Supply chain coordination and decisions under effort-dependent demand and customer balking behaviour

Guang-Dong Liu*

College of Economics Management,
Beijing University of Posts and Telecommunications,
Beijing 100876, China
and
Laboratory of Anhui Province,
College of Business and Key Logistics,
Fuyang Normal University,
Fuyang, Anhui 236037, China
Email: 1359162826@qq.com
*Corresponding author

Tian-Jian Yang

College of Economics Management,
Beijing University of Posts and Telecommunications,
Beijing 100876, China
Email: frankytj@bupt.edu.cn

Xue-Mei Zhang

Logistics Laboratory of Anhui Province,
College of Business and Key,
Fuyang Normal University,
Fuyang, Anhui 236037, China
Email: xmz@mail.ustc.edu.cn

Abstract: The paper explores supply chain coordination under a sales effort-dependent demand and customer balking scenario and analyses the impacts of revenue- and cost-sharing contracts on the decisions of supply chain members. This paper subsequently develops a two-echelon supply chain consisting of one supplier and one retailer and examines two models that incorporate customer balking and sales efforts: in one model, the retailer offers a revenue sharing-only contract, and in the other model, the retailer and the supplier bargain on the revenue and cost-sharing contract. The results show that the revenue- and cost-sharing contract can coordinate the decentralised supply chain better than it can coordinate a centralised supply chain and that the effects of customer balking on the supply chain are clear; when customer balking occurs, the probability of a sale occurring can increase the profit of the supply chain, while the threshold of inventory and the sales effort can improve the marketing demand.

Keywords: revenue- and cost-sharing contract; customer balking behaviour; newsvendor model; Stackelberg game; effort-dependent demand.

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Biographical notes: Guang-Dong Liu is a PhD student in College of Economics Management, Beijing University of Posts and Telecommunications and Lecturer at the Fuyang Normal University. He has published several papers and takes charge of the projects. His research interest focuses on logistics and supply chain.

Tian-Jian Yang is a Professor and Doctoral Supervisor in College of Economics Management, Beijing University of Posts and Telecommunications. He obtained his PhD in Management from the Tianjin University. His research interests include supply chain management, energy-saving and emission-reduction and telecommunication operation management. He has published in a few journals including *International Journal of Production Research*, *Applied Energy*, *Energy Policy* and so on.

Xue-Mei Zhang is an Associate Professor in College of Business, Fuyang Normal University, China. She received her PhD in Management Science and Engineering from the University of Science and Technology of China (USTC) in 2011. Now her major research areas are supply chain management, operation research, product design and risk decision.

1 Introduction

Customer balking is common and a real occurrence in marketing, especially customer balking on the purchase of short life cycle products. For example, customers want to go to the supermarket and buy fresh vegetables. If they find that there are few vegetables in stock, they think that the ones left are not fresh or defective; therefore, they may not purchase any vegetables. Additionally, this phenomenon also exists in other industries. For example, the customers may not purchase products when there is low inventory, because due to their previous purchase experience, they consider the remaining products as old and picked-over and want to shop in places where there are more product choices for purchases. It is clear that customer balking can influence the market demand and the inventory of the retailer. Therefore, the problem is how to determine the optimal ordering quantity to avoid having no inventory and being out of stock.

In addition to analysing customer balking, we also examine the case in which the sales effort can improve sales and decrease inventory. For example, on 'couples shopping day' in 2017, the sales at the Jingdong mall reached 127.1 billion yuan with retailers' promotions, and the sales at Tmall reached 168.2 billion yuan, which showed that sales efforts can have highly significant effects on sales. However, excessive promotion can not only reduce the price of goods and the revenue of stakeholders but can also lead to a decline in the customers' perception of goods, as noted by Delvecchio et al. (2006): when the promotional price is lower than 20% of the original price, the promotion will have a negative effect. Therefore, there can be a bilateral effect between the benefits and costs of a promotion. Moreover, in this paper, we also examine the additional problem of how to choose the best promotional effort that achieves a balance between costs and the interests of the firms' stakeholders.

As stated previously, the extra cost that is generated by the retailer's sales effort is incurred only by the retailer, and the revenue that is generated from the sales effort is shared by the supplier and the retailer, which can lead to a loss of the retailer's profit and enthusiasm. As a result, sales can decrease, and the performance of the supply chain can ultimately be reduced. Therefore, in this paper, the third problem that we examine is how to coordinate the conflicts between the supplier and the retailer.

To avoid customer balking behaviour, the retailer can increase the order quantity to keep inventory at a safe level and can also promote sales efforts, which can raise the cost of both the inventory and the sales effort. Moreover, dual marginal effectiveness can be reduced by coordinating the supply chain. The following questions are relevant for understanding supply chain coordination:

1 How can the optimal order quantity and sales effort be achieved under a customer balking behaviour scenario?

2 How can the profits of stakeholders in the supply chain be maximised?

3 How can the supply chain be perfectly coordinated in the acceptance of contracts by the supply chain members?

In this paper, to answer the above questions, we develop a two-echelon supply chain with sales effort-dependent demand under a customer balking behaviour environment. The system consists of one supplier and one retailer both with risk-neutral behaviour and a stochastic demand that is influenced by the following endogenous variables: sales effort, order quantity and customer balking. First, we formulate two models for a centralised and a decentralised supply chain, and we later coordinate the supply chain by a revenue-sharing-only contract and a revenue- and cost-sharing contract. Next, we analyse the acceptable conditions that can coordinate the total supply chain, and several managerial insights are gained by performing a numerical analysis.

The major contributions of this paper are as follows: first, differing from the programming models, such as Darwish et al. (2015a), Lin (2017) and Pramudyo and Luong (2017), this paper proposes a newsvendor model for analysing customer balking and the sales efforts of the retailer and extends the practical application of the model. Second, the coordination contract is revealed, and the scenario of Pareto improvement is derived, providing the basis for cooperation between suppliers and retailers. Third, the expected reduced sales function is analysed, which differs from existing literature, and the effect of the parameters of customer balking on the supply chain are analysed. Finally, we find that when customer balking occurs, the performance of the supply chain can be improved by enhancing the probability of a sale and by decreasing the threshold of inventory. For managers, the supply chain performance can be improved by increasing the sales effort and maintaining the appropriate inventory.

The remainder of this paper is organised as follows: Section 2 reviews the relevant coordination of supply chain and customer balking literature. Section 3 provides assumptions and notations used in this paper and characterises a one-supplier-one-retailer model under a customer balking scenario. Section 4 studies the models in a centralised and a decentralised system. Section 5 proposes both the revenue-sharing-only contract and the revenue and cost-sharing contract for coordination of the supply chain and determines the conditions for coordinating the supply chain members. Section 6 presents a numerical analysis with respect to key parameters and presents a number of managerial insights. Section 7 outlines the study's conclusions and presents a summary, implications and a discussion on future research.

2 Literature review

The relevant literature to our work in this paper involves two aspects: one aspect focuses on the coordination of the supply chain with effort-dependent demand, and the other aspect addresses customer balking behaviour.

2.1 Coordination of supply chain with contracts

Conducted over a long period of time, there has been a great deal of research conducted on supply chain coordination. There are many types of contracts, such as the wholesale price contract, buy-back contract, revenue-sharing contract, quantity-flexibility contract, sales-rebate contract and so on (see Cachon, 2003; Pasternack, 2001; Giannoccaro and Pontrandolfo, 2004),which can be used to coordinate the supply chain.

In recent years, with the development of the supply chain, there has been a growing body of literature related to the coordination of the supply chain: Zhao and Wei (2014) proposed two models of a centralised and decentralised fuzzy supply chain and designed two contracts under a symmetric and an asymmetric information scenario, to coordinate a supply chain. Ouardighi (2014) wanted to find the potential coordinating power of the supply chain and developed the model of a revenue-sharing contract with a wholesale price contract to improve the design quality of a particular finished product. Ghosh and Shah (2015) analysed a green supply chain with one manufacturer and one retailer and coordinated the supply chain with a cost-sharing contract and bargaining. Darwish et al. (2015b) analysed a supply chain with one vendor in a multi-retailer environment and compared the models of a centralised and decentralised system and coordinated the supply chain with a VMI contract. Zhang et al. (2015) analysed a deteriorating supply chain with price-dependent demand and coordinated the manufacturer and retailer with revenue- and cost-sharing contracts. Shi et al. (2016) studied different coordination performances of revenue-sharing and a two-part tariff contract in a closed-loop supply chain and analysed the effect of the parameters on the manufacturer and the retailer. Xu et al. (2017) considered an MTO supply chain under cap-and-trade regulation and coordinated the system with a wholesale price contract, a cost-sharing contract and a two-part tariff contract. Zheng et al. (2017) developed two models of complete and incomplete information in a reverse supply chain and used the two-part tariff contract to coordinate the system for achieving the equilibrium in a centralised scenario. Jonrinaldi and Zhang (2017) analysed the decision of production stock and transportation in the manufacturing supply chain and obtained the solutions to develop the models of coordination in a centralised, semi-centralised, and a decentralised system. Shafiq and Luong (2017) developed a revenue-sharing contract under uncertain demand and analysed how to coordinate the supply chain using penalties and prior commitments. Hoa and Luong (2017) designed a mixed contract with commitment penalties and obtained the optimal quantity for the retailer and supplier. Xu et al. (2018) analysed a dual-channel supply chain under carbon emission regulation with a supplier and a retailer and coordinated the system with online and offline price discount contracts. Venegas and Ventura (2018) proposed cooperative and non-cooperative models in a decentralised supply chain under price sensitive demand and coordinated the actions of the supplier and buyer with quantity discounts.

In the abovementioned literature, the supply chain coordination was achieved by designing different contracts in different fields, but the above literature does not cover the case in which the retailer's sales effort influences the demand. Several studies have demonstrated that a revenue sharing-only arrangement cannot coordinate the supply chain (see Cachon and Lariviere, 2005; Zhang et al., 2015), which is a case that has been studied by many researchers. For example, Taylor (2002) studied a two-stage supply chain with one manufacturer and one retailer and proposed a target rebate and returns contract to coordinate the system, revealing that the contract could achieve the coordination and a win-win outcome. He et al. (2009) considered a supply chain with effort and a price-dependent stochastic demand and found that the supply chain was coordinated with a returns policy and an SRP contract when demand was affected by both the retail price and the retailer's sales effort. Lau et al. (2012) developed a supply chain with demand-dependent price and sales efforts and found that a volume discount contract could coordinate the system. Zhao and Wei (2014) proposed symmetric and asymmetric information contracts to coordinate the supply chain with effort and price-dependent demand and found that the maximal expected profit under an asymmetric information contract was higher than that under a symmetric information contract. Wei and Xiong (2015) coordinated the supply chain containing a two-stage fashion product with revenue-sharing and a wholesale price contract and analysed the optimal decision in different cases. Other researchers, such as Pang et al. (2014), Hu et al. (2010) and He et al. (2006), also studied supply chain coordination when the demand is dependent on the sales effort.

In the abovementioned literature, we can see that supply chain coordination has been studied according to the development of extended models in a certain number of fields and that optimal decisions can be made by supply chain members, but customer balking behaviour as applicable in supply chain coordination is rarely mentioned in the literature. In the following section, we will review the literature on customer balking.

2.2 Newsvendor model with customer balking

In the literature on customer balking, short life cycle items are studied, such as fashion clothes and perishable or deteriorating items. The classical newsvendor model is the benchmark for these studies and its use has been extended, for instance, by Darwish (2015a) in the development of the newsvendor model that minimised the unit cost and by Ye and Sun (2016) who proposed a newsvendor model with two demand cases for maximising profit under an optimal price and stock quantity analysis. In addition, the newsvendor model with balking was studied relatively earlier by Pasternack (1989) and used to address an analysis of balking when inventory fell below a certain threshold. Next, Moon and Choi (1995) extended the model of Pasternack (1989) by incorporating the distribution free approach and a fixed ordering cost and derived the optimal ordering rule, proving that the distribution free approach was robust. However, today, with the development of the internet, we can order items online with negligible cost; thus, in this paper, the fixed ordering cost is assumed to be zero. When demand is affected by multiple factors, lost sales may occur, which is common, and may lead to an underage cost, which has been incorporated into the extended newsvendor models under customer balking and stochastic demand, such as shown in the literature of Liao et al. (2011). Cheong and Kwon (2013), Yu and Zhai (2014) and Feng (2015) also studied the extensions of the classical model with two uncertain parameters, using customer balking. Among recent papers, the work of Lee and Jung (2014) represents a very meaningful extension of the model because it not only modified the model with the inclusion of balking but also determined the impact of customer balking on performance measures, which has been rarely studied. Lan (2017) analysed a VMI supply chain with customer balking and promotional efforts and took advantage of a wholesale price contract for coordinating the supply chain. Zhang et al. (2018) proposed a supply chain with customer balking and asymmetric information and designed the transfer payment contract to coordinate the supply chain. From the literature above, we can see that a great deal of work has been done that has contributed to studies in the field of customer balking and the application of supply chain coordination, through the use of extensions of the newsvendor model.

Our paper differs from the existing literature in the following three aspects: first, this paper develops an analysis of the supply chain with reduced demand due to customer balking and with effort-dependent demand and is more complex; second, this paper investigates revenue-sharing and cost-sharing contracts especially incorporating the cost of customer balking and the sales effort; and finally, the expected reduced sales function of customer balking that is discussed in this paper is different from that in the existing literature and its application has not yet been analysed.

3 Model descriptions

3.1 Notations and assumptions

In this section, we will define the meanings of the symbols used and make the descriptions of the problems analysed in the paper. A two-echelon supply chain is considered consisting of a risk-neutral supplier and a risk-neutral retailer in a single-period. The supplier provides a certain type of items for the retailer at the wholesale price w, and the retailer has no existing inventory. The retailer then sells the items to customers at the price p and increases the marketing demand through the sales effort; the cost of the sales effort is undertaken by the retailer. See Figure 1.

The main parameters and notations are described in Table 1. In this paper, the following assumptions are proposed for building the models:

1 Let $F(D \mid e)$ be the distribution of demand given the level of sales effort e, where the stochastic demand is increasing in e and $F(0) = 0$; $\partial F(D \mid e) / \partial e < 0$.

2 Let $g_2(e)$ be the sales effort cost of the retailer, where $g_2(0) = 0$, $g_2'(e) > 0$, and $g_2''(e) > 0$, and be assumed to be a quadratic function of e, as has been demonstrated by other researchers (see Taylor, 2002; Zhao and Wei, 2014; Lan, 2017).

3 It is assumed the supplier can not verify the retailer's sales effort level and at the same time the retailer chooses his sales effort level, the order quantity is equal to the supply quantity, and the information is symmetrical.

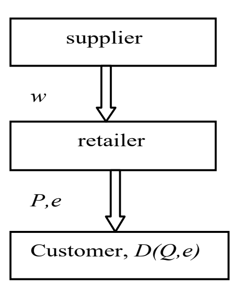
4 It is assumed the items are short life cycle products with a negligible salvage value.

5 The fixed ordering cost is assumed to be zero because the retailers can order items through the internet for a negligible cost, and shortages and second purchasing are not allowed.

Table 1 Main parameters and notations

Parameters	*Notations*
p	The retail price
D	The market demand
$F(x)$	The cumulative distribution function of the demand
$f(x)$	The density function of the demand
c	The unit cost of the item, $\alpha < c < p$
Q	The ordering quantity that satisfies the conditions in the paper
w	The wholesale price
k	The threshold of inventory at which customer balking occurs; $0 < k < Q$
L	The probability of a sale during customer balking; $0 < L < 1$
α	The unit lost cost when balking occurs
e	The sales effort level
$S(Q, e)$	The expected sales
$I(Q, e)$	The expected leftover inventory
$g_1(Q, e)$	The expected lost demand when customer balking occurs
$g_2(e)$	The total sales effort cost
α	The unit cost per sales effort
$\pi(Q, e)$	The profit of the supply chain in the centralised system
$\pi_T(Q, e)$	The total profit of the supply chain in the decentralised system
$\pi_r(Q, e)$	The profit of the retailer with no coordination
$\pi_s(Q, e)$	The profit of the supplier with no coordination
$\pi_r^i(Q, e)$	The profit of the retailer in the case of coordination with a revenue-sharing contract and a revenue and cost-sharing contract; $i = 1, 2$
$\pi_s^i(Q, e)$	The profit of the supplier in the case of coordination with a revenue-sharing contract and a revenue and cost-sharing contract; $i = 1, 2$

Figure 1 Structure of the supply chain



3.2 Models with customer balking

In this section, we develop the model of the expect sales $S(Q, e)$ when there is customer balking (Lee and Jung, 2014; Feng, 2015; Lan, 2017), which is shown as the following:

$$\begin{aligned} S(Q,e) = {} & \int_0^{Q-K} Df\left(D|e\right)d(D) + \int_{Q-K}^{Q-K+\frac{K}{L}} \left(Q-K+L(D-Q+K)\right)f\left(D|e\right)d(D) \\ & + \int_{Q-K+\frac{K}{L}}^{\infty} Qf\left(D|e\right)d(D) \end{aligned} \tag{1}$$

In the expected sales function above, the first term represents the expected sales when the item's demand during the sales period is between 0 and $Q - K$ units; in this case, there is no customer balking behaviour because demand is less than the threshold inventory. The second term denotes the expected sales if demand is between $Q - K$ and $Q - K + K / L$ units; in this case, balking occurs and the probability of a sale becomes L. The balking phenomenon affects $(1 - L)(D - (Q - K))$ units of total demand. Thus, for this range of demand, $Q - K + L((D - (Q - K))$ units will be sold, and $Q - (Q - K + L((D - (Q - K))$ units will be left unsold. The following term captures the expected sales when the demand exceeds $Q - K + K / L$ units.

The expected sales function can be simplified as follows (Lee and Jung, 2014):

$$S(Q, e) = Q - \int_0^{Q-K} F\left(D|e\right)d(D) - L\int_{Q-K}^{Q-K+\frac{K}{L}} F\left(D|e\right)d(D) \tag{2}$$

The expected leftover inventory is shown as in the following:

$$\begin{aligned} I(Q, e) &= \int_0^{Q-K} (Q-D)f\left(D|e\right)d(D) + \int_{Q-K}^{Q-K+\frac{K}{L}} \left(K-L(D-Q+K)\right)f\left(D|e\right)d(D) \\ &= Q - S(Q, e) \end{aligned} \tag{3}$$

And the reduced demand is caused only by customer balking. The expected reduced sales function is shown as in the following and has been extended based on the work of Lee and Jung (2014):

$$g_1(Q, e) = L\int_{Q-K}^{Q-K+K/L} F\left(D|e\right)dx - \int_{Q-K}^{Q} F\left(D|e\right)dx \tag{4}$$

4 Model analysis

4.1 Model analysis for the centralised supply chain

In this section, we consider the centralised supply chain with customer balking behaviour. In this case, the objective of the supply chain is to set the optimal quantity Q and sales effort e to maximise the total profit. If we define the supply chain's expected profit under the case of centralisation as $\pi(Q, e)$, then $\pi(Q, e)$ will be:

$$\pi(Q, e) = pS(Q, e) - cQ - \alpha g_1(Q, e) - g_2(e) \tag{5}$$

In equation (5), the first term is the sales revenue of supply chain centralisation, the second term is the purchasing cost, the third term is the lost sales cost with balking, and the last term is sales effort cost.

Proposition 1: under the centralised system, the promotion effort e^* satisfies equation (6):

$$p\frac{\partial S(Q,e^*)}{\partial e}-\alpha\frac{\partial g_1(Q,e^*)}{\partial e}-g_2'(e^*)=0 \tag{6}$$

Proof: for the tractability, we assume the centralised supply chain solution is well behaved, i.e., $\pi(Q, e)$ is unimodal and maximised with finite arguments.

Under the condition of the optimal effort e^*, from equation (5), we easily take the first partial derivative of $\pi(Q, e)$ with respect to e yielding:

$$\frac{\partial \pi(Q,e^*)}{\partial e}=p\frac{\partial S(Q,e^*)}{\partial e}-\alpha\frac{\partial g_1(Q,e^*)}{\partial e}-g_2'(e^*)=0$$

Thus, equation (6)is proved.

Proposition 2: the optimal order quantity Q^* for the retailer satisfies equation (7) as follows:

$$(1-L)(P+\alpha)F\left((Q-K)\middle|e\right)+\left[L(p+\alpha)-\alpha\right]F\left(\left(Q-K+\frac{K}{L}\right)\middle|e\right)=p-c \tag{7}$$

Proof: from equation (5), taking the first partial derivative of $\pi(Q, e)$ with respect to Q yields:

$$\frac{\partial \pi(Q^*,e)}{\partial Q}=p\frac{\partial S(Q^*,e)}{\partial Q}-c-\alpha\frac{\partial g_1(Q^*,e)}{\partial Q}=0 \tag{8}$$

While

$$\frac{\partial S(Q^*,e)}{\partial Q}=1-F\left((Q-K)\middle|e\right)-L\times F\left((Q-K+K/L)\middle|e\right)+L\times F\left((Q-K)\middle|e\right) \tag{9}$$

$$\frac{\partial g_1(Q,e)}{\partial Q}=LF\left((Q-K+K/L)\middle|e\right)+(1-L)F\left((Q-K)\middle|e\right)-F\left(Q\middle|e\right) \tag{10}$$

Substituting equation (9) and equation (10) into equation (8), we have:

$$(1-L)(P+\alpha)F\left((Q-K)\middle|e\right)+L(p+\alpha)F\left((Q-K+K/L)\middle|e\right)-\alpha F\left(Q\middle|e\right)=p-c$$

4.2 Model analysis for the decentralised supply chain

In this section, the supplier and the retailer make their own decisions separately to maximise their own profit when the supply chain is decentralised. We consider this scenario to be a Stackelberg game with the supplier as the leader. The supplier first sets the wholesale price and then the retailer determines the sales effort and the selling price based on the supplier's announced decisions. In the following, we first use the backward sequential decision-making approach to analyse the optimal response function. For any given wholesale price w, the profit of the retailer $\pi_r(Q, e)$ is as follows:

$$\pi_r(Q, e) = pS(Q, e) - wQ - \alpha g_1(Q, e) - g_2(e) \tag{11}$$

In equation (11), the first term is the sales revenue of the retailer, the second term is purchasing cost of the retailer, the third term is the lost sale cost with balking, and the last term is the sales effort cost of the retailer.

The profit of the supplier $\pi_s(Q, e)$ is as follows:

$$\pi_s(Q, e) = wQ - cQ \tag{12}$$

In equation (12), the first term is the sales revenue of the supplier and the second term is the production cost of the supplier.

In a decentralised system, the sales effort e_d^* for a given order quantity satisfies equation (13)

$$\frac{\partial \pi_r\left(Q, e^*\right)}{\partial e} = p\frac{\partial S\left(Q, e^*\right)}{\partial e} - \alpha\frac{\partial g_1\left(Q, e^*\right)}{\partial e} - g_2'\left(e^*\right) = 0 \tag{13}$$

It can be easily seen that $\frac{\partial \pi_r(Q, e)}{\partial e} = \frac{\partial \pi\left(Q, e^*\right)}{\partial e}$; in this case, the sales effort is valid, as was the case for the centralised supply chain; however, for the supplier, the order quantity Q_d^* for a given effort satisfies equation (14).

$$\frac{\partial \pi_r\left(Q^*, e\right)}{\partial Q} = p\frac{\partial S\left(Q^*, e\right)}{\partial Q} - w - \alpha\frac{\partial g_1\left(Q^*, e\right)}{\partial Q} \tag{14}$$

Under the coordination condition of $\frac{\partial \pi_r(Q^*, e)}{\partial Q} = \frac{\partial \pi\left(Q^*, e\right)}{\partial Q}$; using equation (14) and equation (8), we can easily have $w = c$, indicating that the profit of the supplier is zero; For the manufacturer, it is obviously an unrealistic situation.

In the decentralised supply chain, the supplier, as a leader, may increase the wholesale price in order to earn more profit. However, the retailer may reject the scenario because the retailer must increase the selling price and the sales effort to maximise the profit, which may lead to a decrease in sales and an increase in the sales effort cost. Hence, it becomes crucial for the supplier to design the contract mechanism to coordinate the decentralised system influenced by customer balking behaviour. In the next section, we will present and analyse two contracts to coordinate the supply chain under the customer balking behaviour scenario.

4.3 *Effects of customer balking on the centralised supply chain*

In this section, we will analyse how to influence the centralised supply chain by using the parameters of customer balking in the case in which other parameters are known.

Proposition 3: in the centralised supply chain, the profit function is strictly concave and increasing in relation to the probability of customer balking when $0 < L \leq 1$ and other parameters are fixed.

Proof: we take the first partial derivative and the second partial derivative of (5) with respect to L, using Leibniz's rule and Fubini's theorem, and we have:

$$\begin{aligned} \frac{\partial \pi_c(q,e,L)}{\partial L} &= p\frac{\partial S(Q,e,L)}{\partial L} - \alpha\frac{\partial g_1(Q,e,L)}{\partial L} \\ &= -p\left[\int_{Q-K}^{Q-K+K/L} F(D|e)dD - KF\left((Q-K+K/L)\middle|e\right)/L\right] \\ &\quad -\alpha\left[\int_{Q-K}^{Q-K+K/L} F(D|e)dD - KF\left((Q-K+K/L)\middle|e\right)/L\right] \\ &= (p+\alpha)\left(KF\left((Q-K+K/L)\middle|e\right)/L - \int_{Q-K}^{Q-K+K/L} F(D|e)dD\right) \\ &= (p+\alpha)\int_{Q-K}^{Q-K+K/L}\left[D-(Q-K)\right]f(D|e)dD > 0 \end{aligned} \tag{15}$$

Therefore, Proposition 3 is proved.

Proposition 3 shows that the probability of customer balking can increase the profit of the centralised supply chain when $0 < L < 1$ and other parameters are fixed.

Proposition 4: the profit of the centralised supply chain is strictly concave and decreasing in relation to the threshold of customer balking when $K > 0$.

Proof: we take the first partial derivative and the second partial derivative of (4) with respect to K and we have:

$$\begin{aligned} \frac{\partial \pi_c(Q,e,K)}{\partial K} &= p\frac{\partial S(Q,e,K)}{\partial K} - \alpha\frac{\partial g_1(Q,e,K)}{\partial K} \\ &= p\begin{bmatrix} F\left((Q-K)\middle|e\right) - (1-L)F\left((Q-K+K/L)\middle|e\right) \\ -LF\left((Q-K)\middle|e\right) \end{bmatrix} \\ &\quad -\alpha(1-L)\left[F\left((Q-K+K/L)\middle|e\right) - F\left((Q-K)\middle|e\right)\right] \\ &= -(1-L)(p+\alpha)\left[F\left((Q-K+K/L)\middle|e\right) - F\left((Q-K)\middle|e\right)\right] < 0 \end{aligned} \tag{16}$$

Hence, the profit of the centralised supply chain is decreasing in relation to the threshold of customer balking. Next, we take the second partial derivative of (16), and we have:

$$\frac{\partial^2 \pi_c(Q,e,K)}{\partial^2 K} = -(1-L)(p+\alpha)\begin{bmatrix} f\left((Q-K+K/L)\middle|e\right)\dfrac{1-L}{L} \\ +f\left((Q-K)\middle|e\right) \end{bmatrix} < 0 \tag{17}$$

Hence, the profit of the centralised supply chain is strictly concave in relation to the threshold of customer balking. Incorporating (15) and (16), Proposition 4 is proved. From Proposition 8, it can be seen that the threshold of customer balking can maximise the profit of the supply chain when $K > 0$.

Incorporating Propositions 3 and 4, since we know that the parameters of customer balking lead to the disruption of the profit of the supply chain, we should consider the effects of the parameters of customer balking on the supply chain when the supply chain coordination is studied.

Lemma 1: the expected sales are strictly concave and increasing in relation to the probability of customer balking.

Proof: we take the first partial derivative and the second partial derivative of (2) with respect to L respectively, we have:

$$\begin{aligned}\frac{\partial S(Q,e,L)}{\partial L} &= -\left[\int_{Q-K}^{Q-K+K/L} F\left(D|e\right)dD - KF\left((Q-K+K/L)|e\right)/L\right] \\ &= -(Q-K)\left[F\left((Q-K+K/L)|e\right) - F\left((Q-K)|e\right)\right] \\ &\quad + \int_{Q-K}^{Q-K+K/L} Df\left(D|e\right)dD \\ &= \int_{Q-K}^{Q-K+K/L} Df\left(D|e\right)dD - \int_{Q-K}^{Q-K+K/L} (Q-K)f\left(D|e\right)dD \\ &= \int_{Q-K}^{Q-K+K/L} \left[D-(Q-K)\right]f\left(D|e\right)dD > 0\end{aligned} \tag{18}$$

$$\frac{\partial^2 S(Q,e,L)}{\partial^2 L} = -\frac{K^2}{L^3} f\left((Q-K+K/L)|e\right) < 0$$

Lemma 1 is proved.

From Lemma 1, we find that the probability of customer balking can increase the expect sales when $0 < L < 1$ and other parameters are fixed.

Lemma 2: the expect sales function is strictly concave and decreasing in relation to the threshold of customer balking.

Proof: we take the first partial derivative and the second partial derivative of (2) with respect to L, respectively, and have:

$$\begin{aligned}\frac{\partial S(Q,e,K)}{\partial K} &= \frac{\partial S(Q,e,K)}{\partial K} - \\ &= F\left((Q-K)|e\right) - (1-L)F\left((Q-K+K/L)|e\right) - LF\left((Q-K)|e\right) \\ &= (1-L)\left[F\left((Q-K)|e\right) - F\left((Q-K+K/L)|e\right)\right] < 0\end{aligned} \tag{19}$$

Because $\dfrac{\partial S(Q,e,K)}{\partial K} < 0,$ the expect sales are decreasing in the threshold of customer balking.

We take the second partial derivative of (28) with respect to K and have:

$$\frac{\partial^2 S(Q,e,K)}{\partial^2 K} = -(1-L)\left[f\left((Q-K)|e\right) + \frac{1-L}{L} f\left((Q-K+K/L)|e\right)\right] < 0 \tag{20}$$

Incorporating (19) and (20), Lemma 2 is proved.

From Lemma 2, we can see that the threshold of customer balking can maximise the expected sales when $K > 0$ and other parameters are fixed, but balking increases as the threshold of customer balking increases; therefore, the expected sales are at a maximum level when K is at its minimum level.

From Lemma 1 and 2, we find that the parameters of customer balking can affect the expected sales; therefore, the expected sales are not only affected by the selling price and the ordering quantity but are also affected by the parameters of customer balking.

Lemma 3: the expected reduced sales function is strictly convex and decreasing in relation to the probability of customer balking.

Proof: we take the first partial derivative and the second partial derivative of (3) with respect to L and have:

$$\begin{aligned}\frac{\partial g_1(Q,e,L)}{\partial L} &= \int_{Q-K}^{Q-K+K/L} F\left(D\middle|e\right)dD - KF\left(\left(Q-K+K/L\right)\middle|e\right)\Big/L \\ &= \left(Q-K+K/L\right)F\left(\left(Q-K+K/L\right)\middle|e\right) - (Q-K)F\left((Q-K)\middle|e\right) \\ &\quad -\int_{Q-K}^{Q-K+K/L} Df\left(D\middle|e\right)dD \\ &= -\int_{Q-K}^{Q-K+K/L}\left[D-(Q-K)\right]f\left(D\middle|e\right)dD < 0\end{aligned} \tag{21}$$

$$\frac{\partial^2 g_1(Q,e,L)}{\partial^2 L} = \frac{K^2}{L^3} f\left(\left(Q-K+K/L\right)\middle|e\right) > 0$$

It can be seen that Lemma 3 is proved from (21).

Lemma 4: the expected reduced sales function is strictly convex and increasing in relation to the threshold of customer balking.

Proof: we take the first partial derivatives of (3) with respect to K and have:

$$\begin{aligned}\frac{\partial g_1(Q,e,K)}{\partial K} &= L\left[F\left(\left(Q-K+K/L\right)\middle|e\right)\left(-1+\frac{1}{L}\right) - F\left((Q-K)\middle|e\right)\times(-1)\right] \\ &\quad -F\left((Q-K)\middle|e\right) \\ &= (1-L)\left[F\left(\left(Q-K+K/L\right)\middle|e\right) - F\left((Q-K)\middle|e\right)\right] > 0\end{aligned} \tag{22}$$

And we take the second partial derivative of (22) with respect to K and we derive:

$$\frac{\partial^2 g_1(Q,e,K)}{\partial^2 K} = (1-L)\left[f\left(\left(Q-K+K/L\right)\middle|e\right) + f\left((Q-K)\middle|e\right)\right] > 0 \tag{23}$$

Incorporating (22) and (23), Lemma 4 is proved.

From Lemma 4, we can find that the expected reduced sales are minimum when K is minimum which means that the smaller K is, the smaller the expected reduced sales. Hence, we can reduce K in order to decrease the expected reduced sales that are caused by customer balking.

5 Coordinating the supply chain with two contracts

5.1 Coordination with a revenue-sharing contract

With a revenue-sharing contract, the supplier charges w per unit purchased by the retailer and the retailer sells p per unit. Let φ represent the quota of the supply chain revenue of the retailer at the end of the selling period, and let $(1 - \varphi)$ represent the amount the retailer gives to the supplier. Then, the profit of the retailer and the profit of the supplier are as follows.

$$\pi_r^1 = \varphi p S(Q, e) - wQ - \alpha g_1(Q, e) - g_2(e) \tag{24}$$

$$\pi_s^1 = wQ - cQ + (1-\varphi) p S(Q, e) \tag{25}$$

Proposition 5: supply chain coordination can not be achieved by a revenue-sharing contract under customer balking and sales effort-dependent demand.

Proof: the optimal level e_r^1 of the sales effort for a given order quantity satisfies equation (26):

$$\frac{\partial \pi_r^1\left(Q, e_r^1, \phi\right)}{\partial e} = \varphi p \frac{\partial S\left(Q, e_r^1\right)}{\partial e} - \alpha \frac{\partial g_1\left(Q, e_r^1\right)}{\partial e} - g_2'\left(e_r^1\right) = 0 \tag{26}$$

Comparing (26) and (6), while:

$$\varphi > 0,\ g_2'\left(e\right) > 0 \text{ and } \frac{\partial S\left(Q, e_r^1\right)}{\partial e} > 0$$

Hence

$$\frac{\partial \pi_r^1\left(Q, e_r^1, \varphi\right)}{\partial e} < \frac{\partial \pi\left(Q, e^*\right)}{\partial e}$$

In other words, $e_r^1 < e^*$, and supply chain coordination cannot be achieved.

From Proposition 5, we observe that the revenue-sharing contract cannot coordinate the decentralised supply chain because the retailer bears the total cost (sales effort cost and lost cost of balking) but only gains a fraction of the supply chain revenue; therefore, the retailer would select the lower sales effort. The revenue-sharing only contract cannot coordinate the supply chain under a demand-dependent sales effort, which has been proved by Cachon and Lariviere (2005). Therefore, a better contract should be used to coordinate the supply chain. In the next section, we will design the revenue- and cost-sharing contract for coordinating the supply chain.

5.2 Coordination with a revenue- and cost-sharing contract

In the section, the supplier not only shares in the revenue of the retailer but also shares in the cost of the retailer. Let φ be the fraction of revenue the retailer keeps and $(1 - \beta)$ be the fraction of cost the retailer keeps. Therefore, the expected profit of the retailer $\pi_r^2(Q, e)$ and the expected profit of supplier $\pi_s^2(Q, e)$ are:

$$\pi_r^2(Q,e) = \varphi pS(Q,e) - wQ - (1-\beta)\left(\alpha g_1(Q,e) + g_2(e)\right) \tag{27}$$

$$\pi_s^2(Q,e) = wQ - cQ + (1-\varphi)pS(Q,e) - \beta\left(\alpha g_1(Q,e) + g_2(e)\right) \tag{28}$$

Proposition 6: the supply chain can be coordinated when the coefficient of revenue and cost-sharing φ and the wholesale price w satisfy (29) and (30).

$$\varphi + \beta = 1 \tag{29}$$

$$w = \varphi c \tag{30}$$

Proof: we assume that $\varphi + \beta = 1$ and $w = \varphi c$.

Then

$$\begin{aligned}\pi_r^2(Q,e) &= \varphi pS\left(Q|e\right) - wQ - (1-\beta)\left(\alpha g\left(Q|e\right) + g_2(e)\right) \\ &= \varphi pS\left(Q|e\right) - \varphi cQ - \varphi\left(\alpha g\left(Q|e\right) + g_2(e)\right) \\ &= \varphi\left(pS\left(Q|e\right) - cq - \alpha g\left(Q|e\right) - g_2(e)\right) = \varphi\pi_c(Q,e)\end{aligned} \tag{31}$$

It can be seen that the profit of the retailer is a constant fraction of the centralised supply chain's profit from (31); therefore, the supply chain can be coordinated (see Cachon, 2003).

From Proposition 6, we can find that the revenue- and cost-sharing contract can coordinate the supply chain and that the wholesale price is a constant fraction of the production cost and less than production cost. Thus, Proposition 6 is proved.

From Proposition 6, we can see that unlike the revenue sharing-only contract, the revenue- and cost-sharing contract can coordinate the supply chain. In this case, we can obtain the optimal decision for coordination by adjusting the relationship between w and φ.

6 Numerical analysis

To better explain the preceding conclusions and discover potential regular patterns, this section discusses the models through numerical analysis.

Considering that the stochastic demand x satisfies $x = D(e) \cdot \xi$ (see Taylor, 2002), where $D(e)$ is concave and an increasing function, where $D(0) = 0$, $D(e)' > 0$, $D(e)'' \le 0$, and the marginal effectiveness of effort is decreasing, ξ is a random variable with density function $f(\xi)$ and distribution function $F(\xi)$; hence:

$$f\left(x|e\right) = \frac{1}{D(e)} f\left(\frac{x}{D(e)}\right) \text{ and } F\left(x|e\right) = F\left(\frac{x}{D(e)}\right)$$

Assuming that $\xi \sim$ uniform [0, 100] and $g_2(e) = \frac{1}{2}ae^2$, where $a > 0$ (see Taylor, 2002; Zhao and Wei, 2014; Lan, 2017).

6.1 No coordination for the supply chain

Assume the following: $p = 15$, $c = 6$, $K = 20$, $L = 0.8$, $K/L = 25$, $\alpha = 3$, $w = 9$, $x = e \cdot \xi$, and $a = 100$.

When the sales effort level is given, using equation (7) and (14), we can obtain the ordering quantities in the centralised supply chain (Q_c) and the decentralised supply chain (Q_d), as shown in Table 2.

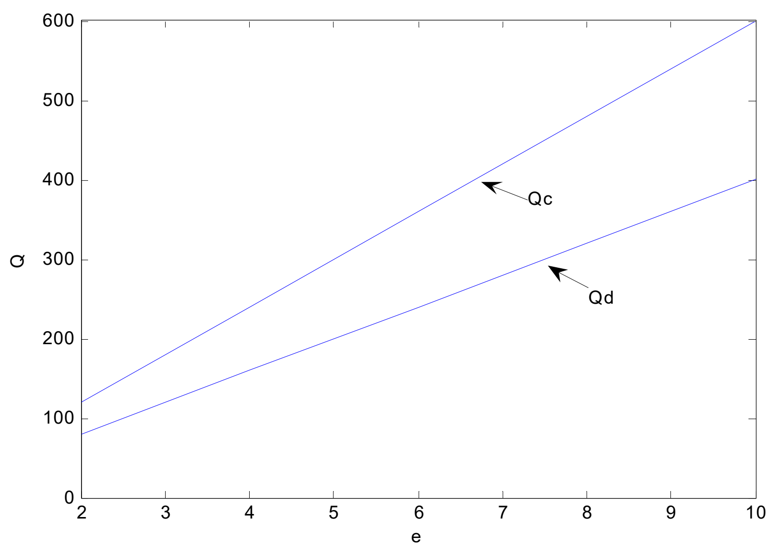
Table 2 Ordering quantity in the centralised and decentralised system

e	2	4	6	8	10
Q_c	120	240	360	480	600
Q_d	80	160	240	320	400

Table 2 shows that the ordering quantity in the centralised and decentralised system increases with the an increasing sales effort and the ordering quantity in the centralised system is greater than that in the decentralised system.

The effects of the sales effort on the optimal ordering quantity in the centralised system and decentralised system are shown in Figure 2.

Figure 2 Effects of *e* on *Q* (see online version for colours)



From Figure 2, it is seen that the optimal ordering quantity (Q) is increasing with the sales effort (e), while the slope of the optimal ordering quantity related to the sales effort in the centralised supply chain is higher than that in the decentralised supply chain; the ordering quantity of a given sales effort in the centralised supply chain is higher than that in the decentralised system.

From Table 2 and Figure 2, it can seen that the conclusions are consistent. Whether it is in a centralised or decentralised system, the supply chain can improve the profits and marketing demand by increasing the sales effort.

In the centralised system, using equations (7) and (5), we can prove that the profit function of the supply chain is jointly concave in e and that the optimal sales effort exists when the profit of supply chain is at its maximum. Therefore, we derive that $e^* = 2.71$ and $Q^* = 163$; substituting $e^* = 2.71$ and $Q^* = 163$ into equation (5), we obtain the maximum profit $\pi(Q, e) = 361.2$.

6.2 Coordination of the supply chain with a revenue- and a cost-sharing contract

To simplify the analysis, only the coordination under a revenue- and a cost-sharing contract are discussed in this section.

Under the coordination conditions of $e_r^2 = e^*, Q_r^2 = Q^*$ and according to Section 6.1, we have $e_r^2 = 2.71$ and $Q_r^2 = 163$. Using equation (21), we have $w = 6\varphi$. Therefore, we assume that w and φ are known when β is known, and the profit of supply chain members is shown in Table 3.

Table 3 Value of parameters of coordination

φ	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
β	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
w	5.4	4.8	4.2	3.6	3	2.4	1.8	1.2	0.6
$\pi_r(Q, e)$	325.08	288.96	252.84	216.72	180.6	144.48	108.36	72.24	36.12
$\pi_s(Q, e)$	36.12	72.24	108.36	144.48	180.6	216.72	252.84	288.96	325.08
$\pi_T(Q, e)$	361.2	361.2	361.2	361.2	361.2	361.2	361.2	361.2	361.2

From Table 3, it can be seen that the wholesale price and the profit of the retailer decrease when the revenue proportion of the retailer decreases and the profit of the supplier increases, while the profit of supply chain is constant; when $\varphi = 0.5$, the profit of the supplier and retailer is the same.

Figure 3 Effects of φ on the profit of supply chain members (see online version for colours)

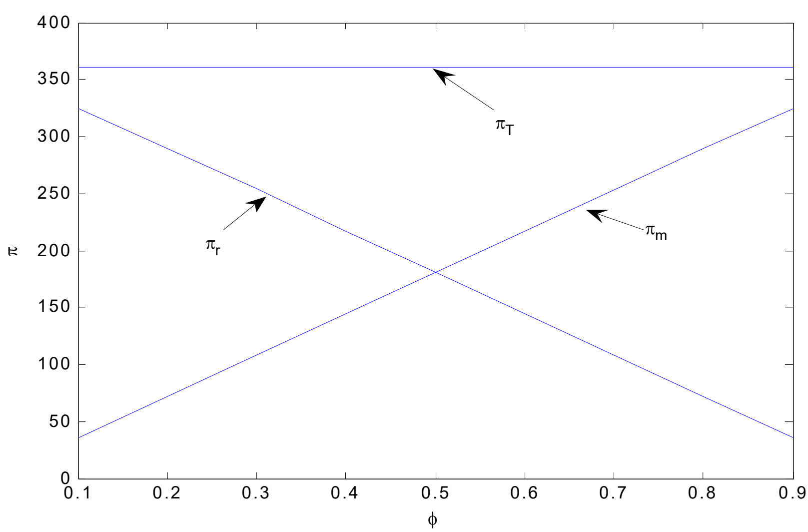


Figure 3 shows that the profit of the supply chain is not influenced by the proportion φ, and, on the contrary, the profits of the supplier and retailer are influenced by the proportion φ. In other words, the profit of the retailer suffers a loss. Therefore, the proportion φ is the key factor in coordinating the supply chain.

From Figure 3 and Table 3, it can be seen that when $\varphi = \beta$, $\pi_r^2(Q, e) = \pi_s^2(Q, e)$, which is a Pareto-improvement scenario under coordination. In this case, we derive that the revenue- and cost-sharing contract can coordinate the supply chain perfectly because the supply chain can achieve the equilibrium between the supplier, and the retailer and the total supply chain is more robust.

6.3 *Effects of uncertain balking parameters on the centralised supply chain*

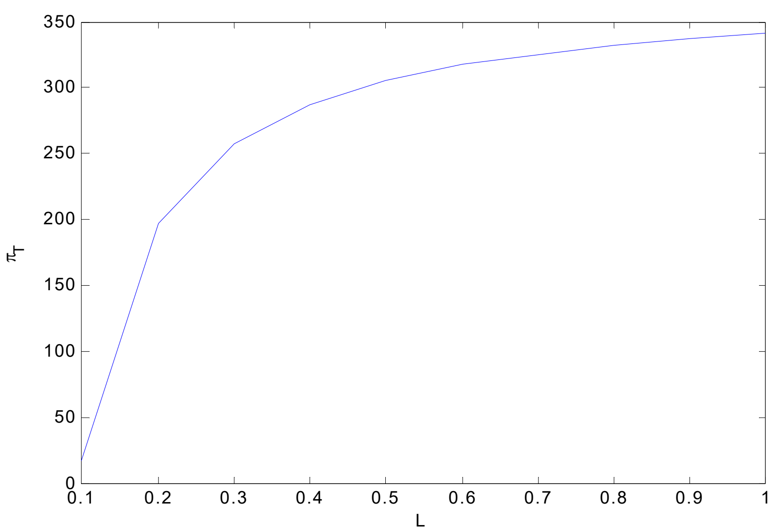
First, in this section, we assume that the probability of a sale during customer balking L is uncertain when $e^* = 2.71$, $Q^* = 163$, $K = 20$ and other parameters are fixed, based on Section 6.1. Therefore, we analyse the effects of L on the profit of the supply chain in the centralised system.

From equation (5), the relationship between L and the profit of centralised supply chain is obtained and shown in Table 4 and Figure 4.

Table 4 Profit of the supply chain with an uncertain L

L	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
π_T	17.28	197.28	257.28	287.28	305.28	317.28	325.85	332.28	337.28	341.28

Figure 4 Effects of L on the profit of the supply chain (see online version for colours)



In Table 4, the profit of the supply chain increases when L increases, as it is obvious that more sales will bring more profit when L increases. Thus, Figure 4 shows that the total profit of supply chain is increasing with L and shows that the relationship between them is nonlinear. As the profit of the supply chain is maximised when $L = 1$, L can improve the profit of supply chain. This is consistent with and derives the same conclusion as Proposition 3.

Corollary1: the relationship between the profit of the supply chain and L is a positive correlation.

Second, it is assumed that the probability of customer balking K is uncertain when $e^* = 2.71$, $Q^* = 163$, $L = 0.8$ and other parameters are fixed based on 6.1. The effects of K on the profit of the centralised supply chain are analysed in this section.

From (5), the relationship between the threshold of customer balking and the profit of the centralised supply chain is obtained and shown in Table 5 and Figure 5.

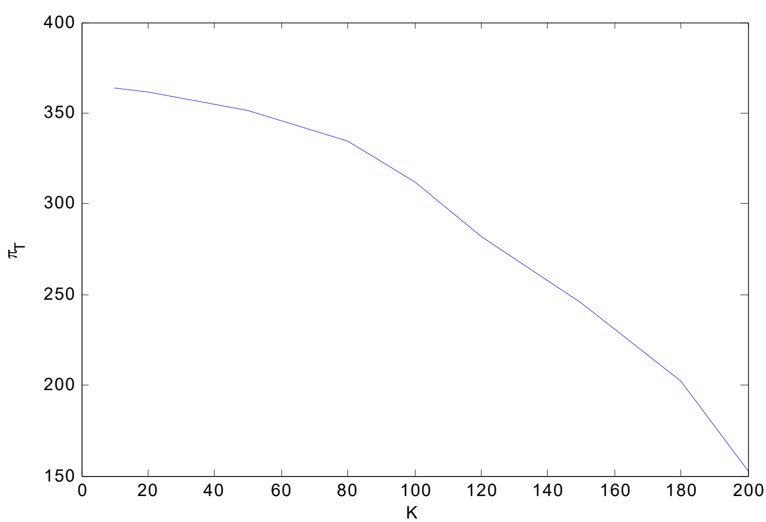
Table 5 Profit of supply chain with uncertain K

K	10	20	50	80	100	120	150	180	200
π_T	363.97	361.48	351.52	334.91	311.66	281.77	245.24	202.07	152.25

From Table 5, it can be seen that the profit of the supply chain decreases with a decrease in K; therefore, the profit performance of the supply chain can be promoted by increasing K.

From Figure 5, it can be seen that the curve is concave and decreasing when $K > 0$, which means that the profit of supply chain decreases when K increases, but it is obvious that there is a upper bound for K and the profit of the supply chain is maximised when K is at its minimum; the observations are the same as those in Proposition 6. Combining Table 5 and Figure 5, Corollary 2 is derived.

Figure 5 Effects of K on the total profit of the supply chain (see online version for colours)



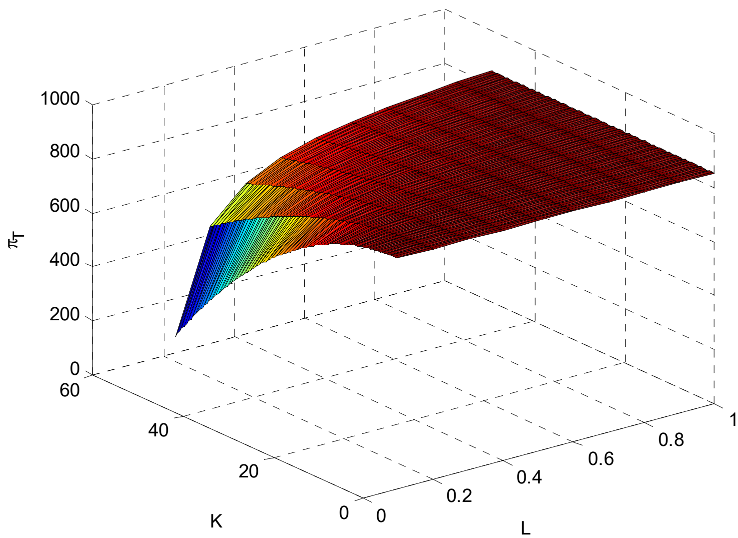
Corollary 2: the profit of supply chain has a negative correlation with K.

A better understanding of the combined effects of K and L on the supply chain is provided in the analysis shown in Figure 6.

From Figure 6, it can be seen that the graph of the supply chain profit is a curved surface that reflects the combined effect of L and K and is at its maximum level when L is at its maximum or K is at its minimum. Compared to the analyses shown in Figure 4 and Figure 5, the analysis shown in Figure 6 is more intuitive and it is easy to understand the combined effects of K and L on the profit of supply chain.

In this section, the numerical analysis shows that the parameters of customer balking have an obvious influence on the performance of supply chain and that a revenue- and cost-sharing contract can coordinate the supply chain to achieve the Pareto-improvement. Managers can improve the performance of the supply chain by raising the probability of a sale during customer balking and reducing the threshold of inventory at which customer balking occurs.

Figure 6 Effects of K and L on the supply chain (see online version for colours)



7 Conclusions

Customer balking behaviour brings a great challenge for retailers and supply chains not only to have sufficient inventory to ensure sales and to meet the market demand but also to control costs to reduce risks. For the supply chain, it is best to satisfy the customer and maximise the benefits of the stakeholders. Therefore, this paper analyses the coordination of the supply chain in a centralised and a decentralised system under a customer balking scenario and presents a numerical analysis. The conclusions are as follows.

First, the sales effort and retail price in the centralised system are lower than those in the decentralised system, but the wholesale price is higher; Second, unlike the revenue-only contract, a revenue-and cost-sharing contract can coordinate the supply chain, and there is a Pareto-improvement scenario for achieving the goal of enhancing the performance of the supply chain. Finally, the parameters of customer balking can obviously influence the profit of the supply chain and be changed for managing the supply chain.

The paper shows that customer balking can impact the supply chain and demonstrates that the extended newsvendor model can be applied in the analysis of supply chain coordination and can be highly practical, as marketing demand is stochastic. Moreover, in this paper, the newsvendor model is shown to be suitable for analysing the problems that were put forward, which were unique in that behavioural economics was introduced into supply chain coordination, and the conclusions reached through using the model were original. In addition, the study results provide implications for managers: marketing demand can be expanded by increasing the retailer's inventory and sales effort in order to reduce customer balking behaviour and to decrease the supplier's wholesale price for additional product orders. Therefore, for managers, these actions can also be the basis for improving work efficiency and managing the supply chain.

In the paper, as information symmetry is assumed, it is therefore also assumed that the information that the retailer collects from the end market is viewed as private information and is not shared with the supplier. Asymmetric information sharing between the supplier and retailer, as well as risk preferences, are also not studied in this paper. In the future, we will further study the coordination of the supply chain under customer balking in selected cases, such as ones involving risk preference, information asymmetry, and a multi-echelon supply chain.

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References

Cachon, G.P. (2003) 'Supply chain coordination with contracts', *Handbooks in Operations Research and Management Science: Supply Chain Management: Design, Coordination and Operation*, Vol. 11, pp.27–339.

Cachon, G.P. and Lariviere, M.A. (2005) 'Supply chain coordination with revenue-sharing contracts: strengths and limitations', *Management Science*, Vol. 51, No. 1, pp.30–44.

Cheong, T. and Kwon, K. (2013) 'The robust min-max newsvendor problem with balking under a service level constraint', *South African Journal of Industrial Engineering*, Vol. 24, No. 3, pp.83–97.

Darwish, M.A., Alenezi, A.R. and Aldaihani, M.M. (2015a) 'Per-unit cost minimisation of the newsvendor problem', *International Journal of Industrial and Systems Engineering*, Vol. 20, No. 4, pp.497–515.

Darwish, M.A., Odah, O.M. and Goyal, S.K. (2015b) 'Vendor managed inventory models for single-vendor multi-retailer supply chains with quality consideration', *International Journal of Industry and System Engineering*, Vol. 20, No. 1, pp.22–57.

Delvecchio, D., Henard, D.H. and Freling, T.H. (2006) 'The effect of sales promotion on post-promotion brand choice: a mesa analysis', *Journal of Retailing*, Vol. 82, No. 3, pp.203–213.

Feng, Y.G. (2015) 'Revenue-sharing contract in supply chain with customer balking', *Systems Engineering*, Vol. 33, No. 12, pp.42–47.

Ghosh, D. and Shah, J. (2015) 'Supply chain analysis under green sensitive customer demand and cost sharing contract', *International Journal of Production Economics*, Vol. 164, No. 1, pp.319–329.

Giannoccaro, I. and Pontrandolfo, P. (2004) 'Supply chain coordination by revenue sharing contracts', *International Journal of Production Economics*, Vol. 89, No. 2, pp.131–139.

He, Y., Yang, D.L. and Wu, Q.L. (2006) 'Revenue-sharing contract of supply chain with effort dependent demand', *Computer Integrated Manufacturing Systems*, Vol. 12, No. 11, pp.1865–1868.

He, Y., Zhao, X., Zhao, L.D. and He, J. (2009) 'Coordinating a supply chain with effort and price dependent stochastic demand', *Applied Mathematical Modelling*, Vol. 33, No. 6, pp.2777–2790.

Hoa, N.T.X. and Luong, H.T. (2017) 'Analysis of a flexible commitment contract with two-way penalties', *International Journal of Industry and System Engineering*, Vol. 27, No. 1, pp.122–160.

Hu, B.Y., Lei, D. and Chen, X. (2010) 'Supply chain option sale-surety contract based on revenue sharing and effort cost partaking', *Journal of Industrial Engineering/Engineering Management*, Vol. 24, No. 3, pp.33–38.

Jonrinaldi, N.A. and Zhang, D.Z. (2017) 'An integrated production, inventory transportation decision in a whole green manufacturing supply chain', *International Journal of Industry and System Engineering*, Vol. 25, No. 4, pp.520–57.

Lan, C.F. (2017) 'Coordinating the VMI supply chain with customer balking and promotional effort', *Soft Science*, Vol. 31, No. 8, pp.139–144.

Lau, H.S., Su, C., Wang, Y.Y. and Hua, Z.S. (2012) 'Volume discounting coordinates a supply chain effectively when demand is sensitive to both price and sales effort', *Computer and Operations Research*, Vol. 39, No. 12, pp.3267–3280.

Lee, S.W. and Jung, U. (2014) 'Customer balking behavior in the newsvendor model: its impact on performance measures and decision under uncertain balking parameters', *International Journal of Production Economics*, Vol. 154, No. 1, pp.274–283.

Liao, Y., Banerjee, A. and Yan, S.Y. (2011) 'A distribution-free newsvendor model with balking and lost sales penalty', *International Journal of Production Economics*, Vol. 133, No. 1, pp.224–227.

Lin, H.J. (2017) 'Lost-sales reduction on coordinated vendor-buyer models of a two-stage supply chain with stochastic supply lead-time', *International Journal of Industrial and Systems Engineering*, Vol. 26, No. 4, pp.549–566.

Moon, I. and Choi, S.J. (1995) 'The distribution free newsboy problem with balking', *Journal of the Operational Research*, Vol. 46, No. 4, pp.537–542.

Ouardighi, F.E. (2014) 'Supply quality management with optimal wholesale price and revenue sharing contracts: a two-stage game approach', *International Journal of Production Economics*, Vol. 156, No. 1, pp.260–268.

Pang, Q.H., Chen, Y. and Yu, Y.L. (2014) 'Coordinating three-level supply chain by revenue-sharing contract with sales effort dependent demand', *Discrete Dynamics in Nature and Society*, No. 1, pp.1–10.

Pasternack, B.A. (1989) *The Newsboy Problem with Balking*, Working Paper, California State University.

Pasternack, B.A. (2001) 'The capacitated newsboy problem with revenue sharing', *Journal of Applied Mathematics and Decision Sciences*, Vol. 5, No. 1, pp.21–23.

Pramudyo, C.S. and Luong, H.T. (2017) 'One vendor-one retailer in vendor managed inventory problem with stochastic demand', *International Journal of Industrial and Systems Engineering*, Vol. 27, No. 1, pp.90–106.

Shafiq, M. and Luong, T. (2017) 'Production allocation decision using revenue sharing contract with prior commitments and two-way penalties', *International Journal of Industry and System Engineering*, Vol. 26, No. 2, pp.247–274.

Shi, Z.Y., Wang, N.M., Jia, T. and Chen, H. (2016) 'Reverse revenue sharing contract versus two-part tariff contract under a closed-loop supply chain system', *Mathematical Problem in Engineering*, Vol. 2, No. 1, pp.1–15.

Taylor, T.A. (2002) 'Supply chain coordination under channel rebates with sales effort effects', *Management Science*, Vol. 48, No. 8, pp.992–1007.

Venegas, B.B. and Ventura, J.A. (2018) 'A two-stage supply chain coordination mechanism considering price sensitive demand and quantity discounts', *European Journal of Operational Research*, Vol. 264, No. 2, pp.524–533.

Wei, Y. and Xiong, L.Y. (2015) 'Contracting fashion products supply chains when demand is dependent on price and sales effort', *Mathematical Problem in Engineering*, No. 1, pp.1–7.

Xu, J.T., Qi, Q. and Bai, Q.G. (2018) 'Coordinating a dual-channel supply chain with price discount contracts under carbon emission capacity regulation', *Applied Mathematical Modelling*, Vol. 56, No. 1, pp.449–468.

Xu, X.P., He, P., Xu, H. and Zhang, Q. (2017) 'Supply chain coordination with green technology under cap-and-trade regulation', *International Journal of Production Economics*, Vol. 183, No. 1, pp.433–442.

Ye, T.F. and Sun, H. (2016) 'Price-setting newsvendor with strategic customers', *Omega*, Vol. 63, No. 1, pp.103–110.

Yu, H. and Zhai, J. (2014) 'The distribution-free newsvendor problem with balking and penalties for balking and stockout', *Journal of system science and system engineering*, Vol. 23, No. 2, pp.153–175.

Zhang, B.F., Wu, D.D. and Liang, L. (2018) 'Trade credit model with customer balking and asymmetric market information', *Transportation Research Part E*, Vol. 110, No. 1, pp.31–46.

Zhang, J.X., Liu, G.W., Zhang, Q. and Bai, Z. (2015) 'Coordinating a supply chain for deteriorating items with a revenue sharing and cooperative investment contract', *Omega*, Vol. 56, pp.37–49.

Zhao, J. and Wei, J. (2014) 'The coordinating contracts for a fuzzy supply chain with effort and price dependent demand', *Applied Mathematical Modelling*, Vol. 38, Nos. 9–10, pp.2476–2489.

Zheng, B.R., Yang, C., Yang, J. and Zhang, M. (2017) 'Pricing, collecting and contract design in a reverse supply chain with incomplete information', *Computers & Industrial Engineering*, Vol. 111, No. 1, pp.109–122.