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Contents

Impact of Product Competition and Power Structure on Pricing Strategy in Dual-channel Supply Chain

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Abstract: The pricing strategy under the interaction of competition and power structure in dual-channel supply chain is studied. A two-level dual-channel supply chain model was constructed, in which the manufacturer has a direct channel to sell products directly to customers. Optimal pricing strategies under three different power structures (Nash equilibrium, Manufacturer Stackelberg, Retailer Stackelberg) in non-competition situation were discussed. Product pricing policies in competition environment were analyzed. Results showed that: compared to Nash equilibrium making decision simultaneously, the leader of Stackelberg game takes the advantage of first-move and makes more profits than in Nash equilibrium; as market competition intensifies, the optimal prices will gradually decrease in competition environment. Numerical examples are given to compare the strategies in non-competition and competition situation and demonstrate the effectiveness of relevant conclusions.

Keywords: dual-channel; supply chain; Stackelberg game; power structure

1. Introduction

The rapid development of Internet changes the way people living and also has a significant impact on channel sales pattern at the same time. Many manufacturers depend not only on traditional retailers to sell products, but also on network sales channel directly to customers.

Extensive literature studies on introducing online sales channel of manufacturer. Chiang et al point out that manufacturers can increase their own profits through opening up direct marketing channels [1]. Furthermore, Tsay and Agrawal discuss the channel conflict issues in dual channel supply chain. Conclusions show that reasonable pricing strategies can achieve a win-win situation between manufacturer and retailer [2]. Boyaci analyzes coordination contracts and suggests that majority of the existing traditional coordination methods can't be suitable to the occasion of dual channel, and proposes penalties contract and compensation-trust contract [3]. Kurata considers price subsidies strategy when brand competition and channel competition coexist so that all parties benefit from the game [4].Liu et al explore joint strategy of production and pricing under information asymmetry [5]. Chiang takes customer preference and channel demand transfer caused by inventory shortage into account and designs a combination mechanism of sharing inventory holding costs and direct channel revenue to coordinate the dual-channel supply chain [6]. Pricing strategies in case of demand disruptions are investigated by Huang et al [7].

With the growing power of retailers, retailers play an increasingly important role in channel strategy, sometimes in a leadership position [8].Therefore, it's necessary to study the pricing problem from the perspective of comparative power between manufacturer and retailer. In practice, there are three possible channel power structures, i.e. Nash equilibrium, manufacturer Stackelberg and retailer Stackelberg [9]. Parts of the study examine the pricing strategies of different power structures in previous work on dual channel supply chain. Cai et al analyze price discounts strategy under three power structures in dual-channel supply chain. Results show the dominant party in power structure has certain advantages [10], but the study focuses on a single complete monopoly product without competition. If product competition is fierce in market, pricing strategy will be influenced by double effect of product competition and power structure, and hypothesis of existing research will not be fully applicable.

Therefore, this paper extends the above literature related to dual-channel supply chain by addressing product competition and power structure, discusses the pricing strategy in different situation, and explores the impact of competition and power structure on pricing strategy. The rest of the paper is organized as follows. Section 2 introduces the model. Section 3 analyzes the industry equilibrium in three different power structures; while in Section 4, we explore settings and equilibrium with production competition. The numerical study of product competition and power structure effects are then presented in Section 5. We conclude the paper in Section 6.

2. Model

In a supply chain consisting of a manufacturer and a retailer, assuming that the total market demand function is a linear down sloping, given as $D = s(1-\beta p)$ .Let s denote the market demand for products, and β denote the price elasticity factor of market. When manufacturer opens up network sales, demand functions of network marketing channel D_d and traditional channel D_r are given as:

$$D_d = (1-u)s(1+\frac{\beta\theta p_r}{1-\theta}-\frac{\beta p_d}{1-\theta})$$

$$D_r = us(1-\frac{\beta p_r}{1-\theta}+\frac{\beta\theta p_d}{1-\theta})$$

pr represents the retail channel price, while pd represents direct channel price. u represents initial market share of traditional retail channel($0 \le u \le 1$, $0 \le \theta \le 1$).1-u represents the initial market share of direct sales channel. θ represents price sensitivity coefficient and reflects the alternative of two channels. u reflects the absolute difference of demand. θ reflects the alternative of two channels. The combination of u and θ can well describe customer preference and difference of two channels. w denotes wholesale price, and c denotes the cost of production.

The objective profit function of retailer is given by:

$$\pi_R = us(1-\frac{\beta p_r}{1-\theta}+\frac{\beta\theta p_d}{1-\theta})(p_r - w)$$

The objective profit function of manufacture is given by:

$$\pi_M = (1-u)s(1+\frac{\beta\theta p_r}{1-\theta}-\frac{\beta p_d}{1-\theta})(p_d - c)$$

$$+(w-c)us(1-\frac{\beta p_r}{1-\theta}+\frac{\beta\theta p_d}{1-\theta})$$

In order to utilize the above model, it's necessary to impose additional inequality constraints on the parameters ① $w\beta \le 1$ ② $\frac{\theta}{1+\theta} \le u \le \frac{1}{1+\theta}$ [11] to guarantee that channel demands are greater than zero and demand functions are decreasing.

3. Pricing Strategies in Different Power Structures Without Product Competition

We discuss three different kinds of power structures, i.e. Nash equilibrium, manufacturer Stackelberg and Retailer Stackelberg respectively. In Nash equilibrium, manufacturer and retailer make their pricing strategies at the same time; neither can use the other's reaction function. In manufacturer Stackelberg game, manufacturer can utilize the retailer's reaction function as part of its strategy to set optimal direct channel price. In retailer Stackelberg game, retailer can take advantage of manufacturer's reaction function to set the retailer's income level and make right decision.

(1) Nash equilibrium

Manufacturer and retailer determine their strategies simultaneously; manufacturer establishes direct sales channel price, retailer establishes his retail price. It can be proved that π_R is a concave function of pr and π_M is concave with respect to pd. The optimal prices for the direct channel and the retailer channel are given by: (a superscript * indicates the optimal value, and the subscript n represents the Nash Equilibrium):

$$p_{rn}^* = \frac{2(1+w\beta)+(c\beta-1-\theta)\theta+u((1-c\beta)\theta(1+\theta)+w\beta(-2+\theta^2)-2))}{(-1+u)(-4+\theta^2)\beta}$$

$$p_{dn}^* = \frac{2(1+c\beta)+(w\beta-1-\theta)\theta+u(-2-2c\beta(1+\theta)+\theta(1+w\beta+\theta))}{(-1+u)(-4+\theta^2)\beta}$$

(2) Manufacturer Stackelberg

Manufacturer is more powerful than retailer in this game. As a leader, manufacturer determines direct channel price first, then retailer determines retail channel price as a follower. Solving the first order condition of π_R , we have $p_r = \frac{1+w\beta-\theta+\beta\theta p_d}{2\beta}$

Substituting the pr into manufacturer's profit function, we get:

$$\pi_M = \frac{s(-u(c-w)(-1+w\beta+\theta-\beta\theta p_d)-(-1+u)(c-p_d)(2+(-1+w\beta-\theta)\theta+\beta(-2+\theta^2)p_d))}{2(-1+\theta)}$$

$$=(s(-u(c-w)(-1+w\beta+\theta-\beta\theta p_d)$$

$$-(-1+u)(c-p_d)(2+(-1+w\beta-\theta)\theta+\beta(-2+\theta^2)p_d)))/2(\theta-1)$$

π_M is a concave function with respect to pd, so the optimal solutions of Manufacturer Stackelberg are (the subscript m denotes Manufacturer Stackelberg):

$$p_{dm}^* = \frac{1+c\beta}{2\beta}+\frac{\theta(-1+u-cu\beta+w\beta)}{2\beta(u-1)(\theta^2-2)}$$

$$p_{rm}^* = \frac{(-1+c\beta)\theta}{4}-\frac{(1+w\beta)}{(\theta^2-2)\beta}-\frac{(3+w\beta+u(-3+c\beta-2w\beta))\theta^2}{(\theta^2-2)(-1+u)\beta} \quad (3)$$

Retailer Stackelberg

In Retailer Stackelberg, retailer is more powerful. As a dominant player in the game, retailer first determines retail channel price, then manufacturer sets direct channel price. Solving the first order condition of π_M , we have $p_d = \frac{1+c\beta}{2\beta}+\frac{\theta p_r}{2}+\frac{u\theta(c\beta-w\beta-1)}{2(u-1)\beta}$.

By substituting pd into π_R , we can obtain the utility function of retailer:

$$\pi_R = \frac{su(w-p_r)(2+(-1+c\beta-\theta)\theta+u(-2+\theta(1+\theta+w\beta\theta-c\beta(1+\theta)))-(-1+u)\beta(-2+\theta^2)p_r)}{2(1-u)(-1+\theta)}$$

π_R is a concave function of pr, so optimal solutions of retailer Stackelberg are given as follows(the subscript r denotes Retailer Stackelberg):

$$p_{rr}^* = \frac{1+w\beta}{2\beta}+\frac{u(w-c)\beta\theta^2-(-1+u)(-1+c\beta)\theta}{2(-1+u)(-2+\theta^2)\beta}$$

$$p_{dr}^{\ *}=\frac{1+c\beta}{2\beta}+\frac{2u(1-c\beta)\theta+2(w\beta-1)\theta+(1-u)(1-c\beta)\theta^2(\theta-1)-\theta(w-c)\beta(\theta^2-2u)}{4(-1+u)\beta(-2+\theta^2)}$$

Following properties are obtained by comparing the optimal prices under different power structures:

(1) In three cases, the optimal prices of retail channel are met the conditions: $\frac{\partial p_r^{\ *}}{\partial u}>0$, $\frac{\partial p_r^{\ *}}{\partial \beta}<0$. The higher the initial market share of retail channel is, the higher the retail channel price is. The higher the price elasticity factor of market is, the lower the retail channel price is.

(2)For $A=\frac{2+\theta}{2w-c\theta+2w\theta-c\theta^2+w\theta^2}$, $B=\frac{2+\theta}{4w-2c+3w\theta-2c\theta}$, $C=\frac{\theta^2}{(2+\theta)(w-c)+c\theta^2}$, $Y=\frac{\theta((2-\theta^2)(1-c\beta)+(w\beta-1)\theta)}{2w\beta(2-\theta^2)-\theta(\theta-2+\theta^2)+c\beta(1+\theta)(-4+2\theta+\theta^2)}$, $X=\frac{-2+\theta-c\beta\theta+\theta^2-w\beta(\theta^2-2)}{2(w\beta-1)-(c\beta-1)\theta(1+\theta)}$,the optimal retail prices under different power structures have the following relationships, as shown in Table 1.

Table 1. Comparison of Optimal Retail Price under Different Power Structures

Scope of β	Condition	Scope of u	Relationship
$\beta\in(0,C]$			$p_{rn}^{\ *}\le p_{rm}^{\ *}<p_{rr}^{\ *}$
$\beta\in(C,B]$	and	$u\in[\frac{\theta}{1+\theta},Y]$	$p_{rn}^{\ *}\le p_{rm}^{\ *}<p_{rr}^{\ *}$
	and	$u\in(Y,\frac{1}{1+\theta}]$	$p_{rm}^{\ *}<p_{rn}^{\ *}<p_{rr}^{\ *}$
$\beta\in(B,A]$			$p_{rm}^{\ *}<p_{rn}^{\ *}\le p_{rr}^{\ *}$
$\beta\in(A,\frac{1}{w}]$	and	$u\in[\frac{\theta}{1+\theta},X]$	$p_{rm}^{\ *}<p_{rr}^{\ *}\le p_{rn}^{\ *}$
	and	$u\in(X,\frac{1}{1+\theta}]$	$p_{rm}^{\ *}<p_{rn}^{\ *}<p_{rr}^{\ *}$

Table 2. Comparison of optimal direct price under different power structures

Scope of β	Condition	Scope of u	Relationship
$\beta\in(0,E]$			$p_{dn}^{\ *}<p_{dr}^{\ *}\le p_{dm}^{\ *}$
$\beta\in(E,C]$	and	$u\in[\frac{\theta}{1+\theta},Z]$	$p_{dn}^{\ *}<p_{dr}^{\ *}\le p_{dm}^{\ *}$
	and	$u\in(Z,\frac{1}{1+\theta}]$	$p_{dn}^{\ *}<p_{dm}^{\ *}<p_{dr}^{\ *}$
$\beta\in(C,D]$	and	$u\in[\frac{\theta}{1+\theta},Z]$	$p_{dn}^{\ *}<p_{dr}^{\ *}\le p_{dm}^{\ *}$
	and	$u\in(Z,Y]$	$p_{dn}^{\ *}\le p_{dm}^{\ *}<p_{dr}^{\ *}$
	and	$u\in(Y,\frac{1}{1+\theta}]$	$p_{dm}^{\ *}<p_{dn}^{\ *}<p_{dr}^{\ *}$
$\beta\in(D,B]$	and	$u\in[\frac{\theta}{1+\theta},Y]$	$p_{dn}^{\ *}\le p_{dm}^{\ *}<p_{dr}^{\ *}$
	and	$u\in(Y,\frac{1}{1+\theta}]$	$p_{dm}^{\ *}<p_{dn}^{\ *}<p_{dr}^{\ *}$
$\beta\in(B,A]$			$p_{dm}^{\ *}<p_{dn}^{\ *}\le p_{dr}^{\ *}$
$\beta\in(A,\frac{1}{w}]$	and	$u\in[\frac{\theta}{1+\theta},X]$	$p_{dm}^{\ *}<p_{dr}^{\ *}\le p_{dn}^{\ *}$
	and	$u\in(X,\frac{1}{1+\theta}]$	$p_{dm}^{\ *}<p_{dn}^{\ *}<p_{dr}^{\ *}$

As can be seen from Table 1, the optimal retail prices in different power structures are influenced by market price elasticity factor and market share of retail channel. When the market price elasticity factor is small and in the range of (0, C], the optimal retail price in Nash equilibrium is smallest. When the market price elasticity factor is great and in the range of (B, 1/w], optimal retail price in Manufacturer Stackelberg is smallest. When the market price elasticity factor is in the range of (C, B], the optimal retail price depends on the retail channel market share.

(3)For $D=\frac{1}{w\theta-c\theta+2w-c}$, $E=\frac{\theta^2}{2(\theta+1)(w-c)+w\theta^2}$, $Z=\frac{\theta(1-c\beta+(w\beta-1)\theta)}{2w\beta+\theta(1-\theta)+c\beta(1+\theta)(\theta-2)}$, $Y=\frac{\theta((2-\theta^2)(1-c\beta)+(w\beta-1)\theta)}{2w\beta(2-\theta^2)-\theta(\theta-2+\theta^2)+c\beta(1+\theta)(-4+2\theta+\theta^2)}$, and the values of A, B, C are defined above. Optimal direct channel prices under different power structures have different relationships in different range, as shown in Table 2.

Similar to optimal retail price, the optimal direct price also depends on market price elasticity factor and market share of retail channel. When the market price elasticity factor is small and in the range of (0, C], the optimal direct price in Nash equilibrium is smallest. When the market price elasticity factor is great and in the range of (B, 1/w], optimal direct channel price under manufacturer Stackelberg is smallest. When the market price elasticity factor is in the range of (C, B], the optimal direct channel price depends on the retail channel market share.

(4) ${\pi_{Mn}}^* < {\pi_{Mm}}^*$, ${\pi_{Rn}}^* \le {\pi_{Rr}}^*$. In Manufacturer Stackelberg case, the manufacturer's profit is more than the situation of Nash equilibrium. Similarly, the retailer's profit in Retailer Stackelberg case is more than the situation of Nash equilibrium. With respect to Nash equilibrium which making decision simultaneously, Stackelberg game's dominant party has first-mover advantage.

4. Pricing Strategy with Product Competition

When homogeneous products exist in the market, manufacturer and retailer face competition of substitute product. The substitute product supply chain is an integrated supply chain. In substitute product supply chain, manufacturer maximizes profits according to the whole supply chain and determines the prices of substitute product p2. Part of market demands will be transferred because of market competition, assuming the transfer ratio is ρ and $0<\rho<1$.The greater ρ is, the greater impact on original product is, the more competitive in the market is. According to literature [12], demands of original product in direct channel and retail channel are changed and given by:

$$D_r = us(1-\rho)[1-\frac{\beta p_r}{(1-\theta)(1-\theta_1)}+\frac{\beta\theta(2-\theta_1)p_d}{2(1-\theta)(1-\theta_1)}+\frac{\beta\theta_1(2-\theta)p_2}{2(1-\theta)(1-\theta_1)}]$$

$$D_d = (1-u)s(1-\rho)[1-\frac{\beta p_d}{(1-\theta)(1-\theta_2)}+\frac{\beta\theta(2-\theta_2)p_r}{2(1-\theta)(1-\theta_2)}+\frac{\beta\theta_2(2-\theta)p_2}{2(1-\theta)(1-\theta_2)}]$$

Demand function of substitute product is:

$$D_2 = s\rho[1-\frac{\beta p_2}{(1-\theta_1)(1-\theta_2)}+\frac{\beta\theta_1(2-\theta_2)p_r}{2(1-\theta_1)(1-\theta_2)}+\frac{\beta\theta_2(2-\theta_1)p_d}{2(1-\theta_1)(1-\theta_2)}]$$

θ_1 denotes the cross price elasticity between substitute product price and original product retail channel price, while θ_2 means cross price elasticity between substitute product price and original product direct channel price.

Profit functions of retailer and manufacturer in original product supply chain are:

$$\pi_{1R} = D_r(p_r-w)$$

$$= us(1-\rho)[1-\frac{\beta p_r}{(1-\theta)(1-\theta_1)}+\frac{\beta\theta(2-\theta_1)p_d}{2(1-\theta)(1-\theta_1)}+\frac{\beta\theta_1(2-\theta)p_2}{2(1-\theta)(1-\theta_1)}](p_r-w)$$

$$\pi_{1M} = D_d(p_d-c)+(w-c)D_r$$

$$= (1-u)s(1-\rho)[1-\frac{\beta p_d}{(1-\theta)(1-\theta_2)}+\frac{\beta\theta(2-\theta_2)p_r}{2(1-\theta)(1-\theta_2)}+\frac{\beta\theta_2(2-\theta)p_2}{2(1-\theta)(1-\theta_2)}](p_d-c)$$

$$+(w-c)us(1-\rho)[1-\frac{\beta p_r}{(1-\theta)(1-\theta_1)}+\frac{\beta\theta(2-\theta_1)p_d}{2(1-\theta)(1-\theta_1)}+\frac{\beta\theta_1(2-\theta)p_2}{2(1-\theta)(1-\theta_1)}]$$

Total expected profit function of substitute supply chain is:

$$\pi_2 = D_2(p_2-c_2)$$

$$= s\rho[1-\frac{\beta p_2}{(1-\theta_1)(1-\theta_2)}+\frac{\beta\theta_1(2-\theta_2)p_r}{2(1-\theta_1)(1-\theta_2)}+\frac{\beta\theta_2(2-\theta_1)p_d}{2(1-\theta_1)(1-\theta_2)}](p_2-c_2)$$

c2 is the production cost of substitute products. In competitive environment, original product and substitute product compete with Nash Game. Assume the optimal retail price of original product is pr** in competitive environment, the optimal direct channel price is pd**, the optimal price of substitute product is p2**.

Theorem 1：If

$$H = \begin{bmatrix} 4 & -\theta(2-\theta_1) & -\theta_1(2-\theta) \\ -\theta(2-\theta_2)(1-\theta_1) & 4(1-\theta_1) & -\theta_2(2-\theta)(1-\theta_1) \\ -\theta_1(2-\theta_2) & -\theta_2(2-\theta_1) & 4 \end{bmatrix}$$

$$K = \begin{bmatrix} \frac{2}{\beta}[(1-\theta)(1-\theta_1)+w\beta] \\ \frac{2}{\beta}(1-\theta)(1-\theta_1)(1-\theta_2)+\frac{u\theta(w-c)(2-\theta_1)(1-\theta_2)}{1-u}+2c(1-\theta_1) \\ \frac{2}{\beta}[(1-\theta_1)(1-\theta_2)+c_2\beta] \end{bmatrix}$$

, then $p^{**} = \begin{bmatrix} {p_r}^{**} \\ {p_d}^{**} \\ {p_2}^{**} \end{bmatrix} = H^{-1}K$.

From Theorem 1 we can see that in our settings, when there is product competition, optimal pricing strategy is not affected by the ratio of market share, but closely related to price cross elasticity; the ratio of market share determines profits of supply chain competitors.

5. Numerical Study

In this section, using several numerical experiments, we illustrate some relate issues about pricing strategy with product competition and power structure in dual-channel supply chain. let $w=2$, $\beta=0.1$, $c=1$, $\theta=0.3$, $s=100$.

(1) In the case without competition, the impact of retail channel market share u on optimal values under different power structures is explored. Because $\theta=0.3$, u must range in [0.23, 0.77]. We change the value of u in the range of [0.3, 0.7] taking 0.05 as steps of calculation. The optimal retail prices, direct channel prices, the profits of retailer and manufacturer under three different power structures are shown in Table 3.

As can be seen from Table 3, optimal retail channel prices in three power structures increase as the increase of retail market share. It's accordance with $\frac{\partial {p_r}^*}{\partial u}>0$. The optimal direct prices increase as retail market share increases. Retailer's profits increase as the increase of retail market share, but the manufacturer profits reduce, and ${\pi_{Mn}}^* < {\pi_{Mm}}^*$, ${\pi_{Rn}}^* \le {\pi_{Rr}}^*$.

(2) In the case without competition, the impacts of θ and u together on both sides of the supply chain are ex-

amined. In this paper, the market share and channel retailer price elasticity factor reflects the needs of customer choice. Take Nash equilibrium as example, profits of manufacturer and retailer are discussed when u and θ change at the same time. In the range of [0.1,0.9], θ changes in steps of 0.1 and determines the range of u is $[\frac{\theta}{1+\theta}, \frac{1}{1+\theta}]$. Figure1 shows influence trends of manufacturer's and retailer's profit in Nash equilibrium when θ and u change together.

Table 3. Impact of u on optimal value in different power structures

	Nash Equilibrium				Manufacturer Stackelberg				Retailer Stackelberg			
u	prn*	pdn*	∏Rn*	∏Mn*	prm*	pdm*	∏Rm*	∏Mm*	prr*	pdr*	∏Rr*	∏Mr*
0.30	5.227	4.848	44.637	156.983	5.236	4.905	44.873	157.014	5.303	4.860	44.660	157.536
0.35	5.229	4.865	52.158	149.080	5.237	4.914	52.394	149.101	5.306	4.877	52.185	149.520
0.40	5.233	4.885	59.718	141.177	5.239	4.924	59.935	141.190	5.309	4.896	59.749	141.504
0.45	5.236	4.908	67.327	133.275	5.240	4.936	67.501	133.281	5.312	4.920	67.363	133.488
0.50	5.240	4.936	75.002	125.373	5.243	4.950	75.100	125.374	5.317	4.948	75.042	125.472
0.55	5.246	4.970	82.763	117.471	5.245	4.968	82.744	117.471	5.322	4.982	82.807	117.456
0.60	5.252	5.013	90.643	109.569	5.248	4.990	90.448	109.572	5.329	5.024	90.691	109.440
0.65	5.260	5.068	98.693	101.668	5.253	5.018	98.240	101.68	5.337	5.079	98.746	101.424
0.70	5.271	5.141	107.001	93.768	5.258	5.055	106.162	93.798	5.348	5.152	107.058	93.408

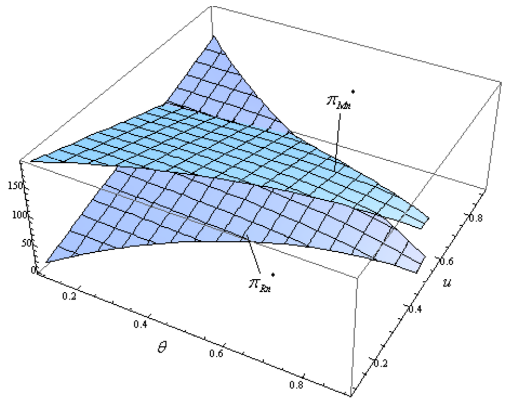

Figure 1. Optimal Manufacturer's and Retailer's Profits when θ and u Change (Nash Equilibrium)

When $u = 0.7$, θ is in a range of [0.1,0.4]. It can be seen from Figure 1, in Nash equilibrium, the retailer's profit decreases as θ increases, while the manufacturer's profit increases as θ increases. When $u = 0.5$, it means intense competition in market. The market share of direct channel equals the share of retail channel. Then θ is in the range of (0, 1), and retailer's profit decreases as θ increases; the manufacturer's profit first increases and then decreases as θ increases.

(3) In the case with competition, effects of product competition on pricing strategy of supply chain are investigated. Let $c_2 = 1.2$, $\theta_1 = 0.4$, $\theta_2 = 0.3$ and other parameters remain the same as above. Similar with the situation without competition, when u is in the range of $[0.3, 0.7]$ and changes as steps of 0.05 to calculate the optimal strategies. Impacts of products competition on pricing strategies and profits of supply chain are shown in Figure 2 and Figure 3.

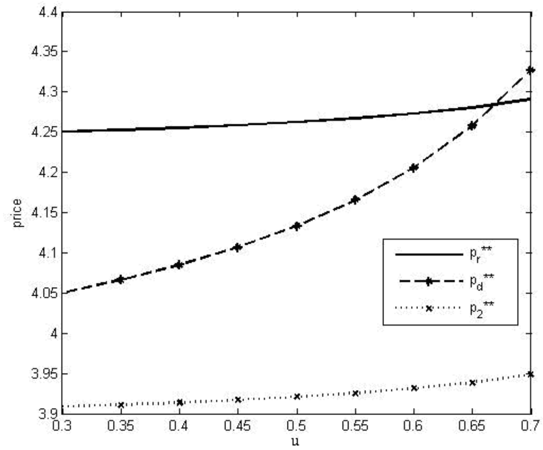

Figure 2. Impact of Product Competition on Pricing Strategy of Supply Chain

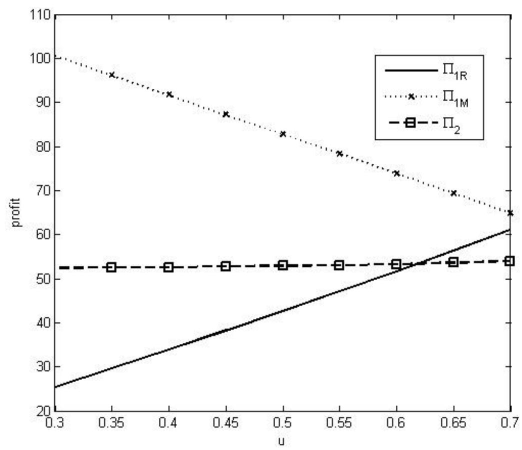

Figure 3. Impact of Product Competition on Profits of Supply Chain

The join of homogeneous product makes retail channel price and direct price of original product drop significantly compared to the single product situation. The competition has become fierce. Manufacturer and retailer of original product are beginning to compete for the market share with lower prices. And same with the case of a single product, retail channel price, direct channel price and the price of substitute product increase as with the increase of retail market share. The increase of retailer market share in original product doesn't have a greater impact on overall profit of substitute product supply chain. The change trends of original product manufacturer's and retailer's profits with respect to retail market share are consistent with non-competitive circumstance.

(4) In the case with competition, effects of price elasticity on supply chain pricing strategy are investigated. Let $u = 0.65$ and other parameters remain the same as above ($\theta_2 = 0.3$). Let $\theta_1 \in [0.1, 0.9]$, θ_1 changes in steps of 0.1. The impact on supply chain pricing strategy with change of θ_1 is shown in Figure 4. Let $\theta_1 = 0.4$, $\theta_2 \in [0.1, 0.9]$ and θ_2 changes in steps of 0.1. Other variables keep constant. Figure 5 shows the impact of θ_2 on supply chain pricing strategy.

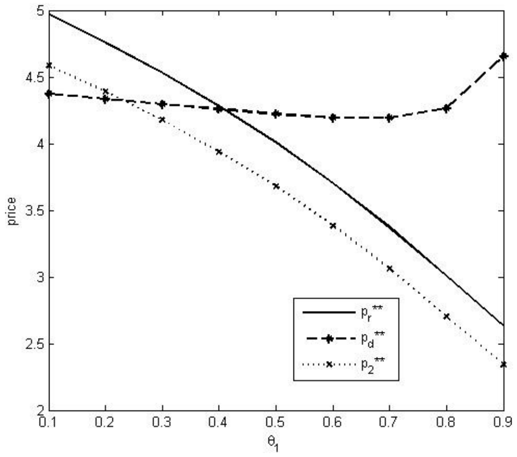

Figure 4. Impact of θ_1 on Pricing Strategy

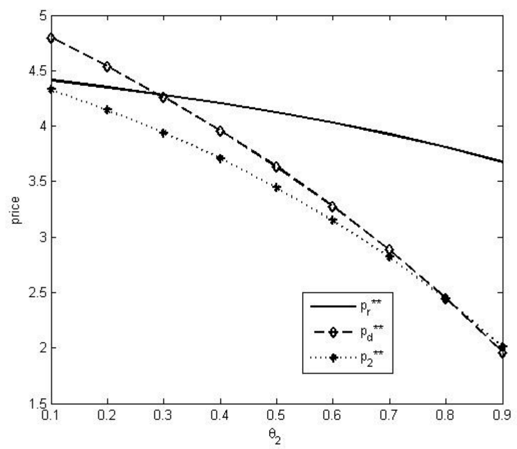

Figure 5. Impact of θ_2 on Pricing Strategy

θ_1 represents the cross elasticity of p2 and pr, θ_2 represents the cross elasticity of p2 and pd . With the increase of θ_1, the competition between two retail channel of different products increased. In retail channel, original product and substitute product compete on price. pr** and p2** gradually drop down caused by intense competition. θ_1 has little effect on pd**. At the beginning pd**has a smaller rate of decline, when θ_1 increases to a certain extent, pd** increases. With the increase of θ_2 , pd**、p2**、pr** decrease. pd** has maximum reduced rate, pr** has minimum rate of decrease.

6. Conclusions

In this paper, we investigate product competition and power structures in dual-channel supply chain; compare the optimal pricing strategy under three different power structures: Nash equilibrium, the manufacturer Stackelberg and Retailer Stackelberg, analyze optimal strategy in competitive market environment, and take numerical calculation as comparative analysis. Results show that: compared to Nash equilibrium, Stackelberg game's dominant party has first-mover advantage and obtains more profit than Nash equilibrium case; when there is product competition, as market competition intensifies, prices will gradually reduced. The research provides references on pricing strategy for supply chain members to make right decision in different power structures with a competitive environment. However, this paper assumes the market demand function is determined, while demand in reality is affected by many factors with uncertainty. Therefore, the case with uncertain demand is worth further study.

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