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Pricing Strategy of Dual-Channel Garment Supply Chain Considering Consumer Fairness Preference

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ABSTRACT
Due to the inconsistency of the main body in dual channels, direct conflicts between online manufacturers and traditional retailers exist. In this paper, the demand function and the profit function of online manufacturers and traditional retailers are constructed according to master-slave game theory, consumer utility model and consumer fairness preference theory model, and the pricing strategies of online manufacturers and traditional retailers are discussed. The results show that the increase of consumer fairness preference will lead to the price war between online and offline channels, and the overall service level of supply chain will decline, which is also unfavourable for consumers.

Keywords: *Dual-channel supply chain, Pricing strategy, Consumer fairness preference, Small and medium-sized garment enterprises.*

1. INTRODUCTION

The continuous expansion of garment e-commerce market has brought great pressure to traditional channel retailers. Due to the particularity of garment industry, consumers usually choose offline channels to try on products, and ultimately buy in the online channel with lower price, which resulting in online and offline dual channel conflict. The online and offline integration of "new retail" can well solve the problem of dual channel conflict[1], but for most small and medium-sized garment enterprises, due to the existence of free riding behaviour, overlapping of online and offline fields and inconsistent interests of channel members, dual channel conflict has a great impact on small and medium-sized garment industry.

Taking small and medium-sized garment manufacturing enterprises as the research object, this paper discusses the pricing strategy when there are conflicts between traditional channel retailers and online channel manufacturers. In this case, there is a competitive relationship between manufacturers and retailers. Due to the inconsistency of decision-makers in the supply chain, both sides may damage the overall interests of supply chain and reduce the consumer shopping experience when they pursue their own maximum interests. Therefore, the conflict between online and offline sales channels can be alleviated through reasonable pricing strategy, so as to maximize the overall interests of supply chain[2].

2. BASIC HYPOTHESIS AND MODEL CONSTRUCTION

2.1 Basic Hypothesis and Parameter Description

In order to study the pricing strategy of dual-channel supply chain of small and medium-sized garment enterprises under the influence of consumer fairness preference, this paper considers that the supply chain is composed of manufacturers and traditional retailers, manufacturers wholesale products to traditional channel retailers while open online channels to sell homogeneous products. The structure of dual-channel supply chain in this paper is shown in "Figure 1".

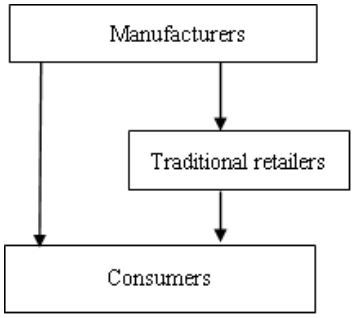

Figure 1 The structure of dual-channel supply chain.

The transaction information in the market is symmetrical, and consumers will make purchase decisions according to their own utility maximization after fully comparing the prices and services of online and offline sales channels.

Basic assumptions of the model are as follows:

Hypothesis 1: the supply chain is composed of manufacturers and traditional retailers. Manufacturers wholesale products to traditional retailers and open online channels to sell homogeneous products.

Hypothesis 2: consumers are bounded rational, so the demand function can be determined by the consumer fairness preference model and the utility function.

Hypothesis 3: pricing strategy for only one product.

Hypothesis 4: resources are limited, inventory cost and shortage cost are existed.

Hypothesis 5: traditional retailers and online manufacturers have different market positions and play a master-slave game.

The parameter description is shown in "Table 1".

Table 1. Parameter description

Symbol	Implication
v	consumer valuation of products
p_t	unit price of traditional channel
p_d	unit price of online channel
λ	coefficient of consumer fairness preference
h	consumers' acceptance of online channel
C_t	fixed cost of traditional channel
C_d	fixed cost of online channel
U	consumer utility
π	profit
s_t	service level of traditional channel
s_d	service level of online channel
Q	market demand
w	manufacturer's wholesale price
α	service sensitivity coefficient of traditional channel
β	service sensitivity coefficient of online channel

2.2 Model Construction

2.2.1 Consumer Utility Function

For consumers, product price and service level determine the consumer utility[3]. Combined with the consumer utility model and reference dependent preference, the utility of unit product purchased by consumers through traditional channel and online channel can be obtained. The function expression is as follows:

$$U_t = v + \alpha s_t - p_t - \lambda(p_t - p_d) \quad (1)$$

$$U_d = hv + \beta s_d - p_d - \lambda(p_d - p_t) \quad (2)$$

Among them, v represents consumer's utility evaluation of unit product through traditional channel, hv represents consumer's utility evaluation of unit product through online channel. Whether consumers buy products through traditional channel or online channel, they will choose to buy products only when consumer utility $U > 0$. By $U_t = 0$, $U_d = 0$, the critical utility can be obtained.

$$v_t = p_t - \alpha s_t + \lambda(p_t - p_d) \quad (3)$$

$$v_d = \frac{p_d - \beta s_d + \lambda(p_d - p_t)}{h} \quad (4)$$

In the dual-channel shopping environment, consumers usually choose to buy products in the channel with higher utility[4], that is, when $U_t = U_d$, the critical value $\hat{v}$ can be obtained.

$$\hat{v} = \frac{(1-2\lambda)(p_t - p_d) - \alpha s_t + \beta s_d}{1-h} \quad (5)$$

It needs to be discussed in the following three situations:

- (1) When $v_t > v_d$ and $\hat{v} \geq 1$, consumers will choose to buy only through online channel;
- (2) When $v_t > v_d$ and $0 < \hat{v} < 1$, consumers' product evaluation utility $v \in (v_d, \hat{v})$, consumers choose to buy through online channel; consumers' product evaluation utility $v \in (\hat{v}, 1)$, consumers choose to buy through traditional channel;
- (3) When $v_t < v_d$, consumers will choose to buy only through traditional channel.

2.2.2 *Demand Function*

This paper assumes that the demand is in the unit market, and the market demand is evenly distributed between [0,1]. In this case, the demand function can be expressed by the consumer utility function.

- (1) When $v_t > v_d$ and $\hat{v} \geq 1$, $Q_d = 1 - v_d = 1 - \frac{p_d - \beta s_d + \lambda(p_d - p_t)}{h} = \frac{h - p_d + \beta s_d - \lambda(p_d - p_t)}{h}$, $Q_t = 0$;
- (2) When $v_t > v_d$ and $0 < \hat{v} < 1$, $Q_d = \hat{v} - v_d = \frac{(1-2\lambda)(p_t - p_d) - \alpha s_t + \beta s_d}{1-h} - \frac{p_d - \beta s_d + \lambda(p_d - p_t)}{h}$, $Q_t = 1 - \hat{v} = 1 - \frac{(1-2\lambda)(p_t - p_d) - \alpha s_t + \beta s_d}{1-h}$;
- (3) When $v_t < v_d$, $Q_d = 0$, $Q_t = 1 - v_t = 1 + p_t + \alpha s_t - \lambda(p_t - p_d)$

The demand function is:

$$(Q_d, Q_t) = \begin{cases} \left(\frac{h - p_d + \beta s_d - \lambda(p_d - p_t)}{h}, 0\right) & I_1 \\ \frac{(\lambda+\lambda h+h)p_t - (1+\lambda+\lambda h)p_d - \alpha h s_t + \beta s_d}{h(1-h)}, & I_2 \\ \quad 1 - \frac{(1+2\lambda)(p_t - p_d) - \alpha s_t + \beta s_d}{1-h} & \\ 0, 1 + p_t + \alpha s_t - \lambda(p_t - p_d) & I_3 \end{cases}$$

I_1: $p_t < \frac{(1+\lambda+\lambda h)p_d + \alpha h s_t - \beta s_d}{(1+\lambda)h+\lambda}$

I_2: $\frac{(1+\lambda+\lambda h)p_d + \alpha h s_t - \beta s_d}{(1+\lambda)h+\lambda} < p_t < \frac{1-h+(1+2\lambda)p_d + \alpha s_t - \beta s_d}{1+2\lambda}$

I_3: $p_t > \frac{1-h+(1+2\lambda)p_d + \alpha s_t - \beta s_d}{1+2\lambda}$

2.2.3 *Profit Function*

This paper assumes that the production cost of manufacturer is 0, so the profit functions of the retailer and the manufacturer could be constructed through the demand function. The expressions are as follows.

Profit function of retailer:

$$\pi_t = (p_t - w)Q_t - C_t - \frac{\eta}{2}s_t^2 - \frac{X^2}{2}r^+ + \frac{1}{2} - X + \frac{X^2}{2}r^- \quad (6)$$

Profit function of manufacturer:

$$\pi_d = wQ_t + p_d Q_d - C_d - \frac{\eta}{2}s_d^2 \quad (7)$$

Profit function of overall supply chain:

$$\pi = \pi_t + \pi_d = p_t Q_t + p_d Q_d - C_t - C_d - \frac{\eta}{2}s_t^2 - \frac{\eta}{2}s_d^2 - \frac{X^2}{2}r^+ + \frac{1}{2} - X + \frac{X^2}{2}r^- \quad (8)$$

3. PRICING STRATEGIES OF DIFFERENT MARKET POSITIONS

3.1 Pricing Strategy When Manufacturers Dominate

3.1.1 *Retailers' Pricing Strategy*

According to the master-slave game theory[5], when the manufacturer is the leader, the retailer is the follower, and the retailer makes its own pricing strategy according to the principle of profit maximization. In this case, the demand function of traditional channel and online channel can be expressed as:

$$Q_t = 1 - \frac{(1-2\lambda)(p_t - p_d) - \alpha s_t + \beta s_d}{1-h} \quad (9)$$

$$Q_d = \frac{(\lambda + \lambda h + h)p_t - (1 + \lambda + \lambda h)p_d}{h(1-h)} - \frac{\alpha h s_t + \beta s_d}{h(1-h)} \quad (10)$$

According to the master-slave game model, s_t, s_d, C_d, C_t are exogenous variables, so the pricing decision problem can be transformed into an optimization problem.

$$\max \pi_t = (p_t - w)Q_t \quad (11)$$

The profit function of online channel manufacturer is,

$$\max_{s.t.\ p_t} \pi_d = wQ_t + p_d Q_d \quad (12)$$

The profit function of traditional channel retailor is,

Currently, the supply chain is in a non-cooperative state. Traditional channel retailers and manufacturers will make pricing strategies based on the principle of maximum self-interest. According to the theory of master-slave game, the reverse derivation method is used to get the optimal solution of online retail channel pricing and traditional retail channel pricing. Bring formula (9) into formula (11), $\frac{\sigma \pi_t}{\sigma p_t}$ is obtained.

$$\frac{\sigma \pi_t}{\sigma p_t} = 1 - \frac{(-w + p_t)}{1-h} - \frac{(-p_d + p_t)}{1-h} \quad (13)$$

Let $\frac{\sigma \pi_t}{\sigma p_t} = 0$, the retailer's price response function is obtained.

Proposition 1:

$$p_t^* = \frac{1 - h + w + 2w\lambda + p_d + 2\lambda p_d - \beta s_d + \alpha s_t}{2 + 4\lambda} \quad (14)$$

Among then,

$$\frac{(1+\lambda+\lambda h)p_d + \alpha h s_t - \beta s_d}{(1+\lambda)h + \lambda} < p_t < \frac{1 - h + (1+2\lambda)p_d + \alpha s_t - \beta s_d}{1 + 2\lambda}$$

The value range of manufacturer's pricing w can be obtained.

When $\lambda \leq \frac{1}{2}$,

$$\frac{[2 + \lambda h - h + 3\lambda + 4\lambda^2(1+h)]p_d'}{h + \lambda - \lambda h - 2\lambda^2(1+h)} + \frac{2(\lambda+1)(\alpha h s_t - \beta s_d)}{h + \lambda - \lambda h - 2\lambda^2(1+h)} - \frac{1 - h + \alpha s_t - \beta s_d}{1 - 2\lambda} \leq w' \leq \frac{4(1-h)(1+\lambda)}{(1+2\lambda)(1-2\lambda)} + \frac{(1+6\lambda)p_d' + 2(1+\lambda)(\alpha s_t - \beta s_d)}{(1+2\lambda)(1-2\lambda)} - \frac{1 - h + \alpha s_t - \beta s_d}{1 - 2\lambda}$$

When $\lambda \geq \frac{1}{2}$,

$$\frac{4(1-h)(1+\lambda) + (1+6\lambda)p_d'}{(1+2\lambda)(1-2\lambda)} + \frac{2(1+\lambda)(\alpha s_t - \beta s_d)}{(1+2\lambda)(1-2\lambda)} - \frac{1 - h + \alpha s_t - \beta s_d}{1 - 2\lambda} \leq w' \leq \frac{[2 + \lambda h - h + 3\lambda + 4\lambda^2(1+h)]p_d'}{h + \lambda - \lambda h - 2\lambda^2(1+h)} + \frac{2(\lambda+1)(\alpha h s_t - \beta s_d)}{h + \lambda - \lambda h - 2\lambda^2(1+h)} - \frac{1 - h + \alpha s_t - \beta s_d}{1 - 2\lambda}$$

From proposition 1, it can be seen to all that the optimal pricing of traditional channel increases when traditional channel service level improves, and decreases online channel service level improves. So, the service level will have a certain impact on pricing, and also affect consumers' purchase decisions.

3.1.2 Manufacturers' Pricing Strategy

After predicting the pricing strategies of traditional channel retailers, manufacturers will further adjust their pricing strategies order to maximize their own interests[6]. Bring formula (14) into formula (9) and formula (10), bring formula (9)

and formula (10) into formula (12), and combining the two equations, the optimal pricing strategy of manufacturers can be obtained.

$$p_d^* = \frac{(h-1)(4h+4\beta s_d - h^2 - h^3 - 8\alpha h s_t)}{(h-2)(h^2-6h+4)} + \frac{(h-1)(4\beta h s_d + 3\alpha h^3 s_t - 3\beta h^2 s_d)}{(h-2)(h^2-6h+4)}$$

$$w^* = \frac{h - 6\alpha s_t + 8\beta s_d - 3h^2 + 5\alpha h s_t - 7\beta h s_d + 2}{(h-2)(h^2-6h+4)}$$

Proposition 2: When $0 < h < 3 - \sqrt{5}$, with the improvement of service level of traditional channel, the optimal pricing of traditional channel increases, so does the online channel. When $h > 3 - \sqrt{5}$, with the improvement of service level of traditional channel, the optimal pricing of both traditional channel and online channel will be reduced.

Proposition 2 shows that only paying attention to the service quality of traditional channel will lead to the decline of overall benefits, which also reflects the law of marginal diminishing utility brought by services. Therefore, when determining the optimal service level, the traditional channel retailor should make scientific decisions according to the actual operating conditions to ensure the maximization of the overall benefits.

3.2 Pricing Strategy When Retailers Dominate

3.2.1 Pricing Strategies of Manufacturers and Retailers

Similarly, this section also uses the reverse derivation method to solve the problem. Finding the first order partial derivative of p_d and w in manufacturer's profit function.

$$\frac{\sigma \pi_d}{\sigma p_d} = -\frac{w(-1-2\lambda)}{1-h} + \frac{2(-1-\lambda-h\lambda)p_d}{h[1-h]} + \frac{(h+\lambda+\lambda h)p_t + \beta s_d - h\alpha s_t}{h[1-h]} \quad (14)$$

$$\frac{\sigma \pi_d}{\sigma w} = 1 - \frac{(1+2\lambda)(-p_d+p_t) + \beta s_d - \alpha s_t}{1-h} \quad (15)$$

Let $\frac{\sigma \pi_t}{\sigma p_t} = 0$, $\frac{\sigma \pi_t}{\sigma w} = 0$, combining the two equations, the retailer's pricing and the manufacturer's optimal wholesale price can be obtained.

$$p_d^* = \frac{-(w+2w\lambda)h[1-h]}{2(-1+h)(1+\lambda+h\lambda)} + \frac{(-1+h)\big((h+\lambda+\lambda h)p_t + \beta s_d - h\alpha s_t\big)}{2(-1+h)(1+\lambda+h\lambda)}$$

$$p_t^* = -\frac{(-1+h)(2(-1+h)(1+\lambda+h\lambda)+(\beta+2h\beta\lambda)s_d)}{(1+2\lambda)\big((-1+h)(2+h(-1+\lambda)+\lambda)+(1+2\lambda)h[1-h]\big)} + \frac{(-1+h)(\alpha(-2+h-2\lambda)s_t)}{(1+2\lambda)\big((-1+h)(2+h(-1+\lambda)+\lambda)+(1+2\lambda)h[1-h]\big)}$$

$$w^* = -\frac{(-1+h)(-2+2h-2\lambda+2h^2\lambda+\beta s_d)}{(1+2\lambda)(-2+3h-h^2-\lambda+h^2\lambda+h[1-h]+2\lambda h[1-h])} + \frac{(-1+h)(2h\beta\lambda s_d - 2\alpha s_t + h\alpha s_t - 2\alpha\lambda s_t)}{(1+2\lambda)(-2+3h-h^2-\lambda+h^2\lambda+h[1-h]+2\lambda h[1-h])}$$

3.2.2 Pricing Strategy Under the Neutral Consumer Fairness Preference

Neutral consumer fairness preference means $\lambda = 0$. The solution process has been reflected in the above, so this section gives the results and propositions directly.

$$p_t = -\frac{(-1+h)(2(-1+h)+\beta s_d + (-2+h)\alpha s_t)}{(2-h)(-1+h)+h[1-h]}$$

$$p_d^* = \frac{2h[1-h](-1+h+\beta s_d - \alpha s_t)}{\big(2\big((2-h)(-1+h)+h[1-h]\big)\big)} + \frac{(-1+h)(-2(-1+h)-\beta(-2+2h)s_d}{\big(2\big((2-h)(-1+h)+h[1-h]\big)\big)}$$

$$w^* = -\frac{(-1+h)(-2+2h+\beta s_d - 2\alpha s_t + h\alpha s_t)}{-2+3h-h^2+h[1-h]}$$

Proposition 3: When the service level of traditional channel is improved, the demand of online channel is declining, while the demand of traditional channel is not affected.

Proving:

$$\frac{\sigma Q_t}{\sigma s_t} = 0$$

$$\frac{\sigma Q_d}{\sigma s_t} = \frac{\alpha}{2(h-1)} < 0$$

Under the condition of neutral consumer fairness preference, the first partial derivative of the demand function of traditional channel with respect

to the service level of traditional channel is 0, which indicates that the demand of traditional channel does not change with it, while the demand of online channel shows a decline trend.

The main reason for this phenomenon is that consumers are completely rational now. When the service level of traditional channel is improved, the traditional retailers will increase the pricing, while the online manufacturers will reduce the pricing. The increase of demand brought by the improvement of traditional channel service level is offset by the reduction of demand caused by price difference in dual channels; Therefore, the improvement of traditional channel service level will cause the decrease of online channel demand, which is extremely unfavorable for the overall supply chain, which limits the improvement of service level in the garment industry.

Proposition 4: When the service level of traditional channel is improved, the optimal pricing of traditional channel shows an increasing trend, while the optimal pricing of online channel shows a downward trend.

Proving:

$$\frac{\sigma p_t^*}{\sigma s_t} = -\frac{(2-h)\alpha}{2(1-h)} > 0$$

$$\frac{\sigma p_d^*}{\sigma s_t} = -\frac{\alpha h}{2(1-h)} < 0$$

The improvement of service level means the increase of sales cost, so the traditional channel will choose to improve pricing under the operation pressure. The improvement of service level will reduce the demand of online channel. In order to retain consumers, online manufacturers will choose to reduce the price, which will cause the price war between traditional channel and online channel. This is unfavourable for the whole supply chain, but also harmful for consumers.

4. MODEL RESULTS AND ANALYSIS

In order to further explore the impact of consumer fairness preference, this section discusses the impact of consumer fairness preference on optimal pricing decision through numerical simulation.

4.1 The Impact on Pricing Strategy When Retailers Dominate

Considering the consumer fairness preference, the expressions of decision-makers in supply chain are complex. According to the assumptions in the model, the setting of parameter value range and the actual situation, the simulation numerical analysis is carried out. Let $h = 0.6$, $v = 0.8$, $\alpha = 0.3$, $\beta = 0.2$, $s_t = 0.7$, $s_d = 0.3$, the value range of degree of consumer fairness preference $\lambda \in (0,\ 0.33)$. When the retailer is in the leading position, the impact of consumer fairness preference on pricing and profit of manufacturer online channel and retailer traditional channel are shown in "Figure 2" and "Figure 3".

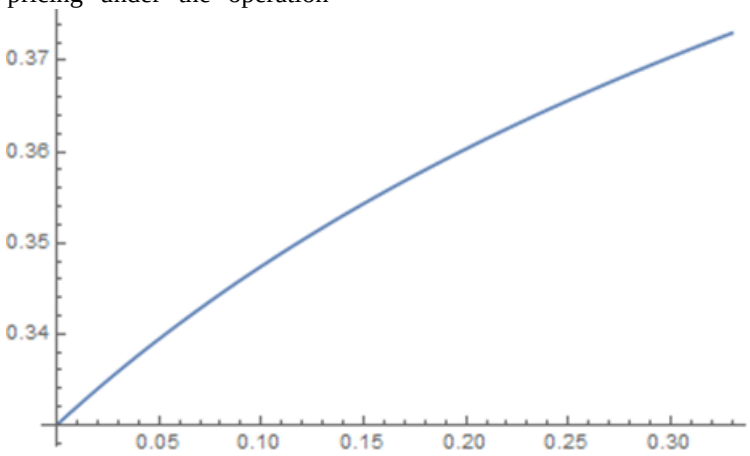

Figure 2 The impact of consumer fairness preference on optimal pricing of online channel.

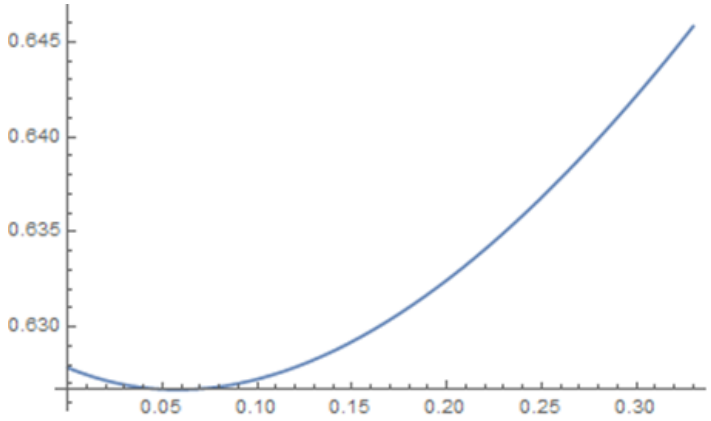

Figure 3 The impact of consumer fairness preference on optimal pricing of traditional channel.

It can be seen from "Figure 2" and "Figure 3" that the optimal pricing of traditional channel is significantly higher than that of online channel when the retailer is in the leading position. When the degree of consumer fairness preference increases, the optimal pricing of online channel shows an increasing trend, while the optimal pricing of traditional channel first decreases and then increases.

The main reason for this situation is that when the degree of consumer fairness preference increases, the online channel could attract more consumers because of its price advantage, so the manufacturer may get higher profits through the online channel. While the traditional channel retailers will lose more customers. In order to maintain the balance of revenue and expenditure, the traditional channel retailers have to increase their pricing to make profits. So, this situation is beneficial to the overall revenue of the supply chain. But for consumers, both online and offline channels will increase the pricing to a certain extent, which is unfavourable for them.

4.2 The Impact on Pricing Strategy When Manufacturers Dominate

Similarly, Let $h = 0.6$, $v = 0.8$, $\alpha = 0.3$, $\beta = 0.2$, $s_t = 0.7$, $s_d = 0.3$, the value range of degree of consumer fairness preference $\lambda \in (0,\ 0.33)$. When the manufacturer is in the leading position, the impact of consumer fairness preference on pricing and profit of manufacturer online channel and retailer traditional channel are shown in "Figure 4" and "Figure 5".

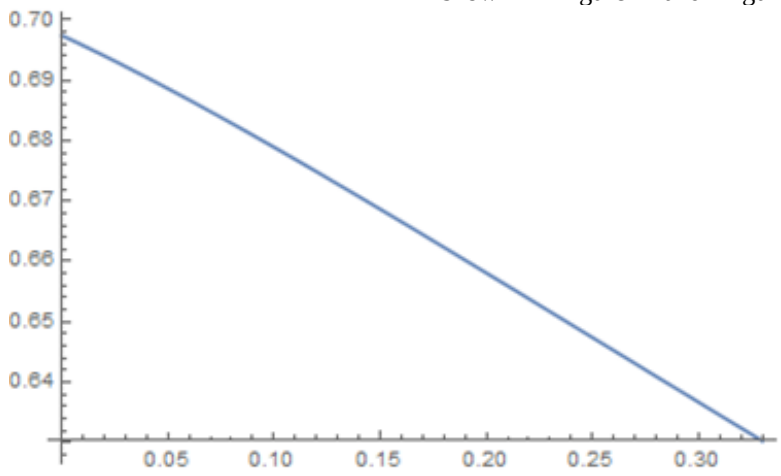

Figure 4 The impact of consumer fairness preference on optimal pricing of online channel.

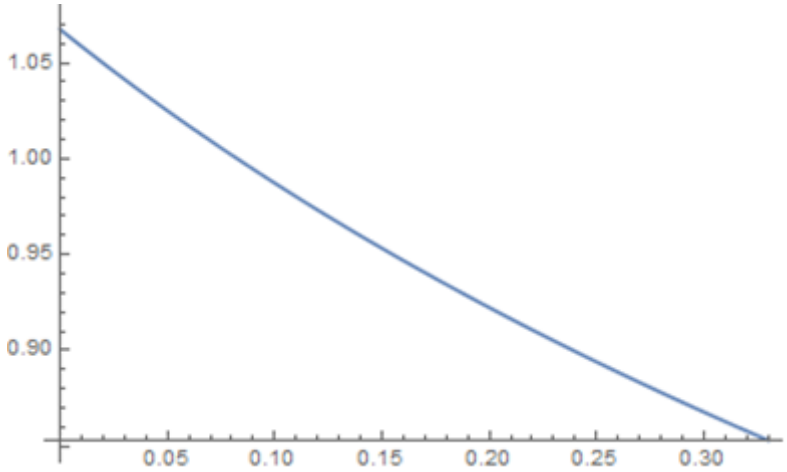

Figure 5 The impact of consumer fairness preference on optimal pricing of traditional channel.

"Figure 4" and "Figure 5" show that when the manufacturer is in the leading position, with the increase of consumer fairness preference, the optimal pricing of traditional channel and online channel both show a downward trend, and the optimal pricing of traditional channel is significantly higher than that of online channel.

5. CONCLUSION

Based on the dual-channel sales of small and medium-sized garment enterprises, this paper analyses the impact of consumer fairness preference on pricing strategy, and points out the optimal pricing strategy of each channel. The results show that:

- (1) When the retailer is in the dominant position, with the increase of consumer fairness preference, the pricing of both online and offline channels will increase, which is beneficial to the overall revenue of supply chain, but harmful to consumers;
- (2) When the manufacturer is in the leading position, with the increase of consumer fairness preference, the price of online and offline channels will decrease, but the price of offline channel will be still higher than online channel, so it is unfavourable for traditional channel retailers.

Based on the research results, the following management implications are obtained:

- (1) For the overall profit of supply chain, the increase of consumer fairness preference will reduce the overall profit, resulting in a price war between online and offline channels, but at the same time, the total demand of supply chain will increase. For the overall interests and long-term development of supply chain, manufacturers and traditional retailers should cooperate to control the degree of consumer fair preference to a certain extent.
- (2) For the traditional channel retailers, with the increase of consumer fairness preference, the profit presents a downward trend. Therefore, the traditional channel retailers should actively cooperate with manufacturers to reduce the operating pressure, and achieve a win-win situation. At the same time, traditional channel retailers should also improve their service level to attract more consumers.
- (3) For manufacturers, with the increase of consumer fairness preference, the demand and profit of online channel will increase, and the price advantage will also appear. However, manufacturers should also realize that with the increase of consumer fairness preference, the profit of traditional channel will decrease, which is unfavourable to the whole supply chain. It will decline the overall demand of supply chain, and will also have a certain impact on the demand of online channels. Therefore, manufacturers should actively cooperate with retailers to improve the overall profit of supply chain.

AUTHORS' CONTRIBUTIONS

Dan Liu wrote the manuscript, Dongxue Zuo and Haitao Wen were responsible for data simulation and analysis, Chun Wang contributed to revising and editing.

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