Research on Long-term and Short-term Decision of Supply Chain Based on Customer Returns

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Abstract

With the rapid development of e-commerce, the problem of product return aroused the attention of enterprises not only, but also the interest of many scholars. Although the role of the e-commerce platform cannot be ignored in e-commerce, the effect of e-commerce platform is rarely considered in most of the researches of return under e-commerce model. In order to study the impact of the revenue-sharing contract on the supply chain’s decision based on customer returns, we consider a supply chain composed of a manufacturer and an e-commerce platform, then construct a model that includes market demand, customer returns and advertising effect, and at last solve the manufacturer’s and platform’s optimal decision in the context of cooperation and non-cooperation by game theory. Finally, we make an analysis about the decision and decision results based on short-term and long-term cooperative and non-cooperative game. The results show that: 1) the increase of product return rate leads to a higher product’s price and a lower advertising effort of the e-commerce platform; 2) the equilibrium price, equilibrium advertising effort and equilibrium profit of the supply chain all depend on the game model between the manufacture and the platform and time.

Keywords: Revenue Sharing, Customer Return, Advertising, Goodwill.

1. INTRODUCTION

The rapid development of e-commerce attracts more and more enterprises to join in it. The research data of iResearch consultation show that e-commerce market transactions in China were $5.2 trillion in the third quarter of 2016, increased by 30.8 percent. China's online shopping transaction scale was 3.8 trillion RMB in 2015, 36.2% over the same period in 2014; of which, B2C accounted for 51.9% of the annual share and surpassed C2C for the first time. Unlike traditional retail, high product return rate of e-commerce swallowed the original part of the profits of the enterprise. Therefore, many e-business enterprises pay high attention to the return problem, whereas it is still difficult to put an end to the occurrence of customer returns. The issues of customer return also aroused the interest of scholars, such as Mukhopadhyay and Setaputra (2007), Bonifield, Cole (Bonifield et al., 2010), Chen and Bell (2009; 2011; 2012; 2013). They all did their research on the return policy and the decision-making of the enterprise under the return policy. The Dekker and Vlachos’ research showed that the customer return rate achieved 35% (Vlachos and Dekker, 2007) in online shopping. In some fashion products, the products return rate reached up to 74% (Mostard and Teunter, 2006). Return management is a very important issue because returns lead to an average of 3.8% loss of profits each year (Petersen and Kumar, 2010). Compared to offline retailing, return issues are more closely related to online retailing because customers have no chance to test the quality of the product, which is an important aspect of the customer's valuation of the product. In order to reduce the consumers’ risks of buying and holding unsatisfactory commodities and enhancing the competitive edge of the enterprise, many manufacturers, retailers, and e-commerce providers are taking a full refund policy, Traditional channels such as Wal-Mart, Carrefour, and China Resources Vanguard, and e-commerce channels such as JD.com, Tmall.com, Tmall supermarkets have also taken a full refund of the return policy.

In all the research on the return under e-commerce model, most of them ignore the role of the supply chain. Zhang and Yao studied the pricing problem of manufacturers and retailers in the dual-channel supply chain under the condition of customer return. In the construction and analysis of the online model, the influence of the platform on product sales was neglected (Xu et al., 2010); Rabinovich found that the online retailer's price strategy relied on the quality of products and services (Zhang et al., 2015). In his research, he also ignored the influence of the e-commerce on the supply chain. According to above studies, e-commerce platform play an
important role in the online sales. Therefore, it is especially crucial to study the supply chain decision from the perspective of manufacturers and suppliers.

In the supply chain between manufacturer and e-commerce platform, the commodity does not go through the e-commerce platform; the main income of the e-commerce platform is to share the benefits of manufacturers. For manufacturers, cooperating with a highly influential e-commerce platform can not only increase their online sales revenue and expand their brand impact, but also help to focus on their product development and marketing. For the e-commerce platform, due to the lack of management experience of various products, the business model of platform rental can not only reduce business risk, but also reduce the management costs of different commodities, which allows them to focus on the management of the platform. In the cooperation between the manufacturer and the e-commerce platform, the e-commerce platform is more dominant. Hence the sharing ratio of benefits of the e-commerce platform is solely determined by the platform itself regardless the differences of the manufacturers. And the manufacturers have to choose their partnering platform with a given ratio.

Based on the above discussion, under the circumstances of customer returns and revenue sharing our main research contents are: how to make decision on advertising efforts, how the manufacturers formulate the product price to maximize their respective interests or the interests of the overall supply chain.

2. STATE OF THE ART

The literatures related to our research are basically revenue sharing, customer returns and goodwill. In the following literature review, we will mainly scrutinize these three aspects.

The revenue-sharing contract is evolved on the basis of other contracts and is the most widely negotiated contract. It refers to a coordinating approach which the supply chain members take to reduce the double marginal effect and thus improve the overall performance of the supply chain, the product sales revenue and other reasonable allocation. Chen and Gao pointed out that under the revenue sharing contract, the supplier sells the product to the retailer at a price lower than the prime cost, and at the same time the retailer shares part of the sales revenue with the supplier so as to achieve a higher level of earnings than before (Chen and Gao, 2006). The revenue sharing contract was first applied in the DVD rental industry, and the results showed it has improved the corporate earnings. Mortimer also studied the benefits of the revenue sharing contract on improving the income of the DVD rental industry. The results showed that the revenue sharing contract has significantly improved the overall revenue of the supply chain channel (Mortimer, 2002). There are other scholars such as Xu (2010), Zhang and Liu (2015), VafaArani and Rabbani (2016), Xu and Li (2016), Hu and Xu (2017) proved that the revenue sharing contract improved the performance of supply chain from different angles. The above studies are based on the traditional business model, which the main mode of revenue sharing is the manufacturer distributed their product to retailers at a lower price, and share certain interests from the retailer's income. However, this model is not suitable for B2C mode because the retailer does not exist in this mode, and the wholesale price does not exist based on the traditional model. Therefore, the existing researches have some limitations.

With the rapid development of e-commerce, the return problem does not only attract the attention of enterprises, but has also aroused the interest of many scholars. In the research related to the return policy, Mukhopadhyay and Setaputra studied the multi-level pricing, return policy and quality policy, etc. (Mukhopadhyay and Setaputra, 2007); Bonifield and Cole focused on the relationship between quality and the flexibility of return policy in direct sales model. By analyzing the relationship between the generality of the return policy and the quality of retailers, they proved that the generality of the return policy increased the category of non-consumables (Bonifield et al., 2010); Both (Mukhopadhyay and Setaputra, 2007) and (Bonifield et al., 2010) analyzed the impact of return on distributors and retailers in direct sales, but they ignored the impact of direct selling channels on distributors and retailers' decisions. In the study of product pricing, Zhang and Yao studied the pricing problems of manufacturers and retailers in the dual-channel supply chain under customer return conditions. The results showed that the higher return rate leads to the revenue loss of the retailers, manufacturers and the overall supply chain (Zhang and Yao, 2015). Nevertheless, the model construction and the analysis of online sales in the study ignored the influence of the sales platform on sales and returns. Rabinovich found that online retailer's price strategy depends on the quality of products and services (Rabinovich et al., 2008). But the study ignored the impact of the revenue sharing ratio of the online sales platform on retailer pricing. Chen and Bell considered customer return is the function of product sales and product prices, and studied the optimal pricing and optimal order of the enterprise (Chen and Bell, 2009). McWilliams (2012) studied the return of competitive sales for both low-quality and high-quality retailers, and the results showed that returns were
beneficial to low-quality retailers and undermined the interests of high-quality retailers. Liu, Choi, Yuen and Ng (2012) studied the issue of decision-making of consumer returns based on the retailer's return policy and product quality, retailer pricing, return price and quality. Xiao, Shi and Yang (2010) studied the retailer's optimal return policy and the coordination problem of supply chain contract; Li and Xu (2012) studied the return policy in the pre-sale and normal sales model on the basis of multi-sales.

From the above research on the return of goods, we found that the studies of return model under the B2Care still relatively limited, and none of them consider the influence of sales platform on supply chain pricing and return policy. In the study of the return under the background of traditional business model, there are few to take revenue sharing into the supply chain decision-making. The studies that considered the retailers’ or manufacturers’ goodwill as a factor are also very few. This paper will fill the research gaps of neglecting the impact of the sales platform and goodwill on customer sales.

The earliest person who studied the impact of corporate advertising on the brand's reputation is Jorgensen (2000). He used the Nerlove-Arrow model to reflect the advertising can not only promote the current product sales, but also indirectly affect the product sales in long-term by influencing the brand goodwill. On the basis of Jorgensen et.al (2000), Jorgensen et.al (2001) considered the situation that the brand profit was affected by the decline of the marginal revenue in the process of sales. By the comparison between the cooperative and non-cooperative game, study showed that the profit of the channel members under the cooperative game is higher than the profit of the channel members under the non-cooperative game (Jorgensen et al., 2001). Based on the model of advertising sales, He et al. studied the issues of advertising cooperation and product pricing, and compared the supply chain advertising decisions and channel profit under the cooperative game and decentralized decision-making. They found that the supply chain profit in centralized decision-making is higher than that in decentralized channel. The results also showed that if there is no advertising cooperation, the pricing and advertising decision of the supply chain members under the decentralized decision will have double marginal effect (He et al., 2009).

In the current research on dynamic advertising, there are few studies focused on the influence of time on supply chain decision and outcome. And the results are also consistent, that is, the pricing of products under cooperative decision is lower than that of non-cooperative product pricing. Meanwhile, profit of the cooperative channel is higher than that of the non-cooperative channel. After introducing the time factors, we found that the product pricing under the cooperative game is not necessarily lower than the non-cooperative product pricing, and the channel profit under the cooperative game is not necessarily higher than the non-cooperative game channel profit.

The present research also has the following shortcomings. First of all, for the customers in the online shopping, they will inevitably consider the reliability and influence of the business platform, that is, the credibility of the platform. But in the existing studies of online shopping and return, it is rarely involved; Second, the platform leasing is in the prevalence in the current e-commerce, whereas the study of this model is still relatively limited; Finally, the current studies of goodwill will treat Goodwill as a constant regardless of time factors. Nevertheless, in fact, corporate reputation will be varied with time, which will lead to different business decisions and results. This study tries to solve the shortcomings described above.

In the next section of the study we will establish the model and give out the corresponding analysis. Section 4 will solve the model, and the time-dimension is used to analyze the long-term and short-term supply chain decision.

3. METHODOLOGY

This paper examines the supply chain that consists of a manufacturer and an e-commerce platform. The manufacturer sells the product to the consumer through the e-commerce platform, which shares a proportion of the manufacturer’s sales revenue. In practice, the Share is called technical service fee rate. In order to expand the influence, the e-commerce platform invests to advertising the platform to improve the goodwill of the platform, and thus attract more manufacturers and customers. At the moment of \( t \), the level of advertising input of the platform is \( A(t) \), and the level of goodwill accumulated by the platform is recorded as \( G(t) \). The product price is \( p(t) \). Through the improved Nerlove-Arrow model, equation (1) depicts the favorable rate of change of the platform:
\[
G(t) = \lambda A(t) - \delta G(t), \quad G(0) = G_0
\]

(1)

\(G_0\) is the initial impression of the consumer on the platform, and \(G_0 > 0\). \(\lambda\) is the coefficient of influence on the rate of change in favorability of the ad platform, and \(\lambda > 0\). \(\delta\) is the bad rate of goodwill.

The cost function of advertising is the quadratic function of the level of advertising input:

\[
C(A(t)) = kA(t)^2
\]

(2)

Taking into account the price of the product, the favorable effect of the platform on the sales, equation (3) gives the sales function of the sales:

\[
Q(t) = \alpha - \beta p(t) + \gamma G(t)
\]

(3)

\(\alpha, \beta, \gamma\) is a constant greater than zero. \(\alpha\) reflects market potential, indicating the market demand for products in terms of product prices and goodwill for good business platform. \(\beta\) for the sales price of the sensitivity, and also on behalf of the market competition in the same degree of competition. The greater the \(\beta\), the more competitive the market is, and the more sensitive the consumer is to the price of the product. \(p\) is the selling price of the product. \(\gamma\) for the goodwill of the platform on the impact of sales rate. It is greater than zero, indicating that the platform is good for the positive sales of goods to promote the role. This has been widely used in many literatures, such as Nerlove and Arrow (1962), Chintagunta and Jain (1992), Viscolani and Zaccour (2009).

\[
R(t) = vQ(t)
\]

(4)

Empirical studies showed a strong linear relationship between product returns and sales (Anderson, 2009). Hess and Mayhew and Anderson (2006) showed that customer returns rise as product prices and total sales have risen through an empirical research. Based on this, we assume that the consumer returns \(R\) is a fixed ratio of total product sales. In equation (4), \(0 \leq v \leq 1\), \(v=0\), which indicates that there is no customer return, and \(v=1\) indicates that products have been purchased by customers are all returned.

\(x\) is the technical service fee charged by the electricity provider platform. In the online retail channel, the e-commerce platform occupies the leading role within the supply chain. Powerful service platforms typically charge different technical service rates based on different products sold by the manufacturer rather than the difference of the manufacturers, and it will remain unchanged for a long period of time. Therefore, in the next analysis of this article, the technical service fee rate \(x\) of the electricity provider platform is regarded as an exogenous variable, and the residual value of the return product is assumed to be zero.

In reality, the customer place orders and pay the fee online. The payment will not immediately reach the manufacturer's account, but temporarily reach the e-commerce platform account and be escrowed by the e-commerce platform. When the customer received the good and confirm the receipt of payment in the e-commerce Platform system, the money will be transferred from the e-commerce platform’s escrowing account to the collection account of the manufacturer. If the customer needs to return, after receiving the goods they can apply for the return directly. E-commerce platform will confirm the return application, and give the return payment to the customer directly. The payment of goods will not go through the manufacturer. The technical service fee charged by the e-commerce platform is based on the actual sales of the manufacturer, hence the return goods will not be charged by the e-commerce platform.

According to this, equation (5) and (6) give the profit function of the manufacturer and thee-commerce platform at time t:

\[
\Pi_m(t) = (1 - x)p(t)(Q(t) - R(t)) - cQ(t)
\]

(5)

\[
\Pi_e(t) = xp(t)(Q(t) - R(t)) - kA(t)^2
\]

(6)
The profit function of the supply chain is:

$$\Pi_i(t) = p(t)(Q(t) - R(t)) - c Q(t) - kA(t)^2$$  \hspace{1cm} (7)$$

The subscript m, e, c represents the manufacturer, the electricity provider platform, the supply chain related decision, the profit and so on. In the next model solving and analyzing section, the superscript d, c indicates the corresponding expression of the supply chain under decentralized decision and centralized decision.

In the infinite time, the manufacturer and the business platform determine their optimal product price and advertising investment to maximize their profits. Their value function satisfies the HJB equation. Equation (8), (9) and (10) give the value function of the manufacturer and the electricity provider platform and the supply chain, where $\rho$ is the time discount rate.

$$\rho V_m = (1-x)p(Q-R) - cQ + V_m(\lambda A - \delta G)$$  \hspace{1cm} (8)$$

$$\rho V_e = xp(Q-R) - kA^2 + V_e(\lambda A - \delta G)$$  \hspace{1cm} (9)$$

$$\rho V_c = p(Q-R) - cQ - kA^2 + V_c(\lambda A - \delta G)$$  \hspace{1cm} (10)$$

4. RESULT ANALYSIS AND DISCUSSION

4.1 Steinberg game

In the Steinberg main game structure, the e-commerce platform as a channel leader determines its optimal advertising investment on the basis of a given technical service fee rate $x$. As a follower, the manufacturer determines its product price according to the Service rates and advertising given by the business platform. In the order of the game, we first calculate the manufacturer's price under the given conditions, and then calculate the optimal advertising investment for the profit maximization.

Given the power of the commercial platform advertising $A$, through the differential game theory, proposition 1 gives the manufacturer the product price function.

**Proposition 1:** For a given payment of e-commerce platform advertising, the manufacturer's product price function is:

$$p^d = \frac{\alpha + \gamma G}{2\beta} + \frac{c}{2(1-x)(1-v)}$$  \hspace{1cm} (11)$$

From the proposition 1 we can see, (1) the manufacturer's product price consists of two parts, namely, $\frac{\alpha + \gamma G}{2\beta}$ and $\frac{c}{2(1-x)(1-v)}$. The first part of the price influenced by the basic needs of the market, and the second part of the price influenced by the production costs and product returns rate. (2) $p^d$ for $x$ and $v$, respectively, derived $\frac{\partial p^d}{\partial x} > 0$ and $\frac{\partial p^d}{\partial v} > 0$. Thus, the price of the product increases along with the increase of the technical service fee rate of the e-commerce platform, and the increase of the product return rate leads the manufacturer to increase the price of the product. $\frac{\partial p^d}{\partial A} = 0$ and $\frac{\partial p^d}{\partial G} > 0$ can be seen, product prices are not directly related to the advertising efforts of e-commercial platform but positively correlated with the goodwill of e-commerce platform.

Substituting equation (3), (4) and (11) into equation (5) and making it greater than or equal to zero yields:

$$x \leq 1 - \frac{c}{\rho(x)(1-x)}$$
Because the goodwill of business platform changes with time and is always not less than zero, and \( x \) is the exogenous variable, so if the above formula is established, \( x \) must be less than \( 1 - \frac{c^\beta}{a(1-v)} \), then minimum value \( 1 - \frac{c^\beta}{a(1-v)} \).

Make \( \bar{x} = 1 - \frac{c^\beta}{a(1-v)} \), obviously, \( 0 < \bar{x} < 1 \). When \( x \geq \bar{x}, P^d_m \leq 0 \), manufacturers cannot benefit from the platform, and will turn to other sales platform or sales channels. When \( x < \bar{x}, P^d_m > 0 \), the manufacturer gains positive benefit, hence they will sell the product through the platform. so, for the e-commerce platform, the proportion of its share of revenue has a ceiling. In practice, there are upper bounds on the share of revenue sharing for different providers. For example, T Mall charges a maximum of 5%, Jingdong Mall charges a maximum of 15% and Ebay charges a maximum of 10%.

Equation (3) and (4) can be obtained by substituting equation (9)

\[
A^d = \frac{2V^d}{2k} \quad (12)
\]

\[
V^d_c = \frac{1}{2} f_1 G^2 + f_1 G + f_1 \quad (13)
\]

\[
V^d_v = f_1 G + f_2 \quad (14)
\]

\[
\Delta^d = \sqrt{(2\delta + \rho)^2 - \frac{(1-v)\gamma^2\lambda^2}{k\beta}}
\]

\[
f_1 = \frac{k(2\delta + \rho \pm \Delta^d)}{\lambda^2}
\]

In the case where the goodwill \( G \) is not less than zero, \( f_1 \)'s bigger solution \( \frac{k(2\delta + \rho + \Delta^d)}{\lambda^2} \) make there exist a situation in which the degree of dilution of the advertising platform is negative, thus excluding the solution. Followed by the solution we get:

\[
f_1 = \frac{k(2\delta + \rho - \Delta^d)}{\lambda^2}
\]

\[
f_2 = \frac{(1-v)\gamma\alpha}{\beta(\rho - \Delta^d)}
\]

\[
f_3 = \frac{x\alpha^2(1-v)}{4\rho\beta} - \frac{x\alpha^3\beta}{4\rho(1-x)^2(1-v)} + \frac{(1-v)^2\gamma^2\lambda^2\alpha^2}{4k\beta(\rho + \Delta^d)^2}
\]

Substituting (15) and (16) into (14) and substituting (12), proposition 2 can be found.

**Proposition 2**: In the Steinberg game, the optimal advertising decision for the business platform is:

\[
A^d = \frac{2\delta + \rho - \Delta^d}{2\lambda} G + \frac{(1-v)\gamma\lambda\alpha}{2k\beta(\rho + \Delta^d)}
\]
A derivative can be obtained \( \frac{\partial A^d}{\partial G} > 0 \). At different stages, the advertising platform will pay according to the level of goodwill. The higher goodwill results in the higher advertising price that the e-commerce platform needs to pay. \( A^d \) derivatives on the \( v \) can be obtained \( \frac{\partial A^d}{\partial v} < 0 \), that is, the increase in customer return rate will reduce the commercial platform advertising efforts. \( A^d \) on the \( x \) for the lead \( \frac{\partial A^d}{\partial x} > 0 \), that is, the higher share of revenue that the e-commerce platform holds, the bigger advertising efforts that e-commerce platform needs to pay.

Substituting (12) and (14) into (1):

\[
G = \left( \frac{\lambda^2 f_2}{2k} - \delta \right) G + \frac{\lambda^2 f_3}{2k}
\]

(19)

The solution can lead to proposition 3

**Proposition 3:** Under Steinberg game, the function of customer’s favorable impression on the platform is:

\[
G^d(t) = G^{dtr} + (G_0 - G^{dtr}) e^{-\frac{t\lambda^2 f_3}{2k}}
\]

(20)

Among them

\[
G^{dtr} = \frac{\lambda^2 f_2}{2k\delta - \lambda^2 f_1} = \frac{(1-v)x\alpha_\gamma \lambda^2}{4k\delta \rho (\rho + \delta) - (1-v)x\gamma^2 \lambda^2}
\]

(21)

As time approaches infinity, \( G^d(t) \) tends to be its stable value \( G^{dtr} \). The stable value \( G^{dtr} \) of the goodwill of the e-commerce platform is affected by the technical service fee rate. The derivative of \( G^{dtr} \) on \( \delta, \lambda, x, \beta \) is \( \frac{\partial G^{dtr}}{\partial \delta} < 0, \frac{\partial G^{dtr}}{\partial \lambda} > 0, \frac{\partial G^{dtr}}{\partial x} > 0, \frac{\partial G^{dtr}}{\partial \beta} < 0 \). The stable value of the goodwill of the e-commerce platform becomes smaller as the declining rate of goodwill becomes larger, and it becomes greater as goodwill creates greater efficiency of the advertisement. When the technical service fees are charged more by the platform, the stability of the goodwill also increased. Because when \( x \) becomes larger, the price of the product will also increase. In order to compensate the reduced market sales because of the increased price, e-commerce platform will put more advertising efforts to increase sales and improve the goodwill of the platform at the same time. The greater the sensitivity of the sales volume to price is, the less the influence of the reputation of the platform. At this point, the customer is more sensitive to the price of the product, and the impact of the goodwill on the purchase decision becomes smaller. Hence the platform will be more inclined to reduce the cost of advertising to force the manufacturer to lower down the price of the product and thus promote product sales. The derivative of \( G^{dtr} \) on \( v \) is \( \frac{\partial G^{dtr}}{\partial v} < 0 \). That is, the improvement of the product return rate will reduce the goodwill of the platform.

Make the supply chain value function

\[
V^d = \frac{1}{2} h_i G^2 + h_i G + h_i
\]

(22)

Similarly,

\[
h_i = \frac{(1-v)\gamma^2 \lambda^2 - \beta k (2\delta + \rho - \Delta^d)^2}{2 \beta \lambda^2 \Delta^d}
\]
\[ h_2 = -x\alpha\gamma(1-v)[k\beta(2\delta + \rho)^2 - (1-v)\gamma^2\lambda^2] + k\beta\Delta'[2\rho(\alpha - \nu\alpha - c\beta) + \Delta'(1-v)(2+x)\alpha - 2c\beta)] \\
2k\beta^2\Delta'(\rho + \Delta')^2 \]

\[ h_3 = \frac{\alpha(\alpha - \nu\alpha - 2c\beta)}{4k\rho} + \frac{c^2k\beta^2(1-2x)}{4k\beta^2(1-v)(1-x)^2} + \frac{x\alpha\gamma^2(1-v)(2h_2\beta(\rho + \Delta') - x\alpha\gamma(1-v))}{4k\beta^2(\rho + \Delta')^2} \]

4.2 Cooperative game

Under the cooperative game structure, in order to maximize the overall profitability of the supply chain, manufacturers and e-commerce providers jointly determine the product price and advertising investment. At this point, the manufacturer and the e-commerce platform have the same decision-making goals as part of the supply chain. Equation (23) gives the objective function of supply chain under cooperative game.

\[ \rho V_e = p(1-v)(\alpha - \beta p + \gamma G) - k\Delta^2 - c(\alpha - \beta p + \gamma G) + V_e(\lambda A - \delta G) \]  

Through the differential game theory, proposition 4 gives the optimal price of the product.

**Proposition 4:** Under the cooperative game, the best price of the product is:

\[ p' = \frac{\alpha + \gamma G}{2\beta} + \frac{c}{2(1-v)} \]  

Compared to the Steinberg game, the price of the product under the cooperative game has the same structure as the price under the non-cooperative game. The factors other than x have the same effect on the product price. The price of the product under the cooperative game is equal to the price when x=0 under the Steinberg game, that is, the optimal price of the product under the cooperative game has nothing to do with x.

Equation (23) takes the derivative of A and makes it equal to zero:

\[ \lambda^2 \frac{\lambda V_e'}{2k} = A' \]  

\[ V_e' = \frac{1}{2} e_1 G^2 + e_2 G + e_3 \]  

\[ V_e'' = e_1 G + e_2 \]  

\[ \Delta^2 = \sqrt{(2\delta + \rho)^2 - (1-v)\gamma^2\lambda^2} \]

\[ e_1 = \frac{k(2\delta + \rho + \Delta^2)}{\lambda^2} \]

\[ e_1 \]’s bigger solution \[ \frac{k(2\delta + \rho + \Delta^2)}{\lambda^2} \] makes it possible that the e-commerce platform advertising payment is negative, thus excluding the solution. Followed by the solution we get:

\[ e_1 = \frac{k(2\delta + \rho - \Delta^2)}{\lambda^2} \]  

800
\[ e_2 = \frac{(1-v)\alpha \gamma - c \beta \gamma}{\beta (\rho + \Delta')} \]  

(29)

\[ e_3 = \left( \frac{1}{4 \rho \beta (1-v)} + \frac{\gamma^2 \lambda^2}{4 k \rho \beta^2 (\rho + \Delta')^2} \right) (\alpha - v \alpha - c \beta)^2 \]  

(30)

**Proposition 5:** Cooperative game, the best advertising pay:

\[ A'^* = \frac{2 \delta + \rho - \Delta'}{2 \lambda} G + \frac{\gamma \lambda ((1-v)\alpha - c \beta)}{2 k \beta (\rho + \Delta')} \]  

(31)

Compared to the Steinberg game, the cost of advertising under the cooperative game considered the cost factor $\frac{\gamma^2 e_k}{2 k (\rho + \Delta')}$. In contrast to the effect of $x$ on the price of cooperation, the advertising effort under the cooperation is equal to the contribution of $x=1$. $A'$ derivative with respect to $G$ and then get $\frac{\partial A'^*}{\partial G} > 0$. $A'$ derivative with respect to $v$ and then get $\frac{\partial A'^*}{\partial v} < 0$. That is, in the cooperative game, return still play a negative role to advertising efforts.

Replace (25) (28) (29) into (1):

\[ e_G^c = \frac{e_2 \lambda^2}{2 k} - \delta G e_2^c \lambda^2 + e_3^c \lambda^2 G \]  

(32)

**Proposition 6:** Under the cooperative game, the goodwill function of the platform is:

\[ G'(t) = G'' + (G_0 - G') e^{-\frac{(6 \gamma^2 e_k)}{2 k}} \]  

(33)

Among them

\[ G'' = \frac{e_2 \lambda^2}{2 k \delta - e_2 \lambda^2} = \frac{\gamma \lambda (\alpha - v \alpha - c \beta)}{4 k \delta \beta (\delta + \rho) - (1-v) \gamma^2 \lambda^2} \]  

(34)

$G''$ derivative with respect to $\delta, \lambda, x$ and then get $\frac{\partial G'}{\partial \delta} < 0, \frac{\partial G'}{\partial \lambda} > 0, \frac{\partial G'}{\partial x} = 0$. It shows that the stability value of the goodwill of the platform is becoming smaller as the declining rate of the goodwill of the platform becomes larger. And it becomes larger with the increase of the coefficient of the sensitivity of the platform advertisement. In the cooperative game, the stable value of goodwill is not related to $x$. $G''$ derivative with respect to $v$ and then get $\frac{\partial G'}{\partial v} < 0$, that is, the increase in customer return rate will reduce the stability of the platform's goodwill.

**4.3 Comparative analysis**

In this section, we analyze the supply chain decision and channel profit under the Steinberg game and the cooperative game respectively from the long and short term. In the short-term comparative analysis, the goodwill of the Steinberg game and of the cooperative game decision are the same. In the long-term comparative analysis, the goodwill of the platform under cooperation and non-cooperative decision-making change with time. Hence, analysis should bring equation (20) are (33) into the corresponding equation respectively.

**4.3.1 A Comparative Analysis of Goodwill in Electric Business Platform**
Equation (34) minus equation (21) yields:

$$
\Delta G^{ss} = G^{cst} - G^{dss} = \gamma \lambda^2 \left( \frac{(1-v)\alpha - c\beta}{4k\beta(\delta + \rho)} - \frac{(1-v)x\alpha}{4k\beta(\delta + \rho) - (1-v)\gamma^2} \right)
$$

$\Delta G^{ss}$ derivative with respect to $x$ and then get $\frac{\partial \Delta G^{ss}}{\partial x} < 0$, and $\Delta G^{ss}(x=0)>0$, $\Delta G^{ss}(x=1)<0$. Let $\Delta G^{ss}=0$ and then have $x_{\Delta G^{ss}=0}=\bar{x}$. As the maximum of $x$ is no bigger than $\bar{x}$, so when $x_{\Delta G^{ss}=0}<\bar{x}$ and during $[0, x_{\Delta G^{ss}=0}]$, $\Delta G^{ss} \geq 0$; when $x_{\Delta G^{ss}=0}=\bar{x}$, during $[0, \bar{x}]$, $\Delta G^{ss} = 0$; when $x_{\Delta G^{ss}=0}>\bar{x}$, during $[0, \bar{x}]$, $\Delta G^{ss} \geq 0$;

![Figure 1. The curve of balanced goodwill over x](image1)

Equation (33) minus equation (20) yields:

$$
\Delta G = G^{c} - G^{d} = G^{cst} - G^{dss} + (G_0 - G^{cst}) e^{-\left(\delta + \frac{\gamma^2}{2k}\right)t} - (G_0 - G^{dss}) e^{-\left(\delta - \frac{\gamma^2}{2k}\right)t}
$$

When $\Delta G^{ss}>0$, $\Delta G>0$; when $\Delta G^{ss}=0$, $\Delta G=0$; when $\Delta G^{ss}<0$, $\Delta G<0$;

![Figure 2. The curve of goodwill over time](image2)

<table>
<thead>
<tr>
<th>$c$</th>
<th>0</th>
<th>0.5</th>
<th>1</th>
<th>1.5</th>
<th>2</th>
<th>2.5</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\bar{x}$</td>
<td>1</td>
<td>0.94</td>
<td>0.88</td>
<td>0.81</td>
<td>0.75</td>
<td>0.69</td>
<td>0.63</td>
</tr>
<tr>
<td>$x_{\Delta G^{ss}=0}$</td>
<td>1</td>
<td>0.93</td>
<td>0.86</td>
<td>0.79</td>
<td>0.71</td>
<td>0.64</td>
<td>0.57</td>
</tr>
</tbody>
</table>

Table 1 The $\bar{x}$ and $x_{\Delta G^{ss}=0}$ under different costs

We take $\rho=0.02$, $\gamma=0.08$, $\beta=5$, $\gamma=1$, $\lambda=5$, $\delta=0.5$, $k=20$, $\alpha=50$ as an example of the analysis and found that
although the theoretical analysis of the existence of $x_{\Delta G^{SS}=0}<\bar{x}$ situation, in reality there is often not only one e-commerce platform but multiple e-commerce platform competing with each other, hence the e-commerce platform lowers down $x$ in order to maintain or improve competitive advantage, and thus the reality of $x$ is often lower than $x_{\Delta G^{SS}=0}$. For example, Jingdong Mall’s range of $x$ is 0.01% - 15%, while T-mall’s range of $x$ is 0% - 5%. These are much lower than the theoretical $x_{\Delta G^{SS}=0}$, and $x_{\Delta G^{SS}=0}>\bar{x}$. Accordingly, in the next analysis, we only consider the case of $\Delta G^{SS}>0$, $\Delta G>0$. As can be seen from Figure 1, $\Delta G^{SS}$ and $\Delta G$ decrease as $x$ becomes larger, which means that the motivation for cooperation between manufacturers and manufacturers is stronger when $x$ is lower; the motivation for cooperation between manufacturers and manufacturers the weaker when $x$ is bigger.

4.3.2 Short-term comparative analysis

(1) the price comparison

Equation (24) minus equation (11) yields:

$$\Delta p = p^*-p^d = -\frac{xc}{2(1-x)(1-v)} < 0$$

In the short term, the price of the product under the cooperative game is always lower than the price of the product under the Steinberg game. That is, for customers, they are always able to benefit from the short-term cooperation between the manufacturer and the e-business platform.

(2) advertising comparison

Equation (31) minus equation (18) yields:

$$\Delta A = A^*-A^d = \frac{1}{2\lambda} (G(\Delta^d - \Delta^*) + \frac{\gamma\lambda^2(\beta c(\rho + \Delta^d) - \alpha(1-v)(\rho-x\rho-x\Delta^d+\Delta^*)))}{k\beta(\rho + \Delta^*)(\rho + \Delta^d)}$$

(35)

$\Delta A$derivative with respect to $x$ and then get $\frac{\partial \Delta A}{\partial x} < 0$, easy to know that the difference of advertising effort between the cooperative game and the Steinberg game is monotonic, that is, it decreases with the increase. Substitute $x=0$ and $x=1$ into equation (35) and then have $\Delta A(x=0)>0$, $\Delta A(x=0)<0$. There is $x_{\Delta A=0}$ satisfies $\Delta A(x=x_{\Delta A=0})=0$. When $x_{\Delta A=0}<\bar{x}$, during $[0, x_{\Delta A=0}], \Delta A\geq 0$; during $(x_{\Delta A=0}, \bar{x}]$, $\Delta A<0$; when $x_{\Delta A=0}\geq\bar{x}$, during $[0, \bar{x}]$, $\Delta A\geq 0$.

![Figure 3. The trend of advertising efforts over x](image)

(3) profit comparison

Channel profits of non-cooperation and cooperation game in short term were:
\[ V_c^d = \frac{1}{2} h G^2 + h_i \]
\[ V_c^e = \frac{1}{2} e G^2 + e_i \]

Substitute \( e_1, e_2, e_3, h_1, h_2, h_3\) into \( V_c^d, V_c^e\), the high complexity of \( V_c^d, V_c^e\) expression makes it difficult to compare and analyze by modeling. Therefore, we analyze the profit of channel under different decision-making structures. Take \( \rho=0.02, v=0.2, \beta=5, \gamma=1, \lambda=5, \delta=0.5, k=20, \alpha=50, G_0=0.1, e=E, c=2, G=1 \).

![Figure 4. Channel profit curve](image)

As can be seen from the figure, when \( x_{\Delta VC=0} < \bar{x} \), if \( x < x_{\Delta VC=0} \), then \( V_c^e > V_c^d \); if \( x = x_{\Delta VC=0} \), then \( V_c^e = V_c^d \); if \( x > x_{\Delta VC=0} \), then \( V_c^e < V_c^d \).

In the case of non-cooperation, the channel profit is affected by \( x \). In the range of \( x \), the channel profit increases with the increase of \( x \). And the channel profit is irrelevant with \( x \) under the cooperation model. If \( x < x_{\Delta VC=0} < \bar{x} \), \( V_c^e > V_c^d \); if \( x_{\Delta VC=0} < x < \bar{x} \), \( V_c^e < V_c^d \). Therefore, whether platform and manufacturers will cooperate under short-term depends on the scope of \( x \).

4.3.3 Long-term comparative analysis

(1) Price comparison analysis

Substituting equation (33) into (24), substituting equation (20) into (11), then subtracting:

\[ \Delta p = p^c - p^d = \frac{\gamma (G_c^G - G_d^G)}{2\beta} - \frac{xc}{2(1-x)(1-v)} \]

Easy to know when \( G_c^G - G_d^G = \frac{xc\beta}{(1-x)(1-v)\gamma} \), \( \Delta p=0 \); when \( G_c^G - G_d^G > \frac{xc\beta}{(1-x)(1-v)\gamma} \), \( \Delta p>0 \); when \( G_c^G - G_d^G < \frac{xc\beta}{(1-x)(1-v)\gamma} \), \( \Delta p<0 \). It is known from the analysis of 4.3.1 that \( G_c^G - G_d^G \) becomes larger with the extension of \( t \). When \( t=t_0 \), \( G_c^G - G_d^G = \frac{xc\beta}{(1-x)(1-v)\gamma} \). Hence, it is easy to know, when \( t<t_0 \), \( \Delta p<0 \); when \( t=t_0 \), \( \Delta p=0 \); when \( t>t_0 \), \( \Delta p>0 \).
Figure 5. The product price curve over time

Figure 5 shows that the price of the product under the cooperative game has obviously improved with the extension of time, and the price of the product under the Steinberg game has also increased, whereas the change is not significant. In reality, when a market is monopolized by an enterprise, the price of the product is often higher than the price of the product in the perfectly competitive market. Therefore, without considering the competition, the product price under the long-term cooperation between the e-commerce platform and manufacturers is higher than under the long-term non-cooperation.

(2) Advertising comparative analysis

Substituting equation (33) into (31), after equation (20) and (18)

\[ \Delta A = A^c - A^d = \frac{\lambda}{2k} (e_1 G^c - f_1 G^d + e_2 - f_2) \]

According to the expression of \( e_1, f_1, e_2, f_2 \), it is easy to know \( e_1 > f_1, e_2 > f_2 \). Based on the analysis of 6.1, in the case of \( e_1 > f_1, e_2 > f_2 \), when only consider \( G^c > G^d \), \( \Delta A > 0 \).

Figure 6. The trend of advertising efforts over time

It can be seen from Figure 6, the advertising effort under Steinberg game has not changed significantly in the long term, the advertising effort under the cooperation is significantly improved in the initial period, but it tends to achieve a stability as time goes by. The advertising effort under long-term cooperation is higher than the non-cooperation. As can be seen from the analysis of 4.3.3, the prices of products under the cooperation will gradually increase and exceed the prices of non-cooperative products in the long term, which will inevitably lead the supply chain to put more advertising effort into promoting product sales. And the increase in advertising will in turn lead to the increase of product prices.

(3) long-term channel profit comparative analysis

Long-term channel profits under the non-cooperation and cooperation game were:
Similar to the analysis of the short-term channel profit, the profitability of the channel after the substitution of \( e_1, e_2, e_3, h_1, h_2, h_3, G^c, G^d \) is very complex and cannot be modeled. Therefore, we also use the form of case study to analyze the long-term channel profit. Take \( \rho=0.02, V=0.2, \beta=5, \gamma=1, \lambda=5, \delta=0.5, K=20, \alpha=50, G_0=0.1, e=E, c=2, x=0.08 \).

Combined with 4.3.3, it can be seen that in the long-term non-cooperation situation, the e-commerce platform advertising cost has not increased significantly over time so the goodwill and the cost of e-commerce platform maintain a basic state of stability. The price of the manufacturer’s is also remained basically stable under the long-term non-cooperation situation. According to sales model we can see that product sales will not be a substantial increase or decline. Consequently, the channel profits remain stable in the case of long-term non-cooperation.

![Figure 7. Long-term channel profit curve over time](image)

Long-term cooperation, although the product price in the long-term cooperation is higher than the price of non-cooperation under certain conditions, and to a certain extent, the demand of the product is therefore decreased, the final demand is improved thus the overall profit channel increased because the reputation of the e-commerce platform is much higher than the corresponding value of non-cooperation.

5. CONCLUSION

In order to study the long-term and short-term decision-making of the supply chain with the customer return, this article, by introducing the goodwill of the e-commerce provider platform, made a research on the pricing decision and advertising decision of a supply chain composed of an e-commerce platform and a manufacturer, and the goodwill and the channel profits of e-commerce platform under different decisions. Finally, this paper drew the following main conclusions:

(1) The increase of customer return rate does not only raise the manufacturers’ product price, but also reduce the degree of advertising efforts of the e-commerce platform and the stable value of the goodwill of the e-commerce platform.

(2) In the short term, the price of the products under the cooperative game is always lower than that of the Steinberg game. However, the advertising efforts and the channel profits in different decision-making modes are not absolutely different due to the share of revenue sharing.

(3) In the long term, the price of the product under the cooperative game is higher than the price of the product under the Steinberg game, and the advertising effort and the channel profit under the cooperative game are always higher than that of Steinberg's advertising effort and channel profit.
This study is different from the existing researches which neglect time factor in the decision-making of manufacturers and platform firms. It makes this research has a strong practical value on the pricing decision and advertising decision of manufacturers and platform providers. The main limitation is that the product demand function is predetermined to be linear. In reality, the demand function of the product is not completely linear, and it is more inclined to be a nonlinear function. This research assumed that the product demand function is linear, which is similar to many other literatures. For one of the reasons, it is easy to solve and analyze. And the reason 2 is to assume the linearity of the product demand function does not affect the main conclusions of this study.

On the basis of this article, the implications towards future research could be: 1) the introduction of competitive elements. The object of this study is a supply chain composed of a manufacturer and e-commerce platform. In the future work, we can consider different types of the supply chain, such as multiple manufacturers with one e-commerce platform, multiple e-commerce platforms with one manufacturer, or multiple manufacturers with multiple e-commerce platforms, etc; 2) the introduction of product brand reputation. More and more well-known brands join in the online sales channels makes the consumers are not only influenced by the product price but also the reputation of product brand when making purchase decision. Therefore, in the future research, we can consider the impact of the brand reputation on customer decision-making.

REFERENCES

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