The Selling Mode in a Supply Chain with Online Retailing

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Abstract. In this paper, we consider a supply chain in which two competitive manufacturers sell products through an exclusive pure play e-tailer besides their traditional offline channels. Using a game-theoretical model, we analyze the e-tailer’s optimal choice for the selling mode in the presence of upstream competition, cross-channel spillover and cost asymmetry between the online and offline channels. We reveal that the e-tailer always prefers the agency selling mode to the reselling mode, if the spillover effect of the e-channel on the offline channel is negative. Otherwise, the e-tailer prefers the reselling mode to the agency selling mode, if the cost advantage of the e-channel over the offline channel is small and the competition between the upstream manufacturers is intense.

Introduction

It has been a global phenomenon that many customers choose to purchase products through online channel because of its great convenience, large product variety, low price and search cost, etc[1,2]. Driven by this noticeable trend, some manufacturers have begun to sell their products through the Internet channel, such as Lenovo and Sony[3]. In 2013, Amazon had over 2 million sellers whose sales accounted for roughly 40% of its total sales[4].

Many prior researches on multi-channel emphasize the cannibalization effect of the e-channel on the offline channel[5]. However, recently some scholars claim that e-channel and offline channel may target different kinds of customers, leading to consumer segmentation[6,7]. Therefore, the introduction of the e-channel actually expands the potential market of the offline channel.

Currently, the e-tailer mainly uses two different selling mode: reselling mode and agency selling mode. One key difference between these two selling formats lies in who retains the control rights over the retail prices[8,9]. For reselling mode, the e-tailer acts as a conventional merchant who purchases products from the manufacturers and then resells them to customers. Thus, it is the e-tailer that sets the retail price. However, for agency selling mode, the e-tailer acts as a multi-sided platform in which the manufacturers and the customers can directly interact with each other. The manufacturers decide retail prices independently, but they have to share a certain portion of revenues with the e-tailer as referral fees. For instance, Amazon charges its sellers a different commission fee for every sale through its marketplace depending on the category of the goods, e.g., 6% for PCs, and 15% for mobile phones[10].

The comparison between the reselling mode and the agency selling mode for online platform is first introduced by Hagiu[11]. Some researches focus on the price difference between these two selling formats[12-14]. In addition, [15] studies the impact of third-party information on quality and fitness on the e-tailer’s preference for different selling arrangements, demonstrating that its choice for selling format can function as a strategic tool to extract more profits.

This paper is closely related to [9] which models competition between downstream platforms. In contrast, we focus on competition between upstream manufacturers. We find that the effect of the competition on the e-tailer’s preference for different selling modes in our model is opposite to that in [9]. Moreover, we discuss the impact from the cost advantage of the online channel over the offline channel on the e-tailer’s optimal choice for selling mode, which is not considered in [9].

The remainder of this paper proceeds as follows: section 2 describes and analyzes the model. In section 3, we numerically give conditions for the e-tailer’s preference for different selling format. Section 4 concludes our main findings and proposes some managerial implications.
The Model

Model Description

We consider a supply chain consisting of two symmetric manufacturers and a pure play e-tailer. The monopoly e-tailer has the power to determine its retailing format which may be reselling or agency selling mode. Each manufacturer sells products through both the traditional retailer (i.e., offline channel) and the e-tailer (i.e., e-channel).

Assume that the demand of manufacturer \( i \)'s products sold through the e-channel is given by

\[
q_i = \frac{1}{1 + \beta} - \frac{p_i}{1 - \beta} + \frac{\beta p_j}{1 - \beta^2}.
\]

(1)

In Eq.(1), \( i, j = 1, 2, i \neq j \), \( 0 \leq \beta < 1 \) captures the competition intensity and also the degree of differentiation between the two manufacturers\(^{[8,9]} \), which might be resulted by brand loyalty, customer service, etc. Larger \( \beta \) implies that the degree of differentiation is lower and the competition is more intense. If \( \beta = 0 \), the two manufacturers are fully different and there is no competition.

Assume that the offline demand of each manufacturer is \( Q + \gamma(q_i + q_j) \), where \( Q \) represents the base demand of the offline channel, and \( \gamma \in [-1, 1] \) is the cross-channel spillover coefficient. One can see that \( \gamma \) can be either positive or negative, suggesting that the e-channel may bring additional revenues or generate channel conflicts for the offline channel. Without loss of generality, we normalize the offline price to 1, implying that \( \gamma \) does not alter the offline channel price. The underlying reasons may include established reference prices, high menu costs and so on\(^{[8]} \). Moreover, the unit selling cost of the e-channel is assumed to be 0, but that of the offline channel is \( c \), \( 0 \leq c \leq 1 \). This assumption is reasonable because in practice the e-channel is typically more cost effective. Larger \( c \) represents larger cost advantage of e-channel over offline channel. Based on these assumptions, we know that the offline profit of each manufacturer is \( (1-c)(Q + \gamma(q_i + q_j)) \).

Model Analysis

According to the selling format that the e-tailer chooses, we analyze the optimal decisions of the manufacturers and the e-tailer in two different settings.

Reselling Mode. First, we consider the setting where the e-tailer chooses the reselling mode (RR). In this case, the timing of the game is as follows:

(i) \( \text{Stage 1} \): two manufacturers decide their wholesale prices \( w_1 \) and \( w_2 \) simultaneously;

(ii) \( \text{Stage 2} \): the e-tailer jointly decides the retail prices \( p_1 \) and \( p_2 \) for the two products.

The manufacturers try to maximize their profits as follows:

\[
\text{Max } \pi_1^{RR} = (1-c)(Q + \gamma(q_i + q_j)) + w_i q_i,
\]

(2)

\[
\text{Max } \pi_2^{RR} = (1-c)(Q + \gamma(q_i + q_j)) + w_j q_j.
\]

(3)

And the e-tailer is trying to maximize its profit as follows:

\[
\text{Max } \pi_E^{RR} = (p_1 - w_1)q_1 + (p_2 - w_2)q_2.
\]

(4)

By using backward induction method, we can obtain the equilibrium for RR in Proposition 1.

Proposition 1. With reselling mode, the optimal wholesale prices and retail prices are as follows:

\[
w_1^{RR^*} = w_2^{RR^*} = (1-\beta)|1-\gamma(1-c)|/(2-\beta), \quad p_1^{RR^*} = p_2^{RR^*} = [2-\beta + (1-\beta)|1-\gamma(1-c)|]/(2-\beta).
\]

Proof. First, we analyze the e-tailer’s optimal decisions given the manufacturers’ wholesale prices. From Eq. (1) and (4), we know that the Hessian matrix of \( \pi_E^{RR} \) with respect to \( p_1 \) and \( p_2 \) is is negatively definite. Thus, the optimal solution satisfies the first-order conditions:

\[
\frac{\partial \pi_E^{RR}}{\partial p_1} = (1-\beta - 2p_1 + w_1 + 2\beta p_2 - \beta w_2)/(1-\beta^2) = 0,
\]

\[
\frac{\partial \pi_E^{RR}}{\partial p_2} = (1-\beta - 2p_2 + w_2 + 2\beta p_1 - \beta w_1)/(1-\beta^2) = 0.
\]
By solving the above equations, we obtain the e-tailer’s best response function \( p_{i}^{RR}(w_i) = (1 + w_i) / 2, i \in \{1, 2\} \). Inserting them into Eqs. (2)-(3), we know that manufacturer \( i \) chooses \( w_i \) to maximize \( \pi_{i}^{RR} = (1-c)[Q + \gamma(q_i(p_i^{RR}, p_j^{RR}) + q_j(p_i^{RR}, p_j^{RR})] + w_i q_i(p_i^{RR}, p_j^{RR}). \)

The second derivative of \( \pi_{i}^{RR} \) with respect to \( w_i \) is \( \partial^2 \pi_{i}^{RR} / \partial w_i^2 = -1/(1-\beta^2) < 0 \). Thus, \( \pi_{i}^{RR} \) is a concave function of \( w_i \). So the unique optimal solution satisfies the first-order conditions, i.e.,

\[
\frac{\partial \pi_{i}^{RR}}{\partial w_i} = (1-\beta)[1-\gamma(1-c)] - 2w_i + \beta w_j) / [2(1-\beta^2)] = 0,
\]

\[
\frac{\partial \pi_{j}^{RR}}{\partial w_j} = (1-\beta)[1-\gamma(1-c)] - 2w_j + \beta w_i) / [2(1-\beta^2)] = 0.
\]

By solving the above equations, we obtain the optimal wholesale prices \( w_{1}^{RR}, w_{2}^{RR} \). Inserting \( w_{i}^{RR} \) into \( p_{i}^{RR}(w_i) \), we can get the optimal retail prices \( p_{i}^{RR} \).

**Agency Selling Mode.** In this section, we consider the setting where the e-tailer chooses the agency selling mode (AA). The fundamental difference of this mode compared with RR lies in that now it is the manufacturer that controls the e-channel price. In this case, the timing of the game is as follows:

(i) **Stage 1:** the e-tailer jointly determines the ratios of the revenue share (i.e., unit agency fees) \( a_i \) and \( a_j \) for the two manufacturers;

(ii) **Stage 2:** two manufacturers decide their e-channel retail prices \( p_1 \) and \( p_2 \) simultaneously.

The two manufacturers try to solve the following problem:

\[
\max_{p_1} \pi_1^{AA} = (1-c)[Q + \gamma(q_1 + q_j)] + (1-a_1)p_1q_1, \tag{5}
\]

\[
\max_{p_2} \pi_2^{AA} = (1-c)[Q + \gamma(q_1 + q_j)] + (1-a_2)p_2q_2. \tag{6}
\]

And the e-tailer tries to solve the following problem:

\[
\max_{a_1, a_2} \pi_e^{AA} = a_1p_1q_1 + a_2p_2q_2. \tag{7}
\]

Using similar solving method as section 2.2.1, we obtain the equilibrium of AA in Proposition 2.

**Proposition 2.** With agency selling mode, the optimal ratios of revenue share and retail prices are:

\[
a_{i}^{AA} = a_{j}^{AA} = a_{j}^{AA} = 1 - (M + \gamma(1-c))(1-\beta)/(1-\beta^2),
\]

\[
p_{i}^{AA} = p_{j}^{AA} = (1-\beta)(1-a_{i}^{AA} - \gamma(1-c))/(1-\alpha(1-c)(1-\beta^2)),
\]

where \( M = \{54\gamma^2(1-c)^2(1-\beta) + [54\gamma^2(1-c)^2(1-\beta)^2 - 108\gamma(1-c)(1-\beta)(1-\beta)](1)^2(1-\gamma)^2[1/3](3\times2^{1/3})\}. \)

Proof. First, we analyze the manufacturers’ optimal decisions given the e-tailer’s ratios of revenue share. The second-order derivatives of Eqs. (5)-(6) with respect to \( p_i \) \( (i = 1, 2) \) are as follows:

\[
\partial^2 \pi_{i}^{AA} (\partial p_i)^2 = -2(1-a_i)/(1-\beta^2) < 0,
\]

which indicates that the second-order condition holds. Thus, the optimal solution satisfies the first-order conditions, i.e.,

\[
\frac{\partial \pi_{i}^{AA}}{\partial p_i} = (1-a_i)[1-2p_i - \beta(1-p_i)] - \gamma(1-\beta)(1-c))/(1-\beta^2) = 0,
\]

\[
\frac{\partial \pi_{j}^{AA}}{\partial p_j} = (1-a_j)[1-2p_j - \beta(1-p_j)] - \gamma(1-\beta)(1-c))/(1-\beta^2) = 0.
\]

As the two manufacturers are symmetric, we let \( a_1 = a_2 = a \). By solving the above equations, we obtain the manufacturers’ best response function \( p_{i}^{AA} = p_{j}^{AA} = p_{i}^{AA}(a) = (1-\beta)(1-a - \gamma)/(1-\alpha(2-\beta)) \).

Inserting them into Eq. (7), the e-tailer chooses \( a \) to maximize \( \pi_{e}^{AA} \).

\[
\pi_{e}^{AA} = [2a(1-\beta)(1-a - \gamma(1-c)]/[1-\alpha + \gamma(1-\beta)(1-c))]/[(1-a)^2(2-\beta)^2(1+\beta))],
\]

\[
\partial^2 \pi_{e}^{AA} (\partial a)^2 = -2(1-\beta)(1-c)\phi(\gamma)/(1-a)^2(2-\beta)^2(1+\beta), g(\gamma) = (1-\beta)(1-c)(2+\alpha + \beta(1-a), \phi(\gamma) = g(\gamma).
\]

According to the sign of \( \gamma \), we divide it into three settings:

(i) For \( \gamma = 0 \), we have \( \pi_{e}^{AA} = 2a(1-\beta)/(1-\beta)^2(1+\beta) \) and \( g(\gamma) = 0 \). \( \pi_{e}^{AA} \) is increasing with \( a \). Thus, the e-tailer will set the optimal unit agency fee \( a^* \). (ii) For \( \gamma < 0 \), we have \( \lim_{\gamma \to -\infty} g(\gamma) = (1-\alpha) \).
From \( g'(\gamma) = (1-\beta)(1-c)(2+\alpha) > 0 \), we have \( g(\gamma) < 0 \) and \( \phi(\gamma) > 0 \) for \( \gamma < 0 \). (iii) For \( \gamma > 0 \), we have \( \lim_{\gamma \to 0^+} g(\gamma) = \beta(1-\alpha') \). Similarly, from \( g'(\gamma) > 0 \), we have \( g(\gamma) > 0 \) and \( \phi(\gamma) > 0 \) for \( \gamma > 0 \).

Taken together, we have \( \phi(\gamma) \geq 0 \), so that \( \frac{\partial^2 x_{e}^{AA}}{\partial \alpha^2} \leq 0 \). Thus, the optimal solution satisfies the first-order condition:

\[
\frac{\partial x_{e}^{AA}}{\partial \alpha} = (1-\beta)[3\alpha^2 - \alpha^3 + \gamma(1-c)][1+\gamma(1-c)(1-\beta)] + \alpha[3+\gamma^2(1-c)^2 - \beta\gamma(1-c)(1+\gamma(1-c))] / [(1-\alpha)(2-\beta)^2(1+\beta)] = 0
\]

Therefore, we can obtain the optimal unit agency fees \( a_1^{AA} \) and \( a_2^{AA} \). Inserting them into \( p^{AA}(\alpha) \), we get the optimal retail prices \( p^{AA} \) in Proposition 2.

The E-tailer’s Optimal Choice for the Selling Mode

By comparing the e-tailer’s optimal profits in RR and AA, we show the e-tailer’s optimal choice for the selling format in Fig. 1. From Fig. 1, we observe that:

(i) For \( \gamma < 0 \), the e-tailer would rather choose AA than RR. This is because in RR, to weaken the negative effect of the e-channel on their offline channels, the manufacturers are inclined to charge high wholesale prices for the e-tailer, which incurs high retail prices and low e-channel demand as well. By comparison, in AA, the e-tailer can encourage the manufacturers to reduce their e-channel retail prices to enhance the online sales via adjusting the agency fee.

(ii) For \( \gamma > 0 \), if \( \gamma \) is sufficiently large, the e-tailer prefers RR to AA, due to that the e-tailer benefits from low wholesale prices in RR, whereas the e-tailer is hurt by low retail price and unit agency fee in AA. Otherwise, if \( \gamma \) is sufficiently small, the e-tailer’s optimal choice for selling format also depends on the magnitude of the competition intensity \( \beta \) and the cost advantage of the e-channel over the offline channel \( c \). In RR, large \( \beta \) will induce a drastic decrease in wholesale prices, which weakens the double marginalization and benefits the e-tailer. Moreover, the e-tailer jointly decides the retail prices for the products of the two manufacturers to optimize its profit, which internalizes the competition. Thus, the e-tailer prefers RR to AA, if \( \beta \) is large; otherwise, the e-tailer sticks to AA.

(iii) When \( \gamma > 0 \), as \( c \) increases, the manufacturers increase their wholesale prices in RR, so the double marginalization effect is enhanced. Thus, the e-tailer tends to switch from RR to AA as \( c \) becomes large. Particularly, \( c = 1 \) means that the manufacturers cannot secure any profit from the offline channel, so that \( \gamma \) has no influence on the manufacturers’ total profits. In this extreme case, the e-tailer’s optimal selling format is only dependent on the competition between the manufacturers. As is indicated by the regions below or above the horizontal dotted line in Fig. 1, we know that if the competition between the two manufacturers is mild, the e-tailer chooses AA to leverage the upstream competition; otherwise it chooses RR to internalize the upstream competition. In general, the e-tailer’s preference for AA is strengthened as \( c \) increases, but is weakened as \( \beta \) increases.

Figure 1. The effect of \( \beta \), \( \gamma \), and \( c \) on the e-tailer’s preference for selling mode.
Summary

In this paper, we reveal that when the cross-channel spillover coefficient is negative, the e-tailer will unambiguously choose the agency selling mode, because it dampens the double marginalization, which is unavoidable in the reselling mode. When the cross-channel spillover coefficient is positive but small, the e-tailer prefers agency selling to reselling mode, if the competition intensity is small, otherwise the e-tailer prefers reselling mode to agency selling mode. We also show that the agency selling mode will become more prevalent, when the cost advantage of the e-channel over the offline channel is more pronounced. In summary, the e-tailer trades off between the channel efficiency in agency selling mode and the competition cushion effect in reselling mode.

These results shed some light on the operation management in the electronic retailing industry. We highlight the importance that the e-tailer should take into account the cross-channel spillover effect when deciding its optimal selling format. In our setting, we assume that the competition and the cross-channel spillover are exogenous. In fact, both the manufacturers and the e-tailer are able to endogenize these variables to some extent. For example, if the manufacturers sell complementary products in different channels, the demand stimulating effect of the e-channel on the offline channel can be increased. And the e-tailer can affect the competition intensity between the manufacturers via e.g., deliberately selecting its suppliers or frequently making part of its suppliers obsolete. In addition, with the rising of Industry 4.0, advanced production and management methods may change the operation cost of the manufacturers among multiple channels dramatically, which may influence the e-tailer’s preference for different selling formats. Thus, it is necessary for the e-tailer to obtain the detailed information about its suppliers’ operation cost before choosing optimal selling mode.

References


