Bargaining in a Two Echelon Supply Chain with Price and Retail Service Dependent Demand

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***Abstract*—This paper considers the price and retail service level decisions between a manufacturer and a retailer in a two echelon supply chain. The market demand is linked directly to the retailer's retail price and retail service level. Three different kinds of game models including two Stackelberg games and one Vertical-Nash game are built to examine how power structures affect the performance of the supply chain members. The retail service level is determined by the supply chain members cooperatively based on the Nash bargaining scheme. Finally, the results of the proposed models are analyzed via a numerical example. It is shown that the manufacturer and the retailer make their largest profits in the Vertical-Nash and Retailer-Stackelberg games, respectively, and the customers obtain their highest service level in the Retailer-Stackelberg game.**

***Index Terms*—supply chain, game theory, service level, Nash bargaining**

I. Introduction

WITH the improvement of the living standard of people, people become more and more sensitive to service level they could enjoy rather than a single price factor. The retailer can also use the retail service as an effective tool to compete against the direct channel. In recent years, many researchers have begun take price and service into consideration to deal with the supply chain management.

In a traditional supply chain, Iyer [1] studied the channel coordination mechanism when the retailers competed in price and service. Tsay and Agrawal [2] analyzed the price and service choices of two non-cooperating and cooperating retailers, and found that the supply chain members could achieve coordination only under very limiting conditions. Xiao and Yang [3] formulated a price and service competition model of two supply chains with one risk neutral supplier and one risk aversion retailer under demand uncertainty. Giri et al. [4] analyzed the coordination mechanisms of the supply chain with retail price and sales effort dependent demand. Ma et al. [5] investigated the optimal channel strategies under three different supply chain power structures with quality and marketing effort dependent demand. Ma et al. [6] also studied the channel coordination problem with one retailer and one manufacturer, where the demand is a linear function of the retail price, marketing effort level and quality effort level. Lu et al. [7] proposed a price and service competition model with two manufacturers and a common retailer in a liner demand function, where the customers were sensitive to both selling price and service level of the manufacturers. Wu [8] focused on a price and service decisions model with two manufacturers and a retailer, where the manufacturers produced the new and remanufactured products. Han et al. [9] analyzed a price and service competition problem with one manufacturer and two retailers. Wu [10] studied the pricing and quantity decisions between two competing supply chains with demand uncertainty. Wu [11] proposed the service related bargaining models between one manufacturer and one retailer with two competing supply chains. Sang [12] studied the service and selling effort decisions with one manufacturer and one retailer.

In a closed-loop supply chain, Gao et al. [13] studied the pricing and effort decisions with three different channel power structures. In a dual-channel supply chain, Yan and Pei [14] analyzed the pricing and retail service decisions with a liner demand function. Dan et al. [15] also studied the optimal prices and retail services decisions in a centralized and a decentralized dual channel supply chain. Some researches also studied the price and service decisions in a fuzzy environment, where the demand was a fuzzy liner function of the selling price and service level. For instance, Zhao et al. [16] analyzed a price and service competition model with two manufacturers and one retailer in fuzzy environments. Zhao and Wang [17] studied the pricing and retail service decisions between one manufacturer and two retailers with fuzzy demands. In addition, Sang [18] studied the price and service decisions in an uncertain environment, in which the market base, manufacturing cost and selling cost were all considered as uncertain variables.

Most of the existing literatures have discussed the service level determined by the manufacturer or the retailer. However, in practical, the service level is usually decided cooperatively between the supply chain members. In this paper, we mainly discuss the conditions where the manufacturer and the retailer pursue three different power structures, namely Manufacturer-Stackelberg game, Retailer-Stackelberg game and Vertical-Nash game. The manufacturer and the retailer set the wholesale price and sale margin, separately, and they determine the retail service cooperatively based on the Nash bargaining scheme.

The rest of the paper is organized as follows. The problem and notations related to this paper are described in Section II. Three different kinds of game models are developed in Section III, and then the numerical example is shown in

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Section IV. Concluding remarks and some directions for future research are provided in Section V.

II. Problem Descriptions

Consider a two-echelon supply chain consisting of one manufacturer and one retailer. The manufacturer sells his product to the retailer, and then the retailer retails it to the customer. We assume the manufacturer produces only one item and the retailer sells only single item.

We model the demand faced by the manufacturer and the retailer as a function of the retail price p, and retail service level s, which is given by

$$q = \alpha - \beta p + \gamma s \tag{1}$$

where α, β, $\gamma > 0$. α represents the market potential, β represents the sensitivity of demand to price, and γ represents the demand expansion effectiveness coefficient of the retail service level by the retailer.

Further, let w denote the wholesale price per unit charged to the retailer by the manufacturer, c the manufacturer's cost of producing its item and m the retailer's profit margin on the item. As the retail price p can be treated as the total of the profit margin m and the wholesale price w. Then the demand for the product can be rewritten as

$$q = \alpha - \beta(w+m) + \gamma s \tag{2}$$

It is assumed that the marginal cost of the retailer is not affected by the retail service level. Further, the cost of achieving retail service level requires fixed investment, which is a quadratic function of service level s. It is given by $\frac{1}{2}\eta s^2$, where the parameter η is the investment coefficient.

Thus, the manufacturer's and the retailer's profit functions can be derived respectively as

$$\Pi_M = (w-c)\left[\alpha - \beta(w+m) + \gamma s\right] \tag{3}$$

$$\Pi_R = m\left[\alpha - \beta(w+m) + \gamma s\right] - \frac{1}{2}\eta s^2 \tag{4}$$

When the manufacturer and the retailer take part in the Nash bargaining scheme, they determine the retail service s cooperatively

$$\underset{s}{\mathrm{Max}}\,\Pi = \underset{s}{\mathrm{Max}}\,\Pi_M \Pi_R \tag{5}$$

III. Model Analysis

In this section, we examine the supply chain actors how to set their optimal solutions when they pursue different power structures. We mainly discuss the conditions where the manufacturer and the retailer pursue three non-cooperative games: the manufacturer dominates the channel, the retailer dominates the channel, and the manufacturer and retailer have an equal bargaining power.

A. **Manufacturer-Stackelberg game**

The MS (Manufacturer-Stackelberg) game scenario arises in the market where the manufacturer dominates the supply chain. In this case, firstly, the manufacturer sets the wholesale price w using the retailer's reaction function. Then, the retailer sets the profit margin m so as to maximize his expected profit. Finally, the manufacturer and the retailer determine the retail service level s cooperatively based on the Nash bargaining scheme.

Theorem 1. If $4\beta\eta - 3\gamma^2 > 0$, then the optimal solutions in the MS game are

$$w^* = \frac{(\alpha-\beta c)\sqrt{\beta\eta\left(\beta\eta+\gamma^2\right)} + 3\alpha\beta\eta + \beta\left(5\beta\eta-\gamma^2\right)c}{\beta\left(8\beta\eta-\gamma^2\right)} \tag{6}$$

$$m^* = \frac{(\alpha-\beta c)\left(\sqrt{\beta\eta\left(\beta\eta+\gamma^2\right)} + 3\beta\eta\right)}{2\beta\left(8\beta\eta-\gamma^2\right)} \tag{7}$$

$$s^* = \frac{(\alpha-\beta c)\left[2\sqrt{\beta\eta\left(\beta\eta+\gamma^2\right)} - \left(2\beta\eta-\gamma^2\right)\right]}{\left(8\beta\eta-\gamma^2\right)\gamma} \tag{8}$$

Proof: We first solve for the profit function of the retailer

$$\underset{m}{\mathrm{Max}}\,\Pi_R = m\left[\alpha - \beta(w+m) + \gamma s\right] - \frac{1}{2}\eta s^2$$

The first order condition gives

$$\frac{\mathrm{d}\,\Pi_R}{\mathrm{d}\,m} = -2\beta m + \alpha - \beta w + \gamma s$$

The second order condition gives

$$\frac{\mathrm{d}^2\,\Pi_R}{\mathrm{d}\,m^2} = -2\beta < 0$$

Thus the profit function of the retailer is strictly concave in m.

By solving $\frac{\mathrm{d}\,\Pi_R}{\mathrm{d}\,m} = 0$, we have

$$m^*(w,s) = \frac{1}{2\beta}(\alpha - \beta w + \gamma s) \tag{9}$$

Solving for the profit function of the manufacturer

$$\underset{w}{\mathrm{Max}}\,\Pi_M = (w-c)\left[\alpha - \beta(w+m) + \gamma s\right]$$

Substituting $m^*(w,s)$ in (9) into the above equation, we have

$$\underset{w}{\mathrm{Max}}\,\Pi_M = \frac{1}{2}(w-c)\left[\alpha - \beta w + \gamma s\right]$$

The first order condition gives

$$\frac{\mathrm{d}\,\Pi_M}{\mathrm{d}\,w} = \frac{1}{2}(-2\beta w + \alpha + \gamma s + \beta c)$$

The second order condition gives

$$\frac{\mathrm{d}^2\,\Pi_M}{\mathrm{d}\,w^2} = -\beta < 0$$

Thus the profit function of the manufacturer is strictly concave in w.

By solving $\frac{\mathrm{d}\,\Pi_M}{\mathrm{d}\,w}=0$, we have

$$w^*(s)=\frac{1}{2\beta}(\alpha+\beta c+\gamma s) \tag{10}$$

Substituting $w^*(s)$ in (10) into (9), we have

$$m^*(s)=\frac{1}{4\beta}(\alpha-\beta c+\gamma s) \tag{11}$$

From the above values of $w^*(s)$ and $m^*(s)$, we derive the profits of the manufacturer and the retailer as a function of s

$$\Pi_M{}^*(s)=\frac{(\alpha-\beta c+\gamma s)^2}{8\beta}$$

$$\Pi_R{}^*(s)=\frac{(\alpha-\beta c+\gamma s)^2}{16\beta}-\frac{1}{2}\eta s^2$$

When the manufacturer and the retailer take part in the bargaining process, we substitute the above values to solve

$$\underset{s}{\mathrm{Max}}\,\Pi=\underset{s}{\mathrm{Max}}\,\Pi_M{}^*(s)\Pi_R{}^*(s)$$

$$=\frac{(\alpha-\beta c+\gamma s)^2}{8\beta}\left[\frac{(\alpha-\beta c+\gamma s)^2}{16\beta}-\frac{1}{2}\eta s^2\right]$$

The first order condition gives

$$\frac{\mathrm{d}\,\Pi}{\mathrm{d}\,s}=-\frac{1}{32}(\alpha-\beta c+\gamma s)\Big[\left(8\beta\eta-\gamma^2\right)\gamma s^2$$
$$+2(\alpha-\beta c)\left(2\beta\eta-\gamma^2\right)s-(\alpha-\beta c)^2\gamma\Big]$$

The second order condition gives

$$\frac{\mathrm{d}^2\,\Pi}{\mathrm{d}\,s^2}=-\frac{1}{32\beta^2}\Big\{\left(4\beta\eta-3\gamma^2\right)(\alpha-\beta c)^2$$
$$+3\gamma s\left[2(\alpha-\beta c)\left(4\beta\eta-\gamma^2\right)+\left(8\beta\eta-\gamma^2\right)\gamma s\right]\Big\}$$

The second order condition is negative for $4\beta\eta-3\gamma^2>0$.

Let $\frac{\mathrm{d}\,\Pi}{\mathrm{d}\,s}=0$, we have

$$s^*=\begin{cases}-\dfrac{\alpha-\beta c}{\gamma}\\ \dfrac{(\alpha-\beta c)\left[2\sqrt{\beta\eta\left(\beta\eta+\gamma^2\right)}-\left(2\beta\eta-\gamma^2\right)\right]}{\left(8\beta\theta-\gamma^2\right)\gamma}\\ \dfrac{(\alpha-\beta c)\left[-2\sqrt{\beta\eta\left(\beta\eta+\gamma^2\right)}-\left(2\beta\eta-\gamma^2\right)\right]}{\left(8\beta\theta-\gamma^2\right)\gamma}\end{cases} \tag{12}$$

If $8\beta\eta-\gamma^2>0$, the second value of s^* is positive, which is true in the region $4\beta\eta-3\gamma^2>0$.

Substituting s^* into (10) and (11), we obtain w^* and m^* showed in (6) and (7).
The proof of Theorem 1 is completed.

B. **Retailer-Stackelberg game**

The RS (Retailer-Stackelberg) game scenario arises in the market where the retailer dominates the supply chain. In this case, firstly, the retailer sets the profit margin m using the manufacturer's reaction function. Then, the manufacturer sets the wholesale price w so as to maximize his expected profit. Finally, the manufacturer and the retailer determine the retail service s cooperatively based on the Nash bargaining scheme.

Theorem 2. If $2\beta\eta-3\gamma^2>0$, then the optimal solutions in the RS game are

$$w^{**}=\frac{(\alpha-\beta c)\sqrt{\beta\eta\left(\beta\eta+\gamma^2\right)}+3\alpha\beta\eta+\beta\left(13\beta\eta-4\gamma^2\right)c}{4\beta\left(4\beta\eta-\gamma^2\right)} \tag{13}$$

$$m^{**}=\frac{(\alpha-\beta c)\left(\sqrt{\beta\eta\left(\beta\eta+\gamma^2\right)}+3\beta\eta\right)}{2\beta\left(4\beta\eta-\gamma^2\right)} \tag{14}$$

$$s^{**}=\frac{(\alpha-\beta c)\left[\sqrt{\beta\eta\left(\beta\eta+2\gamma^2\right)}-\left(\beta\eta-\gamma^2\right)\right]}{\left(4\beta\eta-\gamma^2\right)\gamma} \tag{15}$$

Proof: We first solve for the profit function of the manufacturer

$$\underset{w}{\mathrm{Max}}\,\Pi_M=(w-c)\left[\alpha-\beta(w+m)+\gamma s\right]$$

The first order condition gives

$$\frac{\mathrm{d}\,\Pi_M}{\mathrm{d}\,w}=-2\beta w+\alpha+\gamma s+\beta c-\beta m$$

The second order condition gives

$$\frac{\mathrm{d}^2\,\Pi_M}{\mathrm{d}\,w^2}=-2\beta<0$$

Thus the profit function of the manufacturer is strictly concave in w.

By solving $\frac{\mathrm{d}\,\Pi_M}{\mathrm{d}\,w}=0$, we have

$$w^{**}(m,s)=\frac{1}{2\beta}(\alpha+\beta c-\beta m+\gamma s) \tag{16}$$

Solving for the profit function of the retailer

$$\underset{m}{\mathrm{Max}}\,\Pi_R=m\left[\alpha-\beta(w+m)+\gamma s\right]-\frac{1}{2}\eta s^2$$

Substituting $w^{**}(m,s)$ in (16) into the above equation, we have

$$\operatorname*{Max}_{m}\Pi_R=\frac{1}{2}m\left[\alpha-\beta c-\beta m+\gamma s\right]-\frac{1}{2}\eta s^2$$

The first order condition gives

$$\frac{\mathrm{d}\,\Pi_R}{\mathrm{d}\,m}=\frac{1}{2}\left(-2\beta m+\alpha-\beta c+\gamma s\right)$$

The second order condition gives

$$\frac{\mathrm{d}^2\,\Pi_R}{\mathrm{d}\,m^2}=-\beta<0$$

Thus the profit function of the retailer is strictly concave in *m*.

By solving $\frac{\mathrm{d}\,\Pi_R}{\mathrm{d}\,m}=0$, we have

$$m^{**}(s)=\frac{1}{2\beta}(\alpha-\beta c+\gamma s) \tag{17}$$

Substituting $m^{**}(s)$ in (17) into (16), we have

$$w^{**}(s)=\frac{1}{4\beta}(\alpha-\beta c+\gamma s)+c \tag{18}$$

From the above values of $m^{**}(s)$ and $w^{**}(s)$, we derive the profits of the manufacturer and the retailer as a function of *s*

$$\Pi_M{}^{**}(s)=\frac{(\alpha-\beta c+\gamma s)^2}{16\beta}$$

$$\Pi_R{}^{**}(s)=\frac{(\alpha-\beta c+\gamma s)^2}{8\beta}-\frac{1}{2}\eta s^2$$

When the manufacturer and the retailer take part in the bargaining process, we substitute the above values to solve

$$\begin{aligned}\operatorname*{Max}_{s}\Pi&=\operatorname*{Max}_{s}\Pi_M{}^{**}(s)\Pi_R{}^{**}(s)\\&=\frac{(\alpha-\beta c+\gamma s)^2}{16\beta}\left[\frac{(\alpha-\beta c+\gamma s)^2}{8\beta}-\frac{1}{2}\eta s^2\right]\end{aligned}$$

The first order condition gives

$$\begin{aligned}\frac{\mathrm{d}\,\Pi}{\mathrm{d}\,s}=&-\frac{1}{32\beta^2}(\alpha-\beta c+\gamma s)\left[\left(4\beta\eta-\gamma^2\right)\gamma s^2\right.\\&\left.+2(\alpha-\beta c)\left(\beta\eta-\gamma^2\right)s-(\alpha-\beta c)^2\gamma\right]\end{aligned}$$

The second order condition gives

$$\begin{aligned}\frac{\mathrm{d}^2\,\Pi}{\mathrm{d}\,s^2}=&-\frac{1}{32\beta^2}\left\{\left(2\beta\eta-3\gamma^2\right)(\alpha-\beta c)^2\right.\\&\left.+3\gamma s\left[2(\alpha-\beta c)\left(2\beta\eta-\gamma^2\right)+\left(4\beta\eta-\gamma^2\right)\gamma s\right]\right\}\end{aligned}$$

The second order condition is negative for $2\beta\eta-3\gamma^2>0$.

Let $\frac{\mathrm{d}\,\Pi}{\mathrm{d}\,s}=0$, we have

$$s^{**}=\begin{cases}-\dfrac{\alpha-\beta c}{\gamma}\\ \dfrac{(\alpha-\beta c)\left[\sqrt{\beta\eta\left(\beta\eta+2\gamma^2\right)}-\left(\beta\eta-\gamma^2\right)\right]}{\left(4\beta\eta-\gamma^2\right)\gamma}\\ \dfrac{(\alpha-\beta c)\left[-\sqrt{\beta\eta\left(\beta\eta+2\gamma^2\right)}-\left(\beta\eta-\gamma^2\right)\right]}{\left(4\beta\eta-\gamma^2\right)\gamma}\end{cases} \tag{19}$$

If $4\beta\eta-\gamma^2>0$, the second value of s^{**} is positive, which is true in the region $2\beta\eta-3\gamma^2>0$.

Substituting s^{**} into (17) and (18), we have w^{**} and m^{**} showed in (13) and (14).
The proof of Theorem 2 is completed.

C. **Vertical-Nash game**

The VN (Vertical-Nash) game scenario arises in the market where both the manufacturer and the retailer are not in a position to dominate the supply chain. In this case, firstly, the manufacturer determines the wholesale price *w*, and the retailer makes the profit margin *m* simultaneously and independently. Then, the manufacturer and the retailer determine the retail service *s* cooperatively based on the Nash bargaining scheme.

Theorem 3. If $3\beta\eta-4\gamma^2>0$, then the optimal solutions in the VN game are

$$w^{***}=\frac{(\alpha-\beta c)\sqrt{\beta\eta\left(9\beta\eta+16\gamma^2\right)}+9\alpha\beta\eta+\beta\left(27\beta\eta-8\gamma^2\right)c}{4\beta\left(9\beta\eta-2\gamma^2\right)} \tag{20}$$

$$m^{***}=\frac{(\alpha-\beta c)\left(\sqrt{\beta\eta\left(9\beta\eta+16\gamma^2\right)}+9\beta\eta\right)}{4\beta\left(9\beta\eta-2\gamma^2\right)} \tag{21}$$

$$s^{***}=\frac{(\alpha-\beta c)\left[3\sqrt{\beta\eta\left(9\beta\eta+16\gamma^2\right)}-\left(9\beta\eta-8\gamma^2\right)\right]}{4\left(9\beta\eta-2\gamma^2\right)\gamma} \tag{22}$$

Proof: Solving for the profit function of the retailer

$$\operatorname*{Max}_{m}\Pi_R=m\left[\alpha-\beta(w+m)+\gamma s\right]-\frac{1}{2}\eta s^2$$

The first order condition gives

$$\frac{\mathrm{d}\,\Pi_R}{\mathrm{d}\,m}=-2\beta m+\alpha-\beta w+\gamma s$$

The second order condition gives

$$\frac{\mathrm{d}^2\,\Pi_R}{\mathrm{d}\,m^2}=-2\beta<0$$

Thus the profit function of the retailer is strictly concave in m. By solving $\frac{\mathrm{d}\,\Pi_R}{\mathrm{d}\,m}=0$, we have

$$m^{***}(w,s)=\frac{1}{2\beta}(\alpha-\beta w+\gamma s) \tag{23}$$

Solving for the profit function of the manufacturer

$$\underset{w}{\mathrm{Max}}\,\Pi_M=(w-c)\left[\alpha-\beta(w+m)+\gamma s\right]$$

The first order condition gives

$$\frac{\mathrm{d}\,\Pi_M}{\mathrm{d}\,w}=-2\beta w+\alpha+\gamma s+\beta c-\beta m$$

The second order condition gives

$$\frac{\mathrm{d}^2\,\Pi_M}{\mathrm{d}\,w^2}=-2\beta<0$$

Thus the profit function of the manufacturer is strictly concave in w.

By solving $\frac{\mathrm{d}\,\Pi_M}{\mathrm{d}\,w}=0$, we have

$$w^{***}(m,s)=\frac{1}{2\beta}(\alpha+\beta c-\beta m+\gamma s) \tag{24}$$

From (23) and (24), we have

$$m^{***}(s)=\frac{1}{3\beta}(\alpha-\beta c+\gamma s) \tag{25}$$

$$w^{***}(s)=\frac{1}{3\beta}(\alpha-\beta c+\gamma s)+c \tag{26}$$

From the above values of $m^{***}(s)$ and $w^{***}(s)$, we derive the profits of the manufacturer and the retailer as a function of s

$$\Pi_M{}^{***}(s)=\frac{(\alpha-\beta c+\gamma s)^2}{9\beta}$$

$$\Pi_R{}^{***}(s)=\frac{(\alpha-\beta c+\gamma s)^2}{9\beta}-\frac{1}{2}\eta s^2$$

When the manufacturer and the retailer take part in the bargaining process, we substitute the above values to solve

$$\underset{s}{\mathrm{Max}}\,\Pi=\underset{s}{\mathrm{Max}}\,\Pi_M{}^{***}(s)\Pi_R{}^{***}(s)$$
$$=\frac{(\alpha-\beta c+\gamma s)^2}{9\beta}\left[\frac{(\alpha-\beta c+\gamma s)^2}{9\beta}-\frac{1}{2}\eta s^2\right]$$

The first order condition gives

$$\frac{\mathrm{d}\Pi}{\mathrm{d}s}=-\frac{1}{81\beta^2}(\alpha-\beta c+\gamma s)\Big[2(9\beta\eta-2\gamma^2)\gamma s^2+(\alpha-\beta c)(9\beta\eta-8\gamma^2)s-4(\alpha-\beta c)^2\gamma\Big]$$

The second order condition gives

$$\frac{\mathrm{d}^2\,\Pi}{\mathrm{d}\,s^2}=-\frac{1}{27\beta^2}\Big\{(\alpha-\beta c)^2(3\beta\eta-4\gamma^2)+2\gamma s\Big[(\alpha-\beta c)(9\beta\eta-4\gamma^2)+(9\beta\eta-2\gamma^2)\gamma s\Big]\Big\}$$

The second order condition is negative for $3\beta\eta-4\gamma^2>0$.

Let $\frac{\mathrm{d}\,\Pi}{\mathrm{d}\,s}=0$, we have

$$s^{***}=\begin{cases}-\dfrac{\alpha-\beta c}{\gamma}\\[2mm] \dfrac{(\alpha-\beta c)\left[3\sqrt{\beta\eta(9\beta\eta+16\gamma^2)}-(9\beta\eta-8\gamma^2)\right]}{4(9\beta\eta-2\gamma^2)\gamma}\\[2mm] \dfrac{(\alpha-\beta c)\left[-3\sqrt{\beta\eta(9\beta\eta+16\gamma^2)}-(9\beta\eta-8\gamma^2)\right]}{4(9\beta\eta-2\gamma^2)\gamma}\end{cases} \tag{27}$$

If $9\beta\eta-2\gamma^2>0$, the second value of s^{***} is positive, which is true in the region $3\beta\eta-4\gamma^2>0$.

Substituting s^{***} into (25) and (26), we have w^{***} and m^{***} showed in (20) and (21).

The proof of Theorem 3 is completed.

IV. Numerical Example

In this section, we tend to further elucidate the above proposed three different games. The following parameters are used for illustration:

$$\alpha=100,\ \beta=4.0,\ \gamma=4.0 \text{ and } c=10.0.$$

Based on the analysis showed in the Section III, we present the results of the optimal prices, the retail service level and the profits of the supply chain members in the MS, RS and VN games in Tables I and II.

TABLE I
OPTIMAL PRICES AND SERVICE LEVEL FOR DIFFERENT η

Structure	η	w	m	s
MS	7.00	32.90	11.45	5.81
	7.50	32.71	11.35	5.41
	8.00	32.53	11.27	5.06
	8.50	32.38	11.19	4.76
	9.00	32.25	11.12	4.49
RS	7.00	23.02	26.04	12.08
	7.50	22.80	25.60	11.20
	8.00	22.61	25.22	10.45
	8.50	22.45	24.90	9.97
	9.00	22.30	24.61	9.21
VN	7.00	27.97	16.88	10.63
	7.50	27.63	16.62	9.87
	8.00	27.34	16.40	9.21
	8.50	27.09	16.21	8.64
	9.00	26.87	16.04	8.13

TABLE II
OPTIMAL PROFITS OF SUPPLY CHAIN MEMBERS FOR DIFFERENT η

Structure	η	Π_M	Π_R	Π_{SC}
MS	7.00	1049.17	406.53	1455.70
	7.50	1031.04	405.76	1436.80
	8.00	1015.38	405.12	1420.50
	8.50	1001.71	404.57	1406.28
	9.00	989.69	404.12	1393.81
RS	7.00	678.04	845.48	1523.52
	7.50	655.44	840.22	1495.66
	8.00	636.25	835.85	1472.10
	8.50	619.77	832.17	1451.94
	9.00	605.45	829.05	1434.50
VN	7.00	1139.15	743.89	1883.04
	7.50	1105.25	740.09	1845.34
	8.00	1076.35	736.93	1813.28
	8.50	1051.42	734.27	1785.69
	9.00	1029.70	732.01	1761.71

Based on the results showed in Tables I and II, we find:

1) The wholesale price w is the highest in the MS case, which is a result of the manufacturer being the leader in pricing of the item, followed by the VN and then the RS cases. The profit margin of the retailer m is the lowest in the MS case, because under this case the manufacturer charges a high wholesale price. The retail service level s is the highest in the RS case and the lowest in the MS case. It indicates that the RS case is a preferred policy for customers as they receive the highest retail service level.
2) The manufacturer makes his largest profit in the VN case, and the smallest in the RS case, and the retailer makes his largest profit in the RS case, and the smallest in the MS case. The profit of the manufacturer is larger than that of the retailer in the MS case, and the profit of retailer is larger than that of the manufacturer in the RS case. It indicates that the actor who is the leader in the supply chain holds advantage in obtaining higher profit. The profit of the whole supply chain denoted by Π_{SC} is the largest in the VN case when no actor is a pricing leader.
3) The profit margin of the retailer, wholesale price, service level, and profits of the manufacturer and the retailer all decrease as the service investment coefficient increases. This is consistent with our intuition.

V. Conclusion

This paper proposes a two echelon supply chain management, where the manufacturer and the retailer pursue three different kinds of scenarios: Manufacturer -Stackelberg, Retailer-Stackelberg and Vertical-Nash games, and they determine the retail service level cooperatively based on the Nash bargaining scheme. The models contain two strategic variables, price and retail service level, which is truly representative of the electronic industry.

Based on the discussions above, two main findings can be obtained. First, in the Manufacturer- Stackelberg game, the manufacturer has a higher profit than the retailer. However, in the Retailer-Stackelberg game, the retailer has a higher profit than the manufacturer. This indicates "first-mover advantage" of Stackelberg Game. Second, the profit of the whole supply chain is the largest in the Vertical-Nash game when no actor is a pricing leader.

One limitation of this paper is that we only consider one manufacturer and one retailer in a two echelon supply. Another limitation is that we only consider the case with linear demand function. Future research can be done for the cases including two or more competing supply chain members or in a multiple echelon supply chain. Still, we will extend the models to the case with non-linear demand functions.

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