Research on Pricing Strategy of Dual-Channel Retailers from the Perspective of Consumer Preference

TingTing Jiao and YingHui Wu(✉)

School of Economics and Management, Jiangsu University of Science and Technology, Zhenjiang 212100, Jiangsu, China
209040107@stu.just.edu.cn, wyh@just.edu.cn

Abstract. Aiming at the channel equilibrium problem in the retail market, this paper considers consumers' subjective purchase channel preference, Based on the different subjective channel preferences of consumers for online platforms and offline channels, this paper introduces the factor of subjective preference to describe the profit model. On this basis, the MNL (Multinominal Logit) model is used to describe consumers' choice behavior and establish an optimal profit model established to study the retailer's profit maximization through reasonable pricing under the background of dual channels, and helps the retailer grasp the change of channel selection proportion under different cost ranges, and gives practical management suggestions.

Keywords: Subjective channel preference · Dual-channel · Reasonable pricing · MNL Model

1 Introduction

As customers' purchasing habits and e-commerce models evolve, the dual-channel retail model has presented new opportunities. Dual-channel retailing entails online platform channels and offline store channels, with the corresponding distribution system referred to as the dual-channel supply chain Li et al. [1] (2016). Maximizing profits under the dual-channel mode has emerged as a critical issue for retailers' development.

Previous research on dual-channel profits mainly focused on pricing issues. For instance, Correa [2] (2016) suggested a pricing policy that involves reducing prices, while Hua Ke and Hu Huang [3] (2017) examined the effect of power structures and expert assessments on the equilibrium price and expected profit of the two-channel system. Additionally. More recently, scholars have shifted their focus to analyzing the impact of consumer decision-making behavior on profits. For example, Ping Wang [4] (2019) studied the evaluation and decision-making process of consumers in selecting from different alternatives. Qian Lei [5] (2019) investigated the effect of consumer strategic behavior on online and offline retailers within the dual-channel supply chain. Moreover, Cheng li Liu [6] (2019) determined the optimal pricing strategy and profit

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by utilizing the Stackelberg game. These studies have demonstrated that ignoring the influence of consumer decision-making behavior on dual-channel profits can be costly.

As such, consumer decision-making behavior's influencing factors have become the focus of subsequent research. Haengju Lee [7] (2019) proposed that multiple consumer segmentation types exist in the potential category selection model. Wen Yu Zhao [8] (2020) studied consumers' channel choices at different shopping stages, highlighting the impact of product type and shopping stage on their purchase decisions and channel choices. Qian Leia [9] (2020) proposed the demand function of the two-period dual-channel model by combining the consumer utility function. Jing ci Xie [10] (2021) concluded that the optimal decision on pricing, demand, and profit under the dual-channel model should be made based on the consumers' purchase preferences. Existing research has progressively demonstrated that consumer types and their preferences are decisive factors in decision-making behavior.

However, the current literature primarily focuses on the objective preferences of different consumer segments, neglecting the subjective preference factors that exist prior to entering the market and tend to remain relatively stable. Building on the above analysis, this paper proposes a more realistic approach that predicts random decision-making behavior based on consumers' subjective preferences. This approach provides practical and effective management suggestions for dual-channel retailers to maximize profits and resource utilization.

2 Problem Description

From the retailer's perspective, the online channel corresponds to operating costs c^{on} and delivery costs $g(t)$, while the offline channel corresponds to operating costs c^{off}. As such, the prices of the same product may not necessarily be the same across different channels.

Assuming that the delivery cost is borne by the retailer R, the unit profit of R's online channel is given by $p^{on} - c^{on} - g(t)$, where t is the delivery time of the product and p^{on} is the price of the product in the online channel.

Assuming that the distance cost is borne by the retailer R, the cost of a consumer traveling to purchase a product at a physical store is denoted as k, where $k \in (0, 1)$. The price of a product offered through the offline channel is denoted as p^{off}, and therefore the retailer R's unit profit per sale through the offline channel is $p^{off} - c^{off} - k$.

Based on the MNL model framework, consumer utility is characterized using a linear utility function. We consider consumer purchase in the online channel with delivery time t, and let r be the consumer's patience factor, where the level of patience decreases as r increases.

The utility of a consumer purchasing any online product is represented by $\omega_1 = u - p^{on} - rt$, where $-rt$ represents the utility loss caused by waiting for delivery after purchasing the product. The consumer's intention to purchase online products is represented by θ_1. The utility of a consumer purchasing any offline product is represented by $\omega_2 = u - p^{off}$, and the consumer's intention to purchase offline products is represented by θ_2., $\theta_1 + \theta_2 = 1$, and without loss of generality, the utility of not purchasing any product is normalized to $u_0 = 0$ and the number of consumers is normalized to

1. Therefore, the proportion of consumers purchasing a certain product is equal to the demand for that product.

3 Model Building and Solving

Based on the above symbol definitions and model assumptions, the maximum profit model of the retailer based on consumer subjective channel preference is shown below:

$$Max\ Z = N_1\left(p^{on} - c^{on} - g(t)\right) + N_2\left(p^{off} - c^{off} - k\right) \tag{1}$$

$$N_1 = \frac{e^{\theta_1\omega_1}}{1 + e^{\theta_1\omega_1} + e^{\theta_2\omega_2}} \tag{2}$$

$$N_2 = \frac{e^{\theta_2\omega_2}}{1 + e^{\theta_1\omega_1} + e^{\theta_2\omega_2}} \tag{3}$$

$$\omega_1 = u - p^{on} - rt \tag{4}$$

$$\omega_2 = u - p^{off} \tag{5}$$

$$\mathrm{g}(t)' < 0, \mathrm{g}(t)'' > 0 \tag{6}$$

$$c^{off} \geq c^{on} \tag{7}$$

$$\theta_1 + \theta_2 = 1 \tag{8}$$

The objective function (1) denotes the maximum profit of the retailer. Constraints (2) and (3) determine the choice probabilities of each channel. Constraints (4) and (5) signify the utility derived from purchasing a product. Constraint (6) expresses that the delivery cost function increases with a decrease in delivery time and the cost of reducing the delivery time increases with the reduction in time. This has been discussed in the previous section. Constraint (7) imposes that offline costs must be greater than online costs. Constraint (8) indicates that consumers have a certain initial preference for one channel and only prefer that channel.

Solving for the optimal price and optimal delivery time using first-order conditions:

$$p^{on^*} - c^{on} - g\left(t^*\right) - \frac{1}{\theta_1} = p^{off^*} - c^{off} - k - \frac{1}{\theta_2} \tag{9}$$

$$p^{on^*} - c^{on} - g\left(t^*\right) - \frac{1}{\theta_1} = \frac{1}{\theta_1}e^{\theta_1\left(u - p^{on^*} - rt^*\right)} + \frac{1}{\theta_2}e^{\theta_2\left(u - p^{off^*}\right)} \tag{10}$$

$$\mathrm{g}\left(t^*\right)' = -r \tag{11}$$

$$\theta_1 + \theta_2 = 1 \tag{12}$$

p^{on^*}, p^{off^*} and t^* correspond to the optimal solutions of p^{on}, p^{off} and t, respectively, where the profit is maximized at the stationary point. Moreover, Eq. (11) demonstrates that when the delivery loss function remains unchanged, the delivery time only depends on the patience factor.

$$N_1 + N_2 = \frac{e^{\theta_1 \omega_1}}{1 + e^{\theta_1 \omega_1} + e^{\theta_2 \omega_2}} + \frac{e^{\theta_2 \omega_2}}{1 + e^{\theta_1 \omega_1} + e^{\theta_2 \omega_2}} = \frac{e^{\theta_1 \omega_1} + e^{\theta_2 \omega_2}}{1 + e^{\theta_1 \omega_1} + e^{\theta_2 \omega_2}} < \frac{1 + e^{\theta_1 \omega_1} + e^{\theta_2 \omega_2}}{1 + e^{\theta_1 \omega_1} + e^{\theta_2 \omega_2}} = 1 \tag{13}$$

When the subjective channel preference is equal to 0.5, the final total purchase proportions N_1 and N_2 are both close to 0.5, but their sum is less than 1. This indicates that there may exist consumers who do not make a purchase. Assuming $\theta_1 = 0$ and $\theta_2 = 1$.

$$Max\ Z_{on} = \frac{p^{on} - c^{on} - g(t)}{1 + 1 + e^{u - p^{off^*}}} \tag{14}$$

Channel prices are positively correlated with operating costs. Only by controlling costs can we fundamentally adjust the pricing of different channels and avoid blindly adjusting prices, which may result in profit loss.

4 Data Analysis

In order to more intuitively reveal the impact of consumer channel preference on the profits of the retailer, this section uses numerical examples to verify the properties.

Based on the given market situation, the parameters are set as follows: $r = 1$, $c^{on} = 2.5$, $c^{off} = 4$, $g(t) = \frac{1}{t}$, $\theta_1 = 0.4$, $\theta_2 = 0.6$, $u = 20$, and $k = 0.5$. Here, $r = 1$ is the normalized consumer patience factor, $g(t) = \frac{1}{t}$ is a delivery cost function that conforms to the model assumptions, $c^{on} = 2.5$ and $c^{off} = 4$ characterize the difference in operating costs between dual channels, and $\theta_1 = 0.4$, $\theta_2 = 0.6$ indicate moderate subjective channel preferences for dual-channel consumers. The value of $u = 20$ represents the initial utility of the product, while $k = 0.5$ suggests moderate distance. Using MATLAB, the optimal values are obtained as follows: $p^{on^*} = 17.1896$, $p^{off^*} = 17.3562$, $t^* = 1$ and $Z = 11.4551$.

Considering the impact of changes in parameter values, the model assumes that $c^{off} \geq c^{on}$. Therefore, when c^{on} varies within the range of (0, 4) and c^{off} varies within the range of (2.5, 8), the trends of different factors affecting channel selection can be observed in Figs. 1 and 2 while maximizing profit.

The selection proportion and operating costs are negatively correlated, and the focus of the decision-making process is on comparing the retailer's post-adjustment subjective preference with the initial preference. If the selection proportion of the retailer cannot exceed the initial preference within the allowed range of adjustment, then the adjustment of this channel should be abandoned, and resources should be focused on the other channel. Furthermore, if the impact of changing operating costs on the equilibrium results is small, in order to avoid wasting resources, other influencing factors can also be considered.

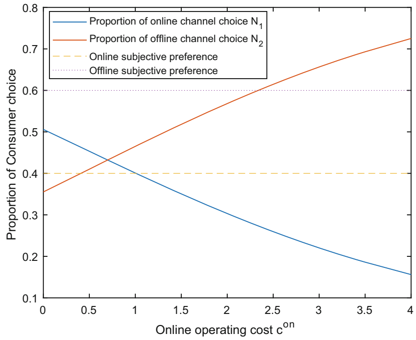

Fig. 1. Trend of the influence of c^{on}

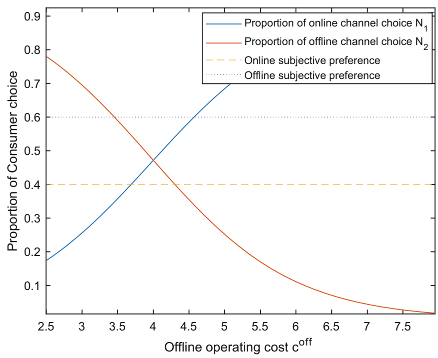

Fig. 2. Trend of the influence of c^{off}

The impact of different subjective preference values on the equilibrium results is shown in Fig. 3.

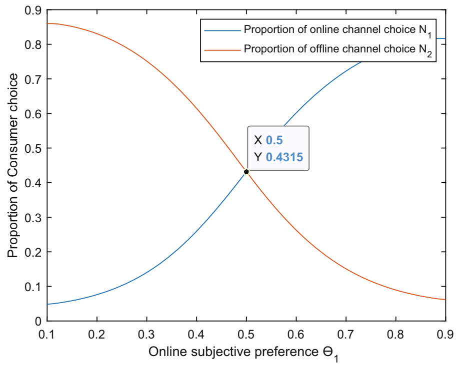

Fig. 3. Trend of the influence of θ_1

When the subjective channel preference value is 0.5, the actual selection proportion of consumers for the two channels is close to but not equal to 0.5. This means that the model allows for the existence of consumers who do not actually make a purchase, which is in line with the real situation.

Comparing the trend charts of the channel selection proportions in all the above analyses, the unit rate of change in the trend chart of the subjective channel preference is the highest, indicating that the sensitivity of the subjective channel preference factor in the consumer selection proportion model is the highest. This phenomenon shows that the key factor characterizing consumer selection behavior is the subjective channel preference. This conclusion also confirms the importance of this study.

5 Conclusion

This paper examines the pricing decisions of dual-channel retailers in light of consumers' channel preferences. By accurately assessing consumers' subjective channel preference and predicting their decision-making behavior, retailers can optimize pricing and demand control to maximize profits. Key findings include the impact of delivery time on consumer patience and its effect on retailers' profits, the importance of considering operating and delivery costs when making omni-channel decisions, and the role of cost limitations in demand migration. Additionally, the study emphasizes the need for retailers to understand consumer preference values and initial channel preferences when making optimal decisions. These insights have important implications for the management of dual-channel retail platforms, though further research is necessary to fully understand the impact of external factors on subjective channel preferences.

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