Information Value in a Dual-channel Supply Chain under Revenue Sharing Contract

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Abstract: This paper assesses the impact of sharing customers' channel preference information on pricing and performance in a dual channel supply chain, where the supplier opens a direct channel and a traditional retailer owns a retail channel. Both the supplier and the retailer perform their forecasting demands based on the ratio of consumers' preferences in the direct channel when we consider the characteristics of consumers' purchase in electronic commerce, while the supplier as a Stackelberg leader designs a revenue sharing contract with the retailer to share the profits in his direct channel. The two scenarios are analyzed under complete information and incomplete information on the ratio of consumers' preferences in the direct channel. The paper finds that information sharing always benefits the supplier, but may hurt the retailer. Therefore, the supplier should design the revenue sharing contract to incent the retailer to share her information. Moreover, the paper obtains the conditions under which the retailer is willing to share her information with the supplier.

Key–Words: Supply chain management; Online channel; Revenue sharing contract; Information sharing; Consumer channel preference; Stackelberge game

1 Introduction

With the further development of electronic commerce technology, a single traditional retail channel has been replacing with the dual channels consisting of a direct channel and a traditional retail channel. Especially, more and more suppliers open their direct channels, the appearance of the direct channel enlarges the competition among the channels and arouses the channel conflicts[1]. In order to solve the channel conflict and improve the efficiency of supply chain operation, more and more researchers have been studying the channel coordination and cooperation problems.

In fact, information sharing is the key problem to realize the coordination of members in supply chains. The information transfer and sharing with the high quality can reduce the uncertainty of the entire supply chains and improve the efficiency of supply chains. Concerning with information sharing problems under dual channel supply chains, there exist a series of fruitful results where most of them are related to information sharing of demand prediction by the market-information-gathering techniques. For example, Yao et al.(2005) estimated optimal order quantities and buyback prices under the assumption of a unknown ratio of customer demand in the direct channel and the coexisting retail channel, and they studied the impact of information sharing on returns policy[2]. Yue et al.(2006) investigated the value of sharing demand forecasts under the 'make-to-order' scenario and 'make-to-stock' scenario, and found the conditions when information sharing has a positive impact on the retailers performance[3]. Yan et al. (2010, 2011) developed a game-theoretic model to examine the value of forecasting information about consumers' willingness to pay in a dual-channel competitive market, and found the effect of information sharing on profits of retailers[4,5]. Noam(2012) discussed a decentralized supply chain with a supplier and several competing retailers and every retailer owns his private information on the marketing demand, he built two signaling games under information sharing among all members and information sharing just between the retailers and the manufacturer[6]. Zissis et al.(2015) analyzed a two node supply chain where the retailer had his own private information and the manufacturer provided quantity discounts. They obtained the theory results and showed that even if there existed asymmetric information, it was possible to realize perfect coordination for the supply chain[7]. In this paper, we also consider asymmetric information and information value problems after information sharing in a dual channel supply chain when consumers' channel preference is considered.

As we know, the development of e-commence results in the change of customers' consuming behaviors. Different with the complementary product market, more and more consumers prefer to buy from the complementary channel (the online channel) or transfer between online and offline channels. There appear the various requests of consumers. To improve the competing advantage, the retailers have to add value to the products in traditional channel such as experience services so that they can absorb more consumers. However, most young people prefer to purchasing in online channel[4,8,9]. Kacen et al.(2002) proposed a measure model to investigate the choice attitudes on six different channels. They observed that the consumers who selected the direct channel paid their more attentions to the eight factors, including price, quality, form of payment, product information and so on[10]. Thus, the channel choice of consumers is a complex problem and plenty of references take consumers' channel preference into their consideration in dual channel supply chain. Chiang et al.(2002) early built the demand functions by considering consumers' acceptance behavior of a direct channel[1]. Muthitacharoen et al.(2006) developed a matrix to prove how the consumers' preference could impacted the business strategies[11]. Koistinen et al.(2009) observed the selections of consumers to the various retail channels and discussed the competitions among them because of the preference of consumers' choices[12]. Pookulangara et al.(2011) surveyed three retail channels and demonstrated consumers' channel shifting behavior. They performed factor analysis and regression to support their results[13]. Kollmann et al.(2012) also empirically investigated consumers' channel choices and proposed that the degree of customers' convenience in online channel had a great advantage over that in offline channel[14]. Balakrishnan et al.(2013) discussed the browse-and-switch behavior of consumers when they first experienced the products in the traditional retail store and then bought the products in the online channel. They combined the uncertainty of consumers' value on the product into an economic model and analyzed the equilibrium solutions and the inclinations to the different channels[15]. Hsiao and Chen (2014) also considered two types of consumers: grocery shoppers and Internet shoppers and showed the interaction between the manufacturer online channel and the pricing decisions[16]. Further, we can see that more and more papers have focused on the research on consumers' channel preferences and this preference can lead to the demand uncertainty. But most of them discuss this problem under demand information sharing. Here, we will explore the demand uncertainty led by consumers' preferences to the channel selections and study the impacts of demand information sharing to a dual channel supply chain.

It is shown that there are various types of the consumers' preferences to the channel selections, such as grocery shoppers, Internet shoppers and browse-switch shoppers etc.[13,15,16]. In fact, because the value of consumers' channel selections varies with many factors there exists marketing demand uncertainty when we consider the consumers' preferences to the channel selections[10]. Therefore, in this paper, we introduce a supplier-retailer dual channel supply chain that consists of a mix of the traditional retail channel and a direct channel. We take the portion of consumers' preferences to the channel selections as the stochastic variable because of the value uncertainty of consumers to channel selections. Meanwhile, to avoid the channel conflict, the supplier with the online channel designs a revenue sharing contract with the retailer and transfer the part of his profit to the retailer, the revenue sharing contract is often applied among the members in supply chains[17]. The supplier and the retailer will predict the marketing demand and establish a Stakelberg game model based on the forecasting demand information.

Although many researchers have analyzed Cournot duopoly games in which both parties have the same power[18,19], different with theirs, we here apply the Stakelberg game model. We assume that the supplier as a leader has more control power than the retailer as a follower in supply chains and he can open his own channel to compete with the retailer. Such similar assumption is appeared in the references[16,20] and there exist many real applications in which the suppliers can more control the product channels than the retailers, such as Lenovo, Apple, HP etc. electronic products suppliers. Therefore, by the Stakelberg game model, we can better analyze the existing problems under the above real circumstances.

Simultaneously, because the retailer is close to the market, she has some advantage in predicting the market demand, and has long experiences on the consumers' demand forecasting. Thus this paper assume that the retailer has more exactly demand information than the supplier. Based on the above assumptions, this paper discusses the pricing policies, profits of two members and the entire supply chain under the two cases of information sharing and non-information sharing. Finally, the conditions under which the retailer is willing to share information are given.

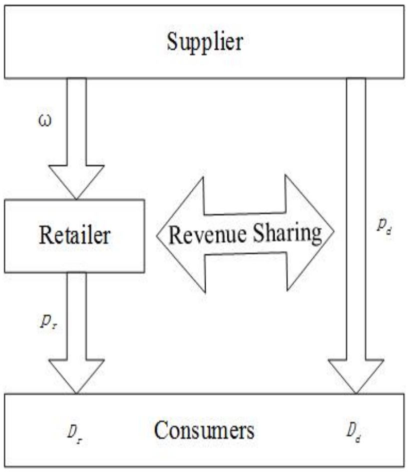

Figure 1: The dual channel supply chain structure

2 Model description

This paper considers a simple mixed supply chain with one supplier(he) who opens a direct channel and one traditional retailer(she). The supplier just produces one single perishable product and consumers can purchase the product either through the retailer or the suppliers direct channel. Based on Yao et al.(2005)[2], opening the direct channel by the supplier always reduces the retailers profit, whether the retailer has stronger or weaker power in supply chains. In order to reduce the retailers boycotting behavior, we assume that a revenue sharing contract is designed between the supplier and the retailer and the part of the revenue from the supplier will be compensated for the profit reduction of the retailer, shown in Figure 1.

A Stakelberg game model is established between the supplier and the retailer and the supplier has the stronger power than the retailer, that is, the supplier is the Stackelberg leader and the retailer is the follower. Further, we assume that the strategy of each party is the best response to his conjecture about the behavior of the rival, namely two agents are rational and risk-neutral. Neither the supplier nor the retailer keeps any inventory.

Referring to Yue et al.(2006)[3], the marketing demand functions are defined as the linear relationship with their own price and the price of the other player. The demand functions are as follows:

$$D_d = \theta a - b_1 p_d + c_1 p_r, \tag{1}$$

$$D_r = (1-\theta)a - b_2 p_r + c_2 p_d, \tag{2}$$

where D_d is the demand in the supplier's direct channel and D_r is the retailer's demand. a is the potential demand of the market; $\theta \in [0, 1]$ is a indicator which reflects the preference of the consumers to the direct channel, it is also called as consumers' preferences to the direct channel, then $1 - \theta$ is a indicator of presenting the preference of the consumers to the retail channel. p_d and p_r are the prices of the supplier and the retailer. b_1 and b_2 are slopes of the demand; c_1 and c_2 are cross-price sensitivities which reflect the degree on how the products of the two channels are substituted. We assume that $b_i \geq c_i, i = 1, 2$ so that the effects of their own price are greater than or equal to the effects of the cross-price[21,22,23]. To maintain analytical tractability, here assume that

$$c_1 = c_2 = e,$$

namely the cross-price effects are symmetric.

To capture uncertainty in market demand such as changes of consumers' preferences to two channels, we assume that the indicator θ is a random variable, and assume that

$$\theta = \bar{\theta} + \varepsilon,$$

where $\bar{\theta}$ is a mean value and ε is truncated normally distributed with mean 0 and variance σ_0^2. The supplier and the retailer perform their forecasting analysis using the market-information-gathering techniques before the sale season and denote f_s and f_r as the supplier's and retailer's forecast of the consumers' preferences θ respectively. Assume that

$$f_s = \theta + \varepsilon_s,$$

$$f_r = \theta + \varepsilon_r,$$

where ε_s and ε_r are normally distributed with mean 0 and variance σ_s^2 and σ_r^2 respectively. The forecast errors ε_s and ε_r may be correlated. It means that they can apply the similar data and methodology and then the prediction values result in higher correlation. The covariance matrix of forecast errors is represented by

$$\Sigma = \begin{bmatrix} \sigma_r^2 & \rho\sigma_r\sigma_s \\ \rho\sigma_s\sigma_r & \sigma_s^2 \end{bmatrix}. \tag{3}$$

Assuming that the covariance is not greater than the variance, i.e.

$$\rho\sigma_s\sigma_r \leq \sigma_s^2,$$

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Based on the results in Winkler (1981)[24], some conditional expectations are give as follows:

$$E[\theta|f_i] = (1-t_i)\bar{\theta} + t_i f_i, \tag{4}$$

$$\theta_I = E[\theta|f_r, f_s] = I\bar{\theta} + Jf_s + Kf_r, \tag{5}$$

$$E[f_r|f_s] = (1-d_s)\bar{\theta} + d_s f_s, \tag{6}$$

$$\begin{aligned} \theta_{IS} &= E[\theta|E[f_r|f_s], f_s] \\ &= I\bar{\theta} + Jf_s + K((1-d_s)\bar{\theta} + d_s f_s), \end{aligned} \tag{7}$$

where

$$t_i = \sigma_0^2/(\sigma_0^2 + \sigma_i^2), i = r, s,$$
$$d_s = (\sigma_0^2 + \rho\sigma_r\sigma_s)/(\sigma_0^2 + \sigma_s^2),$$
$$I = \frac{(1-\rho^2)\sigma_r^2\sigma_s^2}{(1-\rho^2)\sigma_r^2\sigma_s^2 + \sigma_0^2(\sigma_r^2 + \sigma_s^2 - 2\rho\sigma_r\sigma_s)},$$
$$J = \frac{(\sigma_r^2 - \rho\sigma_r\sigma_s)\sigma_0^2}{(1-\rho^2)\sigma_r^2\sigma_s^2 + \sigma_0^2(\sigma_r^2 + \sigma_s^2 - 2\rho\sigma_r\sigma_s)},$$
$$K = \frac{(\sigma_s^2 - \rho\sigma_r\sigma_s)\sigma_0^2}{(1-\rho^2)\sigma_r^2\sigma_s^2 + \sigma_0^2(\sigma_r^2 + \sigma_s^2 - 2\rho\sigma_r\sigma_s)}.$$

Formula (4) is the expectation of θ under the condition f_i. That is, denote $\theta_s = E[\theta|f_s]$ to represent the expectation of θ under the condition f_s. Meanwhile, denote $\theta_r = E[\theta|f_r]$ to represent the expectation of θ under the condition f_r. In formula (5), θ_i represents the expectation of θ under the condition f_s and f_r after sharing the forecast information. In formula (6), $E[f_r|f_s]$ represents the expectation of f_r under the condition f_s, which is deduced by the supplier under asymmetric information. θ_{IS} represents the expectation of θ deduced by the supplier, we can easily obtain that $\theta_{IS} = \theta_S$ and then we use θ_S to replace θ_{IS} in the following discussion. Here we consider no costs occurred during information collecting and forecasting.

In addition, all parameters are positive and well known by both parties except the demand forecasts on consumers' preferences. We consider two cases of symmetric information and asymmetric information on the marketing demand caused by the consumers' channel preferences. The timeline of the event is: first, two members agree on a revenue sharing contract and determine the rate ϕ of revenue sharing. Then they predict the demand by investigating the consumers' preferences to online and offline channels. Further, the supplier makes his wholesale price and the online sale price based on his forecasting and at last, the retailer decides her own retail price according to the supplier's decisions and her demand prediction.

Therefore, the supplier and the retailer maximize their own anticipated profits respectively, as shown below

$$\begin{aligned} \pi_s &= (\omega - c)((1-\theta)a - b_2 p_r + e p_d) \\ &+(1-\phi)(p_d - c)(\theta a - b_1 p_d + e p_r), \end{aligned} \tag{8}$$

$$\begin{aligned} \pi_r &= (p_r - \omega)((1-\theta)a - b_2 p_r + e p_d) \\ &+\phi(p_d - c)(\theta a - b_1 p_d + e p_r), \end{aligned} \tag{9}$$

where π_s and π_r represent the profits of two parties; ω is the wholesale price decided by the supplier, here we assume that $\omega \leq p_d$ to prevent the retailer from buying the products through the direct channel. c is the product cost per unit and ϕ is the percentage of revenue share, that is, the transferring payment from the supplier's profit per product in his direct channel to the retailer.

3 Model solutions under two cases

The timeline of the events is as follows:

(1) As the supplier is the leader in the Stackelberg game, he first makes his pricing decisions according to his demand prediction.

(2) According to the supplier's pricing, the retailer can perfectly infer the value of f_s from the supplier's decisions, then the retailer can combine f_s with her own forecast f_r to determine the retail price. That is an advantage only for the follower in the game.

This section will analyze the two game cases based on this assumption, one case is under asymmetric information on the demand information between two parties and the other is under demand information sharing as a benchmark. To distinct these two cases in our paper, we denote I and NI as the demand forecast information sharing or not.

3.1 Asymmetric information case

In this scenario, the retailer does not share her demand forecast information with the supplier. As discussed above, the retailer as a follower can combine f_s with her own forecast f_r to decide her retail price. However, the supplier as a leader cannot enjoy this advantage, he has to give his decisions according to his own forecasting information.

Thus, the supplier and the retailer make their decisions by maximizing their own anticipated profits respectively, so the profit functions of the supplier and the retailer are decided as follows:

$$\begin{aligned} \pi_{sNI} &= E(((\omega - c)((1-\theta)a - b_2 p_r + e p_d) \\ &+(1-\phi)(p_d - c)(\theta a - b_1 p_d + e p_r))|f_s), \end{aligned} \tag{10}$$

$$\begin{aligned}\pi_{rNI} &= E(((p_r-\omega)((1-\theta)a-b_2p_r+ep_d)\\ &\quad+\phi(p_d-c)(\theta a-b_1p_d+ep_r))|f_r,f_s).\end{aligned} \quad (11)$$

When the demand is influenced by the consumers' preferences to the offline and online channels in a dual channel supply chain, from (10) and (11), we can obtain Proposition 1.

Proposition 1 *Under asymmetric demand information, the optimal decisions* $(p_{dNI}{}^*, \omega_{NI}{}^*, p_{rNI}{}^*)$ *of the supplier and the retailer are as the following:*

$$p_{dNI}{}^* = \frac{e+(b_2-e)\theta_s}{2(b_1b_2-e^2)}a+\frac{1}{2}c,$$

$$\begin{aligned}\omega_{NI}{}^* &= \tfrac{b_1b_2-\phi e^2+(eb_2-b_1b_2-eb_2\phi+e^2\phi)\theta_s}{2b_2(b_1b_2-e^2)}a\\ &\quad+\tfrac{\phi e+b_2}{2b_2}c,\end{aligned}$$

$$\begin{aligned}p_{rNI}{}^* &= (\tfrac{3b_1b_2-e^2+(2b_2e-e^2-b_1b_2)\theta_s}{4b_2(b_1b_2-e^2)}-\tfrac{1}{2b_2}\theta_I)a\\ &\quad+\tfrac{b_2+e}{4b_2}c,\end{aligned}$$

The optimal profits of them satisfy:

$$\begin{aligned}\pi_{sNI}{}^* &= \tfrac{b_1b_2+e^2-2(b_1b_2+e^2-2b_2e)\theta_I}{8b_2(b_1b_2-e^2)}a^2\\ &\quad-\tfrac{(b_1b_2+e^2+2b_2^2-4b_2e)\theta_s(\theta_s-2\theta_I)}{8b_2(b_1b_2-e^2)}a^2\\ &\quad-\tfrac{e^2+(2b_2e-2e^2)\theta_I+(e-b_2)^2\theta_s(\theta_s-2\theta_I)}{4b_2(b_1b_2-e^2)}\phi a^2\\ &\quad+\tfrac{-(b_2+e)+(e-b_2)\theta_I}{4b_2}ac+\tfrac{e-(e-b_2)\theta_I}{2b_2}\phi ac\\ &\quad+\tfrac{b_2^2-e^2+2b_1b_2-2eb_2+2\phi(e^2-b_1b_2)}{8b_2}c^2,\end{aligned} \quad (12)$$

$$\begin{aligned}\pi_{rNI}{}^* &= \tfrac{1}{16b_2}((1-2\theta_I+\theta_s)a-(e-b_2)c)^2\\ &\quad+\tfrac{\phi}{4b_2}\tfrac{e^2+2b_2e\theta_I-e^2\theta_s-(b_2^2-2b_2e)(\theta_s-2\theta_I)\theta_s}{b_1b_2-e^2}a^2\\ &\quad-\tfrac{\phi}{2b_2}(e-(e-b_2)\theta_I)ac+\tfrac{\phi}{4b_2}(b_1b_2-e^2)c^2.\end{aligned} \quad (13)$$

Proof: The profit functions of the supplier and the retailer are given in equations (10) and (11), we perform the derivation of formula (11) with respect to p_r and obtain:

$$\frac{\partial\pi_{rNI}}{\partial p_r} = -2b_2p_r+ep_d+b_2\omega+(1-\theta_r)a+\varphi e(p_d-c).$$

Then

$$p_r{}^* = \frac{1}{2}\omega+\frac{1-\theta_r}{2b_2}a+\frac{(1+\varphi)e}{2b_2}p_d-\frac{\varphi e}{2b_2}c.$$

Where

$$\begin{aligned}\theta_r &= \theta_{IS}=E[\theta|E[f_r|f_s],f_s]\\ &= I\bar{\theta}+Jf_s+K((1-d_s)\bar{\theta}+d_sf_s)=\theta_s,\end{aligned}$$

Similarly, we compute the derivation of formula (10) to ω and we have

$$\frac{\partial\pi_{sNI}}{\partial\omega} = \frac{1-\theta_I}{2}a-b_2\omega+e(1-\varphi)p_d+(\varphi e+\frac{b_2}{2}-\frac{e}{2})c,$$

$$\begin{aligned}\tfrac{\partial\pi_{sI}}{\partial p_d} &= \tfrac{e+(2b_2-e)\theta_s}{2b_2}a+e\omega+(-2b_1+\tfrac{e^2(1+\varphi)}{b_2})p_d\\ &\quad+(b_1-\tfrac{e}{2}-\tfrac{(1+2\varphi)e^2}{2b_2})c=0.\end{aligned}$$

Solve the above equations and we can obtain:

$$p_d{}^* = \frac{e+(b_2-e)\theta_s}{2(b_1b_2-e^2)}a+\frac{1}{2}c.$$

Take $p_d{}^*$ into the above formula, and we can induce the optimal ω^*. Similarly, take $p_d{}^*, \omega^*$ into p_r, and we can obtain the optimal $p_r{}^*$ as shown in Proposition 1. Finally, the optimal profits of two members can be obtained as formulas (12) and (13).

Thus, it's the proof of Proposition 1.

□

From Proposition 1, $p_d{}^*, p_r{}^*$ and ω^* increase with the primary demand a and per unit product cost c, it means that the larger the marketing demand is, or the higher the product cost is, the higher pricing decisions two members make.

3.2 Information sharing case

In this case, the retailer shares her demand forecast with the supplier before making decisions. The retailer and the supplier respectively maximize their own anticipated profits based on two members' prediction information. Then the profits of the supplier and the retailer are as follows:

$$\begin{aligned}\pi_{sI} &= E(((\omega-c)((1-\theta)a-b_2p_r+ep_d)\\ &\quad+(1-\phi)(p_d-c)(\theta a-b_1p_d+ep_r))|f_r,f_s),\end{aligned} \quad (14)$$

$$\pi_{rI} = E(((p_r-\omega)((1-\theta)a-b_2p_r+ep_d) +\phi(p_d-c)(\theta a-b_1p_d+ep_r))|f_r,f). \tag{15}$$

We solve the above equations and obtain the following Proposition 2.

Proposition 2 *Under demand information sharing, the optimal policies $(p_{dI}{}^*,\omega_I{}^*,p_{rI}{}^*)$ of the supplier and the retailer are as follows:*

$$p_{dI}{}^* = \frac{e+(b_2-e)\theta_I}{2(b_1b_2-e^2)}a+\frac{1}{2}c,$$

$$\omega_I{}^* = \frac{b_1b_2-\phi e^2+(eb_2-b_1b_2-eb_2\phi+e^2\phi)\theta_I}{2b_2(b_1b_2-e^2)}a +\frac{\phi e+b_2}{2b_2}c,$$

$$p_{rI}{}^* = \frac{3b_1b_2-e^2+(2b_2e+e^2-3b_1b_2)\theta_I}{4b_2(b_1b_2-e^2)}a +\frac{b_2+e}{4b_2}c,$$

The profits of the supplier and the retailer are given as follows:

$$\begin{aligned}\pi_{sI}{}^* &= \frac{(b_1b_2+e^2)(1-\theta_I)^2+4b_2e\theta_I(1-\theta_I)+2b_2^2\theta_I^2}{8b_2(b_1b_2-e^2)}a^2\\ &-\frac{e^2+(2b_2e-2e^2)\theta_I-(e-b_2)^2\theta_I^2}{4b_2(b_1b_2-e^2)}\phi a^2\\ &+\frac{-(b_2+e)+(e-b_2)\theta_I+2\phi e-2(e-b_2)\phi\theta_I}{4b_2}ac\\ &+\frac{b_2^2-e^2+2b_1b_2-2eb_2+2\phi(e^2-b_1b_2)}{8b_2}c^2,\end{aligned} \tag{16}$$

$$\begin{aligned}\pi_{rI}{}^* &= \frac{1}{16b_2}((1-\theta_I)a-(e-b_2)c)^2\\ &+\frac{\phi}{4b_2}\frac{e^2+(2b_2e-e^2)\theta_I-(b_2^2-2b_2e)\theta_I^2}{b_1b_2-e^2}a^2\\ &-\frac{\phi}{2b_2}(e-(e-b_2)\theta_I)ac+\frac{\phi}{4b_2}(b_1b_2-e^2)c^2.\end{aligned} \tag{17}$$

Proof: In this case, the profit functions of the supplier and the retailer are given in equations (14) and (15), all information is common knowledge to two parties, and $\theta_s=\theta_I$. The solved procedures are same with the case under the proof of proposition 1, we easily obtain:

$$p_r=\frac{1}{2}\omega+\frac{1-\theta_r}{2b_2}a+\frac{(1+\varphi)e}{2b_2}p_d-\frac{\varphi e}{2b_2}c.$$

To the supplier, we compute the derivation of formula (12) to ω and p_d to obtain the optimal solutions $p_{dI}{}^*$ and $\omega_I{}^*$.

Then take $p_d{}^*$, $\omega{}^*$ into p_r, and we can obtain the optimal retail price $p_{rI}{}^*$. Thus, the optimal profits of two members can be obtained as formulas (16) and (17). Proposition 2 is proved.

□

From Proposition 2, we can find that the results under demand information sharing are similar with those under asymmetric demand information. Because the case under demand information sharing is a special example of asymmetric demand information, because $\theta_I=\theta_s$ under demand information sharing. The relationship of θ_I and θ_s can influence the changes of the members' profits caused by demand information sharing. Meanwhile, p_d increases with the increase of θ, it implicates that the more the consumers prefer to the online channel, the price in the direct channel will increase. However, under this case, the retail price p_r and the wholesale price ω decrease with θ increasing.

4 Discussion on information value

According to Proposition 1 and Proposition 2, comparing the pricing policies between two cases of symmetric information and asymmetric information, the variations are as follows:

$$\Delta\omega=\frac{(b_2(e-b_1)-\phi e(b_2-e))(\theta_I-\theta_s)}{2b_2(b_1b_2-e^2)}a, \tag{18}$$

$$\Delta p_d=\frac{(b_2-e)(\theta_I-\theta_s)}{2(b_1b_2-e^2)}a, \tag{19}$$

$$\Delta p_r=\frac{(e(b_2-e)+b_2(e-b_1))(\theta_I-\theta_s)}{4b_2(b_1b_2-e^2)}a. \tag{20}$$

Because the retailer has more experiences to forecast the marketing demand than the supplier, here we assume that she can predict the market demand more exactly. That is, the retailer can know the true market demand, so we know that the variations of pricing policies under two cases are positive proportion to the variation of the predictions between the retailer and the supplier. The more inaccurately the supplier forecasts the demand, the larger the variation of $\theta_I-\theta_s$ is. Further, the online price in electronic commerce often fluctuate sharply because of the impact of marketing demand, so we can assume that $b_1>b_2>e$ to represent this characteristic. From formulas (19) and (20), we have

$$b_2-e>0,$$

$$e(b_2-e)+b_2(e-b_1)<0,$$

and

$$b_1b_2 - e^2 > 0,$$

thus $\Delta p_d > 0$ and $\Delta p_r < 0$. It means that under information sharing, the supplier will increase the direct price, but the retail price will be decreased. In addition, we find that the revenue share proportion ϕ doesn't influence on p_d and p_r, that is, the revenue sharing contract has no effect on the retail price and the direct price, the parameter ϕ of revenue sharing has nothing with the pricing policies whatever demand information is shared or not.

From (18), when $\phi = 0, b_2(e - b_1) < 0$ and then $\Delta\omega < 0$. That means that even if there exists no contract between two members, the supplier's wholesale price will be decreased because the supplier opens an online channel and wins more profits, he will compensate the retailer by reducing the wholesale price in order to eliminate the competition of two channels. Under the revenue share contract, that is $\phi > 0$, then

$$b_2(e - b_1) - \phi e(b_2 - e) < b_2(e - b_1) < 0.$$

So $\Delta\omega$ is further reduced compared with the result under the case of $\phi = 0$. That also means that because the supplier can obtain the profit from information sharing and opening the online channel, he chooses to further decrease the wholesale price to compensate the retailer. At the same time, we find that while ω decreases with ϕ increasing. That is, the value of ϕ will impact the relationship of cooperation between two members. If ϕ is larger enough, that is, when the retailer obtains the more revenue from the supplier's direct channel, the supplier will lose the more power about the marketing. On the contrary, when the reduction of the supplier's wholesale price cannot compensate the loss led by the reduction of the retailer's retail price, the retailer may not like to share her private information. Specially, when $\phi = 0$, the supplier will not transfer his online profit to the retailer, this result is consistent with that in Yao et al.(2005) when they don't consider the revenue sharing contract.

Based on the above analysis, we give the following Proposition 3.

Proposition 3 *Under information sharing, there are the following properties:*

(1) The supplier's direct price will increase and will obtain more profit in his direct channel.

(2) The retailer's retail price will decrease and may lose her profit.

Similarly, the values-added profits of two members because of information sharing are as follows:

$$\begin{aligned} V_s &= {\pi_{sI}}^* - {\pi_{sNI}}^* \\ &= \tfrac{(\theta_s-\theta_I)^2}{8b_2}a^2\left(\tfrac{b_1b_2+e^2+2b_2^2-4b_2e}{b_1b_2-e^2} + \tfrac{2\phi(e-b_2)^2}{b_1b_2-e^2}\right). \end{aligned} \tag{21}$$

$$\begin{aligned} V_r &= {\pi_{rI}}^* - {\pi_{rNI}}^* \\ &= \tfrac{(\theta_I-\theta_s)a}{16b_2}((2-3\theta_I+\theta_s)a - 2(e-b_2)c) \\ &\quad + \tfrac{\phi(b_2(b_2-2e)(\theta_I-\theta_s)+e^2)}{4b_2(b_1b_2-e^2)}(\theta_I-\theta_s)a^2. \end{aligned} \tag{22}$$

Obviously, $b_i > e > 0$, then $V_s \geq 0$ according to formula (21), that is, both parties realizing information sharing will give the supplier the positive profit. Thus, if we can adjust the parameter ϕ to ensure $V_r > 0$, then both members will have the motivation to realize information sharing. Based on formula (22) and $-2(e - b_2)c > 0$, when $\frac{\theta_I-\theta_s}{16b_2}(2 - 3\theta_I + \theta_s) + \frac{\phi(\theta_I-\theta_s)(b_2(b_2-2e)(\theta_I-\theta_s)-e^2)}{4b_2(b_1b_2-e^2)} \geq 0$, we have $V_r > 0$. The first item means that how much value the demand information sharing brings about to the retailer, when there doesn't exist the revenue sharing contract; the second one reveals that both policies of the revenue sharing contract and the demand information sharing will give the changes of the retailer's profit. Thus, we can obtain the following Proposition 4.

Proposition 4 *(1) When $\theta_s \leq \theta_I \leq \frac{2+\theta_s}{3}$, the retailer is willing to share her demand prediction information with the supplier even if the supplier does not transfer his partial profit of the online channel to the retailer.*

(2) If $\theta_I - \theta_s > \frac{1}{\frac{b_2}{e}(\frac{b_2}{e}-2)}$, then the profit of the retailer will increase under the case of demand information sharing with the help of the revenue sharing contract.

(3) When the parameter ϕ satisfies that

$$\frac{(3\theta_I - \theta_s - 2)(b_1b_2 - e^2)}{4((b_2^2 - 2b_2e)(\theta_I - \theta_s) - e^2)} \leq \phi < 1,$$

the supplier can design the revenue sharing contract to incent the retailer to share her private prediction information.

Proof: First, when the revenue sharing contract doesn't considered, that is $\phi = 0$. From the formula (23), if $\frac{\theta_I-\theta_s}{16b_2}(2-3\theta_I+\theta_s) > 0$, then we have $V_r > 0$. Obviously, under this situation, the retailer may be willing to share her demand prediction information with the supplier because she can profit from the demand information sharing.

Thus, simplify $\frac{\theta_I - \theta_s}{16b_2}(2 - 3\theta_I + \theta_s) > 0$, we have

$$\theta_s \leq \theta_I \leq \frac{2 + \theta_s}{3}.$$

Second, under the case $\phi > 0$, then the revenue sharing contract between two members can bring about the positive profit to the retailer, if

$$\frac{(\theta_I - \theta_s)(b_2(b_2 - 2e)(\theta_I - \theta_s) - e^2)}{4b_2(b_1 b_2 - e^2)} > 0,$$

then, because $\theta_I - \theta_s > 0, b_1 > b_2 > e$, we obtain

$$b_2(b_2 - 2e)(\theta_I - \theta_s) - e^2 > 0.$$

That is, $\theta_I - \theta_s > \frac{1}{\frac{b_2}{e}(\frac{b_2}{e} - 2)}$ is proved.

Last, from the equation (23), we can easily reach the conclusion on the constraint of the parameter ϕ.

Therefore, we obtain Proposition 4.

□

The results in Proposition 4 can give some management implications for the supplier to design an efficient revenue sharing contract. Firstly, the revenue sharing contract doesn't always incent the retailer to share her prediction information. From Proposition 4(1), we can know when the retailer knows there are no great difference between the forecasting information of the supplier and hers, she may be active to share her information with the supplier. That is, when the supplier achieves more marketing demand from his direct channel, he has more power to require the retailer to share her information. However, when there is the difference between the forecasting information of the supplier and that of the retailer, the supplier has to design the revenue sharing contract with the retailer and she can be encouraged to share her information, this is Proposition 4(2). Under this case, $b_2 > 2e$, it refers that the retailer has more power in her retail channel than the supplier, and this result is consistent with Yue et al. (2006)[3]. In fact, the proportion of revenue sharing contract ϕ belongs to [0,1], but from the third result of Proposition 4(3), if only ϕ is large enough, the retailer may like to provide her private information with the supplier under the incentive of the revenue sharing contract.

Further, based on Proposition 4(1) and (2), Figure 2 discusses the retailer's value regions of information sharing. We can clearly see that under the asymmetric information of the market demand, we focus on the region B and region C. In region B, because $\theta_s \leq \theta_I \leq \frac{2+\theta_s}{3}$, the retailer has some initiative to share her private information. However, in region C, the supplier has to design the revenue sharing contract to urge the retailer to share her private information

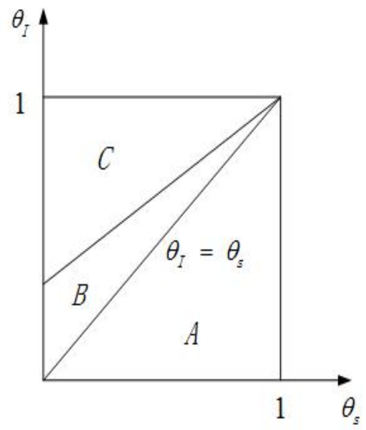

Figure 2: The retailer's regions of information sharing

when $b_2 > 3e$. That is to say, when the retailer occupies more market share, like the furniture with the high quality, the price in online channel has less influences to the consumers than the retail channel, because the consumers may be prefer to experience the products by themselves. Thus, $b_2 > 3e$ is satisfied and the supplier should try to achieve the retailers demand information by the contract.

By the above results, we can obtain our main contributions shown in Table 1. Compared with the results in Yue et al. (2006)[3], we find that our results not only explore the trends of the important decision variables, but also analyze the conditions under which the retailer is actively willing to share her information or by the contract incentive of the revenue sharing contract. Further, we also give the condition under which supplier can incent the retailer by deciding the parameters of revenue sharing contract.

Obviously, we can find that the preferences of the consumers to the direct channel are the important factors in evaluating the value of information sharing. In fact, when $\theta_s \leq \theta_I \leq g_1$ is satisfied, it shows that the supplier owns more proportion of market demands in his direct channel than the retailer. That is to say, the consumers have much more highly preferences to the supplier's online channel, so the supplier can obtain the approximately exact demand information, and under this case, the retailer has to share her information with the supplier even if her profit falls down. However, when $\theta_I - \theta_s > g_2$, the supplier has a relatively small consumers' preferences in his direct channel, he cannot exactly predict the market demand and then has to design a contract of information sharing to transfer his partial profit to the retailer. Further

Table 1: The values of information sharing

Decisions or conditions	Supplier	Retailer	π_s	π_r
p_d	$\uparrow$			
p_d		$\downarrow$		
ω	$\downarrow$			
$\theta_s \leq \theta_I \leq g_1$		Active share	$\uparrow$	$\downarrow$
$\theta_I - \theta_s > g_2$		Contract incentive	$\uparrow$	$\uparrow$
$g_3 \leq \phi < 1$	Contract Incentive to retailer		$\uparrow$	$\uparrow$

where $g_1 = \frac{2+\theta_s}{3}$, $g_2 = \frac{1}{\frac{b_2}{e}(\frac{b_2}{e}-2)}$, $g_3 = \frac{(3\theta_I-\theta_s-2)(b_1b_2-e^2)}{4((b_2^2-2b_2e)(\theta_I-\theta_s)-e^2)}$, and $\uparrow,\downarrow$ denote the decision variables will increase or decrease under demand information sharing respectively.

only when the percentage ϕ of revenue share satisfies the given condition, can the incentive contract from the supplier bring about the realization of information sharing.

Based on the above discussion, we can give the conclusions that with more and more increase of the consumers to go shopping in the online channel, the traditional retailer will be forced to share her demand information and suffer the loss even if the supplier gives her some compensation at the decision of the wholesale price. Thus, the consumers' preferences are the competitive key elements in channel selections.

5 Conclusion

This paper investigates a two level dual channel supply chain with a supplier and a retailer, and the supplier opens his own direct channel. We assume that the supplier designs a revenue sharing contract with the retailer and transfers some of his profit in the online channel to the retailer. A Stackelberg model is established and the optimal pricing decisions and the optimal profits under two demand prediction cases of information symmetry and asymmetry are analyzed. We show that the supplier always benefits from information sharing, the retailer will be better off only under some conditions. The supplier is able to provide incentives to induce the retailer to share her private information even when the retailer does not voluntarily do so, such as, a larger proportion of revenue sharing contract. Further, the range of the parameters relationship under which the retailer likes to share her private information is given.

Although this paper provides more managerial insights to decision makers in the supply chain, there are some limitations. Firstly, our research can be extended to realize the coordination mechanism under information asymmetry. Second, our paper assumes that there exists only one kind of perishable product in the dual channel supply chain. An extension is to analyze when there are two or more than two products, how do the members in dual channel supply chains make decisions? In addition, we assume that two members in supply chains are risk-neural, the risk attitude of members should be paid more attention in the future.

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