Pricing decisions in dual-channel supply chains with service cooperation under asymmetric information

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Abstract—This paper analyzes a dual channel supply chain with service cooperation under asymmetric information. We consider the games with asymmetric risk information and symmetric information respectively, derive the corresponding equilibrium strategies, and conduct detailed comparisons and analyses. We study the impact of service quality and asymmetric information on the optimal strategies. We find that the impact of manufacturer’s service quality on direct channel price is greater than its on retail price, and retailer’s service quality has a greater impact on retail price under with asymmetric information. Retailer would like to share his private information with manufacturer in order to get more profits.

Index Terms—Dual-channel supply chain, asymmetric information, service cooperation.

I. INTRODUCTION

With the rapid development of the e-commerce market, more and more enterprises introduced direct channel on the basis of the traditional retail channels to gain more market share and greater economic profits. When a manufacturer sells through a traditional retailer and also has a direct channel to consumers, such a distribution system is called a dual-channel (or multi-channel) distribution system. Customers prefer dual channels, which benefit them by providing more shopping choices and lower prices, so manufacturers are forced to or voluntarily introduce direct channels as a strategic necessity. Retailers have also realized that it is unwise to boycott the direct channel and drive customers to buy elsewhere (Hanover, 1999). So we suppose in this paper that dual-channel supply chains already exist even in the presence of channel conflicts.

Empirical studies have shown that service quality (Devaraj et al., 2002; Rohm and Swaminathan, 2004) and transaction costs (Liang and Huang, 1998) are the major factors contributing to consumer acceptance of the direct channel. There are indications that service quality even goes beyond product price as one of the main reasons for consumers’ preference for the direct channel (Reichheld and Schefter, 2000). In order to survive or win in today’s market competition, enterprises make great efforts to seize advantages in market competition. As a manufacturer is both a supplier of and competitor with a retailer, many enterprises not only concentrate on competition, but also start to focus on cooperation with their retailers to face challenges together. In addition, whether the supply chain’s members are cooperative or not, they must face a wide variety of uncertainties. Some of them come from outside supply chain system, while some of them come from inside. The inside uncertainties are usually caused by asymmetric information. So, this paper will discuss a dual-channel supply chain with service cooperation under complete information and asymmetric information separately. We assume the supply chain with a risk averse manufacturer and a risk averse retailer, where the retailer’s risk averse value is common knowledge in symmetric scenario and private information in asymmetric scenario. Specifically, we examine the effects of service quality, consumer sensitivity to service, cost, and wholesale price on pricing and equilibrium outcomes. In addition, we investigate how service cooperation affects the equilibrium and what the effect of coordination will be on the asymmetric information.

II. LITERATURE REVIEW

In the last decade, a considerable amount of research has done on dual channel supply chain. Chiang et al. (2003) studied a price-setting game between a manufacturer and a retailer in a dual-channel supply chain based on consumer choice model. Based on Chiang’ work, Yan (2008) used a game theory approach to investigate the strategic role of profit sharing and found that both the manufacturer and the retailer will benefit from a dual-channel profit-sharing strategy. Cai et al. (2009) and Cai (2010) studied the influence of channel structures and pricing schemes on the dual-channel supply chain. Chen et al. (2012) investigate the contracting strategies in a dual-channel supply chain. Zhang et al. (2012) studied the effect of product substitutability and relative channel status on pricing decisions under different power structures. According to their results, the wholesale price contract could coordinate the dual-channel supply chain.

Empirical studies reveal that the service quality on the direct channel has an impact on the consumers’ online shopping. Dumrongsiri et al. (2008) consider the impact of retailer’s service quality on a dual-channel supply chain in which a manufacturer sells to a retailer as well as to consumers directly. They reach an interesting conclusion that a higher retailer’s service quality may lead to a higher manufacturer’s profit in a dual-channel supply chain. Xiao(2010) studied service cooperation pricing strategy in a dual-channel supply chain.
with symmetric information. Dan et al. (2012) examine the retail services in a centralized and a decentralized dual-channel supply chain using the two stage optimization technique and Stackelberg game. Their results imply that retail services could strongly influence the manufacturer and the retailer’s pricing strategies. In this paper, we consider that the service quality impact on demand, and supply chain members respond to market by service cooperation.

On the other hand, there have been a number of studies on asymmetric information. Desiraju (1997) who found that channel performance could be improved by appropriate levels of price and service in the case of asymmetric information. Viswanathan (2000) studies the mixed channel issue from the product-differentiation point of view and concludes that the more different the product is in the two channels, the more benefits for the channels. Samar et al. (2008) investigated information sharing by a value-adding retailer in a dual-channel hi-tech supply chain based on a Stackelberg game. Çakanyildirim et al. (2012) find that information asymmetry of price and service in the case of asymmetric information.

These differences in risk attitudes and risk perceptions may vary quite dramatically up and down the channel. These differences in risk attitudes and risk perceptions may be played out in different operating strategies. In our research, we assume the manufacturer and the retailer are risk averse, and the retailer’s attitude is private information. With this assumption, we study the impact of service quality and asymmetric information on the optimal strategies.

III. THE MODEL

We consider a single period, single product model with a risk averse manufacturer and a risk averse retailer. The manufacturer sells to the retailer as well as to the consumers directly. Consumers may choose the retailer (retail channel) or the manufacturer (direct channel) to obtain the good.

We begin with describing the consumer choice process. For a given product, whether consumers would purchase the product is determined by two factors: price and service quality. The first factor is simply represented by different prices in two channels. Let \( p_1 \) and \( p_2 \) denote the unit price at the direct channel and the retailer, respectively. The second factor is also important: different service characteristics of online channel and conventional retail stores affect consumer behavior. In our model, we represent service quality as an integrated representation of those different characteristics of the two channels. The service quality at the direct channel is \( s_1 \) and the service quality at the retailer is \( s_2 \). Different consumers have different sensitivity to the service quality offered by the two channels. For example, some consumers may put a higher value on the ability to physically experience the good than the others. We represent this sensitivity by \( \lambda \). For different consumers, \( \lambda \) is randomly drawn from a uniform distribution with support on \([\frac{1}{2}, \frac{1}{2}]\).

We assume that the demand function on each channel is linear and depends on service quality, its own price and the price of the other player. Specifically, the demand functions are given in (1) and (2):

\[
Q_1 = (\theta + \rho)\bar{a} - p_1 + \lambda s_1 - b(p_1 - p_2) \quad (1)
\]

\[
Q_2 = (1 - \theta)\bar{a} - p_2 + \lambda s_2 - b(p_1 - p_2) \quad (2)
\]

where \( Q_1 \) is the demand on direct channel and \( Q_2 \) is the retailer’s demand. \( \bar{a} \) is a random variable and \( \bar{a} = a + \epsilon \), where \( a \) is the base level of demand, \( \epsilon \) is a random variable with mean zero and variance \( \sigma^2 \). \( \theta \) reflects and allocating percentage. \( \rho \) is the percentage added of market size owning to the establishment of the direct channel. \( b \) measures the marginal rate for the perceived price different, and \( be(0,1) \).

The rest of the model describes the policies and costs at the manufacturer and the retailer. \( c \) is the manufacturer’s marginal production cost. The cost to the retailer for service \( (s_2) \) is \( c(s_2) \) per unit and to the manufacturer for service \( (s_1) \) is \( c(s_1) \) per unit. We assume a quadratic cost function for the service-adding process; specifically, we use the functional form:

\( c(s_i) = \frac{1}{2}\eta_is_i^2, i = 1, 2 \), where \( \eta_i \) is an efficiency parameter for the service-added cost. As retailers can give the service to the customers directly, their service cost can be lower than the manufacturers (Xu, 2006). So we assume that \( \eta_1 > \eta_2 \).

This paper considers that the manufacturers transfer the direct channel’ services to the retailers and the retailers get paid from the manufacturers. The service cooperation model as follows:

![Fig. 1. Service cooperation structure model of dual channel.](image)

All that the manufacturer can do is encourage desirable retailer behavior by choosing his wholesale price and service cost subsidies appropriately. The retailer will take the wholesale price and service cost subsidies as given and choose his price and service quality to maximize his utility. When retailer provide service \( (s_1) \) to manufacturer, he will get \( \frac{1}{2}\eta_1s_1^2 \) from manufacturer, and also have cost \( \frac{1}{2}\eta_2s_2^2 \).

With the above notations and assumptions, the retailer's profit function is determined by:
\[ \pi_r = \left(p_2 - w - \frac{1}{2} \eta_2 s^2 \right) Q_2 + \left( \frac{1}{2} \eta_1 s^2 - \frac{1}{2} \eta_2 s^2 \right) Q_1 \]  

(3)

And the manufacturer’s profit function is determined by:

\[ \pi_m = \left(p_1 - c - \frac{1}{2} \eta_1 s^2 \right) Q_1 + (w - c) Q_2 \]  

(4)

The dual-channel supply chain’s joint profit function can be obtained and expressed as:

\[ \pi_{sc} = \left(p_1 - c - \frac{1}{2} \eta_1 s^2 \right) Q_1 + \left(p_2 - c - \frac{1}{2} \eta_2 s^2 \right) Q_2 \]  

(5)

Under mean-variance framework, \( U(\pi) = E(\pi) - k \sqrt{Var(\pi)} \), the retailer’s utility function is:

\[ U_r(\pi_r) = \left(p_2 - w - \frac{1}{2} \eta_2 s^2 \right) Q_2 + \left( \frac{1}{2} \eta_1 s^2 - \frac{1}{2} \eta_2 s^2 \right) Q_1 - k_r \sigma \times \left[ \left(p_2 - w - \frac{1}{2} \eta_2 s^2 \right)(1 - \theta) + \left( \frac{1}{2} \eta_1 s^2 - \frac{1}{2} \eta_2 s^2 \right)(\theta + \rho) \right] \]  

(6)

where \( k_r \) is the parameter denoting the retailer’s risk attitude. \( k_r > 0 \) denotes the retailer is risk neutral player. \( k_r < 0 \) denotes the retailer is risk averse player. A higher \( k_r \) implies that retailer scarves risk much more.

Under mean-variance framework, the manufacturer’s utility function is:

\[ U_m(\pi_m) = \left(p_1 - c - \frac{1}{2} \eta_1 s^2 \right) Q_1 + (w - c) Q_2 - k_m \left[ \left(p_1 - c - \frac{1}{2} \eta_1 s^2 \right)(\theta + \rho) + (w - c)(1 - \theta) \right] \sigma \]  

(7)

where \( k_m > 0 \) denotes the manufacturer is risk averse player. And the risk averse value is common knowledge.

We use a Stackelberg leader-follower game model with the manufacturer as the leader. Employing backward induction technique, we can solve the game. The sequence of moves in the game model is as follows:

1) Manufacturer decides the wholesale price \((w)\) and the direct price \((p_1)\).

2) Retailer follows by setting the retail price \((p_2)\) in response to the manufacturer’s wholesale price \((w)\) and the direct price \((p_1)\).

A. Symmetric information

In symmetric information case, retailer’s risk averse value is common knowledge. The first-order derivative of \( U_r(\pi_r) \) with respect to \( p_2 \) is given by:

\[ \partial U_r(\pi_r)/\partial p_2 = (1 - \theta)(a - k_r \sigma + \lambda s_2 - 2(1 - b)p_2 - b p_1 + \frac{1}{2} b(\eta_1 - \eta_2)s^2 + (1 - b)(w + \frac{1}{2} \eta_2 s^2)) = 0 \]  

(8)

The second-order derivative of \( U_r(\pi_r) \) with respect to \( p_2 \) is given by \( \partial^2 U_r(\pi_r)/\partial p_2^2 = -2(1 - b) < 0 \). Therefore, \( U_r(\pi_r) \) is a concave function of \( p_2 \). Solving the first-order condition of \( (8) \), we have:

\[ p_2^*(w, p_1) = \frac{1}{2(1-b)}(1 - \theta)(a - k_r \sigma + \lambda s_2 - 2 b p_1 + \frac{1}{2} b(\eta_1 - \eta_2)s^2 + (1 - b)(w + \frac{1}{2} \eta_2 s^2)) \]  

(9)

which is an increasing function of both direct price \((p_1)\) and wholesale price \((w)\), but \( \alpha \) is the decreasing function of his risk averse value and standard deviation of demand.

In stage 1, manufacturer decides his wholesale price and the direct channel price to maximize his objective function according to \( p_2^*(w, p_1) \). Let \( H^m \) be the manufacturer’s objective function’s Hessian matrix. The matrix is:

\[ H^m = \begin{bmatrix} -(1-b) & 0 \\ 0 & \frac{(b^2 - 2)}{(1-b)} \end{bmatrix} \]  

(10)

Because \( H^m_{11} = -(1-b) < 0 \) and \( \det(H^m) = (2 - b^2) > 0 \). Hence, Hessian matrix is a negative definite matrix. \( u_m(\pi_m) \) is joint concave in \( w \) and \( p_1 \). As a result, the Stackelberg equilibrium solutions under symmetric risk averse value information are as follows:

\[ p_1^{SV} = \frac{1}{4(2-b^2)}(a(4(\theta + \rho) + b(2 - 6 \theta - 4 \rho)) - 4(\theta + \rho)k_m \sigma + 2 \eta_1 s^2 + 4(c + \lambda s_2) + b(2c + 2(2(\theta + \rho)k_m - (1 - \theta)k_r)\sigma + \eta_2 s^2 - 2 \lambda(2s_1 - s_2)) - b^2(4c + \eta_2 s^2 + s^2)) \]  

(11)

\[ p_2^{SV} = \frac{1}{4(2-b^2)}(2a(3 - 3 \theta - \theta(\rho + b(2 - 2 \theta + 3 \rho) + 2(2 \theta k_m - (1 - \theta)k_r)\sigma + 2(2 - 2 k_m \sigma + s_2(6\lambda + \eta_2 s^2) - b(6c - 2(\theta + \rho)k_m \sigma + 2 \lambda s_1 + (\eta_1 + \eta_2) s^2 + \eta_2 s^2)) - b^2(2c + (1 - 2 \eta_2 s^2) - b^2(4c + \eta_2 s^2 + (2 \lambda s_2 + b(2 \eta_1 - \eta_2) s^2) - (1 - b) \eta_2 s^2) \]  

(12)

\[ w^{SV} = \frac{1}{4(2-b^2)}(2 - 4b)c + 2(1 - \theta) + (2k_m - k_r)\sigma + 2 \lambda s_2 - b(2 \eta_1 - \eta_2) s^2(1 - b) \eta_2 s^2 \]  

(13)

The “SV” in the superscript denotes the optimal solution under symmetric information.

**Conclusion 1**: The higher the manufacturer’s quality value is, the direct channel’s price is higher, the retail price is lower.

**Proofing**: according to the assumptions, we have \( \lambda, b \in (0,1) \) and \( \eta_1 > \eta_2 \), consequently \( \frac{\partial^2 \pi_r}{\partial \sigma^2} = \frac{2(1-b)+\lambda(1-b)^2+\eta_2^2}{4(1-b)^2} > 0 \). In a similar way, we get \( \frac{\partial^2 \pi_r}{\partial \sigma^2} = \frac{b(\lambda(1-b)+\eta_1+\eta_2\eta_1^2)}{2(1-b)(2-b^2)} > 0 \).

**Conclusion 2**: The higher the retailer’s service quality, the direct channel’s price and retail price is higher.

**Proofing**: In a similar way, we have \( \frac{\partial^2 \pi_r}{\partial \sigma^2} = \frac{b(\lambda(1-b)+\eta_1+\eta_2\eta_1^2)}{2(1-b)(2-b^2)} > 0 \). The condition 1 and 2 suggest that manufacturers and retailers will increase direct price and retail price in order to make up for a lot of service costs.

**Conclusion 3**: The direct channel’s price and retail price are both increasing in manufacturer’s service-added cost. The direct channel’s price is decreasing in retailer’s service-added cost and the retail price is increasing in retailer’s service-added cost if \( \frac{\partial}{\partial \sigma} > \frac{1}{\sqrt{b}} \) and vice versa.
Proving: we have \( \frac{\partial^2 V}{\partial \eta_1^2} = \frac{s_1^2}{(2-2b)^2} > 0 \) and \( \frac{\partial^2 V}{\partial \eta_2^2} = \frac{b s_1^2}{(4-1-b)(2-b)^2} > 0 \). And we get \( \frac{\partial p_2}{\partial \eta_2} = \frac{b (s_1^2 - 1)(b - 2)}{(b + 2)(2-2b)^2} > 0 \). Consequently, \( \frac{\partial^2 V}{\partial \eta_1^2} > 0 \) and \( \frac{\partial^2 V}{\partial \eta_2^2} > 0 \), \( \eta_1^2 > \frac{1-b}{b} \), and vice versa.

According to the conclusion, we find that manufacturers’ service cost have a greater impacts on supply chain. They should be properly reducing the service cost of direct channel.

**Conclusion 4:** The impact of manufacturer’s service quality on direct channel price is greater than its on retail price. And retailer’s service quality has a greater impact on retail price.

Proving: \( \frac{\partial (P_2^* - P_2^D)}{\partial \eta_1} = \frac{2(1-b) + b(1-b)\eta_2 + (2-b)\eta_1 s_1}{2(1-b)(2-b)^2} > 0 \); \( \frac{\partial (P_2^* - P_2^D)}{\partial \eta_2} = -\frac{2(1-b)^2 + (2-b)^2\eta_2 s_1}{2(1-b)(2-b)^2} < 0 \).

Through analyzing the influencing of the service level and service cost to pricing strategy, we can find that manufacturers and retailers will increase direct price and retail price in order to make up for a lot of service costs. Manufacturers should seek cooperate with the retailers whose service cost is low to reduce the service cost of direct channel.

### B. Asymmetric Information

In symmetric information case, we suppose the retailer’s risk averse value is private knowledge. The manufacturer only knows retailer’s risk averse value are \( k_r \) and \( \bar{k}_r \), with probabilities of \( \mu \) and \( 1-\mu \). Because the follower’s information is private, we can use the backward induction technique. Retailer knows his own risk averse value, his response function to be used by the manufacturer is still given by (9). When the retailer’s risk averse value is \( k_r \), his optimal response function is given by:

\[
p_2^*(w, p_1) = \frac{(1-\theta)(a-k_r s_1) + \lambda s_2 - b p_1 + b \eta_1 - b p_2}{2(1-b)(w + b s_2)}
\]

Similar to (12), the retailer’s optimal response function is as follow when his risk averse value is \( \bar{k}_r \):

\[
p_2^*(w, p_1) = \frac{(1-\theta)(a-\bar{k}_r s_1) + \lambda s_2 - b p_1 + b \eta_1 s_1 - b p_2 + (1-\mu) p_2}{2(1-b)(w + b s_2)}
\]

In stage 2, manufacturer’s objective function is:

\[
U_m(\sigma_m) = \left( p_1 - c - \frac{1}{2} \eta_1 s_1 \right)(\theta + \rho) a - p_1 + \lambda s_1 - b p_1 + \left( p_1 - c - \frac{1}{2} \eta_1 s_1 \right) b \left[ \mu p_2 + (1-\mu) p_2 \right] + (w-c) \left( (1-\theta) a + \lambda s_2 - b p_1 - (w-c)(1-b) \right) \left[ \mu p_2 + (1-\mu) p_2 \right] - k_m \left[ \left( p_1 - c - \frac{1}{2} \eta_1 s_1 \right)(\theta + \rho) + (w-c)(1-\theta) \right] \sigma
\]

The objective function’s Hessian matrix \( \nabla^2 U_m(\sigma_m) = \left( \begin{array}{c} -1 \ 0 \\
0 \ (b^2 - 2)/(1-\theta) \end{array} \right) \) is a negative definite matrix.

As a result, the Bayesian equilibrium solution under asymmetric risk averse value information are as follows:

\[
p_1^a = \frac{1}{2(2-b)} \left( a(4(\theta + \rho) + b(2-60 - 4\rho)) - 4(\theta + \rho)k_m + 2\eta_2 s_2^2 + 4(c + \lambda s_1) + b(2c + 2(\theta + \rho)k_m) a + \eta_2 s_2^2 - 2a(2s_1 - s_2) - b^2(4c + \eta_2 s_2^2 + s_1)(1-\theta) \right) \left( 1 - \mu k_r + \mu k_r \right)
\]

\[
p_2^a = \frac{1}{2(1-b)(1-b)} \left( 2a(3 - 30 - b(\theta + \rho) + b^2(-2 + 3e + \rho)) + 2(c - 2k_m a) + s_2(64 + \eta_2 s_2) + 2(2c + 2(\theta + \rho)k_m a + 2\lambda s_1 + \eta_2 s_2^2 + \eta_2 s_2^2) - b(2(1 + (-1 + \theta + \rho)k_m a - \lambda s_1) + 4\lambda s_2 + \eta_2 s_2^2) + b^2(4c + \eta_2 s_2^2 + s_1) + 2a(2k_m - (1-\theta)(1-b)^2) \left( 1 - \mu k_r + \mu k_r \right) \right)
\]

\[
w^a = \frac{1}{4(1-b)} \left( 2a(2 - 2(1 - \theta)) - b - 2k_m \right) \sigma + 2\lambda s_2 - b(2\eta_1 - \eta_2 s_2^2 - (1 - b)\eta_2 s_2^2)
\]

The “a” in the superscript denotes the optimal solution under asymmetric information.

**Conclusion 5:** When retailer’s risk averse value is low type, manufacturer’s price on direct channel under asymmetric information will lower than that under symmetric information and retailer’s price under asymmetric information will higher than that under symmetric information, and vice versa.

Proving: comparing solutions under symmetric information with asymmetric information, respectively, we obtain:

\[
p_1^a - p_1^s = \frac{b \sigma(1-\theta)(a-k_r s_1) + \lambda s_2 - b p_1 + b \eta_1 - b p_2}{2(2-b)^2} \mu k_r + \mu k_r \]

\[
p_2^a - p_2^s = \frac{b \sigma(1-\theta)(a-k_r s_1) + \lambda s_2 - b p_1 + b \eta_1 s_1 - b p_2}{2(2-b)^2} \mu k_r + \mu k_r \]

If \( k_r = \bar{k}_r \), then \( p_1^a < p_1^s \) and \( p_2^a > p_2^s \).

**Conclusion 6:** The more information sharing, the manufacturer and the retailer make better pricing decisions.

Proving: If \( k_r = \bar{k}_r \), then \( p_1^a < p_1^s \) and \( p_2^a > p_2^s \), and \( \frac{\partial (p_1^a - p_1^s)}{\partial \mu} = \frac{b \sigma(1-\theta)(a-k_r s_1) + \lambda s_2 - b p_1 + b \eta_1 - b p_2}{2(2-b)^2} \mu k_r + \mu k_r \) increasing in \( \mu \); \( \frac{\partial (p_2^a - p_2^s)}{\partial \mu} = \frac{b \sigma(1+b)(1-\theta)(\lambda s_2 - b p_1)}{2(2-b)^2} \mu k_r + \mu k_r \) is decreasing in \( \mu \). If \( k_r = \bar{k}_r \), then \( p_1^a > p_1^s \) and \( p_2^a < p_2^s \), \( \frac{\partial (p_2^a - p_2^s)}{\partial \mu} = \frac{b \sigma(1+b)(1-\theta)(\lambda s_2 - b p_1)}{2(2-b)^2} \mu k_r + \mu k_r \) is increasing in \( \mu \). It means that the manufacturer get more accurate information, the supply chain’s member could make better pricing decisions.

### IV. NUMERICAL RESULTS

In this section, we illustrate our results with a numerical example. The parameters for this example are \( a = 240, \sigma = 10, \theta = 0.4, \rho = 0.3, b = 0.5, c = 10, k_m = 1, \eta_1 = 6.5, \eta_2 = 3.5, \alpha = 0.6 \). We assume retailer’s private information is \( k_r = 1 \). The manufacturer knows that the probability of \( k_r = 1 \) is \( \mu \), and that of \( k_r = 2 \) is \( 1 - \mu \).
A. The impact of service quality

We check the impact of service quality on pricing decisions firstly. Let \( \mu = 0.6 \).

Figure 2 illustrates direct channel’s price and retail price are both increasing in service quality and wholesale price is decreasing in service quality. Manufacturers and retailers will increase direct price and retail price in order to make up for a lot of service costs.

![Fig. 2. The impact of service quality on optimal decisions](image)

B. Compare the optimal decisions

We compare the optimal decisions under symmetric information with that under asymmetric information firstly. Let \( s_1 = 5, s_2 = 7 \).

Figure 3 illustrates that manufacturers’ service cost have a greater impacts on supply chain. Manufacturers should seek cooperate with the retailers whose service cost is low to reduce the service cost of direct channel.

![Fig. 3. The impact of service cost](image)

Figure 4 illustrates that when retailer’s risk averse value is low type, manufacturer’s price on direct channel under asymmetric information will lower than that under symmetric information and retail price and wholesale price under asymmetric information will higher than that under symmetric information. Retail price and wholesale price are both decreasing in retailer private information sharing; price on direct channel is increases with more information sharing on supply chain. It means that when manufacturer has less information, he would set a higher wholesale price and lower direct channel’s price to face the uncertainty, and then get the lowest profit. So manufacturers should to seek cooperate with the retailers to get more accurate information, in order to make the best decisions.

![Fig. 4. Compares about optimal decisions.](image)

V. CONCLUSIONS

This paper focus on the optimal pricing strategies for a dual channel supply chain with service cooperation. Compared the optimal decisions under symmetric information with those under asymmetric information, we find that its benefits for retailer to share his private information with manufacturer. And we studies the impact of service quality and service costs, find that manufacturers and retailers will increase direct price and retail price in order to make up for a lot of service costs. Manufacturers should seek cooperate with the retailers whose service cost is low to reduce the service cost of direct channel.

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