Xiongwei Zhou[1], Faqi Jin[1], Xiaohong Chen[1] Feicheng Ma[2],

School of Business, Central South University (1), School of Information and Management, Wuhan University(2)

A Partial Information Sharing Incentive Pricing Model with Demand Uncertainty in Dual-Channel Supply Chain

Abstract. *In this paper the information-sharing incentive problem with uncertain demand is studied, one manufacturer with electronic direct sales and two retailers in dual-channel supply chain under the electronic commerce environment. The partial information sharing incentive pricing model with demand uncertainty in dual channels is built, which is based on the price discrimination strategy to prompt retailers to share their private demand information. By the optimal solution and game equilibrium analysis to the partial information sharing incentive model, the following results are drawn from the partial information sharing incentive model in dual-channel supply chain: the valid conditions of partially sharing uncertain demand information, the stable equilibrium conditions of the price discrimination strategy, and the coexistence conditions of coordinating between traditional channels and electronic channels.*

Streszczenie. *W artykule analizuje się problem zachęty przy dzieleniu się informacją . Rozpatruje się przypadek gdy jeden wytwórca ze sprzedażą bezpośrednią i dwóch detalistów w podwójnym kanale w środowisku sprzedaży internetowej. (**Model częściowego dzielenia się informacją z niepewnym popytem w podwójnym kanale łańcucha dostaw**)*

Keywords: Demand Uncertainty, Dual-channel, Partial Information Sharing
Słowa kluczowe: niepweny popyt, dzielenie się informacją, sprzedaż bezpośrednia

Introduction

With the recent rapid development of e-commerce, the channel structure of the supply chain has undergone great changes. Nowadays, direct sales channels have been reconstructed in internet by many companies, they coexist with retail channels, so the coordination and conflict of the resulting hybrid dual-channel supply chain becomes a new research focus. Tsay et al (2000) proposed the coordination mechanism for dynamic channel structure with price and service competition [1]. Chiang et al (2003) studied strategy analysis of dual-channel design in the supply chain, and analyzed the basic framework and dynamic coordination mechanism of the direct sales channels and traditional channels [2]. Yan et al (2007) studied the dual-source channel coordination problem in the supply chain based on supply chain double source master-slave response model under the electronic market environment 3. Xing et al (2008) studied the optimal strategy of suppliers and retailers by the game analysis of supply and demand in B2B e-market environment, and drew a conclusion by numerical analysis that retailers benefit from price volatility increasing in B2B e-market [4]. Xiong et al (2007) studied the channels coordination problem based on the impact of dynamic pricing on different contracts in the network environment 5. Pu et al studied the impact of direct sales model on existing strong retail channels in network environment 6. Guo et al (2008) analyzed dual channel's conflict and coordination in the electronic market [7]. Chen et al (2006,2008) studied respectively the price competition between e-commerce retailers and traditional retailers and the two-channel retailer's pricing strategy in the Internet environment [8]-[9]. However, these researchers did their work under the assumption of complete information, and they mainly studied channel conflict and price problem in dual-channel supply chain. They did not pay attention to the asymmetric information between manufacturers and retailers in dual-channel supply chain so that they did not consider information sharing impacts on supply chain in dual-channel.

Yao etc. firstly researched on a series information sharing problem in dual-channel supply chain based on value adding. Yao etc. (2005a) studied the retailers' wholesale price in hybrid channel structure, and get the optimal wholesale price based on Stackelberg and Betrand competition [10]. Meanwhile, Yao etc. (2005b) designed a direct channel supply chain model with return policy, and analyzed the impact of sharing demand forecast information in their model, and finally found that information sharing was profitable for both manufacturers and retailers [11]. Yao etc. (2008) also found that retailers are willing to share their private information when retailers with value-added are in hybrid channels high-tech supply chain [12]. Chen et al (2008) studied the impact of service competition for dual-channel sales [13]. Ai and Tang etc. studied the performance problems of information sharing between retail channels and manufacturers dominated electronic direct sale channels, and got the results that the information sharing performance is different from the traditional channels structure [14]. From the viewpoint of revenue sharing co-operation mechanism, Chen and Ai (2008) studied the information sharing problem of traditional channels and e-channels and analyzed the impact of market competition, market risks, the potential market size, and the ability of information predicting on dual-channel information sharing and revenue sharing strategy selection [15]. It is obvious that the retailers' information sharing in the mix dual-channel has become the latest hot point. But they only discussed the impact of information sharing from the view of the centralized and decentralized supply chain, rather than did research and design information sharing incentive mechanisms. Generally, information sharing can be divided into complete information sharing and partial information sharing in terms of the number of enterprises involved. In the above study, they regarded information sharing as complete information sharing and no information sharing [11]-[12], but actually, it's is very common that only part of enterprises are participating in information sharing. Although Yao et al (2008) considered the supply chain system consisted of one manufacturer M and two retailers (R_1 and R_2), and they also considered the case of partial information sharing, but they studied retailer's cost information sharing in dual-channel [16]. In this paper we shall probe a partial information sharing model with demand uncertainty, and design information-sharing incentive model using price discrimination strategy.

Information sharing in supply chain can improve the profits of manufacturers and wholesalers as well as the overall function of the supply chain, but it can not improve the performance of the retailers [17]-[18]. In this study, assuming that the effect of information sharing in the dual-channel is the same as in the physical supply chain, our study would focus on three aspects (1) sharing demand

information, considering the impact of demand uncertainty private information on supply chain performance; (2) partial information sharing, part of the retailers participating in information sharing; (3) encouraging information sharing by price discrimination strategy 18,19, the wholesale price for retailers participating in information sharing is lower than those for retailers not participating in information sharing. In this paper, the demanded information-sharing incentive mechanism is designed to stimulate retailers to actively share their private demand uncertain information, which is based on partial information sharing and price discrimination strategies in a dual-channel supply chain with electronic direct marketing. Therefore, the said mechanism takes into account two channel supply chains of one manufacturer and two retailers, thinking about how to coordinate manufacturers' electronic direct marketing and retailers' sale channels to develop the optimal wholesale price when the manufacturers dominate, encourages retailers to actively share demand information, improves the validity of the entire supply chain, so as to get the optimal game equilibrium that all retailers share demand information.

2 The partial information sharing incentive model

This paper considers the supply chain system with one manufacturer M and two retailers (R_1 and R_2), and builds a incentive model that part of retailers participate in information sharing with electronic direct marketing channels in accordance with retailers sharing the uncertain demand information or not, as shown in Figure 1. In the model, customers can buy from the two retailers or purchase directly from manufacturer's electronic direct marketing channels. Retailers offer value-added services to customers who are independent of each other, and there isn't level competition between them. But customers transfer freely between retail channels and direct sales channels due to price-sensitivity, acquisition costs, access to opportunities, buying habits and other factors. In the model, manufacturers use price discrimination strategy to encourage retailers to participate in information sharing, to be specific, when retailer R_1 participates in information sharing and retailer R_2 does not participate in information sharing, in order to reward retailer R_1 to share information, the manufacturers offer retailer R_1 at a lower wholesale price than what they would offer to retailer R_2. The specific work structure of the model is three-stage decision sequence. First of all, manufacturers choose whether to implement price discrimination strategy of information sharing incentive mechanism with aim to get demand information of retailers' channels, then decide the wholesale price of retailers' channel and retail price of electronic channels with respect to profit maximization rule; Second, retailers decide whether to share their private demand information; Finally, the retailers come to decide their own selling prices with respect to profit maximization and order, then manufacturers meet the requirements of orders. Assume the notations in the model as follow: π_1 is the profits of retailer R_1, π_2 is the profits of retailer R_2, π_3 is the profits of manufacturer M ; d_1 is the demand of retailer R1, d_2 is the demand of retailer R_2, d_3 is the direct sale demand of manufacturer M; p_1 is retailer R_1's sale price, p_2 is retailer R_2 's sale price, p_3 is the direct sale price of manufacturer M; v_1, v_2 are respectively the incremental value of retailer R_1 and R_2, $c(v_1)$ is the cost of retailer R_1 providing incremental value v_1, $c(v_2)$ is the cost of retailer R_2 providing incremental value v_2; w_1 is the wholesale price of retailer R_1 when sharing information, w_2 is the wholesale price of retailer R_2 when not sharing information; t_i is the signal size that reflects the uncertainty of the market demand, whose value depends on market demand. t_i is subject to normal distribution with mean 0 and variance σ_i^2, that is, t_i~ N (0, σ_i^2). t_i may be negative, i = 1,2.3. Optimal values for all parameters shall be marked by the top right mark "*".

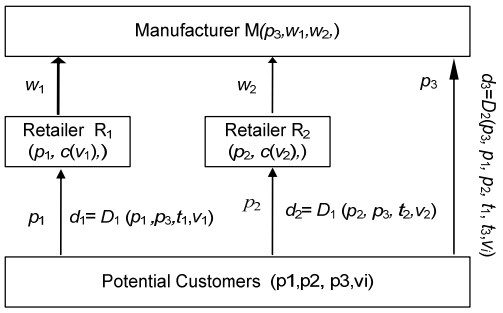

Fig.1. The Partial Information Sharing Incentive Pricing Model

Assume that the demand function of goods meet linear relationship, the dual-channel supply chain system with value added services and channel transfer, the demand functions of retailers and manufacturers are as follows.

The demand function of retailer R_1 participating in information sharing:

$$d_1 = D_1(p_1, p_3, v_1) = a_1 - bp_1 + t_1 + \beta v_1 + \theta(p_3 + v_1 - p_1)$$

The demand function of retailer R_2 not participating in information sharing:

$$d_2 = D_2(p_2, p_3, v_2) = a_2 - bp_2 + t_2 + \beta v_2 + \theta(p_3 + v_2 - p_2)$$ The demand function of manufacturer direct sale channel:

$$d_3 = D_2(p_3, w_1, w_2) = a_3 - bp_3 + t_1 + t_3 + \theta(p_1 - v_1 - p_3) + \theta(p_2 - v_2 - p_3)$$.

Where a_i (i=1,2,3) indicates the basic demand of the market at different sale prices, b indicates the marginal demand and added-value of two channels, that is customers move in proportion between channels according to the difference of price and the added-value [1],[3],[11],[12],[17],b>0, θ>0. In order to compete with electronic direct marketing, the content service retailers have to create value-added service v_i, which satisfies the following cost function [1],[12],[14]:

$c(v_i) = \eta \frac{v_i^2}{2}$, i=1,2. Where η is the cost coefficient of value-added service v_i offered by retailers, η >0.

In order to calculate the profit function simply, we don't consider the marginal cost in various stages of the supply chain, the profit functions of retailers and manufacturer are as follows. The manufacturer's profits come from retailers' purchase and his direct sale.

The profit function of retailer R_1 participating in information sharing: $\pi_1 = (p_1 - c(v_1) - w_1)d_1$ .The profit function of retailer R_2 not participating in information sharing: $\pi_2 = (p_2 - c(v_2) - w_2)d_2$ .The profit function of manufacturer M's direct sale: $\pi_3 = w_1 d_1 + w_2 d_2 + p_3 d_3$.

3 Model Solution

Model solution ideas: solving the model by reverse analysis method, while for uncertainty of market information t_i, if the parties do not have a t_i, then the corresponding side of the model uses 0 (the expectations of t_i) [20]. The model solution satisfies the following expression:

$$\max_{p_3, w_1, w_2} \pi_3 = w_1 d_1 + w_2 d_3 + p_3 d_3$$

s.t. $\max_{p_1, v_1} \pi_1 = (p_1 - c(v_1) - w_1)d_1$

$$\max_{p_2,v_2}\pi_2 = (p_2 - c(v_2) - w_2)d_2$$

3.1 The optimal decision of retailer R1 participating in information sharing

Property 1 If $2\eta(b+\theta)d_1 > [(\beta+\theta)-\eta(b+\theta)v_1]^2$, then the retailer R1's profit π_1 is concave function of the retail price p_1 and service add-value v_1.

Proof: Due to the length of paper, the proofs of Properties and propositions are omitted in this paper.

By solving the retailer's decision problem, we can get the following Proposition 1.

Proposition 1 If $2\eta(b+\theta)d_1 > [(\beta+\theta)-\eta(b+\theta)v_1]^2$, in partial information sharing incentive model of the dual-channels supply chain with demand uncertainty, when retailer R1 participates in information sharing and the manufacturer offers a wholesale price w_1, the optimal equilibrium decision of retailer R_1's sale price p_1 and service add-value v_1 is:

$$p_1^* = \frac{3(\theta+\beta)^2}{4\eta(b+\theta)^2} + \frac{a_1 + \theta p_3 + t_1 + (b+\theta)w_1}{2(b+\theta)} \quad v_1^* = \frac{\theta+\beta}{\eta(b+\theta)}$$

3.2 The optimal decision of retailer R2 not participating in information sharing

As retailer R_2 and retailer R_1 are mutual independent and equal, we can get property 2 with the same reason.

Property 2 If $2\eta(b+\theta)d_2 > [(\beta+\theta)-\eta(b+\theta)v_2]^2$, then the retailer R_2's profit π_2 is concave function of the retail price p_2 and service add-value v_2.

By solving the retailer R2's decision problem, we can get the following Proposition 2.

Proposition 2 If $2\eta(b+\theta)d_2 > [(\beta+\theta)-\eta(b+\theta)v_2]^2$, in the partial information sharing incentive model of dual-channels with demand uncertainty, when retailer R_2 doesn't participate in information sharing, and the manufacturer offers a wholesale price w_2, the optimal equilibrium decision of retailer R_2's sale price p_2 and service add-value v_2 is:

$$p_2^* = \frac{3(\theta+\beta)^2}{4\eta(b+\theta)^2} + \frac{a_2 + \theta p_3 + t_2 + (b+\theta)w_2}{2(b+\theta)} \quad v_2^* = \frac{\theta+\beta}{\eta(b+\theta)}$$

3.3 The optimal decision of manufacturer

Property 3 In the partial information sharing incentive model of dual-channels with demand uncertainty, the manufacturer's profit function is concave function of manufacturer's direct sale price p_3, wholesale price w_1 of retailers participating in information sharing while wholesale price w_2 of retailers not participating in information sharing.

By solving manufacturer's decision problem, we can get the following Proposition.

Proposition 3 In partial information sharing incentive model of dual-channels with demand uncertainty, the optimal equilibrium decision of the manufacturer's direct sale price p_3, the wholesale price $w_1$of retailers participating in information sharing, the wholesale price w_2 of retailers not participating in information sharing is:

$$p_3^* = \frac{a_3 + t_1 + t_3}{2(b+3\theta)} + \frac{+\theta(a_1 + a_2 + a_3 + 2t_1 + t_3)}{2b(b+3\theta)} + \frac{\theta(b-\beta)(\beta+\theta)}{2b\eta(b+\theta)(b+3\theta)}$$

$$w_1^* = \frac{a_1 + t_1}{2(b+\theta)} + \frac{\theta(a_3 + t_1 + t_3)}{2b(b+3\theta)} + \frac{\theta^2(a_1 + a_2 + t_1)}{2b(b+\theta)(b+3\theta)} + \frac{\beta\theta(\beta+\theta)}{b\eta(b+\theta)(b+3\theta)} + \frac{b(b-\theta)(\beta+\theta)^2}{4b\eta(b+\theta)^2(b+3\theta)}$$

$$w_2^* = \frac{a_2}{2(b+\theta)} + \frac{\theta(a_3 + t_1 + t_3)}{2(b+\theta)(b+3\theta)} + \frac{\theta^2(a_1 + a_2 + a_3 + 2t_1 + t_3)}{2b(b+\theta)(b+3\theta)} + \frac{\beta\theta(\beta+\theta)}{b\eta(b+\theta)(b+3\theta)} + \frac{b(b-\theta)(\beta+\theta)^2}{4b\eta(b+\theta)^2(b+3\theta)}$$

Substitute w_1 and w_2 of proposition 3 into proposition 1 and proposition 2 respectively, we can get proposition 4.

Proposition 4 In the partial information sharing incentive model of dual-channels with demand uncertainty, when retailer R_1 participates in information sharing and retailer R_2 doesn't participate in information sharing, their optimal equilibrium decisions of retail price and service added-value are respectively:

$$p_1^* = \frac{3a_1}{4(b+\theta)} + \frac{a_1 + a_2 + 2\theta t_1}{2b(b+\theta)(b+3\theta)} + \frac{\theta(a_3 + t_3) + 2t_1}{2b(b+3\theta)} + \frac{3bt_1}{4b(b+\theta)} + \frac{7b(\beta+\theta)^2}{8b\eta(b+\theta)^2} + \frac{\theta^2(\beta+\theta)(\beta\theta - b)}{b\eta(b+\theta)^2(b+3\theta)}$$

$$p_2^* = \frac{3a_2 + 2t_2}{4(b+\theta)} + \frac{\theta(a_3 + t_3 + t_1)}{2b(b+3\theta)} + \frac{\theta^2(a_1 + a_2 + t_1)}{2b(b+\theta)(b+3\theta)} + \frac{7b(\beta+\theta)^2}{8b\eta(b+\theta)^2} + \frac{\theta^2(\beta+\theta)(\beta\theta - b)}{b\eta(b+\theta)^2(b+3\theta)}$$

$$v_1^* = \frac{\theta+\beta}{\eta(b+\theta)} \qquad v_2^* = \frac{\theta+\beta}{\eta(b+\theta)}$$

We can get the following properties from proposition 1, 2, 3 and 4.

Property 4 The decision-making of retailers' creating added-value is only related to cost coefficient v_i of retailers' producing added-value, price volatility coefficient b, value-added volatility coefficient β and channel diffusion intensity, it has nothing to do with demand uncertainty coefficient t_i.

Property 5 The decision-making of retailers' creating added-value are independent of information-sharing decision, the final added-value of retailers are equal.

3.4 The profit distribution mechanism

Substitute the optimal equilibrium solution of w_1, w_2, p_3, p_1, v_1 and p_2, v_2 from Proposition 3 and Proposition 4 into the profit functions of retailers and manufacturer, we can get optimal profit π_1^*, π_2^* and π_3^* of retailer R1 involved in information sharing, retailer R2 not involved in information sharing and manufacturer's direct channels respectively.

Proposition 5 In partial information sharing incentive model of mix dual-channels with demand uncertainty, the profit of manufacturer, retailer R_1 involved in information sharing, and retailer R_2 not involved in information sharing respectively are:

$$\pi_3^* = \frac{2(\beta+\theta)^2 I}{32b\eta^2(b+\theta)^3(b+3\theta)} + \frac{(\beta+\theta)^2(l^2 - a_2^2 + a_2)}{16\eta(b+\theta)^2} + \frac{(\beta+\theta)^2\theta h(l + a_2 + 1)}{16b\eta(b+\theta)(b+3\theta)} + \frac{(\beta+\theta)^2\theta^2(l + a_2)}{16b\eta(b+\theta)^2(b+3\theta)} + \frac{(\alpha_1 + \alpha_2 + t_1)I + (\beta+\theta)^2 l\theta^2}{16b\eta(b+\theta)^2(b+3\theta)} + \frac{(a_1 + t_1)(l^2 - a_2^2) + a_2^2}{8(b+\theta)} + \frac{(l^2 - a_2^2 + a_2)\theta h}{8b(b+3\theta)} + \frac{(l^2 - a_2^2 + la_2)\theta^2}{8b(b+\theta)(b+3\theta)} + \frac{((b+\theta)h + l\theta)(2(b+\theta)h + l\theta)}{8b(b+\theta)(b+3\theta)} - \frac{((b+\theta)h + l\theta)k}{8b\eta(b+\theta)^2(b+3\theta)} - \frac{m(2(b+\theta)h + l\theta)}{8b\eta(b+\theta)^2(b+3\theta)} + \frac{mk}{8b\eta^2(b+\theta)^3(b+3\theta)}$$

$$\pi_1^* = \frac{(2\eta(b+\theta)(a_1 + t_1) + (\theta+\beta)^2)^2}{64\eta^2(b+\theta)^3}$$

$$\pi_2^* = \frac{(2\eta(b+\theta)(a_2 + 2t_2) + (\theta+\beta)^2)^2}{64\eta^2(b+\theta)^3}$$

Where $I=(\beta+\theta)(b(3\beta-\theta)\theta+4\beta\theta^2+b^2(\beta+\theta)$, $l=a_1+a_2+t_1$, $h=a_3+t_1+t_3$, $k=(\beta+\theta)(4b-3\beta+\theta)$, $m=2\theta(b-\beta)(\beta+\theta)$.

4 Model analysis and discussion

In our partial information sharing incentive pricing model with demand uncertainty in dual-channel supply chain, it should be sure to meet specific conditions to encourage retailers to share private information by using price discrimination strategy. Following, we are going to analyze the validity of partial information sharing pricing incentive mechanism, the stable equilibrium conditions of price discrimination strategies, and coordination mechanism between mix channels.

4.1 The validity of partial information sharing pricing incentive mechanism

In our partial information sharing incentive pricing model with demand uncertainty in dual-channel supply chain, in order to make partial information sharing pricing incentive mechanism effective, we have to make the optimal profits the retailer R_1 involved in information sharing and retailer R_2 not involved in information sharing satisfy $\pi_1^* > \pi_2^*$. Otherwise, retailer R_1 might be unwilling to share their private uncertain demand information. By Proposition 5, there is

$$\pi_1^*-\pi_2^*=\frac{(a_1-a_2+t_1-2t_2)[(\beta+\theta)^2+\eta(b+\theta)(a_1+a_2+t_1+2t_2)]}{\eta(b+\theta)^2}>0$$

Further to simplify, there is

$$\frac{(a_1-a_2+t_1-2t_2)(\beta+\theta)^2}{\eta(b+\theta)^2}+\frac{(a_1+t_1)^2-(a_2+2t_2)^2}{(b+\theta)}>0.$$

So to make partial information sharing pricing incentive mechanism effective, it must meet the conditions that above expression is greater than 0, that is Proposition 6.

Proposition 6 Conditions of validity of partial information sharing pricing incentive mechanism is

$$\frac{(a_1-a_2+t_1-2t_2)(\beta+\theta)^2}{\eta(b+\theta)^2}+\frac{(a_1+t_1)^2-(a_2+2t_2)^2}{(b+\theta)}>0\cdot$$

From the validity condition of partial information pricing incentive mechanism, we can get Property 6.

Property 6 The validity condition of partial information pricing incentive mechanism is related with basic demand and uncertain demand of retailers as well as with cost coefficient η of retailers' creating added-value, price volatility coefficient *b*, added -value fluctuations coefficient β and channel diffusion intensity θ.

4.2 The stable equilibrium condition of price discrimination strategy

For $w_1<w_2$ of the price discrimination strategy, in our partial information sharing incentive pricing model with demand uncertainty in dual-channel supply chain, transform the equations of w_1^* and w_2^*, and simplify them, we get:

$$w_1^*-w_2^*=\frac{a_1-a_2+t_1}{2(b+\theta)}-\frac{\theta^2(a_3+t_1+t_3)}{2b(b+\theta)(b+3\theta)}<0\cdot$$

That is the stable equilibrium condition of price discrimination strategy, Proposition 7.

Proposition 7 In partial information-sharing incentive model of dual-channel supply chain with demand uncertainty, condition of stable equilibrium of price discrimination strategy is to meet the following inequality

$$\frac{a_1-a_2+t_1}{2(b+\theta)}-\frac{\theta^2(a_3+t_1+t_3)}{2b(b+\theta)(b+3\theta)}<0\cdot$$

From condition of stable equilibrium of price discrimination strategy, we can get Property 7.

Property 7 The condition of stable equilibrium of price discrimination strategy is related with basic demand of retailers and manufacturers, and uncertain demand of retailers participating in information-sharing and manufacturer's direct sale as well as price volatility coefficient *b* and channel diffusion intensity θ, while it isn't related with uncertain demand of retailers participating in information-sharing and added -value fluctuations coefficient β.

4.3 Coordination between mix channels

For dual-channel model with the mix-coexistence of manufacturer's electronic direct marketing and retailers' sale, mix dual-channels can co-exist without conflict in the real world only when retail prices of retailers with value-added services and direct sale prices of manufacturer's electronic direct channel meet the following conditions. That is $p_1-p_3\geq 0 \| p_2-p_3\geq 0$ otherwise, the manufacturer's electronic direct marketing is no longer necessary.

Substitute the optimal solution of p_1, p_2 and p_3 into them and simplify them, we get the basic coordination conditions between dual-channel, which is Proposition 8.

Proposition 8 For the coordination of mix dual-channel with demand uncertainty, the basic conditions that allow manufacturer's electronic direct channel to exist are:

$$\frac{6a_1+2t_1}{(b+\theta)}-\frac{4(a_3+t_3)}{(b+3\theta)}-\frac{4\theta(a_1+a_2-t_1)}{(b+\theta)(b+3\theta)}+\frac{(\beta+\theta)(7b\beta+15b\theta+13\beta\theta+21\theta^2)}{\eta(b+\theta)^2(b+3\theta)}\geq 0$$

$$\frac{2(3a_2-2t_1+2t_3-2t_3)}{(b+\theta)}-\frac{2a_3}{(b+3\theta)}-\frac{4\theta[+a_1+a_2-t_1]}{(b+\theta)(b+3\theta)}+\frac{(\beta+\theta)(7b\beta+15b\theta+13\beta\theta+21\theta^2)}{\eta(b+\theta)^2(b+3\theta)}\geq 0$$

Since $p_1-p_3\geq 0 \| p_2-p_3\geq 0$ is the premise to allow manufacturer's electronic direct sale exist, in contrast, if manufacturer's electronic direct sale already exists, only when retail prices and added-value of retailers with value-added services as well as manufacturer's electronic direct sale prices meet the same conditions, mix dual-channel can coexist without conflict in reality; Otherwise, there would be no need for retailers because retailers wouldn't create the extra added-value. Substitute the optimal solution of p_1, v_1, p_2, v_2 and p_3 into the above inequalities and simplify them, we can get Proposition 9.

Proposition 9 The basic coordination conditions to allow retailers with value-added services exist in dual-channel supply chain with demand uncertainty are:

$$\frac{(\beta+\theta)(8b^2-7b\beta+17b\theta-13\beta\theta+11\theta^2)}{\eta(b+\theta)^2(b+3\theta)}+\frac{4a_2+4\theta(a_1+t_1)}{(b+\theta)(b+3\theta)}+\frac{4(a_3+t_3)}{b+3\theta}-\frac{6a_1+2t_1}{b+\theta}\leq 0$$

$$\frac{6a_2-4t_1-4t_3}{\eta(b+\theta)}-\frac{4(a_3+t_3)}{\eta(b+3\theta)}+\frac{4(t_1-\theta a_1-\theta a_2)}{\eta(b+\theta)(b+3\theta)}-\frac{(\beta+\theta)(8b^2+7b\beta-17b\theta+13\beta\theta-11\theta^2)}{\eta(b+\theta)^2(b+3\theta)}\geq 0$$

Proposition 8 and Proposition 9 form coordination conditions for mix dual-channel, which allow retailers with value-added services and manufacturer's electronic direct sale channels co-exist in the dual-channel supply chain. They depend on and compete with each other to create value for benefits maximizing of the dual-channel supply chain.

5 Conclusion

In this paper the information-sharing incentive problem with uncertain demand is studied. We build the partial information sharing incentive pricing model with demand uncertainty in dual channels, then analyze and get the validity of partial information sharing pricing incentive mechanism, the stable equilibrium conditions of price discrimination strategies, and coordination mechanism between mix channels.

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REFERENCES

[1] A. A. Tsay and N. Agrawal. *Manufacturing and Service Operations Manage*,2(2000),No.4, 372-391
[2] W.Y. Chiang, D. Chhajed and J.D. Hess. *Manage. Sci.* 49 (2003), No.1,1-20
[3] N. Yan, X. Huang and B. Liu,Chinese J Manage. Sci., 15(2007),No.3, 98-102
[4] W. Xing, S. Wang and G. Feng. *Sys Engin Theo & Practice*, (2008),No.7,56-60
[5]. Z. Xiong, G. Li, Y.Tang and W. Li. J. *Indust Engin & Engin Manage*, 21(2007),No. 3,49-55
[6]. X. Pu, Q. shi and L. Ling. J. *Manage Sci in China*,10(2007),No.6,49-56
[7]. Y. Guo and L. Zhao. *Sys Engin Theo & Practice*, 28(2008),No.9,59-66
[8]. Y.Chen, H.Wang and H. Shen. *Sys Engin Theo & Practice*, 26(2006),No.1,35-41
[9]. Y.Chen, H. Wang and H.Shen. *J. Indust Engin & Engin Manage*, 22(2008),No.1,34-39
[10]. D. Yao and J. Liu. Omega, 33(2005a),No.3,235-247
[11]. D.Yao,X.Yue,X.Wang and J. Liu. *Inter. J. Prod. Econ.*, 97(2005b),No.2, 196-209
[12] Samar K. Mukhopadhyay, D.Yao and X.Yue. J. *Busi Rsearch*,61(2008),No.9, 950-958
[13]. K. Chen, M. Kaya and Ozalp Ozer. *Manu & Serv Oper Manage*,10(2008),No. 4,65-675
[14]. X. Ai and X. Tang, Y. Ma. J. Manage Sci in China, 11(2008),No.1,12-21
[15]. Z.Chen and X. Ai. *System Engin Theo & Practice*, 28(2008),No.12,42-51
[16] D. Yao and J. J. Liu. *Omega*, 36(2008), No.5, 838-851.
[17] Z.Huang,and A.Gangopadhyay. *in Advanced Topics in Information Resource Management, Edited M. Khosrow-Pour*, Idea Group Publishers, 2005, Vol. 5, 45-58
[18] L. L. Manage Sci, 48(2002),No.9,1196-1212
[19]K. Liu and Z. Zhang. J. *Indust Engin & Engin Manage*,27(2007),No.1, 131-133
[20]Y.Zhang and J. Chen. J. *Indust Engin & Engin Manage*, 18(2004),No.3,118-120

***Authors**: Associate prof. X zhou, School of Business, Central South University, Changsha, 430072, China, E-mail: daweycs@126.com; F Jin, X Chen, F Ma(jinfaqi@sina.com; cxh@mail.csu.edu.cn; fchma@whu.edu.cn*)