COORDINATION MECHANISMS IN SUPPLY CHAIN WITH THIRD PARTY LOGISTICS OUTSOURCING

Winda Narulidea, Oki Anita Candra Dewi
Universitas Internasional Semen Indonesia

ABSTRACT

Purpose: By making logistics outsourcing decision, companies have been able to improve the logistics performance, maintain focus on core business, and minimize distribution cost. However in decentralized condition, there is only limited control of the third party logistics service provider (TPLSP), whose logistics service performance affect the products availability, quality, price, and market share. The paper aim to develop the model of coordination mechanisms in supply chain with third party logistics outsourcing.

Design/methodology/approach: Revenue sharing contracts are developed in the proposed model to coordinate the supply chain consisting of a manufacturer, a TPLSP, and multiple retailers. Moreover the incentive and penalty scheme are implemented in accordance to the supply chain logistics service performance, so the risks and the necessary costs could be allocated to all players.

Findings: To increase the desirability level of the contracts for all players, we should determine the contracts parameter so that all entities could obtain higher profit than in decentralized conditions chain and win-win condition can be achieved.

Originality/value: The paper provides new model of coordination mechanism in supply chain with logistics outsourcing and offers the incentive and penalty scheme into the basic model of revenue sharing contracts.

Keywords: Coordination mechanism, Logistics outsourcing, Revenue sharing contracts, Supply chain

Introduction

This study addresses the problem in the supply chain where the distributor supplies the product through third party logistics service provider (TPLSP) to the market with a relatively long distance. Products brought by TPLSP are then accepted by retailers for sale to consumers in the market. Problems arising from the distance that must be taken and the wide area of market penetration that must be met in the process of distribution of products.

As many problem arisen in decentralized supply chains, company control over the interests of TPLSP can not be done completely. This usually poses a problem if at the time of the product distribution practices carried out by drivers of carrier that are not in accordance with the planning that has been done by the company. To be able to maintain market share in market regions, the company must plan carefully how many products must be sent, whenever the product must be accepted by the distributor, and how the delivery process can maintain the quality of the products received by the distributor.

Incentive alignment needs to be done to improve mutual relationships that are mutually beneficial for all players in the supply chain. This study developed a mechanism. Contracts among players in the supply chain of products with the involvement of logistics outsourcing. Supply contract according to Cachon and Lariviere (2005) is a mechanism that can assist in the supply process with the purpose of parameters. This research develop a mechanism model by using supply contract at supply chain with TPLSP being responsible for distribution process and transportation of product to distributor. The existence of supply contract is able to apply incentive and punishment scheme in accordance with the performance of TPLSP. The values of the parameters on the model determined to increase each player profit in the supply chain and the win-win conditions can be achieved.

Model

We consider supply chain system that include three participants: distributor, TPLSP, and retailer. Products will be delivered from distributor by TPLSP to be ready for selling season in retailer. In the model, we considered that there will be three possible conditions. Two condition of supply chain without revenue sharing contract are whether the supply chain is centralized or decentralized. The third condition is supply chain under revenue sharing contracts. The retailer's demand distribution that will be taken into account for its stocking decision is N(μ;σ). Then we denote F as the normal cumulative density function of N(μ;σ), and F-1 as the inverse normal cumulative density function. It assumed that all of players know the information of the demand distribution.

Notation	Description
r	Unit selling price
$D_{(r)}$	Demand level of end customer
$\prod_h$	Total supply chain profit in centralized condition
Q^o	Optimal order quantity in centralized condition
Q^d	Optimal order quantity in decentralized condition
Q^{RS}	Order quantity under revenue sharing contract
c_u	Understocking cost
c_o	Overstocking cost
ω	Wholesale price set by distributor
c_D	The marginal cost of distributor
c_R	The marginal cost of retailer
c_T	The marginal cost of TPLSP
P	Quoted logistics services price provided by TPLSP
p_T	Negotiated penalty cost under-ordered quantity received on time
α	Ratio of under-ordered quantity received on time ($0 \leq \alpha \leq 1$)
φ_R	Contract parameter (1-φ_R) determine the proportion of retailer revenue to be shared to distributor
φ_D	Contract parameter (1-φ_D) determine the proportion of distributor revenue to be shared to TPLSP
$N(\mu;\sigma)$	Normal distribution function

Table 1: Notation.

Formulation Model under Centralized Supply Chain

The condition of centralized supply chain defines the ideal condition, which all the parties throughout the supply chain are under the same firm/ company and not across to other firms, so that the decision making as a whole will have the same direction: to get the optimal solution for the firm itself. In the centralized supply chain, the supply chain expected profit is given by:

$$\prod_h = r \min\left[Q^o, D_{(r)}\right] - (c_R + c_D + c_T)Q^o \quad (1)$$

The optimal order quantity is characterized by a balance between understock cost and overstock cost. The understock and overstock cost is given as follows:

$$c_u = r - (c_R + c_D + c_T + ((1-\alpha)(P - pt)) \quad (2)$$

$$c_o = (c_R + c_D + c_T + ((1-\alpha)(P - pt)) \quad (3)$$

So that the optimal order quantity is as shown below:

$$Q^c = F^{-1}\frac{c_u}{c_u+c_o} = F^{-1}\frac{r-(c_R+c_D+c_T+((1-\alpha)(P-pt))}{r} \quad (4)$$

Formulation Model under Decentralized Supply Chain

Meanwhile under the decentralized condition, all the players make their own decision respectively. The supply chain performance become suboptimal, because each player want to maximize their own profit, so the double marginalization happened.

The expected profit of retailer is given below:

$$\prod_R^d = r\min\left[Q, D_{(r)}\right] - (\omega + c_R)Q. \quad (5)$$

The understock cost is calculated as $c_u = r - (\omega + c_R)$ and the overstock cost $c_o = (\omega + c_R)$, so that the optimal order quantity is given as follow:

$$Q^d = F^{-1}\frac{[r-(\omega+c_R)]}{r} \quad (6)$$

For distributor, the expected profit is given as follows:

$$\prod_D^d = \omega Q^d - (((1-\alpha)P + \alpha p_T) + c_D)Q^d \quad (7)$$

Likewise, for the TPLSP, the expected profit is given:

$$\prod_T^d = (((1-\alpha)P + \alpha p_T))Q^d - (c_T)Q^d \quad (8)$$

The order of decision making is described below:

a. Distributor will determine the wholesale price ω_i to maximize their own profit as:

$$\omega = max_\omega \prod_D^d = max_\omega\ \omega Q^d - \left(((1-\alpha)P + \alpha p_T) + C_D\right)Q^d \quad (9)$$

b. Retailer will determine the optimal order quantity Q^d as:

$$Q^d = F^{-1}\frac{[r-(\omega+c_R)]}{r} \quad (10)$$

c. The TPLSP will determine the logistics services price P to maximize their own profit and can be modeled as:

$$P = max_P \prod_T^d = max_P\ (((1-\alpha)P + \alpha p_T))Q^d - (c_T)Q^d \quad (11)$$

Formulation Model Under Revenue Sharing Contract

Under revenue sharing contract, retailer will share certain fraction of their revenue to the distributor. The parameter $(1-\varphi_R)$ define the certain fraction of retailer revenue shared to distributor. So the expected profit of retailer is given below:

$$\prod_R^{RS} = \varphi_R\ r\ min\left[Q, D_{(r)}\right] - (\omega + c_R)Q \quad (12)$$

Likewise the distributor will share certain fraction of their revenue to the TPLSP, so that the expected profit of distributor is given as:

$$\prod_D^{RS} = \varphi_D\left[(1-\varphi_R)\left(r\ min\left[Q, D_{(r)}\right]\right) + \omega Q\right] - \left(((1-\alpha)P + \alpha p_T) + C_D\right)Q \quad (13)$$

For the player *i* = 3,4,…,*n*-1 the expected profit is given as: (14)

Meanwhile for the TPLSP the expected profit is given as:

$$\prod_T^{RS} = (1-\varphi_D)\left[(1-\varphi_R)\left(r\ min\left[Q, D_{(r)}\right]\right) + \omega Q\right] + \left((1-\alpha)P + \alpha p_T\right)Q - C_T(Q) \quad (15)$$

If each player try to maximize their own profits, so the equation of optimal order quantity as follows:

$$Q_R^{RS} = F^{-1}\frac{[\varphi_R r-(\omega+c_R)]}{\varphi_R r} \quad (16)$$

while the $c_u = \varphi_R r - (\omega + c_R)$; $c_o = \omega + c_R$.

To obtain coordination in the supply chain, the contract parameter φ_R, φ_D, ω, and P are designed so that the contract can effectively coordinate all the players. To get the order quantity as $Q_R^{RS} = Q^c$, so we obtain the equations as follow:

$$F^{-1}\frac{[\varphi_R r-(\omega+c_R)]}{\varphi_R r} = F^{-1}\frac{r-(c_R+c_D+c_T)}{r}$$

$$\frac{[\varphi_R r-(\omega+c_R)]}{\varphi_R r} = \frac{r-(c_R+c_D+c_T)}{r} \quad (17)$$

$$\omega = (c_R + c_D + c_T)\varphi_R - c_R \quad (18)$$

$$P = (c_R + c_D + c_T)(\varphi_R + \varphi_D)(1 - \varphi_R) - c_T$$

Contract parameter φ_R and φ_D range between 0 to 1, so we can obtain the equations as follow:

$$\varphi_R > \frac{c_R}{c_R+c_D+c_T} \quad (19)$$

$$\varphi_D > \frac{\frac{1}{(1-\varphi_R)}(c_R+c_D)}{[c_R+c_D+c_T]-(\varphi_R+\varphi_D)} \quad (20)$$

The order of decision making is described below:

a. Distributor will determine the wholesale price ω to maximize their own profit as:

$$\omega = max_\omega \prod_D^{rs}$$

$$\omega = max_\omega \varphi_D\left[(1-\varphi_R)\left(r\ min\left[Q^{rs}, D_{(r)}\right]\right) + \omega Q^{rs}\right] - \left(\left((1-\alpha)P + \alpha p_T\right) + C_D\right)Q^{rs} \quad (21)$$

b. Retailer will determine the optimal order quantity Q^{RS} as:

$$Q_R^{rs} = Q^{rs} = F^{-1}\frac{[\varphi_R r-(\omega+c_R)]}{\varphi_R r} \quad (22)$$

c. The TPLSP will determine the logistics services price P to maximize their own profit as:

$$P = max_P \prod_T^{rs}$$

$$P = max_P(1-\varphi_D)\left[(1-\varphi_R)\left(r\ min\left[Q^{rs}, D_{(r)}\right]\right) + \omega Q^{rs}\right] + \left((1-\alpha)P + \alpha p_T\right)Q^{rs} - C_T(Q^{rs}) \quad (23)$$

Numerical Experiment

Numerical example are performed to clarify the proposed model and verify if the model can create the win–win condition, by designing the contract parameters. We use the assumed data from the basic model of the research I. Giannoccaro and P. Pontrandolfo (2004).

Variable	Value
c_R	1
c_T	2
c_D	4
ω	2(P + c_D) = 16
P	$2c_T$ = 4
p_T	2
price r	30
demand D(r)	Normal distribution, mean =100, s.d=30

Table 2: Problem Data

For the purpose of comparing the expected profit, in this research using different ratio of under-ordered quantity received on time ($0 \leq \alpha \leq 1$).

We can conclude that the supply chain as a whole always receives higher profits under the revenue-sharing contract under than without using the RS contract. Therefore it can shows the revenue sharing contract could coordinate the supply chain and get the better supply chain performance, which indicate by higher expected profit. Moreover the expected supply chain profit under RS contract higher than the ideal

condition of centralized supply chain. It shows that the revenue sharing contract is helpful to coordinate the supply chain.

From Fig.4, if we compare all the player expected profit under RS contracts always higher than the expected profit without RS contracts. It means that RS contracts model has high desirability level for all SC players, that obtain higher profit than decentralized condition without RS contracts. Moreover, the rewards and punishment scheme for TPLSP to drive the punctuality of delivery. This scheme implemented to increase logistics outsourcing performance in the supply chain. In the distributor and retailer's perspective, the coordination effect on high profit, due to its benefit to improve the effectiveness and responsiveness to fulfill the customer demand.

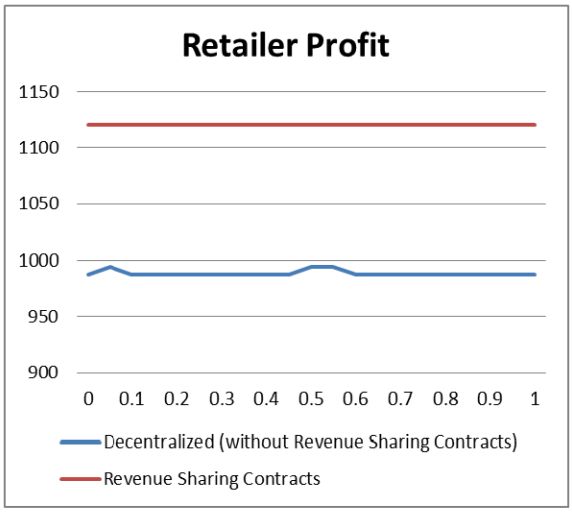

Figure 1: Retailer's expected profit under RS and without RS contract

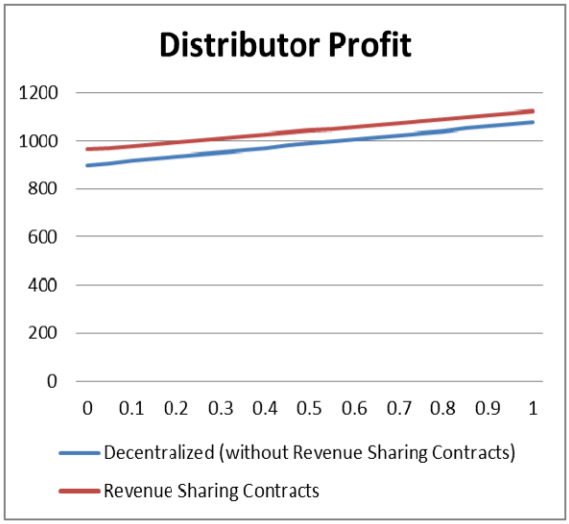

Figure 2: Distributor's expected profit under RS and without RS contract

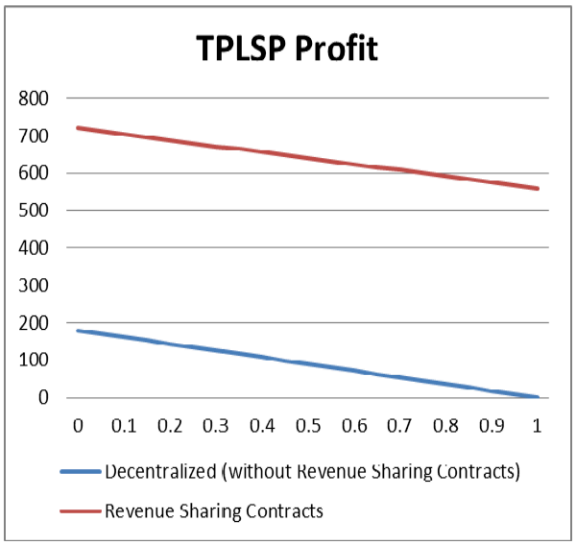

Figure 3: TPLSP's expected profit under RS and without RS contract

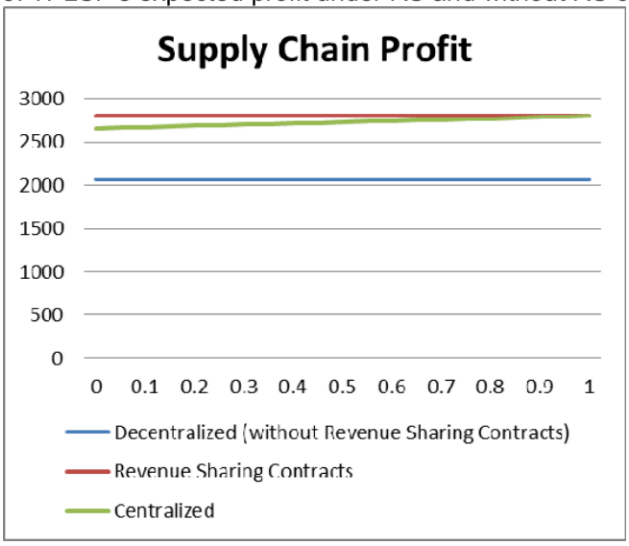

Figure 4: Supply chain's expected profit under RS and without RS contract

Conclusion

Revenue sharing contract model in supply chain involving logistics outsourcing were developed to allocate the profit and risk sharing between supply chain players by implementing the penalty and rewards scheme for TPLSP. Numerical experiment were conducted to simulate the sensitivity of model to the expected profit of each player and the supply chain profit as a whole system. To coordinate the supply chain, revenue sharing contract could be implemented to gain each player's profit. Moreover, the penalty and rewards scheme included in the model to improve the logistics outsourcing performance. The revenue sharing contract model could be implemented in decentralized supply chain to coordinate the logistics outsourcing. With this coordination mechanism model, each player in the supply chain could act with the aim of obtaining the optimal solution for supply chain and it prevents double marginalization practice.

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