Print ISSN: 1738-3110 / Online ISSN 2093-7717
JDS website: http://www.jds.or.kr/
http://dx.doi.org/10.15722/jds.24.01.202401.95

Evaluating the Performance of Revenue Sharing Contract in Three Stage Supply Chain System

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Received: October 21, 2023. Revised: November 23, 2023. Accepted: January 05, 2024.

Abstract

Purpose: Focusing on the complex supply chain operations beyond the simple dyadic relationship, **t**his study evaluates the performance of the revenue sharing contract in three stage supply chain system. **Research design, data, and methodology:** The optimization model is developed to describe the supply chain system where one manufacturer, one wholesaler, and one retailer exist and pursue the maximum level of their own profits. In the numerical examples of the proposed supply chain model, two types of the revenue sharing contract, pairwise and spanning methods, are tested and their performances are compared with the traditional system. **Results:** The numerical analysis reveals that both types of the revenue sharing contract outperform the traditional system. All supply chain members can achieve the improved profits only when they determine the proper combination of revenue share ratios and price discount rates. **Conclusions:** This study finds out that both pairwise and spanning revenue sharing contracts can make the positive outcome that is acceptable to all members in three stage supply chain system. When the proper contract content is agreed among the supply chain members, the revenue sharing contract has the potential to be the practically feasible collaboration program for the multiple stage supply chain system.

Key words: Supply Chain Management, Revenue Sharing Contract, Supply Chain Collaboration, Optimization Model.

JEL Classifications: M11, M19, M21, M29

1. Introduction

The supply chain collaboration has been introduced to overcome the inefficiency inherent in almost every supply chain system and improve the supply chain operations in a way to optimize the system performance (Yan et al., 2017; Zhao et al., 2020). Various programs such as Vendor-Managed Inventory and Quick Response have been developed to coordinate the complex operational processes among individual business entities and accomplish the effective supply chain collaboration (Chow et al., 2012; Sari, 2008; Yao et al., 2007).

The revenue sharing contract has been frequently used in diverse business areas to resolve the common conflict between different companies that belong to the same supply chain system and ultimately realize the supply chain collaboration (Hu et al., 2017; Qin, 2008). Many academic researchers have paid heavy attentions to the revenue sharing contract due to its successful application to the real businesses (Altug & van Ryzin, 2014; Chen & Cheng, 2012). While the past studies address diverse issues regarding the

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revenue sharing contract, most of them focus on the simple dyadic relationship between two supply chain members (Becker-Peth & Thonemann, 2016; Heydari & Ghasemi, 2018; Rasay et al., 2015; Zheng et al., 2015).

The main purpose of this study is to evaluate the performance of the revenue sharing contract in three stage supply chain system. By assuming three stage supply chain structure as the background of the supply chain operations, this study pursues to recognize the genuine value of the revenue sharing contract in the realistic complex supply chain network beyond the dyadic relationship. Furthermore, this study considers two different methods for allocating the revenues to three supply chain members, and finds out how the revenue sharing contract should be managed to improve every supply chain member's profit as well as the whole supply chain profit.

The mathematical model is developed to describe the supply chain system where three members including the manufacturer, wholesaler, and retailer deal with the single product item to maximize their own profits. This study differentiates two types of the revenue sharing contract, which are the pairwise and spanning methods that have distinct ways to allocate the revenues to the supply chain members (van der Rhee et al., 2014; van der Rhee et al., 2010). By using the numerical examples, this study compares two types of the revenue sharing contract with the traditional system in terms of the supply chain profit.

The numerical examples show that both types of the revenue sharing contract can generate greater supply chain profit than the traditional system. In particular, the price discount results in the increased supply chain revenue due to the enlarged market demand. Meanwhile the price discount alone causes the manufacturer's profit loss and the revenue sharing contract becomes the practically feasible collaboration program only when the supply chain members share their revenues. Under either pairwise or spanning revenue sharing contract, every supply chain member can secure the improved profit when the contract content has the particular values of price discount rates and revenue share ratios. This result implies that the supply chain members need to agree on the proper contract content to achieve the successful outcome from the revenue sharing contract.

2. Research Background

The supply chain system found in most industries commonly possess the inevitable deficiency that prevents it from achieving the maximum output, since each individual supply chain members pursues his own profit. The double marginalization is one of the major issues in the field of the supply chain management and diverse supply chain contracts such as price discount contract, buy-back contract, and quantity-flexibility contract have been introduced to resolve this problematic phenomenon and collaborate the supply chain operations (Kumar & Haider, 2011; Sheu, 2011).

The revenue sharing contract is one of the supply chain contracts that are designed to realize the supply chain collaboration and it has been successfully implemented in various business areas including home video rental, fashion apparel, and food supply (Henry & Wernz, 2015; van der Veen & Venugopal, 2005; Xiao & Jin, 2011). According to the revenue sharing contract, the manufacturer or wholesaler receives a portion of the retailer's revenue and, in returns, the retailer purchases the product at the discounted price (Gui-xia et al., 2013; Hou et al., 2017; Hu et al., 2017).

Many academic researchers have studied about the revenue sharing contract and they address various relevant issues including its impact on the supply chain performance, environmental protection, reverse supply chain system, unstable market conditions, and combination with other collaboration programs (Bai et al., 2018; Govindan et al., 2012; Rasay & Mehrjerdi, 2017; Wang et al., 2017; Yao et al., 2008). While a large group of past studies support that the revenue sharing contract improves the supply chain performance and even it successfully coordinates the supply chain operations, most of them examine this contract in the simple supply chain system having only two echelons (Hua et al., 2011; Khouja et al., 2010; Raza, 2018; Vafa Arani et al., 2016). Due to the complex multiple stage supply chain structure found in most industries, the researchers would figure out the realistic nature of the revenue sharing contract only when they observe this contract applied to the intricate supply chain system made of more than two stages.

The limited number of past studies consider the application of the revenue sharing contract to the multiple stage supply chain system with more than two echelons and examine how this contract affects the supply chain performance. In general, most of them commonly conclude that the revenue sharing contract results in profit improvement and even successfully realizes the supply chain coordination. Giannoccaro and Pontrandolfo (2004) evaluate the performance of the revenue sharing contract in three stage supply chain system and focuses on the contract design that specifies the wholesale price and revenue share. Their study identifies the particular contract design that improves all supply chain members' outputs.

In the context of fresh agricultural product supply chain, Yan et al.'s study (2017) examines the mechanism for coordinating three level supply chain in Internet of Things. They develop the modified version of the revenue sharing contract by combining with cost sharing, and propose the optimal solution procedure to maximize the profit. The model analysis indicates that their proposed revenue sharing contract optimizes the supply chain profit through the supply chain coordination.

Hou et al.'s study (2017) evaluates the performance of the revenue sharing contract based on the leader-follower game model. According to their experiment on three echelon supply chain system, the revenue sharing contract leads to the supply chain coordination only in exceptional cases, while it improves the overall supply chain performance.

Rhee et al. (2010) considers two distinct ways to share the revenues and compare with decentralized and centralized decision making cases in their studies on the revenue sharing contract applied to four stage supply chain system. Their model analysis shows that the spanning revenue sharing contract results in the supply chain coordination that is the same outcome from the centralized situation. The numerical examples in another study also support that the spanning method not only coordinates the supply chain but also increase all supply chain members' profits (van der Rhee et al., 2014). While they point out the practical challenge for applying the pairwise revenue sharing contract to the real businesses, two different types of the revenue sharing contract are not directly compared in their study.

Different from most of the past studies assuming the simple supply chain system with two echelons, this study examines the revenue sharing contract in the multistage system including three supply chain members and focuses on their complex interactions beyond the dyadic relationship. In the numerical experiment, the pairwise and spanning methods are directly compared to find out more effective way to allocate the revenues to three supply chain members. Furthermore, by evaluating the effect of price discount rates and revenue share ratios, this study identifies the exact contract contents that result in the profit improvement for every supply chain member as well as the whole system.

3. Supply Chain Models

This study uses the numerical analysis on the supply chain models to examine how the revenue sharing contract performs in three stage supply chain system. The proposed mathematical model characterizes the supply chain system including with three members, which are one manufacturer, one wholesaler, and one retailer. The manufacturer produces one kind of commodity items and supplies them to the wholesaler. The wholesaler processes the products received from the manufacturer and fulfils the retailer's orders. Finally, the retailer purchases the products from the wholesaler and sells them to the retail market. Each individual supply chain member holds the inventory before he supplies the products to the next downstream stage as well as after he receives them from the upstream stage of the supply chain system.

This study differentiates two types of revenue sharing contract, which are the pairwise and spanning methods, and they are distinct ways to allocate the revenues to the supply chain members. The notations used in the proposed mathematical models are illustrated in Table 1.

Table 1: Notations in Mathematical Models

Manufacturer	Wholesaler	Retailer
π_M Profit	π_W Profit	π_R Profit
p_M Unit price	p_W Unit price	p_R Unit price
x_M Production rate	x_W Processing rate	q_R Order quantity
S_M Setup cost	q_W Oder quantity	O_R Ordering cost
α_M Unit inventory cost per price	S_W Setup cost	α_R Unit inventory holding cost per price
ν_M Unit production cost	α_W Unit inventory holding cost per price	D_R Retail market demand
τ_M Unit transportation cost per price	O_W Ordering cost	k_R Potential market size
	ν_W Unit processing cost	d_R Price sensitivity parameter
	τ_W Unit transportation cost per price	
μ_M Price discount rate	μ_W Price discount rate	
λ_M Revenue share ratio	λ_W Revenue share ratio	

3.1. Pairwise Revenue Sharing Contract

The first method to share the revenues is called as the pairwise revenue sharing contract and it employs the contracts made between every pair of adjacent members in the supply chain system. In three stage supply chain system that this study considers, two separate revenue sharing contracts are made between the supply chain members, one between the manufacturer and wholesaler and the other between the wholesaler and retailer. The following mathematical models indicate the optimization problem of three supply chain members.

$$\max_{p_M, x_M} \pi_M = \mu_M \cdot p_M \cdot x_W + \lambda_M \cdot (\mu_W \cdot p_W \cdot D_R + \lambda_W \cdot p_R \cdot D_R) - \frac{S_M \cdot x_W}{q_W} - \frac{\alpha_M \cdot \mu_M \cdot p_M \cdot q_W \cdot x_W}{2x_M} - \nu_M \cdot x_M - \tau_M \cdot \mu_M \cdot p_M \cdot x_W \quad (1)$$

$$\max_{p_W, x_W, q_W} \pi_W = (1 - \lambda_M) \cdot (\mu_W \cdot p_W \cdot D_R + \lambda_W \cdot p_R \cdot D_R) - \mu_M \cdot p_M \cdot x_W - \frac{O_W \cdot x_W}{q_W} - \frac{\alpha_W \cdot \mu_M \cdot p_M \cdot q_W}{2} - \frac{S_W \cdot D_R}{q_R} - \frac{\alpha_W \cdot \mu_W \cdot p_W \cdot q_R \cdot D_R}{2 \cdot x_W} - \nu_W \cdot x_W - \tau_W \cdot \mu_W \cdot p_W \cdot D_R \quad (2)$$

$$\max_{p_R, q_R} \quad \pi_R = (1-\lambda_W)\cdot p_R \cdot D_R - \mu_W \cdot p_W \cdot D_R - \frac{O_R \cdot D_R}{q_R} - \frac{\alpha_R \cdot \mu_W \cdot p_W \cdot q_R}{2} \tag{3}$$

Equation (1) describes the manufacturer's problem to maximize his profit (π_M) by determining his price (p_M) and production rate (x_M) under the pairwise revenue sharing contract. The manufacturer's profit contains the revenue from his sales to the wholesaler, the shared portion of wholesaler's revenue, setup cost, inventory holding cost, production cost, and transportation cost. The joint economic lot size model is used to represent the inventory policy in the proposed supply chain models (Banerjee, 1986). Under the assumption that the inventory holding cost and transportation cost are dependent on the product value, the unit inventory holding cost ($\alpha_M \cdot p_M$) and unit transportation cost ($\tau_M \cdot p_M$) are proportional to the price.

In Equation (2), the wholesaler's problem is to decide his price (p_W), processing rate (x_W), and order quantity (q_W) in a way to maximize his profit (π_W). The wholesaler's profit consists of his portion of sales and shared revenues, purchasing cost, ordering cost, cost of holding inventories before processing, setup cost, cost of holding inventories after processing, processing and transportation cost. The unit inventory holding costs ($\alpha_W \cdot p_M$ and $\alpha_W \cdot p_W$) and unit transportation cost ($\tau_W \cdot p_W$) still depend on the price.

The retailer's problem is illustrated in Equation (3) and he determines his price (p_R) and lot size (q_R) to maximize his profit (π_R). The retailer's profit is comprised of his portion of sales revenue, purchasing cost, ordering cost, and inventory holding cost.

The pairwise revenue sharing contract installs two contracts between the supply chain members. The first revenue sharing contract is made between the manufacturer and wholesaler, and the manufacturer receives the portion of the wholesaler's revenue ($\lambda_M \cdot (\mu_W \cdot p_W \cdot D_R + \lambda_W \cdot p_R \cdot D_R)$). The manufacturer responds to the wholesaler's revenue sharing and provides the price discount to the wholesaler ($\mu_M \cdot p_M \cdot x_W$). According to the second revenue sharing contract made between the wholesaler and retailer, the wholesaler takes the part of the retailer's revenue ($\lambda_W \cdot p_R \cdot D_R$) and, in return, the retailer gets the price discount from the wholesaler ($\mu_W \cdot p_W \cdot D_R$).

3.2. Spanning Revenue Sharing Contract

Under the second method to share the revenues, every supply chain member involves in the single revenue sharing contract, which is represented as the spanning revenue sharing contract. In three stage supply chain system, the retailer's revenue is shared by both manufacturer and wholesaler. The following equations indicate three supply chain members' problems under the spanning revenue sharing contract.

$$\max_{p_M, x_M} \quad \pi_M = \mu_M \cdot p_M \cdot x_W + \lambda_M \cdot p_R \cdot D_R - \frac{S_M \cdot x_W}{q_W} - \frac{\alpha_M \cdot \mu_M \cdot p_M \cdot q_W \cdot x_W}{2x_M} - \nu_M \cdot x_M - \tau_M \cdot \mu_M \cdot p_M \cdot x_W \tag{4}$$

$$\max_{p_W, x_W, q_W} \quad \pi_W = \mu_W \cdot p_W \cdot D_R + \lambda_W \cdot p_R \cdot D_R - \mu_M \cdot p_M \cdot x_W - \frac{O_W \cdot x_W}{q_W} - \frac{\alpha_W \cdot \mu_M \cdot p_M \cdot q_W}{2} - \frac{S_W \cdot D_R}{q_R} - \frac{\alpha_W \cdot \mu_W \cdot p_W \cdot q_R \cdot D_R}{2 \cdot x_W} - \nu_W \cdot x_W - \tau_W \cdot \mu_W \cdot p_W \cdot D_R \tag{5}$$

$$\max_{p_R, q_R} \quad \pi_R = (1-\lambda_M-\lambda_W)\cdot p_R \cdot D_R - \mu_W \cdot p_W \cdot D_R - \frac{O_R \cdot D_R}{q_R} - \frac{\alpha_R \cdot \mu_W \cdot p_W \cdot q_R}{2} \tag{6}$$

The individual supply chain member's decisions and profits appeared in Equations (4), (5), and (6) are identical to the ones of the pairwise revenue sharing contract. Meanwhile, according to the spanning revenue sharing contract, the retailer gives the portions of his revenue to the manufacturer ($\lambda_M \cdot p_R \cdot D_R$) as well as the wholesaler ($\lambda_W \cdot p_R \cdot D_R$). In returns, the retailer receives the price discount from the wholesaler ($\mu_W \cdot p_W \cdot D_R$), once the manufacturer lowers his price for the sake of the wholesaler ($\mu_M \cdot p_M \cdot x_W$).

4. Numerical Experiment

This study conducts the numerical experiment to evaluate the performance of the revenue sharing contract in three stage supply chain system. In the numerical examples of the proposed supply chain model, six parameters have five different values, and the altered parameters include the potential market size, setup cost, ordering cost, unit inventory holding cost per price, unit production cost, and unit transportation cost per price. The total number of cases in the numerical experiment is 15,625 (5^6=15,625), and the output measurements are averaged out. Table 2 shows the values of the parameters used in the base case.

Table 2: Parameters in Base Case

Parameters			
S_M = 70	α_M = 0.02	ν_M = 4	τ_M = 0.02
S_W = 55	α_W = 0.03	ν_W = 2	τ_W = 0.03
O_W = 70	α_R = 0.04	k_R = 2,000	d_R = 6
O_R = 90			

In the numerical experiment, the economic performances of the revenue sharing contract are measured and they include the whole supply chain profit as well as the individual member's profits. To solve the optimization problems in the numerical examples, this study uses MATAB R2003b computer software.

4.1. Impacts of Revenue Share Ratio and Wholesale Price Discount Rate

In the numerical experiments, this study evaluates the supply chain performance when the revenue sharing contract has the different contract content. As the contract content, the combination of revenue share ratios and price discount rates (μ_M, μ_W, λ_M, λ_W) are altered, and the supply chain profit and individual members' profits are monitored. Table 3 shows the list of cases that the pairwise revenue sharing contract is acceptable to all three supply chain members because their profits are greater than in the traditional system. The numerical examples indicate that only a few combinations of revenue share ratios and price discount rates enable the pairwise revenue sharing contract to increase all three supply chain members' profits compared with the traditional system (5 cases out of 256).

In Table 4, the list describes the cases that every supply chain member obtains greater profit under the spanning revenue sharing contracts than in the traditional system. Even in the spanning revenue sharing contract, only the specific contract contents make greater profits for all three members than the traditional system (8 cases out of 256).

Table 3: Pairwise Revenue Sharing Contracts Acceptable to Every Member

$(\mu_M, \mu_W, \lambda_M, \lambda_W)$	Manufacturer's Profit	Wholesaler's Profit	Retailer's Profit	Supply Chain Profit
(0.90, 0.85, 0.10, 0.05)	48,159.74	28,107.49	44,753.59	121,020.82
(1.00, 0.85, 0.05, 0.05)	48,027.36	28,202.49	43,591.45	119,821.30
(0.85, 0.85, 0.10, 0.10)	48,129.40	30,643.72	40,841.01	119,614.13
(0.85, 0.90, 0.10, 0.05)	47,839.34	28,503.59	42,840.78	119,183.71
(0.90, 0.90, 0.10, 0.05)	48,529.18	27,852.80	41,548.67	117,930.65

Table 4: Spanning Revenue Sharing Contracts Acceptable to Every Member

$(\mu_M, \mu_W, \lambda_M, \lambda_W)$	Manufacturer's Profit	Wholesaler's Profit	Retailer's Profit	Supply Chain Profit
(0.90, 0.85, 0.05, 0.00)	46,881.32	29,259.31	45,956.69	122,097.32
(0.95, 0.85, 0.05, 0.00)	48,528.46	27,679.01	44,688.11	120,895.57
(0.85, 0.85, 0.05, 0.05)	47,451.12	31,248.60	41,958.00	120,657.72
(0.85, 0.90, 0.05, 0.00)	47,382.94	28,831.63	44,024.15	120,238.72
(0.90, 0.85, 0.05, 0.05)	48,264.01	30,442.92	40,784.41	119,491.35
(0.90, 0.90, 0.05, 0.00)	48,189.28	28,090.31	42,783.29	119,062.88
(0.95, 0.90, 0.05, 0.00)	48,810.36	27,504.65	41,559.90	117,874.91
(0.85, 0.95, 0.05, 0.00)	48,736.90	27,470.07	40,917.59	117,124.56

4.2. Comparison between Revenue Sharing Contract and Traditional System

This study conducts the further analysis on the numerical examples to compare the revenue sharing contract with the traditional system. Table 5 shows the detailed outcomes obtained from the direct comparison of different supply chain systems. In Table 5, the first supply chain system indicates the traditional system without price discount and revenue sharing.

In the second supply chain system ('Revenue Sharing w/ Maximum SC Profit'), the revenue sharing contract attains the greatest supply chain profit among every combination of price discount rates and revenue share ratios considered in the numerical experiment. When no revenue is shared at all (λ_M= 0.00, λ_W= 0.00), the pairwise and spanning revenue sharing contracts makes the same profits for all three supply chain members. With the maximal possible price discount rates in the numerical examples (μ_M = 0.85, μ_W = 0.85), both pairwise and spanning revenue sharing contracts generate the biggest supply chain profit. This case results in the greater supply chain profit than the traditional system, because of the demand increase and cost savings. Compared with the traditional system, the revenue sharing contract lowers the prices in all three stages and then the decreased prices enlarge total throughput of the entire supply chain system including the retail market demand. Since the inventory holding cost and transportation cost are dependent on the price, the decreased prices also lead to cost savings. Under this type of the revenue sharing contract, however, the manufacturer gets less profit than he does in the traditional system, even though the wholesaler and retailer increase their profits.

'Pairwise Revenue Sharing' in Table 5 represents the case that the pairwise revenue sharing contract obtains the greatest supply chain profit while every supply chain member makes higher profit than he does in the traditional system. The pairwise revenue sharing contract with this particular combination of price discount rates and revenue share ratios has lower prices and higher demands than the previous case. While higher prices let the pairwise revenue sharing contract acquire less supply chain profit than the case of the maximum supply chain profit, it results in greater profit for all three supply chain members by making them share their revenues.

Table 5: Performances of Different Supply Chain Systems

	Traditional	Revenue Sharing w/ Maximum SC Profit	Pairwise Revenue Sharing	Spanning Revenue Sharing
$(\mu_M, \mu_W, \lambda_M, \lambda_W)$	(1.00, 1.00, 0.00, 0.00)	(0.85, 0.85, 0.00, 0.00)	(0.90, 0.85, 0.10, 0.05)	(0.90, 0.85, 0.05, 0.00)
Market demand	494.92	569.63	532.65	539.70
Manufacturer				
Price	92.05	78.55	82.86	82.94
Production Rate	879.53	875.91	879.36	878.48
Setup Cost	291.74	275.14	272.96	270.06
Inventory Holding Cost	78.11	73.61	68.17	70.99
Production Cost	3,515.56	3,500.63	3,514.87	3,511.21
Transportation Cost	1,033.72	899.06	886.63	899.88
Total Cost	4,919.13	4,748.43	4,742.62	4,752.14
Revenue	51,778.68	44,976.31	52,902.36	51,633.46
Profit	46,859.55	40,227.88	48,159.74	46,881.32
Wholesaler				
Price	167.58	142.78	147.29	145.07
Order Quantity	134.34	145.08	136.74	140.15
Processing Rate	559.35	569.63	532.65	540.15
Purchasing Cost	51,778.68	44,976.31	44,363.08	45,033.82
Ordering Cost	291.74	275.13	272.95	270.06
Inventory Holding Cost (Before Processing)	184.65	170.16	169.18	173.57
Setup Cost	236.52	234.22	230.04	229.80
Inventory Holding Cost (After Processing)	255.84	286.32	281.20	280.68
Processing Cost	1,115.56	1,138.08	1,064.03	1,078.72
Transportation Cost	2,500.55	2,452.70	2,365.61	2,360.79
Total Cost	56,363.55	49,532.93	48,746.09	49,427.44
Revenue	83,352.73	81,746.30	76,853.59	78,686.74
Profit	26,989.19	32,213.36	28,107.49	29,259.31
Retailer				
Price	250.85	238.39	244.56	243.38
Order Quantity	115.44	134.17	127.74	129.57
Purchasing Cost	83,352.73	81,746.30	78,848.02	78,686.74
Ordering Cost	385.83	382.08	375.25	374.87
Inventory Holding Cost	385.83	382.08	375.25	374.87
Total Cost	84,124.40	82,510.46	79,598.53	79,436.48
Revenue	124,747.48	136,461.15	124,352.12	125,393.17
Profit	40,623.08	53,950.69	44,753.59	45,956.69
Supply Chain System				
Cost	145,407.07	136,791.83	133,087.25	133,616.06
Revenue	259,878.89	263,183.76	254,108.07	255,713.37
Profit	114,471.82	126,391.93	121,020.82	122,097.32

The case of the spanning revenue sharing contract shows the outcomes that are similar to the case of the pairwise revenue sharing contract. While the numerical experiment shows that the spanning revenue sharing contract results in higher supply chain profit than the pairwise revenue sharing contract, the difference is insignificant. According to Table 5, 'Spanning Revenue Sharing' indicates the case that the spanning revenue sharing contract makes the greatest supply chain profit while every supply chain member's profit is bigger than in the traditional system. In this case, the supply chain profit is less than the one in 'Revenue Sharing w/ Maximum SC Profit', but the spanning revenue sharing contract improves all three supply chain members' profits compared with the traditional system. The spanning revenue sharing contract outperforms the traditional system because of the reduced cost rather than the increased revenue. Just like the pairwise revenue sharing contract, the spanning revenue sharing contract properly allocates the revenues to the supply chain members and makes them have higher profits than in the traditional system.

5. Managerial Implications

This study examines the impact of the revenue sharing contract on the performance of three stage supply chain system. The optimization model is developed to denote the supply chain system where a manufacturer, a wholesaler, and a retailer trade one type of products. The numerical experiment of the proposed supply chain model is conducted to compare two different types of the revenue sharing contracts with the traditional system. The numerical analysis on the revenue sharing contracts reveals the following significant outcomes and they provide the business practitioners with the valuable managerial guidelines.

First, the price discount offered by every member contributes to the increased supply chain profit. The numerical experiment indicates that the supply chain system obtains the biggest profit when the price discounts are employed to the utmost limit in every stage. The reduced prices enlarge the total throughput of the whole supply chain system and consequently result in the increased revenue. By implication, to improve the supply chain profit, all the supply chain members should focus on increasing the total throughput of the entire supply chain system by discounting their prices.

Second, the price discounts without sharing any revenues fail to secure the increased profit for every supply chain member. According to the numerical examples, the supply chain members obtain unequally distributed profits when they do not share their revenues at all. Even when the price discount enlarges the market demand, not every supply chain member gets the benefit from the increased supply chain profit. In three stage supply chain system, in particular, the manufacturer sacrifices his profit without receiving the revenues from other members and he would not agree to accept this contract. This outcome implies that the revenue sharing contract becomes the practically feasible supply chain collaboration program that is acceptable to every supply chain member only when it equips with revenue sharing as well as price discount.

Finally, both pairwise and spanning revenue sharing contracts can make the significant profit improvement for every supply chain member, when the price discount rates and revenue share ratios are properly determined. The numerical experiment reveals that the pairwise and spanning revenue sharing contracts allow all three supply chain members to achieve greater profits than in the traditional system. Meanwhile, this study finds out only the specific combinations of price discount rates and revenue share ratios result in the profit improvement for all supply chain members. This outcome is consistent with the past study identifying that the specific contract design generates the win-win condition for every supply chain member (Giannoccaro & Pontrandolfo, 2004). In the comparison between two different types of the revenue sharing contracts, this study observes that the spanning method generates higher supply chain than the pairwise one, but their difference is minimal. This result emphasizes the importance of having the right contract content when the revenue sharing contract is applied to the supply chain system. Under either pairwise or spanning revenue sharing contract, the supply chain members should carefully agree on the discounted prices and revenue shares to increase their own profits as well as the whole supply chain profit.

6. Conclusion

The revenue sharing contract has attracted widespread interests from both academic researchers and business practitioners who pursue the improvement of the supply chain operations. In particular, the recent movement in the field of the supply chain management indicates that the revenue sharing contract has been implemented to the diverse industries to coordinate the supply chain operations and many researchers evaluate its performance. Meanwhile, most of the past studies examine the revenue sharing contract in the simple context of two-stage supply chain system.

This study evaluates the performance of the revenue sharing contract in three-stage supply chain system. The optimization models are developed to describe the supply chain system where one manufacturer, one wholesaler and one retailer trade one kind of products for maximizing their own profits. Two types of the revenue sharing contracts, which are different in the way to allocate the shared revenues, are tested in the numerical examples of the proposed supply chain models. By monitoring the implementation on three-stage supply chain system, this study intends to find out how the revenue sharing contract performs under the complicated supply chain structure beyond the dyadic relationship.

The numerical analysis sheds light on the significant findings regarding the revenue sharing contract as the supply chain collaboration program and they imply the valuable managerial guidance for the business practitioners.

First, the price discount offered by the supply chain members becomes the effective tool for improving the entire supply chain profit. The lower price caused by the price discount in every stage of the supply chain system leads to larger market demand and the supply chain system consequently achieves greater revenue. This result implies that all the supply chain members should offer the price discounts to enlarge the throughput of the entire supply chain system when they use the revenue sharing contract to increase the supply chain profit.

Second, sharing revenues is definitely required for the supply chain contract to be acceptable to every supply chain member. The numerical analysis reveals that the manufacturer sacrifices his profit without revenue sharing. In the case that the prices are discounted and no revenue is shared among the supply chain members, the supply chain system attains the greatest profit but the manufacturer loses his profit. Only when every supply chain member secures the profitable outcome by sharing revenues, they are willing to participate in the revenue sharing contract and it becomes the practically feasible supply chain collaboration program.

Lastly, the supply chain members should carefully determine the contract contents about price discount rates and revenue share ratios to obtain the benefit from the revenue sharing contract. According to the numerical examples, both pairwise and spanning revenue sharing contracts increase every supply chain member's profit only when the contract content has the specific values of price discount rates and revenue share ratios. This result indicates that the supply chain members need to agree on the appropriate contract contents to receive the positive outcome that they expect from the revenue sharing contract.

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