Agricultural Supplier's Online Sale Mode Choice Under Dual-channel Supply Chain

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Abstract. In this paper, we make a major contribution by examining an agricultural supplier's online sale mode choice. That is, for the supplier, which online sale mode should be adopted, his own online store, an online retailer, or a bricks-and-clicks retailer? To end this, we first study the price decisions under the three kinds of possible online sale modes. We then compare the price decisions among these modes. We find that when the supplier adopts his own online store, the online and offline price are both lowest in these modes. Based on it, we compare the supplier's profits and find that the mode of adopting his own online store can always lead the supplier to get higher performance. That is, if the supplier has the ability to operate his own online store, he'd better set up his own online store. Lastly, we use numerical examples to illustrate our analytic findings and gain more insights.

Introduction

According to china e-business research center (2015), in 2014, the e-business of agricultural products market transaction amount in china has reached $4.2 billion, compared to 2013 increased by 100% [1]. Following the rapid development of e-commerce, many agricultural suppliers begin to develop online channel in addition to their existing traditional channel. However, they face a strategic decision on which online sale mode should be adopted. The first mode is that the agricultural suppliers establish their own online channel and sell agricultural products to consumers directly (mode A), as shown in Fig. 1a. The second mode is that the agricultural suppliers develop online channel by adopting an online retailer (mode B), as shown in Fig. 1b. The third mode is that the agricultural suppliers develop online channel by adopting a bricks-and-clicks retailer (mode C), as shown in Fig. 1c.

To the best of our knowledge, this paper is the first time to study the issue of online sale mode choice. Almost all extant research mainly focuses on whether the supplier should establish online shop as a direct channel in addition to his existing indirect retail channel, i.e., single channel VS dual channel. Chiang et al. (2003) further consider the customer acceptance of an online direct channel and establish a new demand model. They find that the supplier should adopt dual-channel when the customer acceptance is strong enough [2]. Liu and Zhang (2006) find that the supplier can benefit from the dual-channel strategy. However, under the dual-channel, the retailer is always worse off [3]. Xia et al. (2013) identify factors that affect the supplier's motivation to use dual-channel distribution when the supplier produces two complementary products [4]. Chen et al. (2012) find that the supplier and the retailer both can benefit from the dual-channel supply chain [5].

The above-mentioned studies only consider the demand dependent on price. But in real life, the demand is also affected by the quality of service. Therefore, Dumrongsiri et al. (2008) further consider retailer and supplier's service quality simultaneously. They find that the marginal costs have a major impact on the supplier's channel decision [6]. Xu et al. (2012) extends the work of Chiang et al. (2003) by investigating how price and delivery lead time decisions affect channel choice strategy [7]. The above Literatures just consider the supply chain structure which consists of a retailer and a supplier. Ma et al. (2012) extend one supplier to two suppliers, and find that both dominant supplier and retailer can benefit from the dual-channel strategy [8]. Hsiao and Chen (2013) construct a theoretical model with competing suppliers and an active retailer to explain why many leading suppliers opt not to sell online [9].

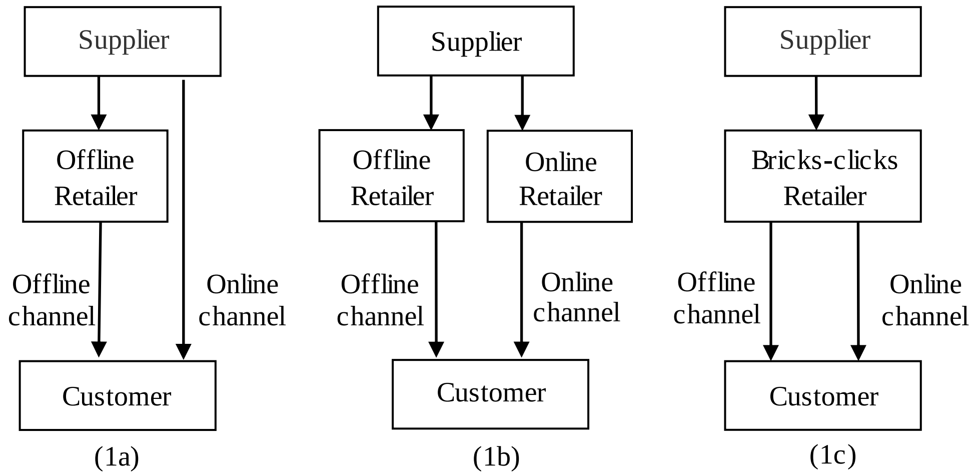

Fig. 1 Supplier's three possible online sale modes

Model assumptions and notation

In this section, we introduce the model of the mode A. The supplier produces a single product at production cost c per unit and supplies the offline retailer at a wholesale price w, and $w > c$. The retailer distributes the product through an offline channel only and sets a unit selling price p_r. Simultaneously, the supplier establish his own on-line store to sell his product at price p_e. Following Hua et al. (2010) [10], we assume that the demand functions are linear in self- and cross-price effects. We use D_r and D_e to denote the offline and online channel's demand respectively. Therefore, the offline and online channel's demand are

$$D_r = (1-\theta)a - b_1 p_r + d_1 p_e \qquad (1)$$

$$D_e = \theta a - b_2 p_e + d_2 p_r \qquad (2)$$

Where a represents the base demand of the product. θ represents the degree of customer preference of the online channel. b_1 and b_2 denote the coefficients of price elasticity of D_r and D_e respectively. d_1 and d_2 denote cross-price sensitivities. Generally, the impact of own channel's price on own channel's demand is greater than cross-price effects, so we assume $b_i > d_i, i = 1,2$. To maintain analytical concisely, we assume $d_1 = d_2 = d$, w is exogenous variable and $c = 0$.

Meanwhile, to ensure the demand is positive, we define $0 \le w \le p_r \le \frac{\theta ad+(1-\theta)ab_2}{b_2 b_1 - d^2}$ and $0 \le w \le p_e \le \frac{(1-\theta)ad+\theta ab_1}{b_2 b_1 - d^2}$.

Sales price decision

In this section, we mainly investigate the price decisions under the three kinds of possible online sale modes.

Mode A. In the mode A, the supplier distributes product through an offline retailer and his own online store. We assume the supplier and offline retailer have balance power, i.e., the supplier and offline retailer decide online and offline price simultaneously. For clarity, we add superscript $()^A$ to denote mode A. The supplier and retailer's profit, denoted as Π_S^A and Π_R^A, are given by

$$\Pi_S^A = w[(1-\theta)a - b_1 p_r^A + dp_e^A] + p_e^A(\theta a - b_2 p_e^A + dp_r^A) \quad (3)$$

$$\Pi_R^A = (p_r^A - w)[(1-\theta)a - b_1 p_r^A + dp_e^A] \quad (4)$$

We then study the existence and uniqueness of Nash equilibrium in their offline and online price. We can have the following Proposition:

Proposition 1. There exists a unique Nash equilibrium in (p_r^{A*}, p_e^{A*}), and the detailed Nash equilibrium solutions are

$$p_r^{A*} = \frac{\theta ad + 2(1-\theta)ab_2 + (2b_2 b_1 + d^2)w}{4b_2 b_1 - d^2}$$

$$p_e^{A*} = \frac{(1-\theta)ad + 2\theta ab_1 + 3b_1 dw}{4b_2 b_1 - d^2}$$

Mode B. In the mode B, the supplier distributes product through an offline retailer and an online retailer. We assume the online and offline retailer have balance power, i.e., online retailer and offline retailer decide online and offline price simultaneously. For clarity, we add superscript $()^B$ to denote mode B. The offline and online retailer's profit, denoted as Π_R^B and Π_E^B, are given by

$$\Pi_R^B = (p_r^B - w)[(1-\theta)a - b_1 p_r^B + dp_e^B] \quad (5)$$

$$\Pi_E^B = (p_e^B - w)(\theta a - b_2 p_e^B + dp_r^B) \quad (6)$$

We then study the existence and uniqueness of Nash equilibrium in their offline and online price. We can have the following Proposition:

Proposition 2. There exists a unique Nash equilibrium in (p_r^{B*}, p_e^{B*}), and the detailed Nash equilibrium solutions are

$$p_r^{B*} = \frac{\theta ad + 2(1-\theta)ab_2 + (2b_2 b_1 + b_2 d)w}{4b_2 b_1 - d^2}$$

$$p_e^{B*} = \frac{(1-\theta)ad + 2\theta ab_1 + (2b_2 b_1 + b_1 d)w}{4b_2 b_1 - d^2}$$

The proof of proposition 2 is similar to the proposition 1, so we omit it.

Mode C. In the mode C, the supplier distributes product through a bricks-and-clicks retailer. For clarity, we add superscript $()^C$ to denote mode C. The online and offline price decision are made to maximize the following the bricks-and-clicks retailer's profit (Π_{RE}^C):

$$\Pi_{RE}^{C} = (p_r^C - w)[(1-\theta)a - b_1 p_r^C + dp_e^C] + (p_e^C - w)(\theta a - b_2\, p_e^C + dp_r^C) \quad (7)$$

From Eq. (7), we can easy to check Hessian Matrix is a negative definite. We then can get the following Proposition:

Proposition 3. The bricks-and-clicks retailer's profit function (Π_{RE}^{C}) is jointly concave in (p_r^C, p_e^C), and the optimal price decisions are characterized by

$$p_r^{C*} = \frac{\theta ad + (1-\theta)ab_2 + (b_2 b_1 - d^2)w}{2(b_2 b_1 - d^2)}$$

$$p_e^{C*} = \frac{(1-\theta)ad + \theta ab_1 + (b_2 b_1 - d^2)w}{2(b_2 b_1 - d^2)}$$

Online sale mode choice

In this section, we mainly focus on the agricultural supplier's online sale mode choice, i.e., which online sale mode is better for the supplier. To end this, we first compare the price decisions among the three kinds of possible online sale modes. We then can get the following Proposition:

Proposition 4. $p_r^{A*} < p_r^{B*}$ and $p_e^{A*} < p_e^{B*}$; $p_r^{A*} < p_r^{C*}$ and $p_e^{A*} < p_e^{C*}$;

From Proposition 4, we know that under the mode A, the online and offline price are both lower than that under mode B and mode C. The customer can benefit from the mode A. However, it is difficult for us to compare price between mode B and mode C. We then compare the profits, and then we can get the following Proposition:

Proposition 5. $\Pi_S^{A*} > \Pi_S^{B*}$, $\Pi_S^{A*} > \Pi_S^{C*}$.

From Proposition 5, we know that if the supplier has the ability to operate his own online store, the optimal online sale mode choice is mode A, i.e., establishes his own online store. However, we are hard to compare profits between the mode B and mode C. Therefore, we will discuss it by using numerical examples in next section.

Numerical examples

In this section, we firstly study that if the supplier does not have the ability to operate their own online store, which mode is better for him. We then will discuss which mode is better for the entire supply chain. We use the following numbers as the base values of the parameters: $a = 1000$, $b_1 = 10$, $b_2 = 12$, $d = 5$, $w = 35$.

Observation 1. Under mode B, the supplier's profits is higher than that under mode C

From Fig. 2a, numerical results can confirm observation 1. It implies that if the supplier does not have ability to operate their own online store, his best choice is to adopt an online retailer to develop online channel. In additional, From Fig. 2, we also can find that when supplier adopts mode C, the degree of customer preference of the online channel has no impact on the supplier's profits.

Observation 2. When the degree of customer preference of the online channel is low, the supply chain's profits under mode B is higher than that under mode A or mode C. Otherwise, the optimal online sale mode choice is mode A for entire supply chain.

For clarity, we use Π_T to denote the profits of supply chain. From Fig. 2b, numerical results can confirm observation 2. From Observation 2, we know that when the degree of customer preference of the online channel is low, the supplier's online sale mode choice is not consistent with supply chain's choice. That is, under this condition, supplier's choice undermines profits of the entire supply chain. It implies that when the degree of customer preference of the online channel is low, supplier or retailer can design a mechanism to coordinate and lead the members of supply chain to achieve win-win situation.

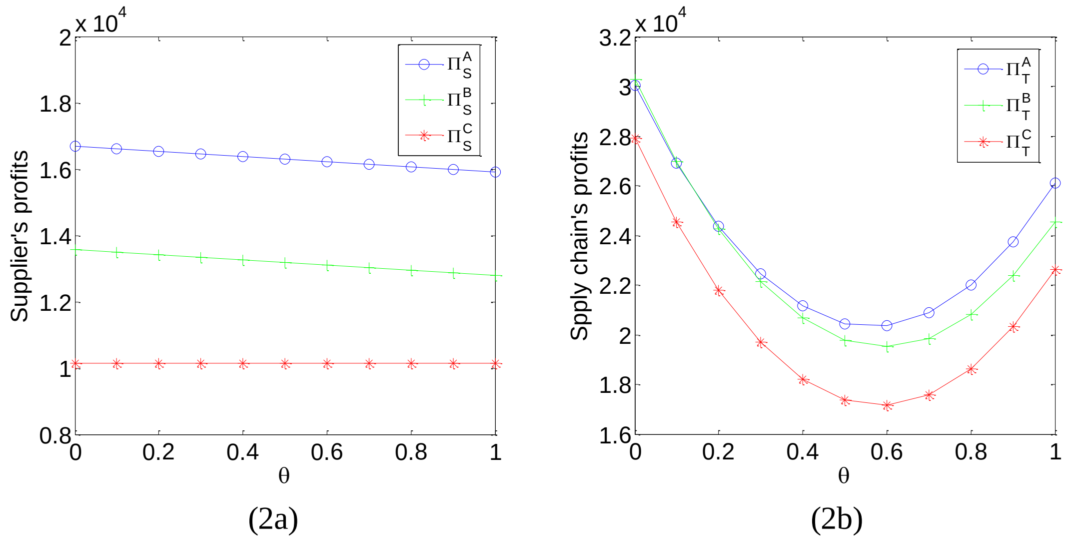

Fig. 2 Profits under three online sale modes

Conclusions

This paper is to answer the following important question: which online sale mode should be adopted for the supplier, his own online store, an online retailer, or a bricks-and-clicks retailer? To answer this question, under each possible mode, we derive the optimal selling prices and find the online and offline price under mode A are both lower than that under mode B or mode C. Based on it, we compare the supplier's profits. Our results show that the mode of adopting his own online store (mode A) is always best choice for the supplier.

Furthermore, numerical examples lead to a few more managerial insights. First, if the supplier does not have ability to operate their own online store, his best choice of online sale mode choice is to adopt an online retailer. Second, when the degree of customer preference of the online channel is low, the supplier's online sale mode choice is not consistent with supply chain's choice. Therefore, supplier or retailer can design a mechanism to coordinate and lead the members of supply chain to achieve win-win situation.

There are a few interesting topics for further research and three are listed here. First, this paper assumes that the demand is certain. In reality, this may or may not be true. Meanwhile, agricultural production is greatly affected by the external environment, so supply also exists uncertain. Therefore, we next will consider uncertain of demand and supply simultaneously. Second, we next can study how to design a coordination mechanism to induce supplier to choice same online sale mode with supply chain.

Acknowledgments

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