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Consideration of a buyback contract model that features game-leading marketing strategies

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ABSTRACT

Enterprises will sacrifice profits for market shares. For this reason, the make-to-stock upstream expects the downstream to order more. The paper argues the game leader sales-oriented upstream, motivating downstream make no shortage, and attempts to execute a buyback contract to reach realistic decisions. In this article, we research a supplier that is a sales-oriented leader and a retailer that is a profit-oriented follower. The retailer is required to order more than its optimal quantity. The primary analysis emphasizes either enhancing the buyback price or reducing the wholesale price. In the results, the buyback contract parameters are limited by both the sales-oriented supplier's retained earnings and the distribution of market demand. Numerical examples are given to illustrate contract parameters that affect the supply chain coordination, the order quantity of the retailer and the profit of the supply chain. The previous buyback contract literature assumes not only that the supplier and retailer are profit oriented but also that they achieve both supply-chain coordination and Pareto optimality. However, the paper discusses the parameters of the buyback contract when the supplier is sales oriented.

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1. Introduction

The making new products in many ways have done jobs. Exactly, the motor vehicle manufacturers have released new products whose functionality and service are higher than ever before due to the trend of motor vehicles purchase quota policy in China. Even the oligopolies have not hesitated to sacrifice profits to increase sales and grab market share. Hence, the marketing strategy would pull the production manufacture. Chen et al. [1] research has shown that a Website infomediary provides retailers with a demand-referral service and customers with incentive rebates. Studies have also examined rebate sensitivity and market share in the context of which policies are optimal to achieve an integrated supply chain. The importance of market share is widely recognized. Pasternack [2] study a buyback contract is one in which the supplier charges a retailer the wholesale price before the selling season and then buys back any unsold products at a buyback price at the end of selling season. Essentially, a buyback contract motivates retailers to order more. Cachon [3] points to a comparative study of classic supply-chain contracts shows that under certain circumstances, a buyback contract is equal to a revenue-sharing contact. He et al. [4], this paper investigates the revenue-sharing contract in supply chains with a sales-oriented supplier, examining both supply-chain collaboration solutions and the Pareto improvement between the supplier and the retailer when the quantity of a retailer's order falls

within a certain range. In addition, it asks whether the classic buyback contract is a solution when a supplier is a game leader that is sales oriented.

The research presents the buyback contract as a return policy pursuant to which the supplier buys back any unsold products at the end of the contract period. In this scenario, the retailer orders an optimal quantity. Lee et al. [5] research the buyback price (or the price subsidy) is used to solve technical problems that lead to a decrease in a product's market price pursuant to reach on price protection in the information technology (IT) industry that discusses these problems. Yan and Huang [6], those researchers discuss the return problem in the electronics market. The solution is for the retailer to sell the unsold products online and then to deduce the optimal order quantities using both the traditional market and the electronic market. Ding and Chen [7] focus on situations in which an appropriate return policy coordinates a three-echelon supply chain, whose members will fully distribute its profit. Cai et al. [8] investigate a specific buyback contract in which the supplier subsidizes the retailer's inventory and the retailer's order quantities exceed the supplier's objective.

Traditionally, the supply-chain contracting literature has focused on aligning economically rational players' incentives. Additionally, the buyback contract research assumes that both suppliers and retailers are not only profit oriented but also achieve both supply-chain coordination and Pareto optimality. In reality, Loch and Wu [9], a portion of the research is distinct from economic incentives, providing experimental evidence that human behaviour affects economic decision making in supply-chain performance. More importantly, supply-chain parties deviate from the predictions of self-interested profit-maximization models. One study, Ho et al. [10] consider how fairness influenced economic outcomes in a supply chain and designed the supply chain contract. In another, Lin and Hou [11], empirical theoretical feedback uncovers the cause of failed buyback contract coordination by analyzing the correlation between wholesale price and buyback price. More recently, Zhang et al. [12] research has considered the loss-averse supplier and how to establish a critical ratio between buyback contracts and share revenue contracts. Another study, Sluis and Giovanni [13] provide an empirical contribution on the subject of coordination with contracts, which has turned out to be primarily based on game theory. In this paper, the supplier has greater motivation to incentivize the retailer to order more than his optimal quantity. The results show the buyback contract parameters how to adjust. A notational system is presented in section 2; the buyback contract with profit-oriented suppliers, realized supply-chain coordination (Chen et al.) [14] and Pareto optimality (Ding et al.) [15] are discussed in section 3; sales-oriented suppliers' buyback-contract strategies are discussed in section 4; numerical examples illustrate the two types of strategies in section 5; and a summary and future research are presented in section 6.

2. Notational systems

This paper assumes the supplier is the leader and the retailer is the follower in a two-echelon supply chain playing the Stackelberg game. The market demand is stochastic x, the density function $f(x)$ and cumulative distribution function $F(x)$, $F(x)$ is a monotone continuous increasing function, and has first derivative $F(0) = 0$. The list of variables below describes this article's notations. And $P(q) = \int_0^q xf(x)dx + \int_q^\infty qf(x)dx$, $I(q) = \int_0^q (q-x)f(x)dx$, $L(q) = \int_q^\infty (x-q)f(x)dx$.

q_1 (q_2) – The order quantity of the profit-oriented (sales-oriented) retailer
w_1 (w_2) – The wholesale per unit of the profit-oriented (sales-oriented) supplier
b_1 (b_2) – The buyback price per unit of the profit-oriented (sales-oriented) supplier
p – The market price per unit of product
c – The supplier's marginal cost per unit
g – The retailer's shortage cost per unit
v – The retailer's salvage value of unsold product
$P(q)$ – The sales quantity

$I(q)$ – The unsold quantity
$L(q)$ – The shortage quantity
$Pr()$ – Probability function

3. Profit-oriented supplier strategies

Because the supplier is profit oriented and strives for maximum profit, the supplier provides the set of buyback contract parameters (w_1, b_1) to the retailer. Here (w_1, b_1) are the wholesale and buyback price per unit of the profit-oriented supplier. The retailer's order quantity is according to the contract parameters above. Then, the expected profits of supplier and retailer are $E\pi_{s1}(q; w_1, b_1)$ and $E\pi_{r1}(q; w_1, b_1)$:

$$E\pi_{s1}(q; w_1, b_1) = (w_1 - c)q - b_1 I(q) \tag{1}$$

$$E\pi_{r1}(q; w_1, b_1) = pP(q) + (b_1 + v)I(q) - gL(q) - w_1 q \tag{2}$$

$P(q)$ are the expected sales; $I(q)$ are the expected total unsold products; and $L(q)$ are the expected shortages.

According to the formula $\frac{\partial \pi_{r1}}{\partial w_1} < 0$, the retailer's profit increases when the wholesale price decreases. When the wholesale price approaches the product cost, the expected profit of retailer, $E\pi_{r1}$, is amended by the other formula, $E\pi(q)$:

$$E\pi(q) = pP(q) + vI(q) - gL(q) - cq \tag{3}$$

Eq. 3 is the optimal profit of the centralized supply chain. Plug these equations into Eq. 1 and Eq. 2, derivative with q and get the optimal order quantity of retailer q_1 and centralized supply chain q^* is satisfied with equations $F(q_1) = \frac{p+g-w_1}{p+g-(b_1+v)}$ and $F(q) = \frac{p+g-w}{p+g-c}$, respectively. The contract parameters are discussed in the context of $F(q_1)$and $F(q)$. If $b_1 = b(w_1)$, which is the buyback price, is a function of the wholesale price, then $q_1 = q^*$. Plug $b(w_1) = \frac{(w_1-c)(p+g-w)}{p+g-c}$ into $E\pi_{s1}(q; w_1, b_1)$ and $E\pi_{r1}(q; w_1, b_1)$, simplify them, just get: $E\pi_{r1}(q; w_1, b_1) = \gamma(E\pi(q^*) + g\mu) - g\mu$; $E\pi_{s1}(q; w_1, b_1) = (1-\gamma)(E\pi(q^*) + g\mu)$.

Let the parameter γ be $\gamma = \frac{p+g-w_1}{p+g-c}$. Given $w_1 > c$, then$\gamma \in (0,1)$, thus the supply chain would be coordinated by the buyback contract with the profit-oriented supplier.

4. Sales-oriented supplier strategies

Because the supplier who strives for maximum sales quantity is sales oriented, it provides the set of buyback contract parameters(w_2, b_2) to the retailer. Here (w_2, b_2) are the sales-oriented supplier's wholesale and buyback prices per unit. The retailer's order quantity is according to the contract parameters set forth above. Then, the expected profits of supplier and retailer are $E\pi_{s2}(q; w_2, b_2)$ and $E\pi_{r2}(q; w_2, b_2)$:

$$E\pi_{s2}(q; w_2, b_2) = (w_2 - c)q - b_2 I(q) \tag{4}$$

$$E\pi_{r1}(q; w_2, b_2) = pP(q) + (b_2 + v)I(q) - gL(q) - w_2 q \tag{5}$$

From the first-order optimal condition of Eq. 5, the optimal order quantity of retailer q_2 is satisfied with:

$$F(q_2) = \frac{p + g - w_2}{p + g - (b_2 + v)} \tag{6}$$

4.1 Maintain the wholesale price and increase the buyback price

In chapter 3, the retailer's optimal order quantity is the centralized supply chain's optimal product when the buyback parameters are $b(w_1) = \frac{(w_1-c)(p+g-w)}{p+g-c}$. The centralized supply chain's

optimal product means that reach supply chain's Pareto optimality. However, the sales-oriented supplier expects maximum sales quantity and minimum (or even no) shortage. Then, the sales-oriented supplier proposes a new incentive contract and requires the retailer's order quantity $q_2 \in (q^*, \hat{q})$. Moreover, $\hat{q}$ makes $\mathrm{L}(\hat{q}) = 0$. Compare $F(q_1)$ and $F(q_2)$ when the sales-oriented supplier would regulate the contract parameters to realize $q_2 \in (q^*, \hat{q})$: one is the buyback price increasing, the other is the wholesale price decreasing.

When the buyback price increases, the contract parameters (w_2, b_2) are satisfied with the following conditions: $(w_2 = w_1, b_2 > b(w_1))$ to build the model P.

$$P: \max_{b_2} F^{-1}\left(\frac{p+g-w_1}{p+g-(b_2+v)}\right) \tag{7}$$

$$s.t.\begin{cases} E\pi_{s2}(q^*; w_2, b_2) \geq E\overline{\pi_{s2}} & (8) \\ E\pi_{r2}(\mathrm{q}; w_2, b_2) \geq E\pi_{r1}(q^*; w_1, b_1) & (9) \\ q \in (q^*, \hat{q}) & (10) \end{cases}$$

Following is a further discussion of this model. The sales-oriented supplier has a higher amount of current revenue when the wholesale price is increased. The inventory cost would also be transferred because the retailer is expected to order products in excess of his optimal order quantity. The next problem is whether the retailer is motivated to pay more.

4.2 Decrease the wholesale price and maintain the buyback price

The supplier's strategy, which remains unchanged with regard to the wholesale price and establishes a higher buyback price, must be confronted with the retailer's capital constraint before the selling season. If the retailer has no financing, the contract will not motivate it to participate. Following is a discussion of another supplier's strategy in that case.

Model

When the wholesale price decreases, the contract parameters (w_2, b_2) are satisfied with the conditions: $(w_2 < w_1, b_2 = b(w_1))$to build the model P'.

$$P': \max_{w_2} F^{-1}\left(\frac{p+g-w_1}{p+g-(b_2+v)}\right) \tag{11}$$

$$s.t.\begin{cases} E\pi_{s2}(q^*; w_2, b(w_1)) \geq E\overline{\pi_{s2}} & (10) \\ E\pi_{r2}(\mathrm{q}; w_2, b(w_1)) \geq E\pi_{r1}(q^*; w_1, b(w_1)) & (11) \\ q \in (q^*, \hat{q}] & (12) \end{cases}$$

In the two models above, Eq. 7 and Eq .9 are the objectives of the supplier's decision-making in which the incentive mechanism is acted on by the contract parameters b_2 or w_2 to guarantee the retailer's maximum order quantity. Eq. 6 and Eq. 10 represent the supplier's reserved earnings. Eq. 7 and Eq. 11 represent the retailer's participation constraints. Eq. 8 and Eq. 12 are decision variables and their domain of definitions; $\hat{q}$ makes $\mathrm{L}(\hat{q}) = 0$

For property 1, the buyback contract parameters are limited by the supplier's reserved earnings and the distribution of market demand when the supplier is sales oriented.

When the wholesale price is decreased, the retailer is motivated to order more products within the capital constraint. Indeed, the supplier's objective, which is to encourage the retailer to order more, results in an expectation of greater market share. Nevertheless, this approach does not necessarily result in higher sales.

4.3 Sales efforts

If more market demand is not created, the supplier would not believe that more orders lead to more sales. In this situation, sales effort would directly change market demand, thus affecting the retailer's order quantity. Tirole [16] shows that sales are not only influenced by market price but also (eventually) related to sales effort. This section will discuss what happens when the retailer's sales efforts satisfy the sales-oriented supplier's objective.

Model

The variable e is sales effort, D_e is stochastic market demand and increasing function. $D_e G(x,e) = Pr(D(e) \le x)$ is distribution function and $\frac{\partial G(x,e)}{\partial e} < 0$ is a monotonic continuous increasing function. Both are changed with sales effort. $g(e)$ is the cost of the retailer's sales effort and $g(0) = 0$ is a monotonic continuous increasing function with the first derivative. $P(q,e)$ is expected sales within sales effort, $P(q,e) = E\min(x, D(e))$. $I(q,e) = E(q - D(e)^+)$

$$P'': \max_e eF^{-1}\left(\frac{p+g-w_1}{p+g-(b_1+v)}\right) \tag{13}$$

$$s.t.\begin{cases} E\pi_{s2}(q^*; w_2, b(w_1)) \ge E\overline{\pi_{s2}} & (14) \\ E\pi_{r2}(\mathrm{q}; w_2, b(w_1)) \ge E\pi_{r1}(q^*; w_1, b(w_1)) & (15) \\ q \in (q^*, \hat{q}) & (16) \end{cases}$$

Sales effort influenced order quantity and expected sales increased. However, sales effort did not solve the retailer's capital constraint.

5 Numerical examples

5.1 Set parameters

A supplier and a retailer align in a two-echelon supply chain with a buyback contract. The supplier has two potential strategies: the sales-oriented strategy and the profit-oriented strategy. Both of the strategies in the above discussion have the same parameters: the market price, $p = 10$, the product cost, $\mathrm{c} = 4$, the salvage value of unit, $g = 2$, the shortage cost of unit, $v = 1$, market demand X is subject to normal distribution, the mean is $\mu = 100$, and the standard deviation is $\sigma = 20$.

5.2 Optimal profit-oriented decisions

The expected shortage: $\mathrm{L}(QC) = 3.6089$.

A wholesale price and a buyback price form a set of buyback contract parameters. Table 1 shows that the retailer's optimal order quantities are $q_c^* = 11.18246$ and the supply-chain revenues are $\pi_c = 52.4831$ with changes in the wholesale price and buyback price. The initial wholesale price is 4 and increases one unit every time until 10; the buyback price, retailer's profit and supplier's profit correspond.

Figure 1 shows that when the supplier is profit oriented, the wholesale price is increased, leading to an increase in the supplier's profits and a decrease in the retailer's profits. However, the supply-chain revenue remains unchanged. The buyback price is higher if the wholesale price is increased.

The following discusses the three numerical strategies when the supplier is sales oriented.

Table 1 Optimal profit-oriented decisions

w	b	π_r	π_s	w	b	π_r	π_s
5	1.3750	43.4227	9.0604	8	5.5000	16.2415	36.2415
6	2.7500	34.3623	18.1208	9	6.8750	7.1812	45.3019
7	4.1250	25.3019	27.1812	q_c^*	11.1824	π_c	52.4831

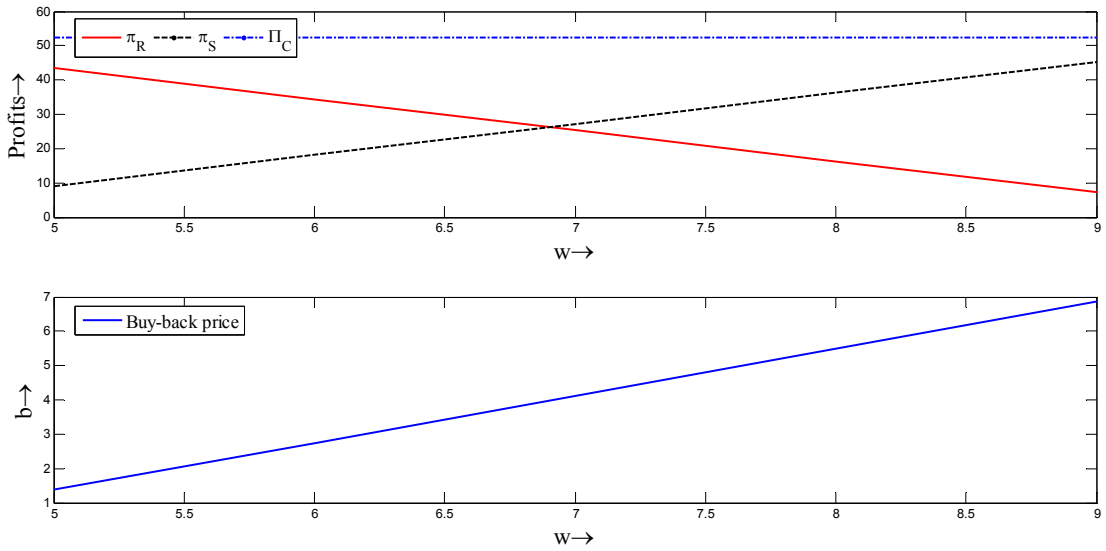

Fig. 1. The wholesale price effect on supply chain performance and buyback price

5.3 Strategy 1: Maintain the wholesale price and increase the buyback price

Here, the expected shortage in the profit-oriented scenario is still used. The five group parameters are set in Table 1: subscript 1 represents the original in the profit-oriented scenario; subscript 2 is the parameter after the buyback price was raised. b_2 is the independent variable in each group and the dependent variables are $\pi_{r2}, \pi_{s2}, \pi_2$. Table 1 is used to make a comparison. Table 2 shows all numerical information up to the incentive mechanism, when the retailer orders more to satisfy the supplier's objective. However, the supplier's lost profits are greater than those of the supply chain. In general, to reach the same order quantity q_2 than optimal quantity in the profit-oriented scenario, the supplier's losses are not equal to the supply chain's losses or the retailer's increments compared to several groups' arguments in strategy 1. The supply chain's revenue is almost unchanged front and back, as Fig. 2 indicates. The supplier's loss is less than the retailer's increments; additionally, whenever the losses or increments decrease, the wholesale price increases. In Fig. 2, the solid line and the dotted line represent the supply chain's performance in the profit-oriented and the sales-oriented scenarios, respectively. It is obvious that the retailer's profit is increasing and the supplier's profits are decreasing, which is the basis of the profit-oriented scenario. However, the increment or the decrement is gradual and the profit lines almost overlap with the increasing wholesale price.

Table 2 Sales-oriented strategy 1

w	(b_1, b_2)	(q_1, q_2)	(π_{r1}, π_{r2})	(π_{s1}, π_{s2})	(π_1, π_2)
5	1.3750→2.0234	111.8236→ 115.4325	43.4227→44.5046	9.0604→7.8694	52.4831→ 52.3740
6	2.7500→3.3058		34.3623→35.2896	18.1208→17.0844	
7	4.1250→4.5882		25.3019→26.0747	27.1812→26.2993	
8	5.5000→5.8705		16.2415→16.8597	36.2415→35.5143	
9	6.8750→7.1529		7.1812→7.6448	45.3019→ 44.7292	

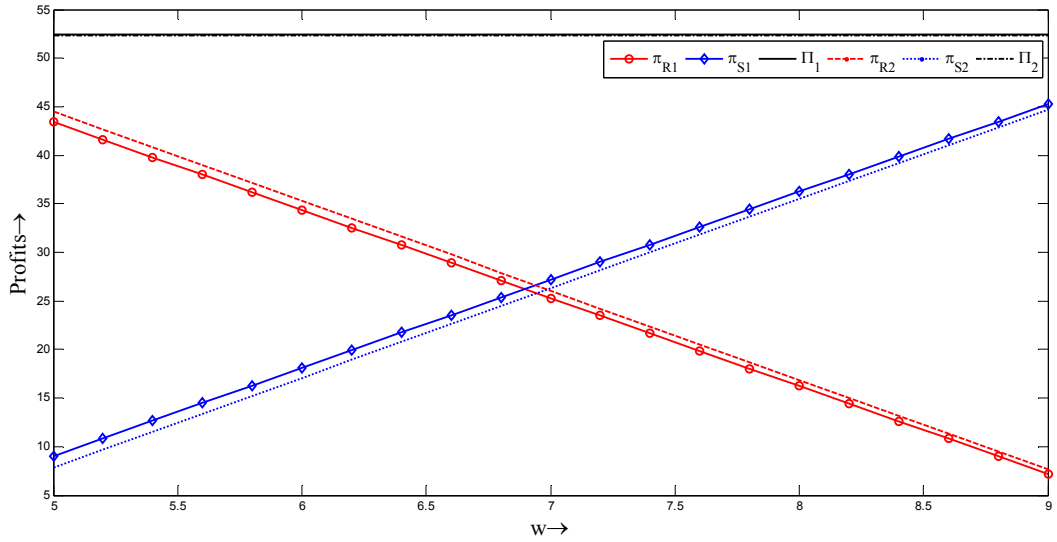

Fig. 2 Supply-chain performance after increasing the buyback price versus making the optimal decision

5.4 Strategy 2: Increase the wholesale price and maintain the buyback price

The parameters are set in accordance with Table 2. The difference is thatw_2 is the independent variable in each group. Table 3 shows the numerical incentive mechanism. Comparing strategy 1 with strategy 2 reveals some differences: each group's parameters show that it is obvious that the retailer makes more profit in strategy 2 than in strategy 1. Additionally, the supplier's decrement is more than the retailer's increments; even the supply chain's revenue remains unchanged in the sales-oriented scenario. In Fig. 3, the solid line and the dotted line are used as in Fig. 2. It is obvious that the area between the solid line and the dotted line is larger than in Fig. 2.

Table 3 Sales-oriented strategy 2

b	(w_1, w_2)	(q_1, q_2)	(π_{r1}, π_{r2})	(π_{s1}, π_{s2})	(π_1, π_2)
1.3750	5→4.4944		43.4227→49.1641	9.0604→3.2099	
2.7500	6→5.5666		34.3623→39.2835	18.1208→13.0905	
4.1250	7→6.6388	111.8236→115.4325	25.3019→29.4029	27.1812→22.9711	52.4831→52.3740
5.5000	8→7.7111		16.2415→19.5223	36.2415→32.8517	
6.8750	9→8.7833		7.1812→9.6417	45.3019→42.7323	

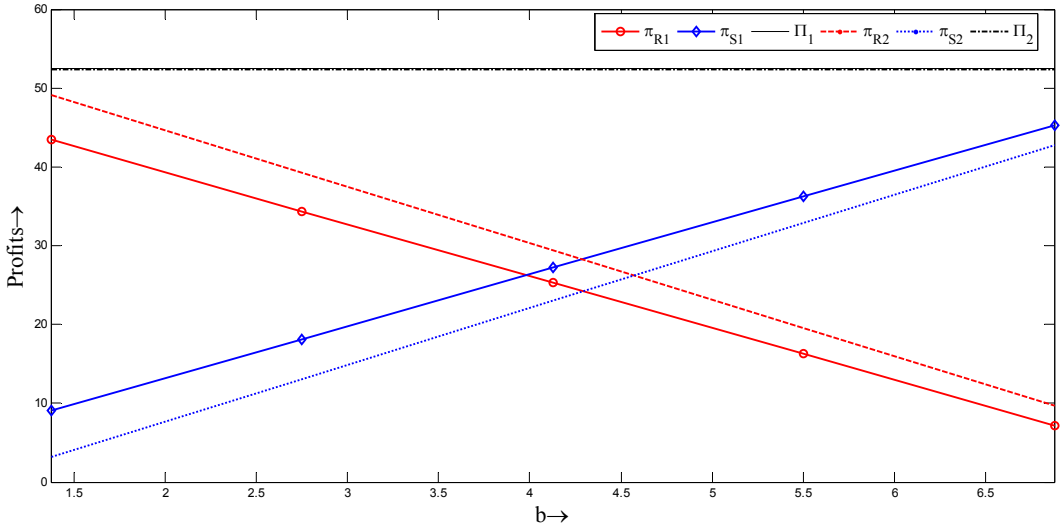

Fig. 3. Supply-chain performance after decreasing the wholesale price versus making the optimal decision

5.5 Strategy 3: Sales effort

This section discusses the retailer's sales effort to order more products. Here, assuming $g(e) = \frac{1}{2}ke^2$ (Xu *et al.*, 2004) [17], $D(e, x) = ex$. (Xu et.al 2004)[17]. k is the ratio of sales effort cost and the independent variable; the other parameters are dependent variables. The first k and e are set as a benchmark, $k = 20, e = 2$. k is increased by 10 every time. The retailer would decide q_e and e using the maximum profits. The calculated results are in Table 4. In accordance with Table 4, Fig. 4 describes the relationship between the independent and dependent variables:

- k and e are negatively correlated except for two inflection points, $k = 26, k = 52$. e experiences any change before $k = 26$ and after $k = 52$;
- k and q are negatively correlated except for two inflection points, $k = 26, k = 52$. q experiences any change before $k = 26$ and after $k = 52$;
- k and the retailer's profit are negatively correlated.

Table 4 Sales-oriented strategy 3

k	e	q_e	π_e
20	2.0000	22.4248	65.2061
30	1.7600	19.7194	46.0887
40	1.3200	14.7896	34.5064
50	1.0600	11.8437	27.5562
60	1.0000	11.1824	22.4831

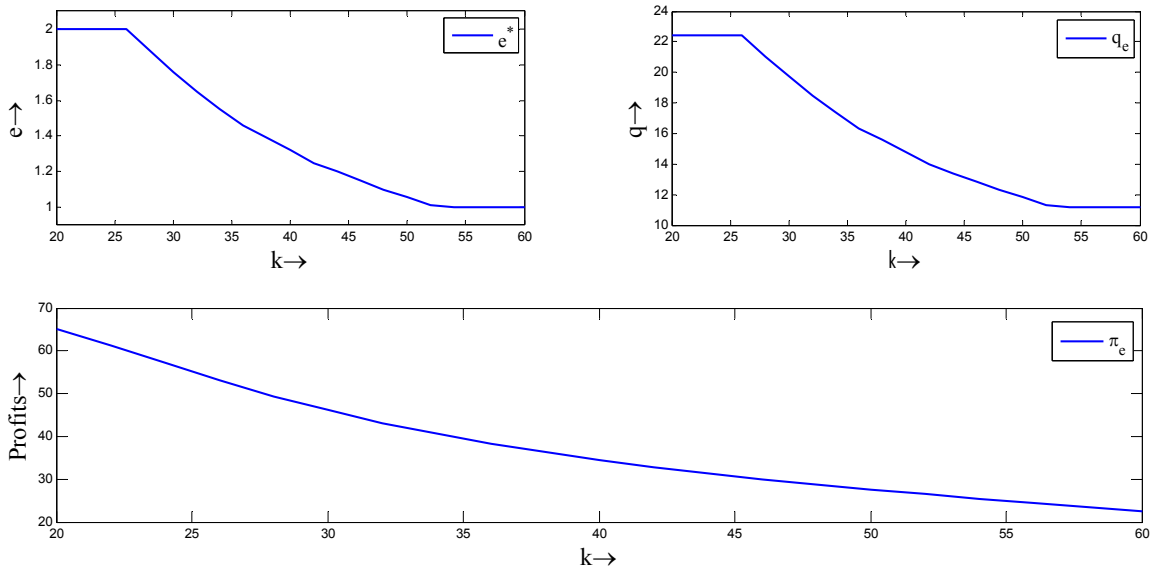

Fig. 4 Relationship of the sales effort cost ratio

6. Conclusion

This paper investigates three supplier strategies to motivate the retailer to order more than its optimal quantity through the mechanism of the buyback contract. The supplier's marketing strategy types in the two-echelon supply chain include both profit-oriented and sales-oriented strategies. Following is the main conclusion:

- The new buyback contract parameters are limited by both the reserved earnings of the supplier and the distribution of market demand when the supplier is sales oriented; the

supplier's expected profit is a decreasing function of the wholesale price or the buyback price. In contrast, the retailer's expected profit is an increasing function of the wholesale price or the buyback price. The supplier would prefer a higher buyback price to stimulate the retailer to order more, but the retailer would prefer a lower wholesale price. The reason for these preferences is that from which the supplier or the retailer benefits on the transfer-payment front.

- Based on the former two figures, the supply-chain revenue experiences almost no change when the supplier motivates the retailer to order more than its optimal quantity. In that situation, it is possible to satisfy the sales-oriented supplier's objective. The issue is how to distribute the supply chain's profit. However, all strategies above are based on the same expected shortage in quantity, meaning that more orders create the need for more sales. The former two strategies do not solve this problem.
- The order quantity must be increased if the retailer strengthens his sales effort. Strategy 3 discusses the retailer's sales efforts, which are made at a certain cost to the retailer. This situation requires an optimal level of sales effort to obtain more profits; however, it leads to smaller orders.

Further research on the fair distribution of supply-chain revenue, with the retailer ordering more and selling as much as possible to effect the supplier's strategy, should be conducted in the future.

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