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Research Paper

Cooperative behavior and information sharing in the e-commerce age

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ABSTRACT

In this research, we consider a supplier-e-tailer supply chain where the e-tailer offers a full return policy (i.e., full refund) to its consumers and both the supplier and the e-tailer have their own information about the product demand of online selling. In this setting, we investigate what effective mechanism can be utilized to motivate the supplier and the e-tailer to share their information and also eliminate information distortion simultaneously, and how the e-tailer's return policy impacts the value of information sharing. Our results show that when the two-part tariff mechanism is implemented, both the supplier and the e-tailer would share their information conditionally. As a result, both the supplier and the e-tailer have their motivations to distort the shared information. However, the cooperative wholesale price with profit sharing is an effective mechanism to be utilized to motivate the supplier and the e-tailer to share their information truthfully and create a win-win solution. Furthermore, our results show that comparing to the two-part tariff mechanism, the cooperative wholesale price mechanism has a competitive advantage to help both the supplier and the e-tailer achieve higher profits. In addition, our results also indicate that both the supplier and the e-tailer have stronger motivation to implement an information sharing arrangement when a full return policy is offered to consumers.

1. Introduction

Product return is an essential option in the post-purchase decision-making process of consumers. As online shopping becomes more commonplace, the return policy is a critical part of doing business in the market today. Unlike consumers who shop at brick-and-mortar stores, online consumers don't have the chance to touch or physically inspect the product before buying it. As a result, consumers return online purchases for a variety of reasons. For example, sellers delivered the wrong product, the products turned out to be different from what was described, the product is defective or became damaged during shipping, the risk (e.g. performance risk, financial risk, and social risk) of keeping the product is perceived to be high, or the consumers change their minds after buying. Therefore, allowing consumers to return the products protects consumers who experience product misfit, wrong order, and other problems.

Having a well-thought-out return policy is the key to attracting and keeping consumers and a lenient return policy potentially increases consumers' willingness to purchase the products and thus leads to more product purchases (Zhang et al., 2017); this in turn creates a competitive advantage for firms. However, product returns also increase monetary costs for companies. According to Stock et al. (2006), the value of products consumers returned to e-tailers in the U.S. market exceeds $100 billion each year. Therefore, the return policy is a set of tradeoffs for a firm: A generous return policy helps improve sales revenue by motivating more consumers to purchase but also results in higher costs due to more product returns. As a result, a key question arises: Should an e-tailer offer a full return policy (i.e. full refund) to consumers and what are the important implications of this on supply chain management?

Due to variations in economy and consumer tastes and preferences, the product demand always is full of uncertainty (Raju & Roy, 2000). However, accurate demand information is essential to firm performance since it contributes to higher firm profit (Taylor & Xiao 2010). Hence, information accuracy about product demand becomes critically important to firms. Industries without information relating to market conditions would have firms behave in a trial and error process (Yan and Pei, 2011). As an effective mechanism to improve information accuracy, information collaboration and sharing between different firms have been recognized as a strategic part of senior managers' agendas for improving firm performance (Willams and Moore, 2007). When information sharing arrangements are implemented, different signals can be pooled to yield more accurate information. It has been acknowledged that accurate information helps firms improve the decision-making, thus eliminating the need for a costly trial and error process; this leads to higher profitability (Taylor & Xiao, 2010). Various

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information sharing approaches, such as collaborative planning, forecasting, and replenishment (CPFR) and electronic data interchange (EDI) have been widely used in the manufacturing and retail industries. For example, Amazon benefits from sharing its information with suppliers about the product sales, product availability, and order processing (Chopra & Meindl, 2001). The e-tailer Spun.com also has been implementing information sharing with its wholesale distributor Alliance Entertainment about product sales and order fulfillments (Randall et al., 2002).

In this research, we study a supplier-e-tailer supply chain under which the e-tailer sells products online to consumers and also offers a full return policy to consumers. Our research focuses solely on those products covered by a return policy. Hence, products such as final sales or perishable goods are excluded from our consideration. The product demand is assumed to be uncertain and thus the supplier and the e-tailer make their own forecasts about the product demand. When the supplier and the e-tailer don't share their forecasts, their own forecasts will be used to set their optimal strategies. However, when the supplier and the e-tailer implement information sharing, the shared forecasts will be used to make their optimal decisions. As Gal-Or et al. (2008) did, we also rely on the notion that the supplier and e-tailer have different private information and their information is complementary; when the supplier and e-tailer share their private information, the complementary information can be pooled together to generate more accurate information.

In our research, we use an analytical model with Bayesian forecasting to show that when a two-part tariff mechanism is implemented, both the supplier and the e-tailer would share their information voluntarily only if the forecasted product demand from the supplier is higher than the forecasted product demand from the e-tailer. As a result, both the supplier and the e-tailer have a motivation to distort their shared information in order to obtain more profit. However, if a cooperative wholesale price with profit sharing mechanism is employed, both the supplier and the e-tailer would always like to share their information truthfully and thus a Pareto result can be achieved. Furthermore, our results show that comparing to the two-part tariff mechanism, the cooperative wholesale price mechanism has a competitive advantage to help both the supplier and the e-tailer achieve higher profits. In addition, our results also reveal that the motivation to implement an information sharing arrangement becomes much stronger for both the supplier and the e-tailer as a full return policy is offered to consumers.

The rest of this paper is arranged as follows. The literature review is presented in Section 2. Model framework is developed in Section 3. Different scenarios are examined and important findings are derived in Section 4. The importance of return policy on the value of information sharing is studied in Section 5. Conclusions and managerial implications are presented in Sections 6 and 7, respectively.

2. Literature review

2.1. Return policy

Substantial research has investigated the issues related to the inventory and replenishment aspects of return policy for firms. For example, Marvel and Peck (1995) investigated retail price and return policy for firms and illustrated that an offered return policy increases a product's retail price. Emmons and Gilbert (1998) studied how uncertain demand is in relation to return policies and illustrated that uncertain demand may lead to higher retail price and that both the supplier and the retailer can profit from a generous return policy that the supplier offered. Yao et al. (2005) found that the supplier's return policy impacts the product price, order quantity, and profit reallocation in a supplier - two retailer supply chain. Ding and Chen (2008) demonstrated that rational contracts can be utilized to improve the coordination of a three-level supply chain with flexible return policies. However, the aforementioned studies mainly examined return policy related to product inventory and replenishment, while we investigate the effect of full return policy on the value of information sharing. Moreover, our paper diverges significantly from the existing literature in that we focus on markets with uncertain online product demand resulting from variations in economic conditions and technologies, consumer tastes, and preferences. Since online product demand significantly influences the firm profit, accurate information about online product demand becomes critically important to firms.

Another stream of research has focused on consumers' responses to a retailer's return policy. For example, Pfau (1997) showed that consumers who have been exposed to disconfirming information from poor product performance or negative advertisements will be motivated to return the products. Davis et al. (1998) revealed that consumers would like to return the purchased product if they found that it is beneficial for them to return and receive the refund. Wood (2001) investigated the effect of a retailer's return policy on an online consumer's purchase decision, and found that a generous return policy motivates a consumer to place an online order. Mukhopadhyay and Setoputra (2004) and Yan (2009) found that not only the consumers but also the retailers prefer a return policy. This is because product returns could positively affect the consumer's future buying behavior and increase consumer's future value to the firm (Petersen & Kumar, 2009; Venkatesan and Kumar, 2004). However, unlike the aforementioned studies that focused on return policy's influences on consumer behavior, we study the strategic importance of full return policy to supply chain management and information sharing.

2.2. Information sharing

Quite a few papers have studied the influence of information sharing on inventory or replenishment management. For example, Gavirneni, Kapuscinski and Tayur (1999) have examined the savings to the supplier due to information sharing in a supplier – retailer supply chain. Cachon and Fisher (2000) demonstrated that the supplier and its retailers benefit from a reduced lead time due to information sharing. Lee et al. (2000) revealed that a two-level supply chain can benefit from information sharing through reduced inventory and cost. Guo and Iyer (2010) showed that a voluntary sharing mechanism motivates the supplier to acquire more information about consumer preferences and demands. However, our work diverges significantly from these papers in that we consider the strategic role information sharing plays on pricing strategies with the consideration of a full return policy.

Corbett et al. (2004) found that full information sharing provides the supplier an advantage in being able to provide an appropriate contract offer to the buyer. Niraj and Narasimhan (2004) and He et al. (2008) revealed that when information is transmitted from an upstream supplier to a downstream retailer, information sharing cannot provide a win-win result to both the supplier and the retailer. Gal-Or et al. (2008) illustrated that the supplier may benefit more from sharing information with a less informed retailer than a more informed retailer in a supplier - two competitive retailer supply chain when the cost of information sharing is being considered. Yan and Pei (2011) showed that information sharing helps improve the supplier's performance, but it has no influence on the retailer when the supplier uses an online channel and also a retailer to distribute its products. However, our research is significantly different from the aforementioned papers. First, prior studies have not addressed the strategic importance of an e-tailer's return policy in affecting consumer demand and firm performance in their information sharing models; however, we address this important issue, since an e-tailer's return policy has become an inseparable part of many products' sales in e-tailing. Second, the aforementioned papers did not consider how cooperative incentives (e.g. cooperative wholesale price plus profit sharing) can be utilized by the supplier and the e-tailer to share their information and create a Pareto solution, while we consider this issue. Third, the aforementioned papers did not address how the offered return policy influences the value of information sharing, while we do. Finally, while the aforementioned papers did not address what effective mechanism can be utilized to eliminate information distortion when sharing information, we do address this issue.

2.3. Cooperation between a supplier and an e-tailer

Only a few studies have examined supply chain coordination between a supplier and an e-tailer. Yao et al. (2008) found that when the e-tailer takes consumer orders and asks the supplier to fulfill the orders, all supply chain players can profit from the revenue sharing. Yan (2010a) used an analytical model to illustrate that the supplier and the e-tailer can achieve a Pareto result through the strategies of cooperative advertising and strategic alliance. Yan and Cao (2017) employed analytical and empirical models to show that revenue sharing can help all supply chain players achieve a win-win situation when the product return uncertainty is considered. The above papers studied the supplier – e-tailer coordination through considering cooperative advertising or revenue sharing, while we consider information sharing about online product demand and address what effective mechanism can be employed to implement information sharing and eliminate information distortion.

In conclusion, our paper addresses a significantly different issue that is not addressed in the current literature. To the best of our knowledge, our paper is the first one to consider the online product demand uncertainty and the e-tailer's full return policy simultaneously in the supplier – e-tailer supply chain to study the strategic value of information sharing in the extant literature. Further, our research also is the first one to propose how a cooperative wholesale price with profit sharing mechanism can be utilized not only as an incentive mechanism to motivate the supplier and the e-tailer to share their private information voluntarily, but also to help the supplier and the e-tailer eliminate any possible information distortion while they are sharing their information. Through an analytical model using Bayesian forecasting, we derive fresh findings and provide important managerial implications for business managers.

3. Model framework

Before we present our model development, we first present the notations used in the analytical models, as summarized in Table 1.

Table 1
Description of notations and their interpretations.

Notations	Interpretations
v	Consumer's consumption value of the product
gv	The decreased consumption value due to online purchase
b	The consumer's sensitivity to the e-tailer' return policy
k	The portion of sales returned from consumers
D	The e-tailer's demand
q	The quantity of returned products
s_1	The supplier's forecast
s_2	The e-tailer's forecast
ε_1	The supplier's forecast error
ε_2	The e-tailer's forecast error
${\sigma_1}^2$	The accuracy of the supplier's forecast
${\sigma_2}^2$	The accuracy of the e-tailer's forecast
ρ	The correlation of the supplier's and e-tailer's forecasts
w	The supplier's wholesale price
p	The e-tailer's retail price
r	The offered return refund
e	The demand uncertainty
$E[\pi_1]$	The supplier's expected profit
$E[\pi_2]$	The e-tailer's expected profit
t_1	The supplier's bargaining power
t_2	The e-tailer's bargaining power

3.1. Model development

We consider a supply chain consisting of a supplier and a downstream e-tailer. The supplier distributes its product to the e-tailer and then the e-tailer sells this product to consumers. When this product can be checked on the spot and a consumer can have it immediately, the consumer's consumption value about this product (i.e. amount willing to pay) is v (Chiang et al., 2003). Considering the situation of online buying, when the identical product is purchased online at a price$p$, the product cannot be checked physically, consumer has to wait to possess it, and post-purchase services are reduced because e-tailer is located at a distance. Therefore, consumers have a less consumption value about this product when this product is purchased online (Chiang et al., 2003). We define the decreased consumption value asgv. Thus the consumer's consumption value of the product when purchased through online is$v(1-g)(q=kd)$. As a result, the consumer with the consumption value $v(1-g)$ would buy the product when he/she has a nonnegative surplus (i.e.$v(1-g)-p\geq 0$). Following the assumption of Chiang et al. (2003), we also assume that v has a uniform distribution from 0 to 1, with a density of 1.

The e-tailer also offers a full return policy (i.e. full refund) to its consumers. When a consumer purchases a product from an e-tailer and pays a price$p$, he or she may decide to return this product to the e-tailer after receiving it. The refund to the consumer is r(i.e.$r=p$). A generous return policy provides consumers less risks to buy (i.e. consumers can receive full refund from product returns due to wrong product, defective product, changing mind, higher price, damaged product during shipping, and others) and thus consumers would have stronger motivation to purchase this product (Petersen and Kumar, 2009; Zhang et al., 2017). In other words, a generous return policy increases demand but higher retail price decreases the demand. Therefore, we can model the demand as:

$$d=1-g-p+br \tag{1}$$

where, $b(0<b<1)$ measures the effect of e-tailer's return policy on consumers' purchases. One might anticipate that the greater the value of b, the more beneficial the return policy and thus the more the consumers are willing to buy. Please note that a full return policy is offered to consumers (i.e. $r=p$).

When a return policy is offered, analytical and empirical evidences show that the quantity of product returns due to various reasons such as wrong product, defective product, consumer's changing mind, higher price, damaged product during shipping, and others, is proportional to quantity sold (Bonifield et al., 2010; Vlachos and Dekker, 2003). For example, fashion e-commerce generally has the highest return ranging from 25%–50%, whereas an online bookseller reported a return of just 0.44% (Briggs, 2013). As a result, the quantity of returned products can be modeled as follows:

$$q=kd \tag{2}$$

where, q is the quantity of returned products and $k(0<k<b)$is the portion of product sales returned from the consumers. Hence, the e-tailer needs to order $d=1-g-p+br$from the supplier and then sell to consumers; however, consumers would like to return some portion of their purchases, thus the real purchases from the e-tailer is$d-q$.

The product demand is always full of uncertainty (Raju and Roy, 2000). As Gal-Or et al. (2008) did, we also assume that the e-tailer faces a linear stochastic demand. Therefore, when a full return policy (i.e. $r=p$) is offered to consumers, the demand function can be rewritten as:

$$D=1-g-p+bp+e \tag{3}$$

where, e is the uncertainty due to changing conditions, different consumer tastes and preferences, and others, and thus has a normal distribution with mean zero and variance${\sigma_0}^2$. The supplier and the e-tailer make a forecast about e individually through market research, consumer database, etc. The forecast from the supplier iss_1, and the forecast from the e-tailer iss_2. Specifically, we have

$$s_1 = e + \varepsilon_1 \tag{4}$$

$$s_2 = e + \varepsilon_2 \tag{5}$$

Where, ε_i $(i = 1, 2)$ is the error of the forecast and$\varepsilon_i \sim N(0, \sigma_i^2)$. The forecast error is measured by variance σ_i^2 $(i = 1, 2)$. A larger variance implies greater forecast error, which means a less accurate forecast. As σ_i^2 $(i = 1, 2)$ ranges from 0 to∞, the forecast goes from being perfectly accurate to being no accurate at all. The forecast errors $\varepsilon_1$and $\varepsilon_2$may be correlated. The covariance matrix of forecast errors can be written as: $\sum = \begin{bmatrix} \sigma_1^2 & \rho\sigma_1\sigma_2 \\ \rho\sigma_1\sigma_2 & \sigma_2^2 \end{bmatrix}$, where, $\rho\sigma_1\sigma_2 \le \sigma_1^2, \rho\sigma_1\sigma_2 \le \sigma_2^2$, and $0 \le \rho \le 1$. When the supplier and the e-tailer have similar data or use the similar information resources to make forecasts, their forecasts would have a higher correlation (largerρ); the value of information sharing decreases with the forecast correlation, because a higher correlation between the forecasts would make the forecast information more of a substitute than a complement (Yan, 2010b; Yue and Liu, 2006).

If the supplier (the e-tailer) has only its own forecast information to make decision, we have the following expression from the elegant works of Vives (1984) and DeGroot (1990):

$$E[e \mid s_i] = E[s_j \mid s_i] = \frac{s_i(\sigma_0^2 + \rho\sigma_1\sigma_2)}{\sigma_0^2 + \sigma_i^2} i = 1, 2 j = 3 - i \tag{6}$$

However, if the supplier (the e-tailer) has both its own and e-tailer's (supplier's) forecast information to make decision, we have the following expression from the elegant works of Vives (1984) and DeGroot (1990):

$$e_{sharing} = E[e \mid s_1, s_2] = \frac{s_1\sigma_0^2(\sigma_2^2 - \rho\sigma_1\sigma_2) + s_2\sigma_0^2(\sigma_1^2 - \rho\sigma_1\sigma_2)}{\sigma_0^2(\sigma_2^2 + \sigma_1^2 - 2\rho\sigma_1\sigma_2) + (1 - \rho^2)\sigma_1^2\sigma_2^2} \tag{7}$$

Both the supplier and the e-tailer would make optimal decisions to maximize their respective profits. The supplier and the e-tailer are assumed to play a Stackelberg mode, in which the supplier acts as the leader and the e-tailer acts as the follower. Specifically, the supplier decides its wholesale price first, and then the e-tailer decides its retail price and return policy to maximize their respective profits. Cotterill and Putsis Jr. (2000) conducted an empirical study to demonstrate that the Stackelberg mode does reflect a strategic interaction between the supplier and its retailer.

4. Analysis

Here we consider optimal policies under three scenarios: (1) asymmetric information between the supplier and the e-tailer, (2) information sharing through two-part tariff between the supplier and the e-tailer, and (3) information sharing through cooperative wholesale price. We then compare these scenarios and examine the value of information sharing and how the e-tailer's return policy influences the value of information sharing.

4.1. Asymmetric information

When the supplier and the e-tailer don't share their information and have asymmetric information about online product demand, the supplier and the e-tailer would use their own information to make decisions and maximize their respective profits. As Chen and Bell (2013) did, we assume a single period problem and thus the returned products cannot be resold in the same period, since the returned products need to be inspected, fixed, and repacked carefully. Thus the profit functions can be written as:

$$E[\pi_1^N \mid s_1] = E[(w - c)(1 - g - p + bp + e) \mid s_1] \tag{8}$$

$$E[\pi_2^N \mid s_2] = E[(p - w)(1 - g - p + bp + e) - pq \mid s_2] \tag{9}$$

where, w is the supplier's whole price and c is the production unit cost and as in Amrouche and Yan (2015), we also assume that $c$is equal to zero in order to simplify the expressions and maintain analytical tractability without losing any generality. $E[\pi_1^N]$and$E[\pi_2^N]$are the supplier's expected profit and the e-tailer's expected profit, respectively, when the supplier and the e-tailer don't share their information and have the asymmetric information. In the Stackberg mode, the supplier uses its own forecast to move first to set the wholesale price$w$ to maximize its profit. Then the e-tailer (follower) sets the optimal retail price and return policy to maximize its profit, based on its forecast and the supplier's wholesale price. In the Stackelberg mode, the e-tailer can deduce the supplier's forecast from the supplier's wholesale price because such a forecast is used by the supplier to set up its wholesale price and thus its forecast is revealed to the e-tailer through the wholesale price (Gal-Or et al., 2008; Mishra et al., 2007). As a result, the e-tailer acting as the follower has both the supplier's and its own forecasts before setting its own retail price. In other words, even if there is no information sharing in the asymmetric information setting, the e-tailer still has the shared information (i.e. the supplier's and its own forecast information) to make optimal decision; however, the supplier acting as the first mover doesn't have this advantage and thus has only its own forecast information to make decision (Gal-Or et al., 2008; Mishra et al., 2007). Therefore, we can rewrite the expected profit of e-tailer as:

$$E[\pi_2^N \mid s_1, s_2] = E[(p - w)(1 - g - p + bp + e) - pq \mid s_1, s_2] \tag{10}$$

Based on the above structure, we summarize the Bayesian equilibrium results in Table 2 as the supplier and the e-tailer don't share their information. Proof is given in Appendix 1.

Table 2 shows some important results. 1) The wholesale price decreases with the product returns but the retail price would not be impacted by the product returns. The reason is that if the retail price increases with the product turns, fewer consumers would like to buy the product due to higher price. As a result, higher cost due to product turns and less demand due to higher retail price would make less profit to the e-tailer. Hence, the e-tailer would not change its retail price but like to deliver this return information to the manufacturer, and then the manufacturer charges a lower wholesale price to the e-tailer to stimulate the market demand. 2) If the product returns are high due to fraudulent returns (e.g. charge-back fraud, also known as friendly fraud when consumers claim a refund for purchased items but don't return the items to sellers (Khan, 2015), buying an item of clothing, wearing it for attending a party, and then returning it (King & Dennis, 2006; Schmidt et al., 1999), buying a product at a lower price in one store but returning it to another store for higher price or changing products and returning the product with a cheaper price (Harris, 2008), and other

Table 2
Equilibrium results in the asymmetric information setting.

Wholesale price, w^N	$\frac{(1 - g + e_M)(1 - k)}{2(1 - b)}$
Retail price, p^N	$\frac{3 - 3g + 2e_{sharing} + e_M}{4(1 - b)}$
Return policy, $r^N = p^N$	$\frac{3 - 3g + 2e_{sharing} + e_M}{4(1 - b)}$
Supplier's expected profit, $E[\pi_1^N]$	$\frac{(1 - g + 2e_{sharing} - e_M)(1 - k)(1 - g + e_M)}{8(1 - b)}$
E-tailer's expected profit, $E[\pi_2^N]$	$\frac{(1 - g + 2e_{sharing} - e_M)^2(1 - k)}{16(1 - b)}$
The total expected profit of whole supply chain, $E[\pi_1^N + \pi_2^N]$	$\frac{(1 - g + 2e_{sharing} - e_M)(1 - k)(3 - 3g + 2e_{sharing} + e_M)}{16(1 - b)}$

Where, $e_{sharing} = E[e \mid s_1, s_2] = \frac{s_1\sigma_0^2(\sigma_2^2 - \rho\sigma_1\sigma_2) + s_2\sigma_0^2(\sigma_1^2 - \rho\sigma_1\sigma_2)}{\sigma_0^2(\sigma_2^2 + \sigma_1^2 - 2\rho\sigma_1\sigma_2) + (1 - \rho^2)\sigma_1^2\sigma_2^2}$, $e_M = E[e \mid s_1] = \frac{s_1(\sigma_0^2 + \rho\sigma_1\sigma_2)}{\sigma_0^2 + \sigma_1^2}$

reasons), the e-tailer would suffer a higher cost and thus profit loss. Therefore, when product returns are high, the e-tailer may need to set a less generous or restricted return policy to consumers. For example, the consumers can be asked to pay a high return shipping or restocking and handling fee when they make the product returns. Doing so would make the consumers realize that the perceived cost of returning the purchased product is high, and thus it is not beneficial to perform fraudulent returns. 3) When the online product demand is forecasted to be greater, higher wholesale and retail prices can be set; both the supplier and the e-tailer benefit more when the forecast information is more accurate (i.e. $\sigma_1^2$and $\sigma_2^2$are smaller).

4.2. The value of return policy to both the supplier and the e-tailer

We here consider a supplier-e-tailer supply chain without the offered return policy. When there is no return policy, the demand function is$d = 1 - g - p + e$. Following the similar model development and analysis shown in 4.1 and comparing each party's profit correspondingly, we investigate how the full return policy influences the profits of all parties in the asymmetric information setting. Based on our analysis, we have the proposition as follows. Proofs are given in Appendix 2.

Proposition 1: *When the e-tailer offers a full return policy to consumers, both the supplier and the e-tailer would benefit from the offered full return policy in the asymmetric information setting.*

Proposition 1 shows that the offered full return policy helps improve the performances of all parties in the asymmetric information setting. When the full return policy is offered to consumers, consumers have least risk to buy from online and thus they have strong motivation to buy. As a result, the e-tailer would benefit from the increased market sales. In the meantime, the supplier also can benefit from the offered full return policy. The rationale is that when the e-tailer sells more, it will buy more from the supplier through wholesale price. As a result, the supplier also benefits from the increased e-tail sales. Therefore, the important managerial implication is that although the full return policy is a very generous return policy and could bring high return cost to the e-tailer, it is a valuable strategy to be utilized to help improve the performances of both the supplier and the e-tailer and create a win-win situation for all parties.

4.3. Two-part tariff mechanism

In this research, we assume that the supplier offers the e-tailer a two-part tariff mechanism to seek sharing its private information. In other words, the supplier takes the lead by offering the e-tailer a wholesale price$w$ and the fixed fee L $(0 < L < 1)$, paid from the supplier to subsidize the e-tailer. The e-tailer can choose either to accept or not to accept the supplier's offer. Once the e-tailer accepts the offer and agrees to implement information sharing arrangement with the supplier, both the supplier and the e-tailer have the shared information and thus have symmetric information about online product demand. As a result, the expected profit functions of the supplier and the e-tailer are given as:

$$E\left[\pi_1^I \mid s_1, s_2\right] = E\left[w(1 - g - p + bp + e) \mid s_1, s_2\right] - L \tag{11}$$

$$E\left[\pi_2^I \mid s_1, s_2\right] = E\left[((p - w)(1 - g - p + bp + e) - pq) \mid s_1, s_2\right] + L \tag{12}$$

where, $E[\pi_1{}^I]$ and $E[\pi_2{}^I]$ are the supplier's expected profit and the e-tailer's expected profit, respectively, when the supplier and the e-tailer share their information through two-part tariff. Based on the above structure, we can summarize the Bayesian equilibrium results in Table 3 as the supplier and the e-tailer share their information through a two-part tariff mechanism. Proof is given in Appendix 3.

Table 3 shows that when the online product demand is forecasted to be greater, higher wholesale and retail prices should be set; however, if the product returns are high due to fraudulent returns and other

Table 3
Equilibrium results in the information sharing setting with two-part tariff.

Wholesale price, w^I	$\dfrac{(1-g+e_{sharing})(1-k)}{2(1-b)}$
Retail price, p^I	$\dfrac{3-3g+3e_{sharing}}{4(1-b)}$
Return policy, $r^I = p^I$	$\dfrac{3-3g+3e_{sharing}}{4(1-b)}$
Supplier's expected profit, $E[\pi_1{}^I]$	$\dfrac{(1-g+e_{sharing})^2(1-k)}{8(1-b)} - L$
E-tailer's expected profit, $E[\pi_2{}^I]$	$\dfrac{(1-g+e_{sharing})^2(1-k)}{16(1-b)} + L$
The total expected profit of whole supply chain, $E[\pi_1{}^I + \pi_2{}^I]$	$\dfrac{3(1-g+e_{sharing})^2(1-k)}{16(1-b)}$

(Where,) $e_{sharing} = E\left[e \mid s_1, s_2\right] = \dfrac{s_1\sigma_0^2(\sigma_2^2 - \rho\sigma_1\sigma_2) + s_2\sigma_0^2(\sigma_1^2 - \rho\sigma_1\sigma_2)}{\sigma_0^2(\sigma_2^2 + \sigma_1^2 - 2\rho\sigma_1\sigma_2) + (1-\rho^2)\sigma_1^2\sigma_2^2}$

reasons, the e-tailer needs to set a less generous or restricted return policy to consumers.

Next, we also examine if both the supplier and the e-tailer can benefit from the offered full return policy in the information sharing setting with two-part tariff through comparing the profits of both the supplier and the e-tailer with return policy with their profits without return policy. Our results show that proposition 1 holds in the information sharing setting with two-part tariff as well.

Furthermore, Table 3 also shows that any improvement in the forecast accuracy of the supplier or e-tailer would lead to higher profits for both the supplier and the e-tailer. The reason is that the supplier or e-tailer uses the shared information to make its decisions, thus the improved forecast information from the supplier or e-tailer would increase the profit for both parties. There is an incentive for both the supplier and the e-tailer to have full information sharing, since full information sharing brings the most accurate information to each player (Vives, 1984). However, is information sharing always profitable? we thus investigate if it is beneficial for both the supplier and the e-tailer to implement an information sharing arrangement through a two-part tariff mechanism, since information sharing among supply chain players has been recognized as a strategic approach to help improve supply chain performance (Willams and Moore, 2007).

4.4. Asymmetric information vs. information sharing

In this section, we assess how information sharing influences the profits of both the supplier and the e-tailer as well as the profit of the whole supply chain, when the supplier and the e-tailer are implementing information sharing arrangement through two-part tariff. Based on our results, we have the following proposition. Proof is given in Appendix 4.

Proposition 2*: When a full return policy is offered to consumers and the supplier utilizes a two-part tariff mechanism to seek sharing the e-tailer's private information about online product demand, both the supplier and the e-tailer agree to implement an information sharing arrangement only if the forecasted online product demand from the supplier is greater than the forecasted online product demand from the e-tailer.*

Proposition 2 suggests that if the supplier and the e-tailer share their information through a two-part tariff, both of them would like to engage in information sharing only under a certain condition – the forecasted online product demand from the supplier is greater than the forecasted online product demand from the e-tailer. The rationale is that when there is no information sharing between the supplier and the e-tailer (i.e., asymmetric information) and the supplier has a greater forecast about online product demand, the supplier would charge a higher wholesale price to the e-tailer; however, when the e-tailer shares its smaller forecast information with the supplier (i.e. information sharing), the supplier would realize that the charged wholesale price due to its greater forecast needs to be lower, since the forecast from e-tailer shows that the online product demand in the market is not as high as the supplier estimates. As a result, the supplier needs to adjust its wholesale price through reducing the wholesale price and charging a lower wholesale price to the e-tailer and then the e-tailer can set a lower retail price to increase market demand. As a result, both the supplier and the e-tailer can benefit from an increased market demand. However, if the forecasted online product demand from the supplier is smaller and the forecasted online product demand from the e-tailer is greater, the supplier would charge the e-tailer a higher wholesale price when the supplier and the e-tailer share their information; and this may lead to higher retail price and thus decreased market demand. Consequently, the e-tailer wouldn't benefit from sharing the supplier's forecast. However, to the supplier, the profit increase from the higher charged wholesale price is more than the profit decrease due to reduced market demand. Thus the supplier always benefits from information sharing. In addition, the whole supply chain profit decreases when the forecasted online product demand from the supplier is smaller than the forecasted online product demand from the e-tailer. In other words, the supplier cannot induce the e-tailer to share its information through paying a fixed fee L (i.e. a payment made to e-tailer to induce it to join an information sharing agreement). This is because the supplier's increased profit is less than the e-tailer's lost profit while sharing information. Hence, only if the forecasted online product demand from the supplier is greater than the forecasted online product demand from the e-tailer, would both the supplier and the e-tailer like to share their information voluntarily.

In general, both the supplier and the e-tailer would agree to share their forecast information only under the condition - the forecasted online product demand from the supplier is greater than the forecasted online product demand from the e-tailer. Otherwise, information sharing equilibrium cannot be reached. However, as shown in the aforementioned information sharing arrangement, the supplier always benefits from sharing the e-tailer's information. Hence, the important question is whether the supplier would like to seek information sharing through distorting its information to induce the e-tailer to share its information; in the meantime, the e-tailer also has a motivation to distort its information.

4.5. Possibility of information distortion

Knowing that the e-tailer would like to share its information with the supplier only if the forecasted online product demand from the e-tailer is lower than the forecasted online product demand from the supplier, the supplier may have a strong motivation to overstate its forecast information rather than reveal it to the e-tailer truthfully. The logic is that when the supplier overstates its forecast information and thus shares this information with the e-tailer, the increased profit due to information sharing will offset the profit loss due to a lower charged wholesale price. However, the e-tailer has a strong motivation to understate its forecast information in order to receive a lower wholesale price. In general, both the supplier and the e-tailer have a strong motivation to distort their respective forecasts while sharing information. Knowing such a fact, neither the supplier nor the e-tailer would trust their shared information and use the shared information to make price and return policy decisions. As a result, both the supplier and e-tailer would not like to share their information since information distortion decreases the value of information sharing. However, as seen in real businesses, definite benefits from information sharing exist for all parties in the supply chain management. Hence, the important question is if there is any effective mechanism(s) which can be utilized by the supplier and the e-tailer to implement an information sharing arrangement, so that both of them can share their information voluntarily all the time. In the meantime, any possible information distortion also can be eliminated and thus truthful information can be shared. Consequently, a Pareto result can be achieved for both the supplier and the e-tailer. Here we propose a valuable and novel approach, which has not been addressed in the extant literature, with respect to the supplier and the e-tailer. In other words, the supplier and the e-tailer can utilize a cooperative wholesale price with profit sharing as an effective mechanism to share their information. Prior research (e.g. Amrouche and Yan, 2015; Ingene and Parry, 1995) shows that cooperative wholesale price effectively coordinates channel distributions in a supplier - retailer supply chain. Implementation through cooperative wholesale price helps solve the issue of double marginalization and motivates the retailer to lower its retail price. Consequently, the product demand from the retailer increases. However, it has not been explored in the extant literature whether the cooperative wholesale price can be utilized as an effective mechanism to help motivate the supply chain players to share their information and in the meantime, eliminate the information distortion in a supplier - e-tailer supply chain.

4.6. The cooperative wholesale price mechanism

Here we propose that the supplier can utilize the cooperative wholesale price mechanism as an effective mechanism to motivate the e-tailer to share its information. When cooperative wholesale price mechanism is implemented to motivate the supplier and e-tailer to share their information, the supplier sets its wholesale price to maximize the whole supply chain profit, not to maximize its individual profit, given that the e-tailer sets the retail price and return policy to optimize its individual profit. Based on the above structure, we summarize the Bayesian equilibrium results in Table 4 as the supplier and the e-tailer share their information through a cooperative wholesale price mechanism. Proof is given in Appendix 5.

Table 4 shows that when the online product demand is forecasted to be greater, higher retail price should be set; however, if the product returns are high due to fraudulent returns and other reasons, the e-tailer has to offer a less generous or restricted return policy to consumers.

Next, we examine if both the supplier and the e-tailer can benefit from the offered full return policy in the information sharing setting with cooperative wholesale price through comparing the profits of both the supplier and the e-tailer with return policy with their profits without return policy. Our results show that proposition 1 holds in the information sharing setting with cooperative wholesale price as well.

Furthermore, we also examine how the cooperative wholesale price influences the profits of both the supplier and the e-tailer through comparing their profits under different scenarios. Based on our comparisons, we have the following proposition. Proof is given in Appendix 6.

Proposition 3:

(a) *When a full return policy is offered to consumers and the supplier and the e-tailer use the cooperative wholesale price mechanism as incentive mechanism to share their information, the e-tailer always benefits from the cooperative wholesale price*;

(b) *the supplier does not benefit from the cooperative wholesale price mechanism*;

Table 4
Equilibrium results in the information sharing setting with cooperative wholesale price.

Wholesale price, w^{II}	0
Retail price, p^{II}	$\frac{1-g+e_{sharing}}{2(1-b)}$
Return policy, $r^{II}=p^{II}$	$\frac{1-g+e_{sharing}}{2(1-b)}$
Supplier's expected profit, $E[{\pi_1}^{II}]$	0
E-tailer's expected profit, $E[{\pi_2}^{II}]$	$\frac{(1-g+e_{sharing})^2(1-k)}{4(1-b)}$
The total expected profit of whole supply chain, $E[{\pi_1}^{II}+{\pi_2}^{II}]$	$\frac{(1-g+e_{sharing})^2(1-k)}{4(1-b)}$

(Where,) $e_{sharing}=E[e\mid s_1,s_2]=\frac{s_1\sigma_0^2(\sigma_2^2-\rho\sigma_1\sigma_2)+s_2\sigma_0^2(\sigma_1^2-\rho\sigma_1\sigma_2)}{\sigma_0^2(\sigma_2^2+\sigma_1^2-2\rho\sigma_1\sigma_2)+(1-\rho^2)\sigma_1^2\sigma_2^2}$

(c) *the whole supply chain always benefits from the cooperative wholesale price mechanism.*

Proposition 3 reveals some important and novel findings. First, propositions 3(a) and 3(b) show that as an incentive mechanism, cooperative wholesale price mechanism is beneficial to the e-tailer but may not be beneficial to the supplier. However, proposition 3(c) reveals that cooperative wholesale price contact helps increase the profit of whole supply chain. Hence, a win-win opportunity does exist for both the supplier and the e-tailer through employing cooperative wholesale price mechanism as an effective mechanism to implement information sharing arrangement. The rationale is that the increased profit for the e-tailer can offset the supplier's profit loss due to cooperative wholesale price. Hence, the supplier also needs to ask the e-tailer to implement another coordination mechanism - profit sharing - while employing cooperative wholesale price as a coordination mechanism to implement information sharing arrangement. As a result, a Pareto result through the cooperative wholesale price with profit sharing mechanism can be achieved for both the supplier and the e-tailer while they are implementing information sharing arrangement.

4.7. Profit sharing mechanism

In this section, we examine how the profit sharing mechanism can be utilized to motivate the supplier and the e-tailer to implement the cooperative wholesale price when the supplier and the e-tailer share their information. Assume a portion $\Delta\pi_1$ of the increased profit is received by the supplier while the remainder $\Delta\pi_2$ is received by the e-tailer. As a result, both the supplier and the e-tailer would accept the profits as follows:

$$\pi_1^{PS} = \pi_1^N + \Delta\pi_1 \tag{13}$$

$$\pi_2^{PS} = \pi_2^N + \Delta\pi_2 \tag{14}$$

$$\Delta\pi_1 + \Delta\pi_2 = \Delta\pi \tag{15}$$

where, $\Delta\pi$ is the increased profit due to implementing information sharing through cooperative wholesale price,$\Delta\pi = \pi_1^{II} + \pi_2^{II} - \pi_1^N + \pi_2^N$,$\pi_1^{PS}$is the supplier's profit with profit sharing, and $\pi_2^{PS}$is the e-tailer's profit with profit sharing.

How does one ensure that the increased profit is divided rationally so that a win-win result can be achieved for both the supplier and the e-tailer? We here use the Nash bargaining mode to divide the increased profit, since the Nash (1950) bargaining mode has been employed in different situations, such as quantity discount (Kohi and Park, 1989), brand competition (Amrouche & Yan, 2012), and so on.

Assume the supplier's utility of $\Delta\pi_1$ is u_1 and the e-tailer's utility of $\Delta\pi_2$ is u_2 and

$$\mu_i(\Delta\pi_i) = (\Delta\pi_i)^{t_i},\ i = 1, 2 \tag{16}$$

where, $t_1(t_1 > 0)$ is the supplier's bargaining power, and $t_2(t_2 > 0)$ is the e-tailer's bargaining power.

The system utility function is given as:

$$\mu_1\mu_2 = (\Delta\pi_1)^{t_1}(\Delta\pi_2)^{t_2} \tag{17}$$

Maximizing u_1u_2 subject to the constraint $\Delta\pi_1 + \Delta\pi_2 = \Delta\pi$ yields

$$\Delta\pi_1 = \frac{t_1}{t_1 + t_2}\Delta\pi \tag{18}$$

$$\Delta\pi_2 = \frac{t_2}{t_1 + t_2}\Delta\pi \tag{19}$$

Here, $\Delta\pi_1 = \frac{t_1}{t_1+t_2}\Delta\pi$ denotes the partial profit the supplier obtains and $\Delta\pi_2 = \frac{t_2}{t_1+t_2}\Delta\pi$ denotes the partial profit the e-tailer obtains.

Based on the above bargaining models, we show that first, if the supplier (e-tailer) is more powerful in bargaining than the e-tailer (supplier), the supplier (e-tailer) will receive a larger partial profit. For instance, when$t_1 > t_2$, we have$\Delta\pi_1 > \Delta\pi_2$. Second, if both the supplier and the e-tailer are equally powerful in bargaining ($t_1 = t_2$), then the supplier and the e-tailer would share the increased profit equally (i.e. $u_1 = \Delta\pi_1 = \frac{1}{2}\Delta\pi$ and$u_2 = \Delta\pi_2 = \frac{1}{2}\Delta\pi$). Once the supplier and the e-tailer agree to share the bargained profit, both of them would be motivated to maximize the whole supply chain profit, and this in turn would maximize their individual profits as well.

4.8. Elimination of information distortion

In general, the cooperative wholesale price with profit sharing mechanism does create a win-win solution for both the supplier and the e-tailer. Hence, they have a strong motivation to share their information voluntarily all the time. However, the important question is when the coordinative wholesale price with profit sharing mechanism can also be utilized effectively to eliminate any possible information distortion while the supplier and the e-tailer are implementing an information sharing arrangement. When the supplier and the e-tailer are implementing an information sharing arrangement, the cooperative wholesale price with profit sharing mechanism does eliminate any possible information distortion and thus motivate the supplier and the e-tailer to share their information truthfully. The rationale is that when the supplier and the e-tailer share their information through the coordinative wholesale price with profit sharing mechanism, the shared information will be used to make optimal decisions to maximize the whole supply chain profit. Then the supplier and the e-tailer share the profit that the whole supply chain generates. Once any distorted information from the supplier or the e-tailer is shared, the decisions wouldn't be optimal, and this will lead to reduced profit for the whole supply chain. Consequently, both the supplier and the e-tailer would receive less profit through profit sharing if any party distorts its shared information. Therefore, it is in the interest of both the supplier and the e-tailer to eliminate any possible information distortion and share their information truthfully when the cooperative wholesale price with profit sharing mechanism is implemented.

4.9. Cooperative wholesale price mechanism vs. two-part tariff mechanism

In this section, we compare the two-part tariff mechanism with the cooperative wholesale price mechanism to investigate which mechanism has a competitive advantage to help the whole supply chain achieve a higher profit as the supplier seeks sharing the e-tailer's private information, which in turn leads to a win-win result to both supply chain players. Based on our results, we have proposition as follows. Proofs are given in Appendix 7.

Proposition 4*: When a full return policy is offered to consumers and information sharing arrangement is implemented, the cooperative wholesale price mechanism has a competitive advantage to help the whole supply chain achieve a higher profit than the two-part tariff mechanism.*

Proposition 4 shows some valuable findings. When the supplier seeks sharing the e-tailer's private information, the cooperative wholesale price mechanism is a more coordinative mechanism to be utilized to help improve the performance of whole supply chain. The rationale is that when the supplier uses the two-part tariff mechanism to seek sharing the e-tailer's private information, each party behaves independently to maximize their own profits. However, when the supplier utilizes the cooperative wholesale price mechanism to seek sharing the e-tailer's private information, the supplier cooperates with the e-tailer to maximize the whole supply chain profit and thus lead to a higher profit for the whole supply chain. When the cooperative wholesale price mechanism generates a higher profit for the whole supply chain, each of supply chain players would benefit from this increased profit through profit sharing. Therefore, business managers should consider the cooperative wholesale price mechanism as the priority choice to implement an information sharing arrangement in a supplier – e-tailer supply chain.

5. The effect of return policy on the value of information sharing

Here we consider how the e-tailer's full return policy influences the value of information sharing when information sharing is implemented through cooperative wholesale price mechanism. When no return policy is offered, the demand function is$d = 1 - g - p + e$. Following the same development shown in the section 4, we have the corresponding proposition as follows. Proof is given in Appendix 8.

Proposition 5*: E-tailer's full return policy increases the value of information sharing to both the supplier and the e-tailer when information sharing is implemented through the cooperative wholesale price mechanism.*

Proposition 5 shows that offering a full return policy does bring higher profits to both the supplier and the e-tailer when the supplier and the e-tailer implement an information sharing arrangement through the cooperative wholesale price mechanism This situation gives rise to some important guidelines. The e-tailer should actively offer a full return policy to consumers when it is doing business through the e-market, particularly when the supplier utilizes the cooperative wholesale price mechanism as incentive to implement an information sharing arrangement with the e-tailer. Proposition 5 also reveals that the offered full return policy motivates both the supplier and the e-tailer to share their information. The reason is that the offered full return policy impacts online product demand, thus the supplier and the e-tailer need to obtain more accurate information about online product demand (through information sharing) to make optimal decisions. The important managerial implication is that when the e-tailer sells products via online and offers a full return policy to consumers, implementing an information sharing arrangement should become an important strategic consideration for both the supplier and the e-tailer since it is a vital approach to help enhance the performances of both supply chain players.

6. Conclusions

In our research, we consider a supplier-e-tailer supply chain where the e-tailer is offering a full return policy to its consumers and both the supplier and the e-tailer have asymmetric information about online product demand. Based on this background, we examine how information sharing equilibrium can be reached, how information distortion can be eliminated, and how the e-tailer's full return policy impacts the motivations of both the supplier and the e-tailer to engage in information sharing. Specifically, we ask these questions: under what condition would both the supplier and the e-tailer have a motivation to share their information? Do the supplier and the e-tailer have the motivation to distort their information while sharing information? What effective mechanism can be utilized to help the supplier and the e-tailer implement information sharing effectively and eliminate any possible information distortion? Thus truthful information can be shared and a Pareto result can be achieved for both the supplier and the e-tailer. Which mechanism can help the supplier and the e-tailer achieve higher profits? How does the e-tailer's full return policy impact the value of information sharing? Our results show that when a two-part tariff mechanism is implemented, both the supplier and the e-tailer would share their information voluntarily only if the forecasted online product demand from the supplier is greater than the forecasted online product demand from the e-tailer. Consequently, both the supplier and the e-tailer have a strong motivation to distort the shared information in order to maximize their own profits. However, if a cooperative wholesale price with profit sharing mechanism is employed, both the supplier and the e-tailer would always like to share their information truthfully and thus a Pareto result can be achieved. Furthermore, our results show that comparing to the two-part tariff mechanism, the cooperative wholesale price mechanism has a competitive advantage to help both the supplier and the e-tailer achieve higher profits. In addition, our results also indicate that both the supplier and the e-tailer have a stronger motivation to engage in information sharing when a return policy is offered. Hence, our research reveals that both the valuable coordination mechanism and the e-tailer's full return policy do play vital roles in motivating the supplier and the e-tailer to share their information and lead to a win-win solution in the supplier – e-tailer supply chain.

7. Managerial implications

Our research investigates important business issues and provides valuable findings and managerial implications for firms. Full return policy is becoming more important today because of the popularity of e-commerce. The average product return rate of e-commerce is reported to be much higher than that of brick-and-mortar purchase. Across all product categories, fashion e-commerce generally has the highest return ranging from 25%–50%, whereas an online bookseller reported a return of just 0.44% (Briggs, 2013). It seems evident that the offered return policy not only influences the online product demand and thus the profits of both the supplier and the e-tailer but also brings cost due to product returns. Hence, while studying e-tailing and the value of e-tailer's full return policy, we need to address the importance of online product demand. However, in the business market, online product demand is always full of uncertainty due to changing economy and changes in consumers' tastes and preferences and others. As a result, accurate information about online product demand plays a critical role in firms' performances.

Our paper thus addresses the strategic importance of information sharing about online product demand in the supplier-e-tailer supply chain where the offered full return policy becomes a core and mandatory factor in stimulating online sales. Nowadays e-commerce is becoming increasingly popular due to new technologies and fast shipping methods, information sharing between the supply chain players has been employed widely. Information sharing helps firms make informed decisions and thus eliminate the need for a costly trial and error process. Particularly when the e-tailer offers a full return policy to consumers, the value of information sharing increases even more for both the supplier and the e-tailer. Hence, both the supplier and the e-tailer have a strong incentive to share their information. However, without considering any incentive or coordination mechanism, information sharing between different parties can become a challenging task. For instance, information sharing may benefit one party but not the other party; consequently both parties would have a strong motivation to distort their shared information in order to obtain extra profit. Hence, some effective and valuable mechanism needs to be developed to help the supplier and the e-tailer implement information sharing arrangement effectively, eliminate any possible information distortion, and create a win-win solution. We thus propose that cooperative wholesale price with profit sharing mechanism can be utilized to motivate the supplier and the e-tailer to implement information sharing and collaboration and achieve a Pareto result. For this to be happen, the e-tailer's return policy also needs to be considered. In the business markets, e-tailers (e.g. Ebags, QVC, Amazon, Overstock, Newegg's, Overstock, etc.) and their suppliers can utilize our findings to enhance their market performances.

Our research can be extended in a variety of ways in future studies. In this paper, our analysis is based on an analytical model. Future research could examine the value of information sharing to supply chain players through empirical studies. Further, our research can be extended to consider other incentive mechanisms (e.g. quantity discount) while investigating the influence of cooperative mechanisms on information sharing.

Appendix 1

$E[\pi_2{}^N | s_1, s_2] = E[((p - w)(1 - g - p + bp + e) - pq) | s_1, s_2]$and $q = kd$.

Through the first order condition, we get

$$p^N = \frac{1 + e - g}{2(1 - b)} + \frac{w}{2 - 2k}$$

We then substitute the value of p^N into

$$E[\pi_1^N \mid s_1] = E[w(1 - g - p + bp + e) \mid s_1]$$

Furthermore, through the first order condition on the supplier's expected profit function, we obtain the optimal wholesale price with the supplier's forecast. Then making further substitutions, we obtain the summarized results in Table 2.

Appendix 2

When there is no return policy, the demand function is $d = 1 - g - p + e$. Following the same proofs as in Appendix 1, we obtain the manufacturer's expected profit without return policy in the asymmetric information setting is$E[\pi_1] = \frac{(1 - g + e_M)(1 - g + 2e_{sharing} - e_M)}{8}$, and the e-tailer's expected profit without return policy in the asymmetric information setting is$E[\pi_2] = \frac{(1 - g + 2e_{sharing} - e_M)^2}{16}$. Further, through comparing the e-tailer's expected profit with return policy with its expected profit without return policy in the asymmetric information setting, we have $E[\pi_1^N] - E[\pi_1] = \frac{(b - k)(1 - g + 2e_{sharing} - e_M)^2}{8} > 0$.

Next, following the same proofs as above and after some computations, we have$E[\pi_2{}^N] - E[\pi_2] > 0$. Thus, proposition 1 is proved.

Appendix 3

When the supplier and the e-tailer share their information through two-part tariff,

$E[\pi_1{}^I | s_1, s_2] = E[w(1 - g - p + bp + e) | s_1, s_2] - LE[\pi_2{}^I | s_1, s_2] = E[((p - w)(1 - g - p + bp + e) - pq) | s_1, s_2] + L$

$q = kd$

Through the first order condition, we find the e-tailer's price as follows, $\frac{\partial(E[\pi_2^I \mid s_1, s_2])}{\partial p} = 0$.

Then we obtain $p^I = \frac{1 + e - g}{2(1 - b)} + \frac{w}{2 - 2k}$.

Furthermore, substituting the values of p^I into.

$E[\pi_1{}^I | s_1, s_2] = E[w(1 - g - p + bp + e) | s_1, s_2] - L$ and letting $\frac{\partial(E[\pi_1^I \mid s_1, s_2])}{\partial w} = 0$.

Then substituting the above results into the corresponding functions, we have the summarized results in Table 3.

Appendix 4

Through profit comparisons, we have

$$E[\pi_1^I] - E[\pi_1^N] = \frac{(1 - k)(e_M - e_{sharing})^2}{8(1 - b)} - L$$

$$E[\pi_2^I] - E[\pi_2^N] = \frac{(1 - k)(e_M - e_{sharing})(2 - 2g + 3e_{sharing} - e_M)}{16(1 - b)} + L$$

$$E[\pi_1^I] + E[\pi_2^I] - E[\pi_1^N] - E[\pi_2^N] = \frac{(1 - k)(e_M - e_{sharing})(2 - 2g + e_{sharing} - e_M)}{16(1 - b)}$$

Thus, information sharing equilibrium through two-part tariff will be reached only if$e_M > e_{sharing}$. Otherwise, a non-information sharing equilibrium can be reached. Thus, we can prove proposition 2.

Appendix 5

When a cooperative wholesale price is implemented while information sharing is being shared, $E[\pi_2{}^{II} | s_1, s_2] = E[((p - w)(1 - g - p + bp + e) - pq) | s_1, s_2]$ and$q = kd$.

Through the first order condition, we find the e-tailer's price as follows, $\frac{\partial(E[\pi_2^{II} \mid s_1, s_2])}{\partial p} = 0$.

Thus we obtain $p^{II} = \frac{1 + e - g}{2(1 - b)} + \frac{w}{2 - 2k}$.

Then the supplier uses its wholesale price to maximize the whole supply chain profit, not its individual profit. Substituting the value of p^{II} into.

$E[\pi_1{}^{II} + \pi_2{}^{II} | s_1, s_2] = E[(p(1 - g - p + bp + e) - pq) | s_1, s_2]$and letting

$$\frac{\partial(E[\pi_1^{II} + \pi_2^{II} \mid s_1, s_2])}{\partial w} = 0$$

Then substituting the above results into the corresponding functions, we have the summarized results in Table 4.

Appendix 6

Comparing the supplier's expected profit under different scenarios, we obtain $E[\pi_1{}^{II}] < E[\pi_1{}^{N}]|andE[\pi_2{}^{II}] > E[\pi_2{}^{N}]|$. Similarly, following the same way, we can prove that$E[\pi_2{}^{II}] + E[\pi_1{}^{II}] > E[\pi_2{}^{N}] \mid + E[\pi_2{}^{N}]$. Thus, proposition 3 is proved.

Appendix 7

Because $E[\pi_1^{II}] + E[\pi_2^{II}] = \frac{(1-g+e_{sharing})^2(1-k)}{4(1-b)}$and.

$E[\pi_1^{I}] + E[\pi_2^{I}] = \frac{3(1-g+e_{sharing})^2(1-k)}{16(1-b)}$, we thus obtain

$$E[\pi_1^{II}] + E[\pi_2^{II}] - E[\pi_1^{I}] - E[\pi_2^{I}] = \frac{(1-g+e_{sharing})^2(1-k)}{4(1-b)} - \frac{3(1-g+e_{sharing})^2(1-k)}{16(1-b)}$$

$$= \frac{(1-g+e_{sharing})^2(1-k)}{16(1-b)} > 0$$

Thus, proposition 4 is proved.

Appendix 8

When there is no return policy, the demand function is$d = 1 - g - p + e$. Following the same proofs as in Appendices 1 and 2, we obtain that when no return policy is offered, the total expected profit of whole supply chain in the information sharing setting with cooperative wholesale price is$\frac{(1-g+e_{sharing})^2}{4}$, which is higher than its profit in the asymmetric information and two-part tariff settings. Further, through comparing the total expected profit of whole supply chain with return policy in the information sharing setting with cooperative wholesale price, $\frac{(1-g+e_{sharing})^2(1-k)}{4(1-b)}$, with its expected profit without return policy, $\frac{(1-g+e_{sharing})^2}{4(1-b)}$, we have.

$\frac{(1-g+e_{sharing})^2(1-k)}{4(1-b)}$-$\frac{(1-g+e_{sharing})^2}{4} = \frac{(1-g+e_{sharing})(b-k)}{4(1-b)} > 0$.

Thus, proposition 5 is proved.

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