

## The Exploration of the Revenue Distribution Based On Revenue-sharing Contract of Supply Chain

Piao Hai-yue

line 1: the School of Economics and Management

line 2: Beijing Jiaotong University

line 3: Beijing, China

e-mail: piaohaiyuebjtu@gmail.com

**Abstract**—With the development of informatization and the commodity economy, the coordination in supply chain becomes more and more important, in addition, revenue-sharing contract is an efficient method to motivate members of supply chain to coordinate. This paper analyzed the revenue-sharing contract modes without supply price, and then came up with a way to calculate revenue distribution fraction based on costs and profit rate on costs. Later, this paper analyzed the decentralized control mode to explore the situation when both the supplier and the manufacturer can earn the optimal profits. Finally, by comparing the revenue-sharing contracts and the non-cooperative modes, there came up with a conclusion that the Revenue-sharing Contract can not only raise the profits of whole supply chain but also each member.

**Keywords**- supply chain; revenue-sharing contract; distribution of profits; profit rate on costs

### I. INTRODUCTION

It is widely believed that pursuing the maximize profits is a firm's natural quality. While, in supply chain, if all the member firms do like that, making their own prices according private prospective, then from the view of the whole supply chain, the profits might not achieve the optimal one, this is the so called Double-Marginal effect. So supply chain excellence requires the coordination of disparate incentives. However, firms lack an incentive to implement those actions. To create that incentive the firms can adjust their terms of trade via a contract to establish a transfer payment scheme. Thus maximize the performance of the supply chain and at the same time enlarge the profits that each firm gains. One type of these contracts that is discussed in this paper is Revenue-sharing contract [1].

With a revenue sharing contract the supplier charges  $w$  per unit purchased plus the retailer gives the supplier a percentage of his revenue. Revenue sharing contracts have been applied recently in the video cassette rental industry with much success. The introduction of revenue sharing coincided with a significant improvement in performance at Blockbuster. Cachon and Lariviere (2000) provide an analysis of these contracts in a more general setting [2]. Mortimer (2000) estimates revenue sharing increased the industry's total profit by 7% [3]. Dana and Spier (1999) study these contracts in the context of a perfectly

competitive retail market [4]. Pasternack (1999) studies a single retailer newsvendor model in which the retailer can purchase some units with revenue sharing and other units with a wholesale price contract [5]. He does not consider supply chain coordination in his model. Chauhan and Proth (2004) came up with the Supplier - the retailers revenue-sharing contract model, analyzed the revenue that each firm acquire under this contract [6]. WANG Yong, PEI Yong established a model of revenue sharing contract which considered into the end - consumer demand with price sensitivity [7], and raised the range of proportion that should be shared by suppliers.

With all kinds of industries gradually being mature and scholars deepening the research of supply chain contract, many scholars began to notice vendors in marketing efforts such as to increase the advertising investment or the level of advertising can stimulate the market demand. JI Xiao-Li raised a buy-back contract with effort-sharing is founded to coordinate incentive discrepancy in supply chain [8].

Although researches on revenue-sharing contract has very thorough, yet for profit distribution problem is more discussion on the distribution fraction of the scope of this paper, and this paper will analyze distribution fraction for further analysis. This paper analyzed the revenue-sharing contract modes without supply price, and then came up with a fraction based on costs and profit rate on costs. Later, this paper analyzed the non-cooperative modes to explore the situation when both the supplier and the manufacturer can earn the optimal profits. Finally, by comparing the revenue-sharing contracts and the non-cooperative modes, there came up with a conclusion that the Revenue-sharing Contract can not only raise the profits of whole supply chain but also each member.

### II. MODEL DESCRIPTIONS

In a Supply chain, when members of the lower level want to make a price, they tend to take the superior supplier supply price into consideration, if the supplier's supply price increase, the inferior members must increase price accordingly. This often results in terminal sales price is on the high side, and to reduce the number of sales, then greatly deviating from the optimal one.

Revenue-sharing contract model puts forward a solution to this phenomenon: under the restriction of the contract, the supplier offer a lower wholesale price, and get revenue from the sellers. Then in this model, suppliers and sellers have to reach agreements about the wholesale price and the rebate way. Both of them are used to distribute revenue. The wholesale price is a form of revenue distribution when sellers get the cost of purchasing, and rebate way is the direct mode of revenue distribution. However, as the presence of the wholesale price often affects the dealer's pricing, it is often the case that from the prospective of supply chain optimal revenue cannot be achieved.

Based on the analysis above, this paper puts forward some suggestions on how to optimize the current benefit-sharing contract model: considering one upstream supplier and a manufacturer, I assume that cancel the wholesale price (make the wholesale price as zero), then the supplier will get certain percentage of revenue regularly from inferior members (manufacturer). The revenue distribution fraction calculation below is just based on this improved benefit-sharing contract model.

#### A. Revenue distribution fraction calculation

Firms in a supply chain should make decisions according to contract requirements so that they can maximum revenue of the whole supply chain. The contract requires: suppliers and manufacturers should be an integral part of the attitude to make responses, making out the retail price and production batch that can help supply chain to gain the optimal revenue. In this process, the supplier provides manufacturer with free raw materials, then manufacturer should regularly pay the supplier its deserved distribution of revenue.

##### • Basic Assumptions

Firstly, the production of the supplier produces are equal to that of manufacturer:  $q_s = q_m$ , and secondly, Sales of products changes as with the price, based on demand of the price of exponential function:  $D(p) = ae^{-bp}$  ( $a > 0$ ), finally the supplier and manufacturer have the same bargain abilities and share information.

##### • For optimal revenue $\Pi$ :

The revenue function can work out the optimal price and sales to meet the maximum profit of the whole supply chain. While it is under decentralized control, manufacturer cannot always price at the optimal one because of the existence of wholesale price. Thus the operation mechanism in this paper can completely eliminate the concerns: without wholesale price, the manufacturer will be able to make price not worrying about whether the retail price can cover the cost of raw materials price, and directly make it at the optimal price. Then both the supplier and manufacturer should cooperate to meet the demand, to achieve the optimal revenue.

Thus follows the calculation of optimal income:

To set  $p$  the sale price of manufacturer,  $C_s$  as the costs per unit of the supplier,  $C_m$  as the costs per unit of the manufacturer except for purchasing price. So according to the demand of the price of exponential function the total revenue of supply chain  $\Pi$  is:

$$\Pi = ae^{-bp}(p - C_s - C_m) \quad (1)$$

When  $\frac{\partial \Pi(p)}{\partial p} = 0$ , I can get the certain value of  $p$  to maximize the value of  $\Pi$ . Considering  $p^*$  as the optimal sale price and  $q^*$  as the corresponding sales in the revenue-sharing contract than I arrive at:

$$p^* = \frac{b(C_s + C_m) + 1}{b} \quad (2)$$

$$q^* = ae^{-bp^*} = ae^{-[b(C_s + C_m) + 1]} \quad (3)$$

So the optimum should be

$$\Pi^* = \frac{ae^{-[b(C_s + C_m) + 1]}}{b} \quad (4)$$

##### • Revenue distribution:

Setting  $\alpha$  to be the ratio of distributing revenue between the supplier and the manufacturer, then:

$$\frac{\alpha}{(1 - \alpha)} = \frac{R_s}{R_m}$$

Added that revenue equals to costs multiply by cost-revenue ratio, so if  $p'_s$  and  $p'_m$  (details will be given later) are the cost-revenue ratio of the supplier and the manufacturer respectively, then:

The revenue of the supplier should be:

$$R_s = C_s \frac{R_s}{C_s} = C_s p'_s \quad (5)$$

Likewise, for the manufacturer,

$$\Pi^* = \frac{ae^{-[b(C_s + C_m) + 1]}}{b} \quad (6)$$

Therefore, the function about  $\alpha$  can be rewritten as:

$$\frac{\alpha}{(1 - \alpha)} = \frac{R_s}{R_m} = \frac{C_s p'_s}{C_m p'_m} \quad (7)$$

$$\alpha = \frac{C_s p'_s}{C_s p'_s + C_m p'_m} \quad (8)$$

Thus the revenues of them should be:

$$\Pi_s = \alpha \Pi = \frac{ae^{-[b(C_s + C_m) + 1]} C_s p'_s}{b (C_s p'_s + C_m p'_m)} \quad (9)$$

$$\Pi_m = \Pi - \Pi_s = \frac{ae^{-[b(C_s + C_m) + 1]} C_m p'_m}{b (C_s p'_s + C_m p'_m)} \quad (10)$$

### III. FEASIBILITY ANALYSIS-COMPARISON TO THE MODE IN DECENTRALIZED SUPPLY CHAIN

The premise ensuring that the revenue-sharing contract can work properly is that the total revenue of the supply chain will increase without reducing each member's revenue. So in this section I try to prove that both the total revenue of the supply chain and the amount that each member gains will improve under the revenue-sharing contract mode in this paper than decentralized supply chain.

#### A. From the perspective of total revenue of supply chain

To ensure that both the supplier and the manufacturer will accept this contract, it is a necessity that the revenue

of both sides under the new mode should surpass the one existed(decentralized control supply chain). So the author here will analyze the revenue of each side respectively under the decentralized control supply chain first.

- For the supplier:

The revenue of the supplier under the decentralized control should be:

$$\Pi_s(w) = ae^{-bw}(w - C_s) \quad (11)$$

When  $\frac{\partial \Pi_s(w)}{\partial w} = 0$ , the revenue of supplier  $\Pi_s(w)$  should be the optimal one. Correspondingly, the optimal wholesale price and the sales should be:

$$w^* = \frac{bC_s + 1}{b} \quad (12)$$

$$q_s(w)^* = ae^{-b(C_s + 1)} \quad (13)$$

- For the manufacturer:

Likewise, the optimal sale price and the sales are:

$$p_m^* = \frac{b(C_m + w^*) + 1}{b} = \frac{b(C_m + C_s) + 2}{b} \quad (14)$$

$$q_m^* = ae^{-[b(C_m + C_s) + 2]} \quad (15)$$

Compare the optimal sales of the supplier and manufacturer, namely  $q_s^* > q_m^*$ ((13) and (15))

In this condition, if the supplier wants to maximize its revenue, it should sale the same quantity with the optimal sales of the manufacturer:

$$q_s = q_m^* = ae^{-[b(C_m + C_s) + 2]} \quad (16)$$

So because they don't share information and the existence of the wholesale price, the supplier always afford the optimal sales of itself. Thus it will waste much more costs. However even though they share the figure of the sales, they can only get the total revenue as follows:

$$\Pi = \Pi_m^* + \Pi_s^* = \frac{2ae^{-[b(C_m + C_s) + 2]}}{b} \quad (17)$$

When compare this total revenue to the one under the mode put forward in this paper, it is obvious that:

$$\frac{\Pi}{\Pi^*} = \frac{\frac{2ae^{-[b(C_m + C_s) + 2]}}{b}}{\frac{ae^{-[b(C_s + C_m) + 1]}}{b}} = \frac{2}{e} < 1$$

To sum up, from the respective of the whole supply chain, the total revenue of the supply chain under the mode of this paper is superior to that under decentralized control.

#### B. From the perspective of the revenue of each member in the supply chain

Though from the respective of the whole supply chain the mode in this paper is superior to the decentralized control, it is still necessary to prove that for each member, their revenue will increase. Only in this condition will each member be willing to cooperate, thus maximizing the total revenue of the whole supply chain. And the following section these issues will be proved.

Just as have been mentioned in the second section, when distribute revenue in this paper, the cost-revenue ratio will be involved in. And in order to ensure that every member will accept and be feasible, the cost-revenue ratio should be the optimal one under the decentralized control.

- Calculating the cost-revenue ratio:
- For the supplier:

$$p_s' = \frac{\Pi_s^*}{C_s} = \frac{ae^{-[b(C_m + C_s) + 2]}}{bC_s} \quad (18)$$

- For the manufacturer:

When to distribute the revenue, the amount of the manufacturer's costs won't include the purchasing price (wholesale price for the supplier), if I still use the cost-revenue ratio under decentralized control as follows:

$$p_m' = \frac{\Pi_m^*}{C_m + w} \quad (19)$$

As the real costs of the manufacturer will reduce as the absence of the purchasing price, the revenue it receives will decrease correspondingly. So in this paper the cost-revenue ratio should be calculated as follows:

$$p_m' = \frac{\Pi_m^*}{C_m} = \frac{ae^{-[b(C_m + C_s) + 2]}}{bC_m} \quad (20)$$

Next I will compare the revenue of each member under the new mode with that under decentralized control.

- For the supplier:

When the function (9) is rewritten by  $p_s'(19)$ ,  $p_m'(20)$ , it will turn out to be:

$$\Pi_s = \frac{ae^{-[b(C_s + C_m) + 1]}}{2b} \quad (21)$$

Comparing the revenue of the supplier under the decentralized control with that under the mode in this paper, I reach the conclusion that:

$$\frac{\Pi_s^*}{\Pi_s} = \frac{\frac{ae^{-[b(C_m + C_s) + 2]}}{b}}{\frac{ae^{-[b(C_s + C_m) + 1]}}{2b}} = \frac{2}{e} < 1$$

So it is obvious that for the supplier, the mode in this paper is superior to the decentralized control supply chain.

- For the manufacturer:

The revenue of the manufacturer under the mode in this paper should be:

$$\Pi_m = \frac{ae^{-[b(C_s+C_m)+1]}C_m p'_m}{b(C_s p'_s + C_m p'_m)}$$

Likewise, it should be rewritten as:

$$\Pi_m = \frac{ae^{-[b(C_s+C_m)+1]}}{2b} \quad (22)$$

Comparing the revenue of the supplier under the decentralized control (17) with that under the mode in this paper (22), I reach the conclusion that:

$$\frac{\Pi_m^*}{\Pi_m} = \frac{\frac{ae^{-[b(C_m+C_s)+2]}}{b}}{\frac{ae^{-[b(C_s+C_m)+1]}}{2b}} = \frac{2}{e} < 1$$

In this way, I am able to prove that both from the respective of the supplier and the manufacturer, the mode in this paper is superior to decentralized control supply chain. So the mode which is under the revenue-sharing contract without wholesale price and distributed according to the cost-revenue ratio is totally feasible.

#### IV. NUMERICAL EXAMPLE ANALYSIS

In order to make further illustration, I will give a concrete numerical example. If the per-unit costs of the supplier is  $C_s = 10$ , and the corresponding one of the manufacturer is  $C_m = 3$ , and in the demand of the price of exponential function,  $a = 10^{13}$ ,  $b = 2$ , then:

TABLE I. NUMERICAL EXAMPLE ANALYSIS

$C_s = 10, C_m = 3,$ $a = 10^{13}, b = 2$	Decentralized supply chain	Revenue-sharing contract without wholesale price
p	14	13.5
w	10.5	0
q	6.91	18.80
$\Pi_s$	3.46	4.70
$\Pi_m$	3.46	4.70
$\Pi$	6.92	9.40

It is obvious that, when the supplier cancels that wholesale price, the sale price of the manufacturer will decrease, therefore, the sales will rise dramatically. And as a result both of the upstream and downstream of the supply chain will enjoy increased revenue, and from the prospective of the whole supply chain, the total revenue will increase at the same time.

#### V. CONCLUSION

This paper raised the mode that supply chain operate canceling the wholesale price and distribute the revenue according to the cost-revenue ratio with a simple supply chain (a supplier and a manufacturer) as background, then

described how to calculate the cost-revenue ratio, it worth attention that downstream supplier (the manufacturer in this paper) doesn't have the purchasing expending, so when deciding the costs and calculating the cost-revenue ratio, I excluded the outlet of the wholesale price. And I analyzed the situation under decentralized control, and then reached the conclusion that the mode raised in this paper can ensure the increasing of revenue not only from the respective of the total supply chain but also for each member. However the interest rates of the capital was not considered in this paper, so I suggest the following researchers study further on the coefficient of revenue distribution should concentrate on this issue.

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