of the platform π and the discount amount t. The result is shown in Figure 8.

According to Figure 8, when $\theta_2\theta_3$ is relatively large, the platform's profit changes greatly with the discount amount t, and shows a trend of first increase and then decrease. When $\theta_2\theta_3$ is relatively small, the profit change of the platform is very small, which indicates that in this case, the discount amount t is not the main factor affecting the profit of platform. At the time, the platform needs to comprehensively consider other factors to increase profit. When $t > 0.85$, the profit in the case of $\theta_1 > \theta_2\theta_3$ is higher than that in the case of $\theta_1 < \theta_2\theta_3$. This is because when the discount amount t is higher, customers have doubted about the motivation of the platform, and thus reduce the intention of add-on items shopping. Moreover, in the case of $\theta_1 < \theta_2\theta_3$, consumers have a lower preference for the original price, which leads to a low possibility of accepting the original price shopping. Therefore, the platform should reasonably set the discount amount t according to consumers' heterogeneous preferences.

(7) Based on consumers' purchase preference at the original price, add-on items preferences and the discount amount preference, this section analyzes the shopping add-on items recommendation service level r on the profit of the platform π.
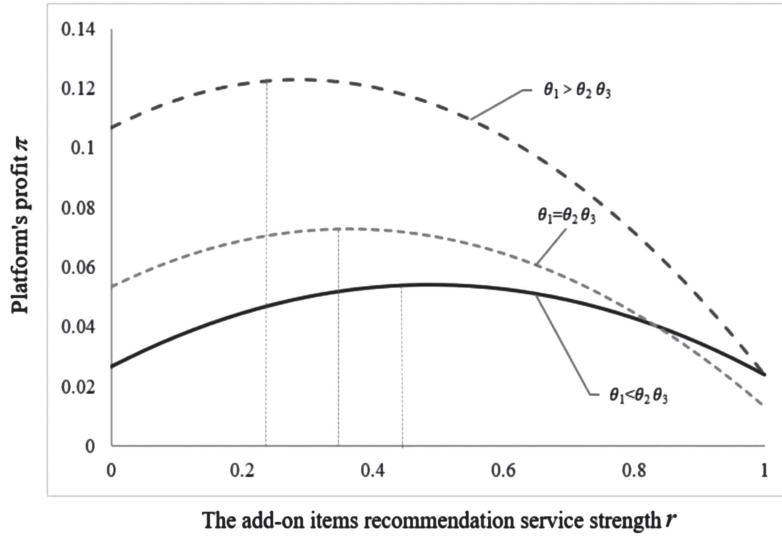
FIGURE 9. The impact of add-on items recommendation service strength on the profit.

Take $\lambda = 0.4, V = 0.6, P_0 = 0.2, t = 0.2, \{\theta_1 = 0.2, \theta_2 = 0.8, \theta_3 = 0.8\}, \{\theta_1 = 0.4, \theta_2 = 0.5, \theta_3 = 0.8\}, \{\theta_1 = 0.8, \theta_2 = 0.2, \theta_3 = 0.2\}$ three sets of data. The relationship between the shopping add-on items recommendation service strength r and the platform's profit π is shown in Figure 9.

According to Figure 9, the platform' profit is a univariate quadratic function of the shopping add-on items recommendation service strength r, which function is open downward and has a unique peak. Concretely, with the increasing of the add-on items recommendation service strength r, the platform's profits show a trend of first increasing and then decreasing. In addition, the profit of platform will be affected by consumers' heterogeneous preferences. When consumers' purchase preference at original price θ_1 increases, the profit of the platform increases. It can be seen from the Figure 9 that the optimal recommendation service strength of the platform should be set between (0.25, 0.5) according to the heterogeneity preference of consumers. This restriction requires managers not to blindly improve the strength of add-on items recommendation service, but also to consider the impact of the cost of the platform recommendation service on the overall profit of enterprises when actually formulating an add-on items recommendation service strength strategy. And enterprises should consider the factors that affect consumer behavior from multiple perspectives and formulate a reasonable add-on items recommendation service strength based on various factors, so as to improve the overall profits.

5. CONCLUSION

Under the full-reduction promotion, the add-on items recommendation service has been one of the valuable marketing strategies for the platform. However, few scholars have explored how the strategy affect consumers' purchase willingness and how to determine the optimal shopping add-on items recommendation service strength for platform that maximizes the profits by setting full-reduction promotion threshold value and discount amount. To fill the gap, this paper introduces the consumers' purchase willingness into the profit function expression of the platform, and constructs a Stackelberg game model to reflect the interaction between the platform's add-on items recommendation service strength and the consumer's purchase willingness. Based on the above model, we explore the optimal shopping add-on items service strength strategy and the influencing factors of the optimal shopping add-on items service strength for platform with full-reduction promotion.

Through derivative analysis method and numerical simulation of our game model, we concluded that:

The optimal add-on items recommendation service strength of the platform changes with the change of reservation price. When the reservation price V increases in a fixed range, the optimal add-on items recommendation service strength of the platform r^* is a monotonic increasing function of the reservation price V, and the profits of the platform increase with the increase of the reservation price. In this case, the add-on items recommendation service provided by the platform has played a positive role. However, when the reservation price exceeds the fixed range, the optimal add-on items recommendation service strength of the platform r^* still increases with the increase of the reservation price V, but $r^* < 0, \lim_{V \to \infty} r^* = 0$, which indicates that it is best decision for the platform to abandon add-on items recommendation service.

The increase of add-on items recommendation commodity price will lead to the decrease of consumers' purchase willingness. And whether $\theta_2\theta_3 P = \theta_1(V - P)$ or $\theta_2\theta_3 P \neq \theta_1(V - P)$, the trend of the impact of recommended commodity price on the optimal shopping add-on items recommendation service strength of the the platform is the same. We further find that there are differences in the impact of the recommendation commodity price on the profits of platform on account of add-on items heterogeneity preference of consumers.

Based on consumers' purchase preference at the original price, add-on items preferences and the discount amount preference, we analyze the impact of the change of discount amount on the optimal shopping add-on items service strength and the profit of the platform, respectively. The results show that the impact of the discount amount on the optimal shopping add-on items recommendation service strength and the profits of the platform shows the same trend of first increasing and then decreasing.

Appropriate recommendation service strength is beneficial to enhancing consumers' willingness-to-pay and then increasing the profits of the platform. Therefore, it is an effective way to improve the performance of the platform to reasonably formulate the discount amount, full-reduction threshold and add-on items recommendation service strength.

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