Supply Chain Coordination with Revenue Sharing Contract in Prospect Theory

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***Abstract*—Revenue sharing contract is widely used in the field of film studios and video rental industry. This paper presents a revenue sharing contract between one manufacturer and one retailer in a two stage supply chain based on prospect theory. The models of centralized decision making system and revenue sharing contract are built by the method of prospect theory, and their optimal policies are also proposed. Finally, an example is given to illustrate and validate the models and conclusions. It shows that the retailer and the manufacturer can be coordinated by the revenue sharing contract in prospect theory, in which they obtain the same total expected utilities as the centralized decision-making system. The change of the level of optimism of the decision marker has no impact on the optimal wholesale price in the revenue sharing contract. However, the optimal order quantity and expected utility of the retailer and the manufacturer all decrease as the level of optimism of the decision marker increases.**

***Index Terms*—supply chain, prospect theory, revenue sharing contract, expected utility**

I. Introduction

IN the demand uncertain setting, revenue sharing contract is often adopted by the manufacturer to encourage the retailer to order more products. This coordination mechanism has attracted a lot of attention from both scholars and practitioners, and has achieved much success in film studios and video rental industry.

Revenue sharing contract as an important kind of popular contract is an instrument for supply chain coordination. Cachon and Lariviere [1] studied the strengths and limitations of the revenue sharing contract. Giannoccaro and Pontrandolfo [2] showed that revenue sharing contract could coordinate members in a three-echelon supply chain. Chen and Cheng [3] developed a price dependent and price independent revenue sharing contracts models in a vendor-buyer channel. Sarathi et al. [4] used a mixed revenue sharing and quantity discounts contract to coordinate a two-echelon supply chain. Wu et al. [5] proposed a revenue sharing contract between a principal and an agent by establishing an uncertain agency model. Recently, Seifbarghy et al. [6] studied a revenue sharing contract in a two level supply chain in which the market demand was a function of the product's price and quality degree. Avinadav et al. [7] took the risk attitude of the supply chain members into consideration to analyze a revenue sharing contract where the demand depended on both price and quality investment. Saha and Sarmah [8] designed a revenue sharing contract to coordinate a distribution channel in which the demand is ramp-type price and effort sensitive of the product. Feng et al. [9] combined revenue sharing and buyback contracts to investigate supply chain coordination of budget constrained members when a financial market was unavailable. Liu et al. [10] investigate a revenue sharing contract with consumers' reference quality effects. Becker-Peth and Thonemann [11] studied behavioral aspects of revenue sharing contracts and analyzed the effect of the reference dependent valuation on inventory decisions. Hu and Feng [12] developed a supply chain model with service requirement in a revenue sharing contract in which both supply and demand were uncertainty.

In addition, some studies have been done on analyzing competition problems of the supply chain actors in the revenue sharing contract. Chakraborty et al. [13] studied the revenue sharing mechanisms with two competing manufacturers and one retailer under a linear stochastic demand. Zhang et al. [14] proposed a revenue sharing and cooperative investment contract for deteriorating items to coordinate a supply chain. Arani et al. [15] proposed a novel mixed revenue sharing option contract for coordinating a retailer-manufacturer supply chain. Hu et al. [16] discussed a revenue sharing contract with one retailer and two manufacturers to investigate the impact of product substitution on the decisions of the retailer. Recently, socially responsible of the supply chain actors was taken into account in the revenue sharing contract. Panda [17] and Hsuel [18] developed a revenue sharing contract embedding corporate social responsibility to coordinate the supply chain.

Some literature also focused on the revenue sharing contract in a multi-echelon supply chain. For example, Rhee et al. [19-20] proposed a spanning revenue sharing contract to coordinate a multi-echelon supply chain with random demand. Feng et al. [21] studied a revenue sharing contract with more than one actor at some echelons in a multi-echelon supply chain. Huang and Huang [22] studied the supply chain coordination problem with three types of channel structures in a three-echelon supply chain. Moon et al. [23] discussed a revenue sharing contract with budget constraints in multi-echelon supply chains. Pang et al. [24] considered a revenue sharing contract in a three-echelon supply chain in which the demand was in the additive form with effort dependent demand. Hu et al. [25] proposed

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revenue sharing contracts with a loss-averse retailer in two different three-echelon supply chain structures. Sang [26-27] studied the supply chain contracts in a three-echelon supply chain where the market demands were considered as trapezoidal fuzzy numbers. Sang [28] further studied a revenue sharing contract in a multi-echelon supply chain with fuzzy demand and asymmetric information.

All studies mentioned above mainly assumed that the supply chain actors were all risk neutral and maximized their expected profits. However, in real life, the profits that the supply chain actors pursued are usually affected by their preference. The prospect theory is the basic theory for decision makers to predict preferences when they face uncertainty. Nagarajan and Shechter [29], Long and Nasiry [30] applied the prospect theory to study the newsvendor problem. Nagarajan and Shechter [29] showed that prospect theory did not explain the observations in the behavioral operations literature regarding the newsvendor problem, and posed a question of why prospect theory was not applied to a fundamental operations management problem. To answer this problem, Long and Nasiry [30] proposed an alternative based on newsvendor's salient payoffs and showed that prospect theory could explain the newsvendor's behavior problem. Zhao and Geng [31] also showed that the general prospect theory model might be powerful in predicting the preferences of decision makers in inventory management.

Then, a natural question is whether the prospect theory can be applied to the supply chain coordination problem. To our knowledge, no one has studied the supply chain coordination mechanism problem based on prospect theory. Therefore, in this paper, we adopt prospect theory to measure the preferences of the supply chain actors, and analyze the revenue sharing contract in the framework of prospect theory.

This study aims at developing the coordination mechanism of the manufacturer and the retailer and pursuing their optimal strategies under an expected utility theory framework. The contributions of this article are as follows. Firstly, we study the revenue sharing contract in the framework of prospect theory, in which the profits of the supply chain actors are affected by their preference. Secondly, we discuss the impacts of the level of optimism of the decision marker and contract parameter on the optimal policies in the revenue sharing contract. Thirdly, we show that the prospect theory can be applied to the supply chain coordination problem. These can improve decision making of the experts in supply chain management.

The rest of the paper is arranged as follows. Section II presents the notations and the assumptions of the problem under consideration. The centralized decision making system and the revenue sharing contract in prospect theory are provided in Section III. A numerical example is given and the optimal solutions are analyzed in Section IV. Finally, Section V draws the conclusion and indicates the way to future research.

II. Notations and assumptions

This paper considers a conventional two-echelon supply chain consisting of one manufacturer and one retailer. The retailer orders the products from the manufacturer and sells them to the customers. The products are sold only in one period. As the lead times of such goods are much longer than their selling season, the retailer has no chance to place a second order.

The following notations are used for a product in the models:

p : the retail price per unit of the product;

w: the wholesale price per unit;

c_m : the per unit product cost incurred to the manufacturer;

c_r : the per unit cost incurred to the retailer;

Q: the order quantity of the retailer;

x: the market demand;

Φ: the fraction revenue of the retailer in the revenue sharing contract and $0 < \Phi < 1$.

Below is a list of relevant assumptions:

1) The market demand x is assumed to be a uniformly distributed on $[\underline{x}, \overline{x}]$.
2) In order to avoid trivial cases, we assume $p > c_m + c_r$. This ensures that the manufacturer and the retailer make positive expected utility.

III. Models and solution approaches

A. Centralized decision making in prospect theory

Consider a supply chain occupied by an integrated-actor, which can also be regarded as the manufacturer and the retailer making cooperation.

The profit of the supply chain system for order quantity Q and market demand x is

$$\Pi_{SC}(Q,x) = p\min\{Q,x\} - (c_m + c_r)Q = \begin{cases} px - (c_m + c_r)Q, & x < Q, \\ (p - c_m - c_r)Q, & x \ge Q. \end{cases} \tag{1}$$

The optimal order quantity that maximizes the expected profit is given by

$$Q^0 = F^{-1}\left(\frac{p - c_m - c_r}{p}\right) \tag{2}$$

Prospect theory model is widely used to predict preferences when decision makers face uncertainty. Similar to Long and Nasiry [30], a piecewise-linear value function for the reference-dependent supply chain problem is assumed as

$$V(y) = \begin{cases} \eta y, & y \ge 0, \\ \lambda \eta y, & y < 0. \end{cases} \tag{3}$$

where η stands for the strength of the reference effects and λ is the coefficient of loss aversion. A higher value of η implies more sensitivity to deviations from the reference point; A higher value of λ indicates more sensitivity to losses in comparison to gains.

Thus, the utility of the supply chain system is

$$U_{SC}(Q,x) = \Pi_{SC}(Q,x) + V(y) \tag{4}$$

We assume the reference profit of the supply chain system $R_{SC}(Q)$ for an order Q is a convex combination the maximum possible profit $(p-c_m-c_r)Q$ and the minimum possible profit $px-(c_m+c_r)Q$. That is, we assume

$$R_{SC}(Q)=\alpha(p-c_m-c_r)Q+(1-\alpha)(px-c_mQ-c_rQ) \quad (5)$$

where the parameter $\alpha\in[0,1]$ can be interpreted as the level of optimism of the decision maker. The higher value of α is the higher expectations of the supply chain system for the final outcome holds.

Let $F(Q)=\int_{\underline{x}}^{Q}f(x)\,\mathrm{d}x$ and $\bar{F}(Q)=1-F(Q)$.

The expected utility of the supply chain system is

$$\begin{aligned}E[U_{SC}(Q)] &= \int_{\underline{x}}^{Q}(px-c_mQ-c_rQ)f(x)\,\mathrm{d}x \\ &+\int_{Q}^{\bar{x}}(p-c_m-c_r)Qf(x)\,\mathrm{d}x \\ &-\lambda\eta\int_{\underline{x}}^{\frac{R_{SC}+(c_m+c_r)Q}{p}}(R_{SC}-px+c_mQ+c_rQ)f(x)\,\mathrm{d}x \\ &+\eta\int_{\frac{R_{SC}+(c_m+c_r)Q}{p}}^{Q}(px-c_mQ-c_rQ-R_{SC})f(x)\,\mathrm{d}x \\ &+\eta\int_{Q}^{\bar{x}}[(p-c_m-c_r)Q-R_{SC}]f(x)\,\mathrm{d}x \\ &=\int_{\underline{x}}^{Q}(px-c_mQ-c_rQ)f(x)\,\mathrm{d}x \\ &+(p-c_m-c_r)Q\bar{F}(Q) \\ &-\lambda\eta\int_{\underline{x}}^{\frac{R_{SC}+(c_m+c_r)Q}{p}}(R_{SC}-px+c_mQ+c_rQ)f(x)\,\mathrm{d}x \\ &+\eta\int_{\frac{R_{SC}+(c_m+c_r)Q}{p}}^{Q}(px-c_mQ-c_rQ-R_{SC})f(x)\,\mathrm{d}x \\ &+\eta(pQ-c_mQ-c_rQ-R_{SC})\bar{F}(Q) \end{aligned} \quad (6)$$

Theorem 1. The optimal order quantity Q^* in centralized supply chain is

$$Q^*=F^{-1}\left(\frac{p-c_m-c_r+\eta(1-\alpha)p}{p+\eta(\lambda-1)\alpha^2p+\eta p}\right)$$

Proof: The first and second derivatives of $E[U_{SC}(Q)]$ in (6) with respect to Q can be obtained as

$$\begin{aligned}\frac{\mathrm{d}E[U_{SC}(Q)]}{\mathrm{d}Q} &=(p-c_m-c_r)-pF(Q) \\ &-\lambda\eta(R'_{SC}+c_m+c_r)F\left(\frac{R_{SC}+c_mQ+c_rQ}{p}\right) \\ &-\eta(R'_{SC}+c_m+c_r)\bar{F}\left(\frac{R_{SC}+c_mQ+c_rQ}{p}\right)+\eta p\bar{F}(Q)\end{aligned}$$

$$\begin{aligned}\frac{\mathrm{d}^2E[U_{SC}(Q)]}{\mathrm{d}Q^2} &=-pf(Q)-\eta pf(Q)-(\lambda+1)\eta\,(R'_{SC}+c_m+c_r) \\ &\times f\left(\frac{R_{SC}+c_mQ+c_rQ}{p}\right)\left(\frac{R'_{SC}+c_m+c_r}{p}\right) \\ &-\lambda\eta R''_{SC}F\left(\frac{R_{SC}+c_mQ+c_rQ}{p}\right) \\ &-\eta R''_{SC}\bar{F}\left(\frac{R_{SC}+c_mQ+c_rQ}{p}\right)\end{aligned}$$

Note that $R'_{SC}+c_m+c_r=\alpha p$ and $R''_{SC}=0$. Therefore, $\frac{\mathrm{d}^2E[U_{SC}(Q)]}{\mathrm{d}Q^2}<0$ and $E[U_{SC}(Q)]$ is concave in Q.

Let $\frac{\mathrm{d}E[U_{SC}(Q)]}{\mathrm{d}Q}=0$, and

$$F\left(\frac{R_{SC}+c_mQ+c_rQ}{p}\right)=\alpha\frac{Q-\underline{x}}{\bar{x}-\underline{x}}=\alpha F(Q).$$

We have

$$\begin{aligned}&(p-c_m-c_r)-pF(Q)-\lambda\eta\alpha^2pF(Q) \\ &-\eta\alpha p[1-\alpha F(Q)]+\eta p[1-F(Q)]=0\end{aligned} \quad (7)$$

Solving (7), we can get the optimal order quantity Q^* as follows

$$Q^*=F^{-1}\left(\frac{p-c_m-c_r+\eta(1-\alpha)p}{p+\eta(\lambda-1)\alpha^2p+\eta p}\right) \quad (8)$$

The proof of Theorem 1 is completed.

Theorem 2. The supply chain system overorders if $\frac{c_m+c_r}{p}>\frac{(\lambda-1)\alpha^2+\alpha}{(\lambda-1)\alpha^2+1}$ and underorders otherwise.

Proof: $F(Q^*)-F(Q^0)=\frac{p-c_m-c_r+\eta(1-\alpha)p}{p+\eta(\lambda-1)\alpha^2p+\eta p}-\frac{c_m+c_r}{p}>0$ if and only if $\frac{c_m+c_r}{p}>\frac{(\lambda-1)\alpha^2+\alpha}{(\lambda-1)\alpha^2+1}$.

The proof of Theorem 2 is completed.

From (6) and (8), we can obtain the optimal expected utility of the supply chain system, which is given by

$$\begin{aligned}E[U_{SC}]^* &=\int_{\underline{x}}^{Q^*}(px-c_mQ^*-c_rQ^*)f(x)\,\mathrm{d}x \\ &+(p-c_m-c_r)Q^*\bar{F}(Q^*) \\ &-\lambda\eta\int_{\underline{x}}^{\frac{R_{SC}+(c_m+c_r)Q^*}{p}}(R_{SC}-px+c_mQ^*+c_rQ^*)f(x)\,\mathrm{d}x \\ &+\eta\int_{\frac{R_{SC}+(c_m+c_r)Q^*}{p}}^{Q^*}(px-c_mQ^*-c_rQ^*-R_{SC})f(x)\,\mathrm{d}x \\ &+\eta(pQ^*-c_mQ^*-c_rQ^*-R_{SC})\bar{F}(Q^*)\end{aligned} \quad (9)$$

B . Revenue sharing contract in prospect theory

In the revenue sharing contract, the retailer shares with the manufacturer a percentage of his revenue. Let Φ be the fraction the manufacturer earns, and then $(1-\Phi)$ is the fraction the retailer keeps.

Thus, we can express the profits of the retailer and the manufacturer as follows

$$\Pi_R(Q,x)=(1-\Phi)p\min(Q,x)-wQ-c_rQ = \begin{cases}(1-\Phi)px-(w+c_r)Q, & x<Q,\\ (1-\Phi)pQ-(w+c_r)Q, & x\ge Q.\end{cases} \quad (10)$$

$$\Pi_M(Q,x)=\Phi p\min(Q,x)+wQ-c_mQ = \begin{cases}\Phi px+(w-c_m)Q, & x<Q,\\ \Phi pQ+(w-c_m)Q, & x\ge Q.\end{cases} \quad (11)$$

The utility of the retailer is

$$U_R(Q,x)=\Pi_R(Q,x)+V(y) \quad (12)$$

The reference profit of the retailer is

$$R_R(Q)=\alpha\left[(1-\Phi)px-(w+c_r)Q\right] +(1-\alpha)\left[(1-\Phi)pQ-(w+c_r)Q\right] \quad (13)$$

Thus, the expected utility of the retailer is

$$\begin{aligned}E\left[U_R(Q)\right]&=\int_{\underline{x}}^{Q}\left[(1-\Phi)px-(w+c_r)Q\right]f(x)\,\mathrm{d}x\\&+\int_{Q}^{\bar{x}}\left[(1-\Phi)pQ-(w+c_r)Q\right]f(x)\,\mathrm{d}x\\&-\lambda\eta\int_{\underline{x}}^{\frac{R_R+(w+c_r)Q}{(1-\Phi)p}}\left[R_R-(1-\Phi)px+(w+c_r)Q\right]f(x)\,\mathrm{d}x\\&+\eta\int_{\frac{R_R+(w+c_r)Q}{(1-\Phi)p}}^{Q}\left[(1-\Phi)px-(w+c_r)Q-R_R\right]f(x)\,\mathrm{d}x\\&+\eta\int_{Q}^{\bar{x}}\left[(1-\Phi)pQ-(w+c_r)Q-R_R\right]f(x)\,\mathrm{d}x\\&=\int_{\underline{x}}^{Q}\left[(1-\Phi)px-(w+c_r)Q\right]f(x)\,\mathrm{d}x\\&+\left[(1-\Phi)p-(w+c_r)\right]Q\bar{F}(Q)\\&-\lambda\eta\int_{\underline{x}}^{\frac{R_R+(w+c_r)Q}{(1-\Phi)p}}\left[R_R-(1-\Phi)px+(w+c_r)Q\right]f(x)\,\mathrm{d}x\\&+\eta\int_{\frac{R_R+(w+c_r)Q}{(1-\Phi)p}}^{Q}\left[(1-\Phi)px-(w+c_r)Q-R_R\right]f(x)\,\mathrm{d}x\\&+\eta\left[(1-\Phi)pQ-(w+c_r)Q-R_R\right]\bar{F}(Q)\end{aligned} \quad (14)$$

Theorem 3. For any $\Phi\in\left(0,\dfrac{c_m}{c_m+c_r}\right)$, the optimal wholesale price w^* in the revenue sharing contract satisfies

$$w^*(\Phi)=(1-\Phi)c_m-\Phi c_r$$

Proof: The first and second derivatives of $E\left[U_R(Q)\right]$ in (14) can be obtained as

$$\begin{aligned}\frac{\mathrm{d}E\left[U_R(Q)\right]}{\mathrm{d}Q}&=(1-\Phi)p-w-c_r-(1-\Phi)pF(Q)\\&-\lambda\eta\left(R_R'+w+c_r\right)F\left(\frac{R_R+wQ+c_rQ}{p}\right)\\&-\eta\left(R_R'+w+c_r\right)\bar{F}\left(\frac{R_R+wQ+c_rQ}{p}\right)+\eta(1-\Phi)p\bar{F}(Q)\end{aligned}$$

$$\begin{aligned}\frac{\mathrm{d}^2E\left[U_R(Q)\right]}{\mathrm{d}Q^2}&=-(1-\Phi)pf(Q)-\eta(1-\Phi)pf(Q)\\&-(\lambda+1)\eta\left(R_R'+w+c_r\right)f\left(\frac{R_R+wQ+c_rQ}{p}\right)\left(\frac{R_R'+w+c_r}{p}\right)\\&-\lambda\eta R_R''F\left(\frac{R_R+wQ+c_rQ}{p}\right)-\eta R_R''\bar{F}\left(\frac{R_R+wQ+c_rQ}{p}\right)\end{aligned}$$

Note that $R_R'+w+c_r=\alpha(1-\Phi)p$ and $R_R''=0$. Therefore, $\dfrac{\mathrm{d}^2E\left[U_R(Q)\right]}{\mathrm{d}Q^2}<0$ and $E\left[U_R(Q)\right]$ is concave in Q.

Let $\dfrac{\mathrm{d}E\left[U_R(Q)\right]}{\mathrm{d}Q}=0$ and $F\left(\dfrac{R_R+wQ+c_rQ}{p}\right)=F\left[\alpha Q+(1-\alpha)\underline{x}\right]=\alpha F(Q)$, we can get the optimal order quantity Q^{**} in the revenue sharing contract as follows

$$Q^{**}=F^{-1}\left(\frac{(1-\Phi)p-w-c_r+\eta(1-\alpha)(1-\Phi)p}{(1-\Phi)\left[p+\eta(\lambda-1)\alpha^2p+\eta p\right]}\right) \quad (15)$$

In order to fully coordinate of the whole channel, we require $Q^{**}=Q^*$ in the revenue sharing contract. From (8) and (15), we can obtain

$$w^*(\Phi)=(1-\Phi)c_m-\Phi c_r \quad (16)$$

Since $w>0$, thus we get $\Phi\in\left(0,\dfrac{c_m}{c_m+c_r}\right)$.

The proof of Theorem 3 is completed.

Theorem 4. For any $\Phi\in\left(0,\dfrac{c_m}{c_m+c_r}\right)$, the retailer and the manufacturer attain their optimal expected utility at w^* in the revenue contract, where

$$E\left[U_R\right]^*=(1-\Phi)E\left[U_{SC}\right]^*,$$
$$E\left[U_M\right]^*=\Phi E\left[U_{SC}\right]^*$$

Proof: Substituting $w^*(\Phi)=(1-\Phi)c_m-\Phi c_r$ and $Q^{**}=Q^*$ into (14), the optimal expected utility of the retailer is given as

$$\begin{aligned}E\left[U_R\right]^*&=(1-\Phi)\int_{\underline{x}}^{Q^*}\left(px-c_mQ^*-c_rQ^*\right)f(x)\,\mathrm{d}x\\&+(1-\Phi)\left(p-c_m-c_r\right)Q^*\bar{F}\left(Q^*\right)\\&-(1-\Phi)\lambda\eta\int_{\underline{x}}^{\frac{R_{SC}+(c_m+c_r)Q^*}{p}}\left(R_{SC}-px+c_mQ^*+c_rQ^*\right)f(x)\,\mathrm{d}x\\&+(1-\Phi)\eta\int_{\frac{R_{SC}+(c_m+c_r)Q^*}{p}}^{Q^*}\left(px-c_mQ^*-c_rQ^*-R_{SC}\right)f(x)\,\mathrm{d}x\end{aligned}$$

$$+(1-\Phi)\eta\left(pQ^*-c_mQ^*-c_rQ^*-R_{SC}\right)\bar{F}\left(Q^*\right)$$
$$=(1-\Phi)E\left[U_{SC}\right]^*$$

Similarly, the optimal expected utility of the manufacturer is given as

$$\begin{aligned}E\left[U_M\right]^* &= \Phi\int_{\underline{x}}^{Q^*}\left(px-c_mQ^*-c_rQ^*\right)f(x)\,\mathrm{d}x\\ &+\Phi\left(p-c_m-c_r\right)Q^*\bar{F}\left(Q^*\right)\\ &-\Phi\lambda\eta\int_{\underline{x}}^{\frac{R_{SC}+(c_m+c_r)Q^*}{p}}\left(R_{SC}-px+c_mQ^*+c_rQ^*\right)f(x)\,\mathrm{d}x\\ &+\Phi\eta\int_{\frac{R_{SC}+(c_m+c_r)Q^*}{p}}^{Q^*}\left(px-c_mQ^*-c_rQ^*-R_{SC}\right)f(x)\,\mathrm{d}x\\ &+\Phi\eta\left(pQ^*-c_mQ^*-c_rQ^*-R_{SC}\right)\bar{F}\left(Q^*\right)\\ &=\Phi E\left[U_{SC}\right]^*\end{aligned}$$

The proof of Theorem 4 is completed.

The value of contract parameter Φ depends on the bargaining power between the retailer and the manufacturer. The total optimal expected utility of supply chain system in the centralized decision marking system can be allocated with specified ratios between the retailer and the manufacturer in the revenue sharing contract.

IV. Numerical Example

In this section, we tend to further elucidate the proposed models with a numerical example. We will analyze that the effective of the parameter α and Φ on the other parameters. Let $p=40\$$, $c_m=15\$$, $c_r=5\$$, $\lambda=1$, $\eta=1$ and $x\sim U[100,200]$.

The optimal order quantity Q^*, wholesale price w^* and expected utility of the retailer and the manufacturer in the revenue sharing contract can be listed in Table I.

TABLE I
OPTIMAL SOLUTIONS FOR DIFFERENT α and Φ

Φ	α	Q^*	w^*	$E[U_R]^*$	$E[U_M]^*$
0.40	0.40	155.00	7.00	1926.00	1284.00
	0.45	152.50	7.00	1861.50	1241.00
	0.50	150.00	7.00	1800.00	1200.00
	0.55	147.50	7.00	1741.50	1161.00
	0.60	145.00	7.00	1686.00	1124.00
0.50	0.40	155.00	5.00	1605.00	1605.00
	0.45	152.50	5.00	1551.30	1551.30
	0.50	150.00	5.00	1550.00	1500.00
	0.55	147.50	5.00	1451.30	1451.30
	0.60	145.00	5.00	1405.00	1405.00
0.60	0.40	155.00	3.00	1284.00	1926.00
	0.45	152.50	3.00	1241.00	1861.50
	0.50	150.00	3.00	1200.00	1800.00
	0.55	147.50	3.00	1161.00	1741.50
	0.60	145.00	3.00	1124.00	1686.00

From Table I, we can obtain the results as follows

1) The optimal order quantity Q^* decreases as the level of optimism of the decision marker increases. In this numerical example, if $\alpha=0.50$, the optimal order quantity Q^* equals to the mean demand, and overorders if $\alpha<0.50$, and underorders if $\alpha>0.50$. It shows that when the decision maker's level of optimism is higher, he only orders the lower quantity. That is to say, he is unwilling to undertake more risk in prospect theory.
2) The different level of optimism of the decision marker does not affect the wholesale price w^*. This is because the decision marker does not affect the wholesale price, and the wholesale price is impacted only by the operational costs c_m and c_r, and the parameter Φ. The optimal wholesale price w^* will decreases as the parameter Φ increases.
3) The optimal expected utility of the retailer and the manufacturer will both decrease along with the raise of the level of optimism of the decision marker. The optimal expected utility of the retailer is decreasing with the increasing of the parameter Φ, while the optimal expected utility of the manufacturer increases as the parameter Φ increases. Moreover, the expected utility of the retailer is equal to that of the manufacturer when $\Phi=0.5$.

V. Conclusion

This paper formulates supply chain coordination problem based on prospect theory, where the manufacturer and the retailer adopt the revenue sharing contract. We show that the retailer and the manufacturer can be coordinated by the revenue sharing contract in prospect theory.

Based on the discussions above, three findings can be obtained. Firstly, as the level of optimism of the decision marker increases, the optimal order quantity of the retailer decreases. Secondly, the different level of optimism of the decision marker does not affect the wholesale price in the revenue sharing contract. Thirdly, with the increasing of the level of optimism of the decision marker, the optimal expected utility of the retailer and the manufacturer will both decrease.

However, there are some possible extensions to improve our models. For example, further work is desirable to test whether our conclusions extend to other forms of demand function. We can also consider the supply chain with multiple competitive retailers and multiple competitive manufacturers or in a multiple stage supply chain based on prospect theory in the future.

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