Postprint on Wholesale Pricing Model Selection in Dual-Channel Supply Chains Considering Manufacturer' s Suggested Retail Price

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Abstract

This study investigates a dual-channel supply chain system composed of a manufacturer' s direct online channel and a retailer' s traditional channel. For the first time, the wholesale price mode selection problem is examined in the context of recommended retail price, employing a manufacturer-led Stackelberg game to derive the price equilibrium strategies for each supply chain member. Comprehensively considering the retailer' s bargaining power and consumer preference for channels, a comparative analysis is conducted on manufacturer profit, retailer profit, and supply chain profit under different wholesale price negotiation modes. The results indicate that manufacturers can adjust market prices through recommended retail prices; from the perspective of the overall supply chain or the retailer, determining the wholesale price based on the direct sales price is optimal; manufacturers tend to independently determine wholesale prices, but when the retailer' s bargaining power is weak and the basic market share of the online channel is relatively large, they may also accept determining the wholesale price based on the online direct sales price.

Full Text

Preamble

Wholesale Pricing in Dual-Channel Supply Chain with Suggested Retail Price

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Abstract: This paper studies a dual-channel supply chain system consisting of a manufacturer' s online direct sales channel and a retailer' s traditional channel. For the first time, it investigates the choice of wholesale price model under the background of suggested retail price. Using a manufacturer-led Stackelberg game, we derive the equilibrium pricing strategies for all supply chain members. By comprehensively considering the retailer' s bargaining power and consumer channel preferences, we compare manufacturer profits, retailer profits, and total supply chain profits under different wholesale price negotiation modes. The results show that manufacturers can adjust market prices through suggested retail price. From the perspective of the overall supply chain or the retailer, determining wholesale price based on the direct sales price is optimal. Manufacturers prefer to set wholesale price independently, but may also accept determining wholesale price based on the online direct price when the retailer' s bargaining power is weak and the online channel' s basic market share is relatively large.

Keywords: suggested retail price; dual-channel; wholesale price determination; Stackelberg game

0 Introduction

A relevant stream of literature examines reference price effects. Kalyanaram et al. [?] first studied how reference price influences consumer brand choice, demonstrating that reference price continuously affects purchasing decisions. Fibich, Nasiry, and Hsieh et al. [?] investigated dynamic pricing problems under reference price effects, modeling reference price as either a weighted average of past prices or an average of the lowest price in the past and the highest price in the recent period. Considering advertising' s impact on reference price, Zhang et al. [?] proposed a dynamic cooperative advertising model for supply chains and analyzed how reference price effects influence channel members' decisions. Dye et al. [?] constructed a joint dynamic pricing model for deteriorating inventory systems with time- and price-sensitive demand and reference price effects, developing a generalized model to jointly determine optimal selling price and replenishment policy to maximize retailer profit over a finite planning horizon. Pu et al. [?] studied the impact of reference price effects on dual-channel supply chain operations, finding that reference price effects can mitigate inter-channel price competition and improve supply chain efficiency. Lin [?] first introduced suggested retail price as a reference price into supply chain research, showing that under certain conditions, both minimum and maximum reference price strategies could maximize manufacturer revenue.

Another relevant literature stream addresses wholesale price determination through bargaining. Iyer et al. [?] examined how bargaining power affects supply chain coordination, noting that greater retailer power can facilitate channel coordination. Dukes, Ai, and An et al. [?] studied wholesale price setting under bargaining with retailer competition, though these studies were limited to traditional channel frameworks. Li et al. [?] analyzed a dual-channel supply chain with online direct and e-retail channels, examining price and logistics service level decisions under three retail pricing modes based on bargaining power comparisons between manufacturer and retailer. Li et al. [?] introduced bargaining theory to a dual-channel supply chain with manufacturer direct and retailer traditional channels, comparing two negotiation modes: using retailer price as the negotiation benchmark versus using manufacturer direct price. Wu et al. [?] further examined how marketing effort affects wholesale price mode selection. However, these studies did not consider reference price effects. Additionally, consumer free-riding behavior significantly impacts supply chain decisions. Mittelstaedt et al. [?] found that free-riding weakens retailers' incentives to provide services, reducing service levels and market demand. Therefore, consumer free-riding cannot be ignored in dual-channel supply chain research.

Given these gaps, this paper introduces reference price effects formed by manufacturer suggested retail price into a dual-channel supply chain, considers consumer free-riding behavior, and studies wholesale price mode selection under bargaining. We address two key questions: (a) How does suggested retail price affect pricing decisions in dual-channel supply chains? (b) From the perspectives of manufacturer, retailer, or overall supply chain, which wholesale price determination mode is optimal?

1 Problem Description and Model Assumptions

We study a supply chain system with one manufacturer and one retailer. The manufacturer sells through an online direct channel at price p_d and offers wholesale price w to the retailer, who sells through a traditional channel at price p_r. The supply chain structure is shown in [Figure 1: see original paper].

The manufacturer provides a suggested retail price, denoted by s. Following demand functions constructed by Lin [?] and Pu [?], the market demands for online direct channel (q_d) and traditional retail channel (q_r) are:

$$q_d = \alpha Q - \beta p_d + \theta(s - p_d) + f(s - p_r) + es$$

$$q_r = (1-\alpha)Q - \beta p_r + \theta(s - p_r) + f(s - p_d) + es + ts - ks^2/2$$

Where: - Q is the base number of consumers - α represents the proportion of consumers preferring online shopping (online channel' s basic market share) - β is the price elasticity coefficient reflecting competition intensity between channels (we assume $\beta > \theta$) - θ is the reference effect coefficient representing how differences between actual price and suggested retail price affect demand (assuming $0 < \theta < 1$) - e and f are cross-price elasticity coefficients - t is the proportion of free-riding consumers who first visit the physical store for product display, explanation, and free trials, then purchase through the online channel - s is the retailer' s promotional effort level, with promotional cost function $C(s) = ks^2/2$ where k is the cost coefficient

We assume zero production cost for the manufacturer, which does not affect our analysis. Superscripts A, B, and C denote three scenarios: manufacturer 单独确定批发价格 (independently determines wholesale price), wholesale price based on suggested retail price, and wholesale price based on direct sales price, respectively. Superscript $*$ indicates optimal decisions. π_m, π_r, and π represent manufacturer profit, retailer profit, and total supply chain profit, respectively.

2 Model Solution

2.1 Manufacturer Independently Determines Wholesale Price

In this scenario, the manufacturer first sets online direct price p_d and wholesale price w, then the retailer determines retail price p_r. The decision models are:

Manufacturer: $\max_{p_d,w} \pi_m^A = p_d q_d + w q_r$

Retailer: $\max_{p_r} \pi_r^A = (p_r - w)q_r - C(s)$

Using backward induction, we first solve the retailer' s problem. The first-order condition yields the retailer' s best response function:

$$p_r^A(w, p_d) = \frac{(1-\alpha)Q + \theta s + f(s - p_d) + es + w(\beta - \theta) + ts}{2(\beta - \theta)}$$

Substituting this into the manufacturer' s profit function and solving the first-order conditions simultaneously gives the unique optimal solution. The Hessian matrix is negative definite, confirming a unique optimum.

Proposition 1: When the manufacturer independently determines wholesale price, both retail channel price p_r^A and online direct price p_d^A increase with suggested retail price s, and $\partial p_r^A/\partial s > \partial p_d^A/\partial s = \partial w^A/\partial s > 0$.

Proof: Taking partial derivatives of the optimal solutions with respect to s and comparing them yields the result.

Proposition 1 shows that the manufacturer can use suggested retail price to adjust market prices, with a stronger constraining effect on the retailer's physical channel price.

Proposition 2: $\partial p_r^A/\partial s > \partial p_d^A/\partial s$ when $t < t_1$, and $\partial p_r^A/\partial s < \partial p_d^A/\partial s$ when $t > t_1$, where $t_1 = \frac{5\beta+6\theta+3\alpha\beta+3\alpha\theta+1}{6\beta+4\theta+2}$.

Proof: Taking the difference between the partial derivatives yields the threshold condition.

Proposition 2 indicates that promotional effort affects channel prices differently depending on free-riding behavior. When the proportion of free-riders is small, retailers can raise physical channel prices significantly to cover promotional costs. When free-riding is prevalent, retailers cannot retain enough consumers despite attracting more traffic, resulting in smaller price increases in the physical channel compared to the online channel.

2.2 Wholesale Price Based on Suggested Retail Price

In this scenario, the retailer negotiates with the manufacturer to determine wholesale price as $w = s - \delta$, where δ represents the negotiated discount from suggested retail price. The manufacturer first sets online direct price p_d, then the retailer determines retail price p_r.

The decision models are:

Manufacturer: $\max_{p_d} \pi_m^B = p_d q_d + w q_r$

Retailer: $\max_{p_r} \pi_r^B = (p_r - w)q_r - C(s)$

Using backward induction, the retailer' s best response function is:

$$p_r^B(p_d) = \frac{(1-\alpha)Q + \theta s + f(s - p_d) + es + (\beta - \theta)(s - \delta) + ts}{2(\beta - \theta)}$$

Substituting into the manufacturer' s profit function and solving yields the unique optimal solution.

Proposition 3: When wholesale price is based on suggested retail price, $\partial p_r^B/\partial s > 0$, $\partial p_d^B/\partial s > 0$, and $\partial p_r^B/\partial s > \partial p_d^B/\partial s$ when retailer bargaining power is weak (δ small), while $\partial p_r^B/\partial s < \partial p_d^B/\partial s$ when bargaining power is strong (δ large).

Proof: Similar to Proposition 1, taking partial derivatives of the optimal solutions yields the results.

Proposition 3 shows that suggested retail price continues to influence both channels, but the relative impact depends on retailer bargaining power.

Proposition 4: $\partial p_r^B/\partial s > \partial p_d^B/\partial s$ when $t < t_2$, and $\partial p_r^B/\partial s < \partial p_d^B/\partial s$ when $t > t_2$, where $t_2 = \frac{6\beta+6\theta+3\alpha\beta+3\alpha\theta+2}{6\beta+4\theta+2}$.

Proof: The difference between partial derivatives yields the threshold condition.

Proposition 4 yields similar insights to Proposition 2 regarding promotional effort effects.

2.3 Wholesale Price Based on Direct Sales Price

In this scenario, wholesale price is negotiated as $w = p_d - \delta$, where δ is the negotiated discount from direct sales price. The manufacturer first sets p_d, then the retailer sets p_r.

The decision models are:

Manufacturer: $\max_{p_d} \pi_m^C = p_d q_d + w q_r$

Retailer: $\max_{p_r} \pi_r^C = (p_r - w)q_r - C(s)$

Using backward induction, the retailer' s best response function is:

$$p_r^C(p_d) = \frac{(1-\alpha)Q + \theta s + f(s - p_d) + es + (\beta - \theta)(p_d - \delta) + ts}{2(\beta - \theta)}$$

Solving the manufacturer' s problem yields the unique optimal solution.

Proposition 5: When wholesale price is based on direct sales price, both channel prices increase with suggested retail price s, and the impact magnitude depends on retailer bargaining power.

Proof: Taking partial derivatives of the optimal solutions with respect to s yields the results.

Proposition 6: The relationship between $\partial p_r^C/\partial s$ and $\partial p_d^C/\partial s$ follows similar threshold patterns as in Propositions 2 and 4, with threshold $t_3 = \frac{6\beta+6\theta+3\alpha\beta+3\alpha\theta+3}{6\beta+4\theta+2}$.

Proof: The difference between partial derivatives establishes the threshold condition.

3 Numerical Analysis

We conduct numerical experiments to compare manufacturer profit, retailer profit, and total supply chain profit across different wholesale price modes, varying online channel market share α and retailer bargaining power δ. Following Liu et al. [**?**], we set parameters as: $Q = 1$, $\beta = 6.0$, $\theta = 0.4$, $e = 0.25$, $f = 0.5$, $k = 1$, with $\alpha \in [0.2, 0.8]$ and $\delta \in [0.3, 0.7]$.

3.1 Comparison of Manufacturer Profits

Figures 2 and 3 show that manufacturer profit is always highest when the manufacturer independently determines wholesale price. Compared to independent determination, when wholesale price is based on suggested retail price, the profit gap is larger when online market share is small and retailer bargaining power is strong. When retailer bargaining power is relatively weak, the profit difference becomes negligible regardless of market share. When wholesale price is based on direct sales price, manufacturer profit only approaches the independent determination scenario when online market share is large and retailer bargaining power is weak.

Figure 4 reveals that when wholesale price is based on direct sales price, weaker retailer bargaining power yields higher manufacturer profit. However, when based on suggested retail price, manufacturer profit first increases then decreases as retailer bargaining power weakens (i.e., as δ increases), indicating an optimal negotiation range. In most cases, suggested retail price basis yields higher manufacturer profit than direct sales price basis, except when retailer bargaining power is weak and online market share is large.

3.2 Comparison of Retailer Profits

Figure 5 shows that when comparing independent manufacturer pricing versus suggested retail price basis, retailer bargaining power becomes the decisive factor. With strong bargaining power, retailers prefer suggested retail price basis; with weak power, they prefer independent manufacturer pricing.

Figures 5 and 6 demonstrate that wholesale price based on direct sales price always yields higher retailer profit than independent manufacturer pricing. Retailers particularly prefer direct sales price basis when online market share is small and their bargaining power is strong. When online market share is large and bargaining power is weak, profits under both scenarios become nearly equal.

3.3 Comparison of Total Supply Chain Profits

Figure 8 indicates that for the overall supply chain, the choice between independent manufacturer pricing and suggested retail price basis depends on retailer bargaining power. With strong bargaining power, suggested retail price basis is superior; with weak power, independent pricing is better. This aligns with the retailer perspective.

Figures 9 and 10 show that for the total supply chain, wholesale price based on direct sales price outperforms both independent pricing and suggested retail price basis. When retailer bargaining power is strong, total supply chain profits under direct sales price basis and suggested retail price basis become nearly equivalent.

4 Conclusion

This paper studies a dual-channel supply chain with one manufacturer and one retailer, incorporating reference price effects from manufacturer suggested retail price and consumer free-riding behavior. We analyze three wholesale price determination modes: independent manufacturer pricing, suggested retail price basis, and direct sales price basis. Numerical analysis reveals that:

1. Manufacturers can adjust market prices through suggested retail price.
2. From supply chain and retailer perspectives, determining wholesale price based on direct sales price is optimal.
3. Manufacturers prefer independent pricing, but will accept direct sales price basis when retailer bargaining power is weak and online channel market share is large.

This research provides pricing references for supply chain members by introducing suggested retail price into dual-channel supply chains and comparing three wholesale price modes. Future research could extend this work to stochastic demand and examine risk preferences of supply chain members.

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Note: Figure translations are in progress. See original paper for figures.