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# Reverse supply chain; the relationship between manufacturer and retailer through open-innovation coordinative strategies

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**Abstract**

A reverse supply chain, as a post-consumption activity, aims at extracting value from products at end of their life cycle (Mafakher and Nasiri, Journal of Cleaner Production 59: 185–196, 2013). As well, company‟s awareness is attracting increasing attention toward sustainable business practices. Open-innovation is a typical example of coordinative activity that a manufacturer should share a profits generated through reverse supply chain with retailer. The aim of this paper provide insights toward open innovation practice in sharing profits between two strategic partners, manufacturer and retailer to maximize an individual profits as well as total profits concurrently in reverse supply chain. For analyzing effects of open innovation strategies, we modeled reverse supply chain environments using system dynamics approach and compared the gap of profits between non-coordinative (decentralized) and coordinative activity. Three cooperative contracts in terms of how to share the cost and profit between two parties are proposed in this paper. Each contract was analyzed according to the following three contract processes. The first stage is that manufacturer proposes contracts to retailer. The second is that retailer evaluates proposed contracts and choices the best contract which can lead to maximize its expected profit. Finally retailer and manufacturer adjust parameters of the best contract for achieving mutual goal of supply chain. Through the experimental results, we discuss best coordinative strategy between manufacturer and retailer in order to maximize a profit in reverse SC.

**Keywords**

Reverse supply chain, Open innovation system dynamics, Contract implementation procedure

**Article History:**

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## 1. INTRODUCTION

Recently, as increasing the needs for activity to return used products from consumer due to the environmental regulation, Firms‟ interests and necessary for open innovation of reverse supply chain have slightly been growth.

Reverse supply chain focuses on collecting products from customers and reusing them to generate value. Open-innovation is a type of coordinative straggles that manufacturer should share the profits generated through reverse supply chain with retailers. (Čirjevskis 2016; Leydesdorff and lvanova 2016; Yusr 2016). The values that reverse supply chains bring is threefold: First, the manufacturer uses the returned products in a remanufacturing process. Second, customer participation in the product return enables open innovation among partners in the supply chain to have a chance to sell new products to participating customers. Third, for auxiliary and consumable products dependent on another device, such as printer ink on printers, the manufacturer can encourage customers to buy new products rather than refurbish or refill used ones when the reverse supply chain is employed.

Because collecting used products to remanufacture for resale is increasingly important for corporate profits, many companies explicitly cooperate in the concept of open innovation with their customers. A participant in supply chain has tried to generate firm‟s value by cooperation with other participants within the same chain. Manufacturers in particular are considering various cooperative strategies such as working with supply chain partners, including retailers and third party logistics (3PL) companies, to increase their used product collection rate (Savaskan et al. 2004).

Generally, various cooperation strategies with partners was done by various contraction methods such as benefit-sharing, sharing of burden of expense (Mafakheri and Nasiri 2013; Govindan and Popiuc 2014; Li et al. 2014; Shi et al. 2016).

This paper reviews a few contract options available with manufacturer and retailer to collect a higher return rate of used products from consumer in reverse supply chain. When comparing of decentralized model (No sharing of benefit or cost with supply chain partners), the effects of coordinative options will be tested in perspective of individual by participant or total supply chain profits through simulation approach.

This paper focuses on understanding the detailed implementation procedure in determining the optimal contracts through the agreement between two partners, manufacturer and retailer.

## 2. LITERATURE REVIEW

Numerous contract forms have been studied, such as buy-back, quantity-flexibility, revenue-sharing, pricediscount, sales-rebate, and quantity-discount (wang 2002; Li et al. 2009; Cachon and Lariviere 2005; Coltman et al. 2009; Seifbarghy et al. 2015). Most of them focused on general supply chain model with a two-stage supplier and retailer. However, a few that deal with the effects on contracts with participants in reverse supply chain model have been studied, to our knowledge. Thus, our literature review extended reverse supply as well as general supply chain in order to recognize the types of contracts model and their distinct implementation.

Gerchak and Wang (2004) reviewed two difference types of contracts between retailer and suppliers. One scheme was a vender management inventory with revenue sharing, and the other was wholesale-price driven contracts. They explored the resulting components‟ delivery quantities equilibrium in this decentralized supply chain and its implications for participants‟ and total expected profits. Through experiment, they indicated revenue sharing should be a best option to supplier to maximize its own profits. Cachon and Lariviere (2005) studied the revenue-sharing contracts in a traditional supply chain model with revenues determined by each retailer‟s purchase quantity and price. Their recommend was that revenue sharing coordinates a supply chain with a single retailer (i.e., the retailer chooses optimal price and quantity) and arbitrarily allocated the supply chain‟s profit. Through comparing among alternative revenue sharing options that include a buy-back contracts, price-discount contracts, quantity-flexibility contracts, sales-rebate contracts, franchise contracts, and quantity discounts, they demonstrated revenue sharing is equivalent to buybacks in the newsvendor case and equivalent to price discounts in the price-setting newsvendor case.

Wang and Zipkin (2009) investigated how the behavior of participant's decision making affects the performance of supply chain under a two-stage supplier-retailer model. Under buy back, they experimented for finding the particular viewpoints in both of when retailer is as leader and supplier as leader. The results showed the case that supplier is as leader can be dominated than the other in maximizing total system profits under same experimental conditions. Kanda and Deshmukh (2009) presented an evaluation of wholesale price, buy back, and quantity flexibility in relation to the decentralized case and in terms of performance measures improvement under three-level supply chains with a single supplier, assembler, and retailer. Kannan et al. (2012) investigated a series on contracts applied on the two echelon supply chain and indicates that revenue sharing contracts offer the highest profit margins for the manufacturer.

## 3. RESEARCH MODEL

### *3.1 Model procedure*

As shown in Fig. 1, our research model greatly follows four steps.

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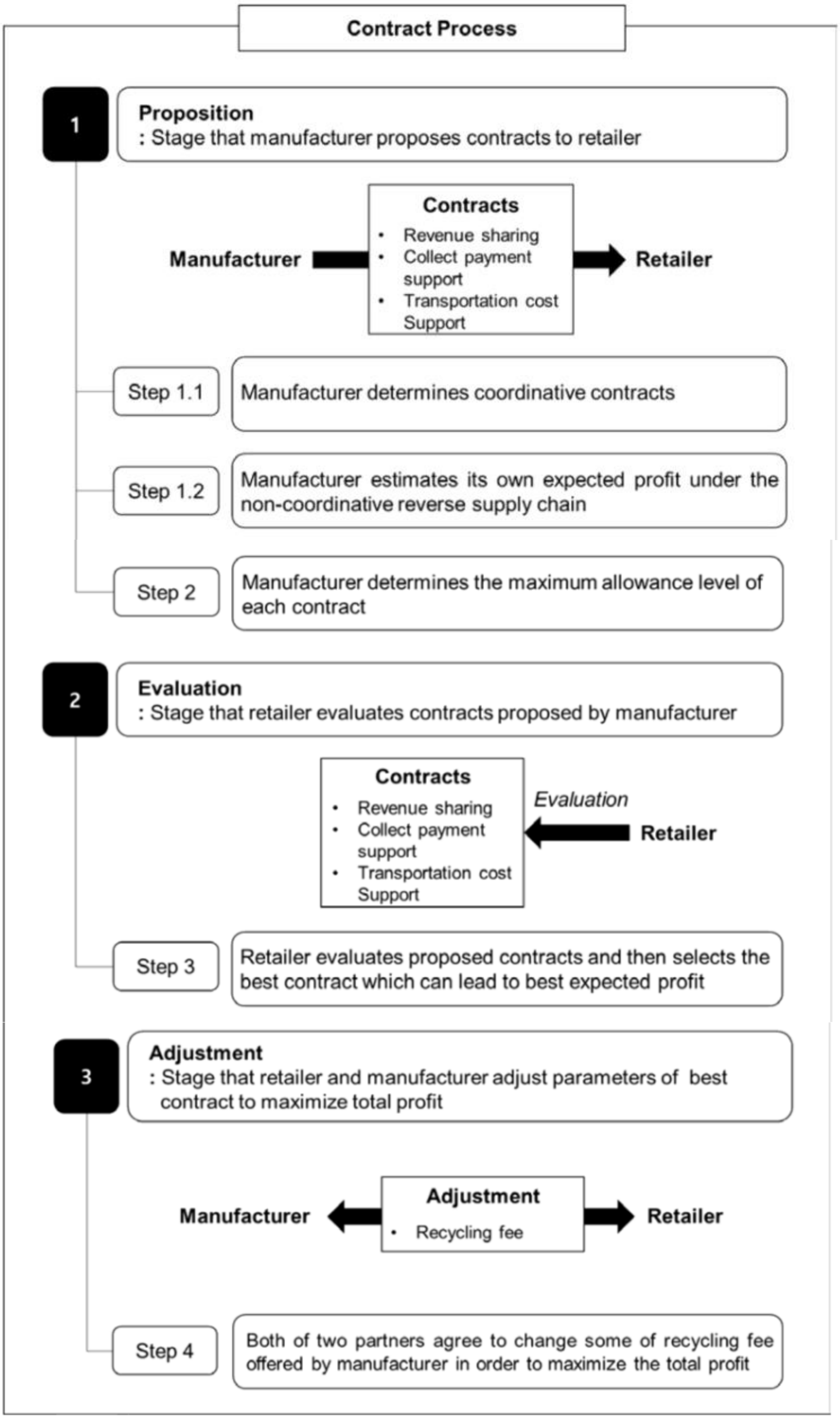
**Fig. 1** Contract procedures between manufacturer and retailer




*Proposition*

Step 1.1 for applying open innovation, manufacturer determines coordinative contracts

In step 1.1, we design three open innovation-based coordinative strategies with manufacturer and retailer; 1) revenue-sharing of manufacturer to retailer, 2) manufacturer‟s financial support for the collect payment to retailer (manufacturer‟s additional payment to retailer in order to accelerate return activity of retailer, eparately with base return fee), and 3) manufacturer‟s support to transportation cost paid by retailer.

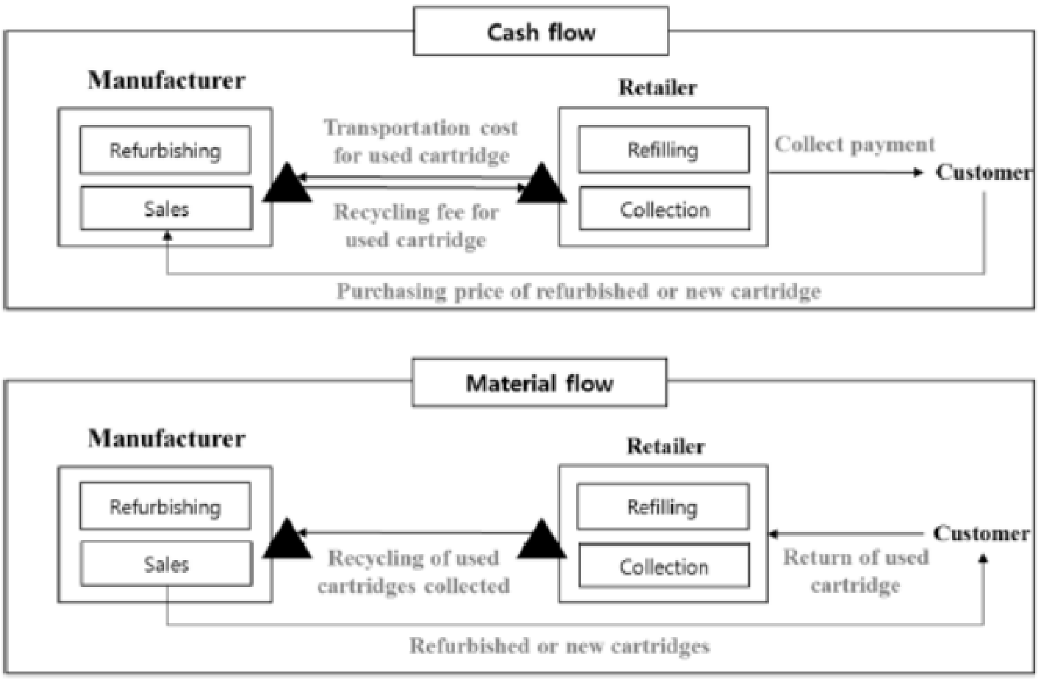
Step 1.2 Manufacturer estimates its own expected profit, without open innovation strategies above.

The experiment to estimate the individual profits of each of manufacturer and collection performance for gaining the effects from excluding open-innovation.

Here, Excluding open innovation means that there is no cooperative contracts between manufacturer and retailer. And they seek to achieve a goal of maximizing its own profit. Here, the profit results under decentralization are used as allowance maximum value when any contracts with manufacturer and retailer are done.

Step 2. Manufacturer determines the maximum allowance level of each contract for estimating the level of open innovation activity with retailers For contracts proposed by step 1.1, we determine the maximum range of allowance that manufacturer can lead to financial support to retailer. Because manufacturer expects to increase its own profits through the cooperation (contract) with partner, the allowance maximum level of each cooperative contract will be determined when its expected profit in the coordinative model is larger than the expected profit in the decentralized model.

**Fig. 2** The flow of reverse supply chain in print cartridge industry




*Evaluation*

Step 3. Retailer evaluates three open innovation strategic proposed from manufacturer, and then selects the optimal contract which can lead to best expected profit.

A manufacturer recommend retailer three open-innovation strategic available and their allowance maximum level that will be offered to retailer. She then, simulates its own profit effects when applying three contracts and finally determines the best that the highest profit is expected, among contracts.

*Adjustment*

Step 4. Both of two partners agree to change some of recycling fee offered by implementing the open innovation.

After final decision of retailer, the detailed of best contract will be proceeded with two partners. In cooperative supply chain, it is more important to maximize total profits than an individual profit of each. Thus, if retailer‟s decision does not satisfy the maximization of total profits, we assume that parameters of contract will be partially adjusted by the process of agreement between partners. In this study, we consider the basic return fee as adjustment parameter. From the initial basic return fee, we experiment the change of total profits by smooth decrement of the value of base return fee. We finally select the adjusted best return fee that maximizes the total profits and the corresponding maximum allowance level.

**Fig. 3** Profit structure of manufacturer and collecting firm under the decentralized

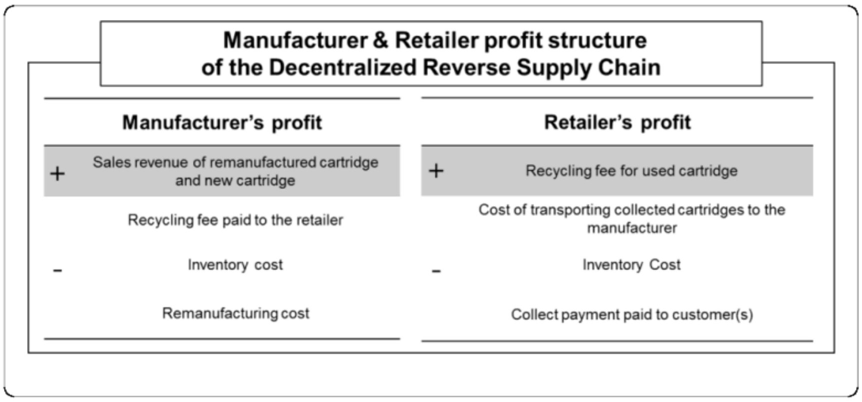



**Fig. 4** Simulation model of decentralized reverse supply chain

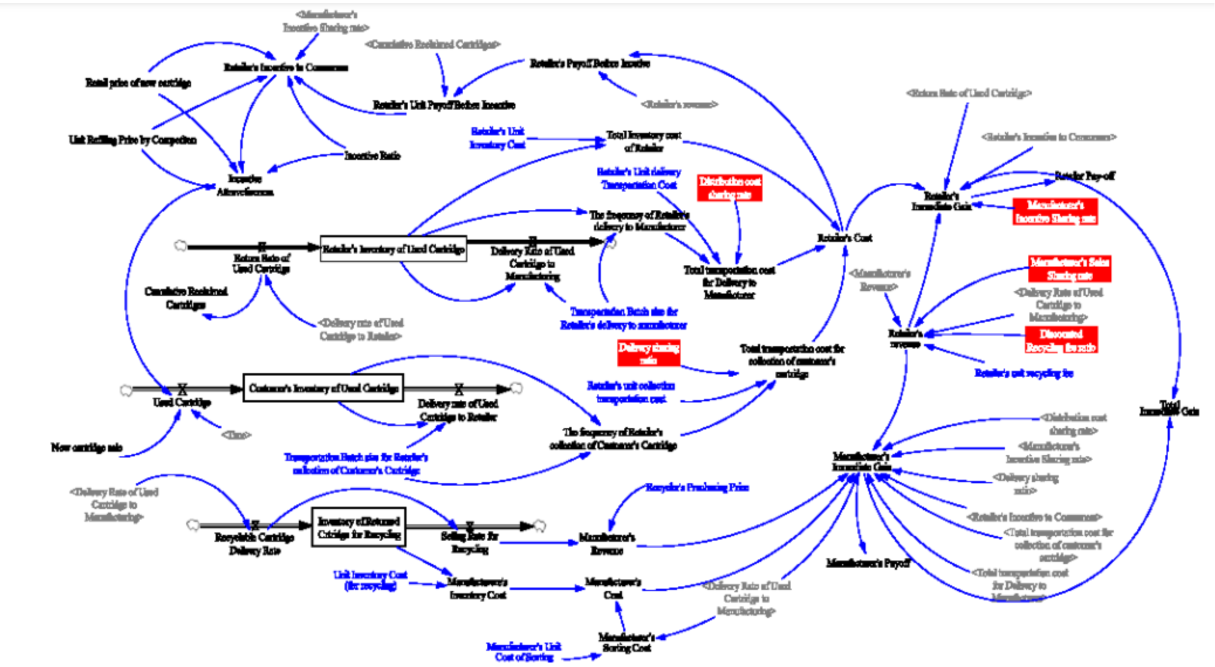


**Table 1** Simulation basic data

| Partner | Variable | Value | Dimension |
|---|---|---|---|
| Retailer | Unit Inventory Cost | 0.05 | $/Unit |
| | Unit delivery Transportation Cost | 300 | $/Unit |
| | Unit Collection Transportation Cost | 6 | $/Unit |
| | Retailer price of new cartridge | 11 | $/Unit |
| | Unit Refilling price by competition | 6 | $/Unit |
| | Transportation Batch size for Retailer's delivery to manufacturer | 1000 | Unit |
| Manufacturer | Unit cost of Refurbishing | 0.05 | $/Unit |
| | Unit inventory cost | 0.05 | $/Unit |
| | Recycler's Purchasing price | 9 | $/Unit |
| | Unit recycling fee | 4 | $/unit |

**Fig. 5** Mechanism of customer returns attractiveness

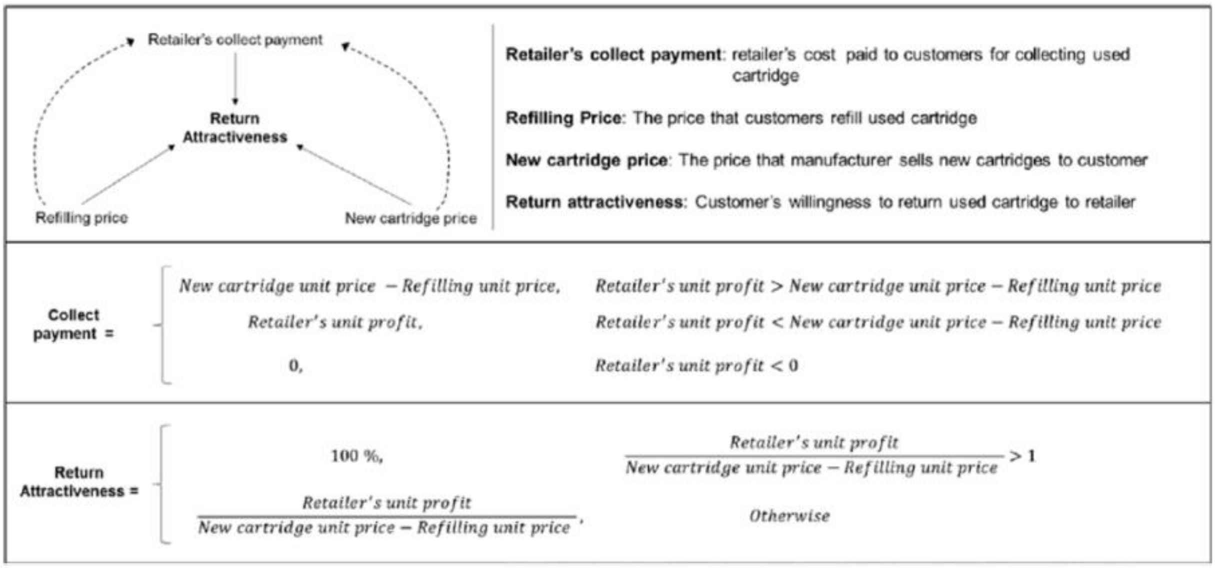


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**Fig. 7** Causal loop diagram of the our study

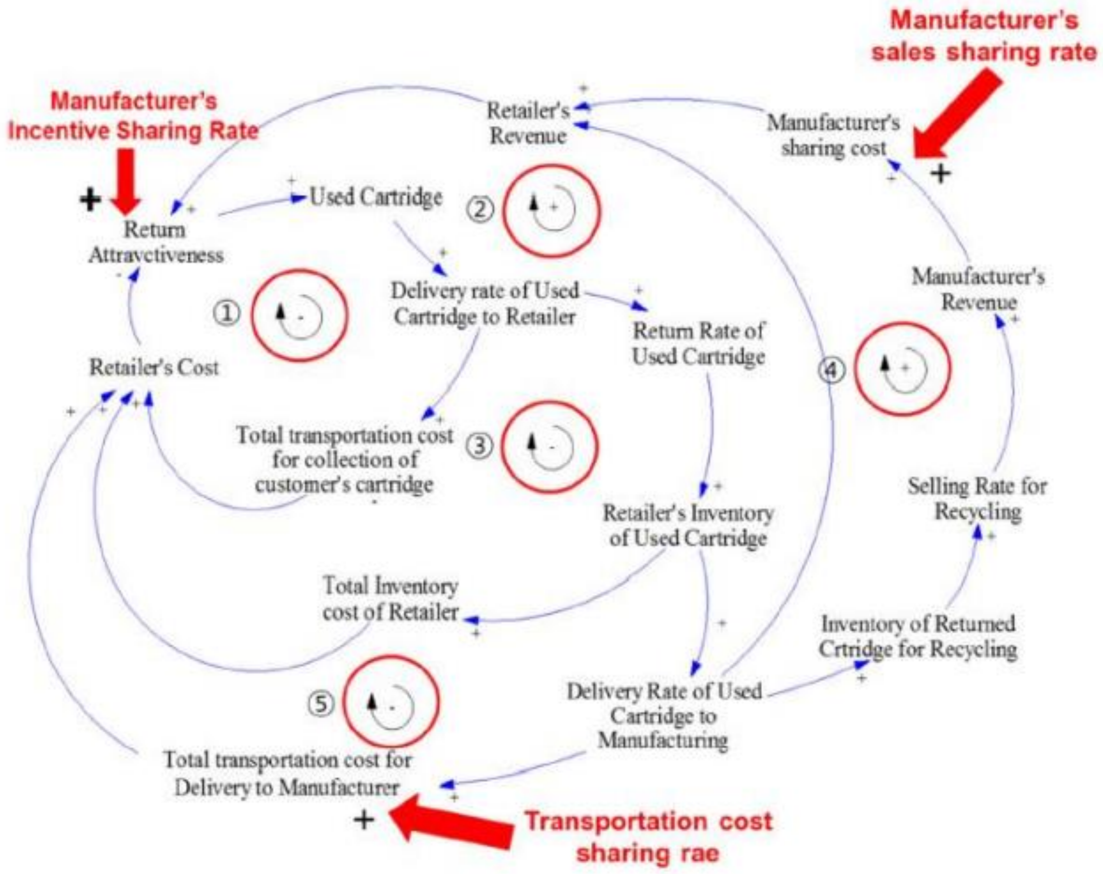
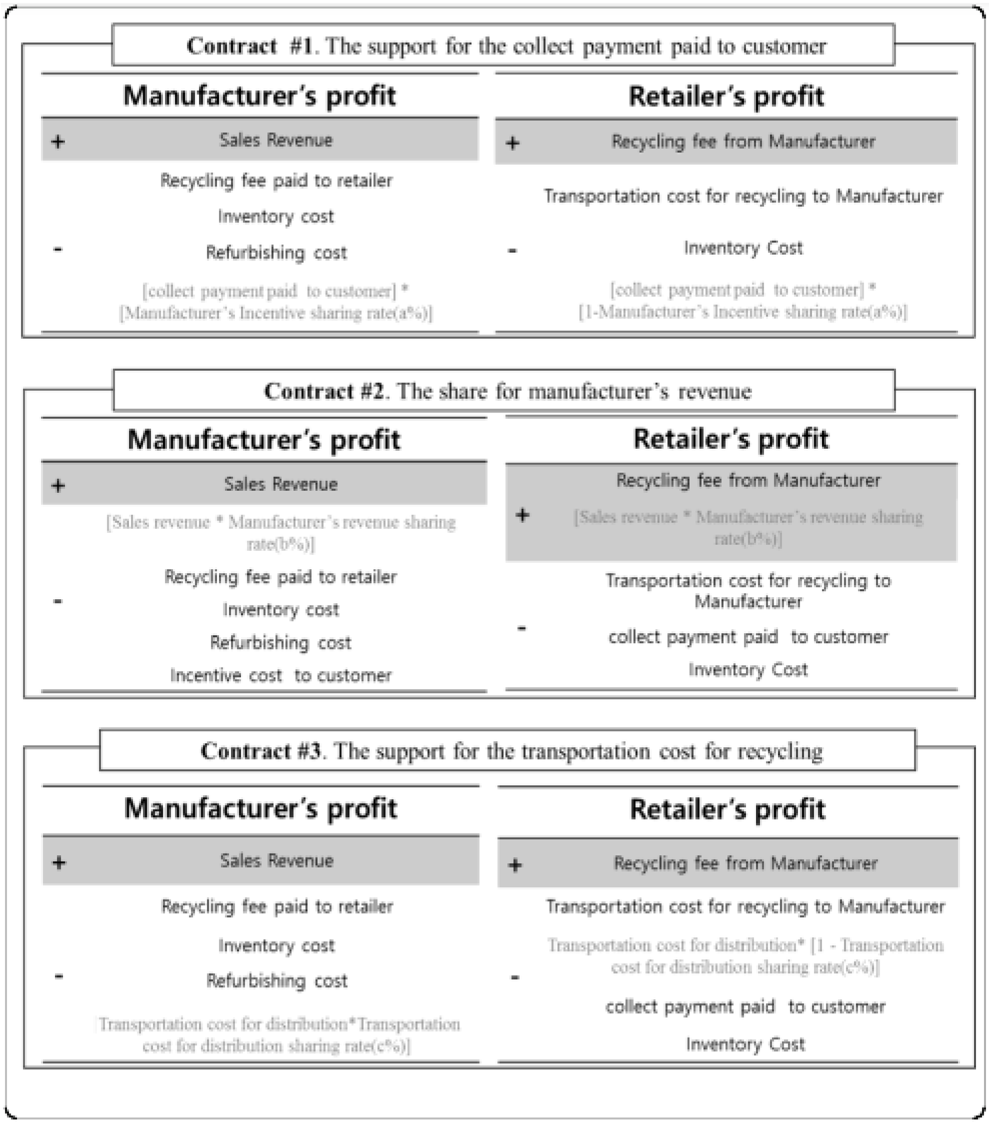


**Fig. 6** Change of profit structure by coordination strategies




*3.2 A framework of reverse supply chain model*

This study considered a reverse supply chain model in print cartridge industry. Figure 2 shows our model structure and flow between manufacturer and retailer.

We assumed that consumers who have used cartridge determine only whether to return or refill used cartridges into the retailer. Refilling payment usually is less expensive rather than buying new one. If consumers decided to return used cartridge to the retailer, retailer would offer collect payment to these customers. When a number of used cartridge collected by retailer are reached at certain quantity, she transport them to the manufacturer. She pays transportation cost for movement of collected cartridges. When used cartridges are delivered to manufacturer, he should pay a unit recycling fee to retailer. All used cartridges go through a sorting process, and based on their conditions, they will be either remanufactured or considered for recycling of their material contents and be resold them to customers (Mafakheri and Nasiri 2013). In this paper, for the simplicity, we assume that a retailer is not responsible for reselling of the remanufactured cartridges.

Figure 3 shows profit structure of retailer and manufacturer. The retailer cost is comprised of inventory cost, reward paid to customer for used cartridge and transportation cost. Her revenue is the recycling fee paid by manufacturer. The manufacturer's burden includes inventory costs, remanufacturing process costs, and recycling fee paid to the retailer. He creates revenue through sales for remanufactured and new cartridges.

Manufacturer would try to collect more used cartridges because remanufactured product can reduce manufacturing cost of raw material. Therefore, Manufacturer would propose contracts which are related to the financial support to retailer for increasing the profit.

**Table 2** Profit estimation under the decentralized reverse supply chain in step 1

| Decentralized Reverse Supply Chain | | | |
|---|---|---|---|
| **Retailer's profit ($)** | **Manufacturer's profit ($)** | **Total profit ($)** | **Return rate (Unit)** |
| 68,393 | 1,126,350 | 1,194,743 | 168,800 |

**Table 3** Profit estimation of coordinative strategy 1 (Incentive sharing)

| Coordinative Reverse Supply Chain (Incentive sharing) | | | | |
|---|---|---|---|---|
| **Incentive sharing rate** | **Retailer profit ($)** | **Manufacturer profit ($)** | **Total supply chain profit ($)** | **Return rate (Unit)** |
| 0% | 68,393 | 1,126,350 | 1,194,743 | 168,800 |
| 5% | 70,907 | 1,145,300 | 1,216,207 | 175,700 |
| 10% | 77,109 | 1,147,952 | 1,225,061 | 182,500 |
| 15% | 86,414 | 1,155,750 | 1,242,164 | 189,400 |
| 20% | 99,088 | 1,157,448 | 1,256,536 | 196,300 |
| 25% | 116,349 | 1,141,808 | 1,258,157 | 203,100 |
| 30% | 136,435 | 1,136,090 | 1,272,525 | 209,600 |
| 40% | 192,858 | 1,080,581 | 1,273,439 | 223,500 |
| 60% | 353,764 | 832,185 | 1,185,949 | 234,200 |
| 80% | 568,686 | 468,092 | 1,036,777 | 235,000 |
| 100% | 843,350 | 40,836 | 884,186 | 235,000 |

*3.3 Simulation model*

System dynamics model is used for analyzing coordination strategies in reverse supply chain as shown in Fig. 4. Table 1 shows used data of manufacturer and retailer in simulation model.

Customer's return attractiveness1) as key important factor is based on the refilling price, the new cartridge price and the retailer's collect payment. We assumed that the refilling price and the new cartridge price are fixed as a market price but, retailer's collect payment fluctuates.

Retailer's collect payment is determined as shown in Fig. 5. If retailer's unit profit is less than zero, retailer does not offer collect payment to customer. Otherwise, the maximum collect payment that retailer can offer to the customer, is calculated by new cartridge price minus refilling price. Therefore, if retailer's unit profit is less than maximum collect payment, she offers certain of her revenue to customer.

Therefore, customer return attractiveness would be 100% if retailer offers maximum collect payment to them. Otherwise, it will be the proportion that retailer's incentive is divided into maximum incentive.

**Table 4** Profit estimation of coordinative strategy 2 (Revenue sharing)

| Coordinative Reverse Supply Chain (Revenue sharing) | | | | |
|---|---|---|---|---|
| **Revenue Sharing** Rate | **Retailer profit** ($) | **Manufacturer profit** ($) | **Total supply chain profit** ($) | **Return rate** (Unit) |
| 0% | 68,393 | 1,126,350 | 1,194,743 | 168,800 |
| 3% | 79,784 | 1,150,740 | 1,230,524 | 180,800 |
| 5% | 88,467 | 1,152,200 | 1,240,667 | 188,600 |
| 7% | 97,468 | 1,160,760 | 1,258,228 | 196,400 |
| 10% | 109,826 | 1,157,150 | 1,266,976 | 208,300 |
| 13% | 125,956 | 1,155,800 | 1,281,756 | 220,000 |
| 15% | 137,348 | 1,145,250 | 1,282,598 | 227,300 |
| 17% | 169,685 | 1,111,500 | 1,281,185 | 230,600 |
| 20% | 238,497 | 1,051,350 | 1,289,847 | 233,000 |

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**Table 5** Profit estimation of coordinative strategy 3 (Transportation cost sharing)

| Coordinative Reverse Supply Chain (Transportation cost sharing) | | | | |
|---|---|---|---|---|
| Manufacturer's support to retailer's transportation cost | retailer profit ($) | manufacturer profit ($) | Total supply chain profit ($) | Return rate (Unit) |
| 0% | 68,393 | 1,126,350 | 1,194,743 | 168,800 |
| 20% | 72,350 | 1,127,892 | 1,200,242 | 171,100 |
| 40% | 72,304 | 1,137,444 | 1,209,748 | 173,500 |
| 60% | 72,990 | 1,162,050 | 1,235,040 | 175,800 |
| 80% | 76,396 | 1,175,856 | 1,252,252 | 178,200 |
| 100% | 77,868 | 1,198,200 | 1,276,068 | 180,300 |

## 4. OPEN-INNOVATION STRATEGIES CONSIDERED IN THIS STUDY

We consider three open-innovation corporative strategies that manufacturer can propose to retailer. First, manufacturer could support some of burdens that retailer should pay, such as collect payment paid to customer and transportation cost for distribution of used cartridge. Also, manufacturer can share a part of its revenue to encourage collection activity of retailer. Figure 6 shows structural variation of profit between manufacturer and retailer for three coordinative strategies. As support rate for three contracts change, Manufacturer's profit would reduce but, retailer's profit would increase as the rate.

Figure 7 shows a causal loop diagram of our reverse supply chain model. This diagram shows influencing relationship between variables in our model. Generally, a causal loop diagram is consisted of two feedback loop, one is reinforce feedback loop as represented shape of plus and the other is negative feedback loop. Our diagram has three negative feedback loops and two reinforce loops.

Each coordination strategy influences feedback loops. If incentive sharing strategy is conducted, this strategy will influence to all feed loops. If revenue sharing strategy is considered, this strategy will influence to number fours reinforce feed loop. If transportation cost sharing strategy is considered, this strategy will influence to number five negative feed loops.

**Table 6** Scope of sharing rate of coordination strategies

| Coordinative Reverse Supply Chain strategies | | |
|---|---|---|
| Incentive Sharing Rate | Revenue Sharing Rate | Transportation cost sharing rate |
| 0% ~ 30% | 0% ~ 15% | 0% ~ 100% |

**Table 7** Optimal sharing rate of coordination strategies based on collecting firm profit

| Coordinative Reverse Supply Chain | | | | | |
|---|---|---|---|---|---|
| Strategies | Optimal Rate | Collecting Firm Profit ($) | Manufacturer Profit ($) | Total Supply Chain Profit ($) | Return Rate (Unit) |
| Incentive Sharing Rate | 30% | 136,435 | 1,136,090 | 1,272,525 | 209,600 |
| Revenue Sharing Rate | 15% | 137,348 | 1,145,250 | 1,282,598 | 227,300 |
| Transportation cost sharing rate | 100% | 77,868 | 1,198,200 | 1,276,068 | 180,300 |

## 5. EXPERIMENT DESIGN AND RESULTS

Table 2 shows the results of step 1. In step 1, we found the individual profits of each of manufacture and retailer in decentralized reverse supply chain model. The profit of manufacturer and return rate of used artridges was $1,126,350 and 168,800 respectively.

Tables 3, 4 and 5 demonstrate experimental results for the profit change of when applying each of three types of contract.. In case of incentive sharing, the acceptable range of manufacturer was to 15%. This means that even if manufacturer share until 15% of customer incentive paid by retailer to customer, manufacture can expect higher profits over those of decentralized reverse supply chain (No incentive sharing).

In same way, experiments for two remaining contracts were also conducted. In case of revenue sharing, the allowance maximum level of manufacturer was to 30%. This means although manufacturer share until 30% of its own profit to retailer, manufacturer is able to get the higher profit over $1,126, 350, its own profit in decentralized reverse supply chain.

In case of manufacturer's support for transportation cost paid by retailer, manufacturer's allowance maximum level was all of costs. Even if manufacturer support all of transportation cost to retailer, he can expect $71,850 (1,198,200 – 1,126,350) over decentralized case. Table 6 shows the maximum allowance that manufacturer can provide its own profit to retailer by each of three contract strategies.

**Table 8** The partial adjustment of 15% revenue sharing under the agreement of two participants

| Manufacturer's Revenue Sharing Rate (15%) | | | | |
|---|---|---|---|---|
| **Adjustment rate** | **Collecting Firm Profit ($)** | **Manufacturer Profit ($)** | **Total Supply Chain Profit ($)** | **Return Rate (Unit)** |
| 0% | 137,348 | 1,145,250 | 1,282,598 | 227,300 |
| 1% | 133,089 | 1,149,040 | 1,282,129 | 226,300 |
| 2% | 127,598 | 1,147,420 | 1,275,018 | 224,900 |
| 3% | 128,412 | 1,151,010 | 1,279,422 | 223,400 |
| 4% | 126,618 | 1,149,110 | 1,275,728 | 221,700 |
| 5% | 126,593 | 1,152,500 | 1,279,093 | 220,300 |
| 6% | 123,124 | 1,150,320 | 1,273,444 | 218,800 |
| 7% | 124,031 | 1,153,510 | 1,277,541 | 217,300 |
| 8% | 121,596 | 1,160,350 | 1,281,946 | 215,800 |
| 9% | 120,791 | 1,154,040 | 1,274,831 | 214,300 |
| 10% | 118,958 | 1,160,600 | 1,279,558 | 212,800 |

In step 3, retailer will select the best that is highest of its own profits among above three contracts and its allowance maximum level proposed by manufacturer (see Table 7). From the results of experiment of step 3, he best contract was found that manufacturer share 15% of his revenue to retailer. In this case, the individual profits of manufacturer and retailers was $ 1,145, 250 and $ 137, 348, respectively and return rate also was 227,300.

Table 8 figures out the results of step 4 procedure. In step 4, it is explained that the partial adjustment of 15% revenue sharing under the agreement of two participants. As mentioned in explanation of research model, we considered base return fee as adjusting factor. As doing the smooth decrement of best return fee paid by manufacturer to collection, we captured the change of the total profit (manufacturer profits, plus retailer profit).

From the results of experiment, we finally demonstrate that the point of maximizing total profits was to retain the existing value of base return fee.

## 6. CONCLUSIONS

In this paper, we propose the detailed open-innovation strategic decision procedure between manufacturer and retailer. For that, we first reviewed three open-innovation strategies; (1) manufacturer's revenue sharing, (2) manufacturer's incentive supports that retailer pay to customer, (3) manufacturer's support of transportation cost paid by retailer.

We first tested whether open-innovation activity has a positive performance effects that decentralized environment by comparing the gap of profits in two case. From the results, to contract between two partners is superior to none between those. Also, in process of contracting between two partners, we finally found the best contract and its allowance maximum level. Above three contact methods, we demonstrate the best is revenue sharing that manufacturer share 15% of his profit to retailer in viewpoints of maximizing total profits. Our future research is follows; through the expansion of the current model, we additionally consider penalty costs from retailer. In current study, we assumed that retailer always can meet manufacturers expected profits after contracting with two partners. However, the sharing of revenue or cost support from manufacturer can be just possible that manufacturer achieve his expected profits through the increment of number of used cartridge returned by retailer. Thus, if retailer doesn‟t keep the promise of contract, manufacturer will require that collection should pay the penalty costs to manufacturer.

**Conflicts of interest:**

The authors declare that they have no conflicts of interests.

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