Manufacturer’s pricing strategy for mixed retail and e-tail channels

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Abstract

With the increasing popularity of e-commerce, manufacturers are selling more of their products through the e-tail (online) distribution channel in addition to the traditional retail (offline) distribution channel. The central issue faced by a manufacturer with the mixed retail and e-tail channels is pricing strategy. In this paper, we investigate the pricing strategies of a manufacturer and a mix of retailers and e-tailers in a two-echelon supply chain with price and service level dependent demands. We compare different pricing options of the manufacturer to discuss its optimal pricing strategy. In addition, we analyse the effects of different manufacturer’s pricing strategies on supply chain profit.

1. Introduction

With the rapid development of e-commerce, more and more manufacturers increasingly use the online e-tail channel besides the traditional offline retail channel to distribute their products. Realizing the differences of the two channels in terms of demand characteristics and service levels, the manufacturers are faced with the issue of channel conflict, that is, they are dealing with pricing the mixed retail and e-tail channels.

Prior literature such as Yao and Liu (2005), Hendershott and Zhang (2006) and Chen et al. (2008) investigate the manufacturer’s pricing strategies for mixed retail and e-tail channels with a game theoretical framework and derive equilibrium pricing policies. While those papers study the setting of a direct e-tail channel owned by the manufacturer, we focus on the scenario of an independent e-tail channel that competes with the offline retail channel. Chen et al. (2012) consider manufacturer’s pricing strategies in a two-echelon supply chain that comprises one manufacturer and two competing retailers, which have different sale costs and warranty period-dependent demand. They discuss the effects of three different manufacturer’s pricing strategies on supply chain decisions and profit, and derive the manufacturer’s optimal pricing strategy with symmetrical and asymmetrical sales cost information. In our paper, the demand is sensitive to both retail price and service level, the distribution channel is a mix of both retailer and e-tailer with different service levels, and we focus on the effect of different service levels on retailer and e-tailer with four different manufacturer’s pricing strategies.

This article investigates the manufacturer’s pricing strategy for a supply chain consisting of one manufacturer and mixed retailing and e-tailing distribution channels. The manufacturer acts as a Stackelberg leader and specifies wholesale prices to each channel. The retailer and the e-tailer acting as Stackelberg followers and decide their retail prices. The manufacturer considers four possible pricing strategies:

1. Strategy I: Manufacturer negotiates with retailer and e-tailer simultaneously according to their service levels, sets a single wholesale price to both channels.
2. Strategy II: Manufacturer negotiates with retailer and e-tailer separately according to their service levels and sets different wholesale prices to the two channels.
3. Strategy III: Manufacturer negotiates only with retailer and sets the wholesale price according to the retailer’s service level to the two channels.
4. Strategy IV: Manufacturer negotiates only with e-tailer and sets the wholesale price according to the e-tailer’s service level to the two channels.

However, several questions of interests emerge:
1. What are the retailer and e-tailer’s optimal prices and the manufacturer’s optimal wholesale price under each of manufacturer’s pricing strategies?
2. What is the effect of manufacturer’s choice of pricing strategy on the supply chain, such as retailer and e-tailer’s decisions and their profits, manufacturer’s decisions and profit, and the total profit of the entire supply chain?
3. Which pricing strategy proposed by the manufacturer should be adopted in response to the different service level scenarios?

This study aims to address these issues and provide insights with regard to the influence of manufacturer’s pricing strategy on supply chain decisions and performance. Compared with previous research, our study concentrates on the evaluation of manufacturer’s pricing strategies in conjunction with the responses of retailers and e-tailers, and related impact on supply chain’s decisions and performance when all channel members are affected by retail price.
and service dependent demands. This is a unique contribution because few analyses of similar studies have made such a connection. In addition, the results of the study can also provide useful guidelines for manufacturers, retailers and e-tailers who face similar challenges.

2. Model Formulations and Assumptions

We model a two-echelon supply chain comprising one manufacturer and a mix of retailer and e-tailer channels, as shown in Figure 1.

![Figure 1. Two-echelon supply chain](image)

We assume that the manufacturer, a Stackelberg leader, sets a wholesale price. The retailer and e-tailer, Stackelberg followers, order products from the manufacturer and then sell them to end-users. The retailer’s unit retail price of the product is \( p^r \) and her value-added service level is \( v^r \). The e-tailer’s unit retail price of the product is \( p^e \) and value-added service level \( v^e \). The manufacturer’s unit manufacturing cost of the product is \( m \). The demand in the mixed retail and e-tailer channels are given as functions of retail price and value-added service level (Yao and Liu 2005, Hu and Li 2012):

\[
D^r(p^r, p^e) = \alpha - p^r + \beta p^e + \gamma v^r \tag{1}
\]

\[
D^e(p^e, p^e) = \alpha - p^e + \beta p^e - \gamma v^e \tag{2}
\]

The forms are common in the economics and operations management literature. Where \( \alpha \) is the market base. We assume the two channels have same market base. \( \beta \) measures the substitution or cannibalization between the two channels, \( 0 < \beta < 1 \). This appears reasonable because sales are relatively more sensitive to retail price at a channel’s own outlet(s) than at the competing channel’s outlets. \( \gamma \) is marginal demand per retail service value added.

\( c(v) \) is adopted to capture the relationship between the marginal service cost and the retail service level, and is a strictly convex service curve. One practical form of the service curve used in previous literature is \( c(v) = \frac{k v^2}{2} \) (e.g., Tsay and Agrawal 2000, Yan and Pei 2009), where \( k \) is referred to as the “service cost factor” and measures the cost effectiveness of the retail service.

In strategy I, we assume that retailer’s retail price is \( p^r_1 \), e-tailer’s retail price is \( p^e_1 \), and the manufacturer’s wholesale price is \( w_1 \). In strategy II, III and IV, we assume that retailer’s retail price is \( p^r_i \), e-tailer’s retail price is \( p^e_i \), the manufacturer’s wholesale price for retailer is \( w^r_i \) and the manufacturer’s wholesale price for e-tailer is \( w^e_i \), where \( i = 2, 3, 4 \).

3. Manufacturer’s Pricing Strategy I

With strategy I, the sequence of events is as follows: the manufacturer acting as the market leader moves first and sets a wholesale price \( w_1 \) to retailer and e-tailer according to their service level to optimize its own profit; then, the retailer and e-tailer observe \( w_1 \) and follow Nash’s equilibrium to determine their optimal retail price.

3.1 The mixed channels’ problem

The retailer faces a problem of defining the retail price \( p^r_1 \) to maximize his profit. In this strategy, the retailer’s profit, which is an one-variables function of \( p^r_1 \) denoted as \( \pi^r_1(p^r_1) \), is

\[
\pi^r_1(p^r_1) = p^r_1 D^r(p^r_1, p^e_1) - w_1 D^r(p^r_1, p^e_1) - c(v) \tag{3}
\]

The first term is sales revenue, and the second term represents the retailer’s purchasing cost. The last term corresponds to the value-added service cost. Then

\[
\pi^r_1(p^r_1) = (p^r_1 - w_1) (\alpha - p^r_1 + \beta p^e_1 + \gamma v^r) - \frac{k v^2}{2} \tag{4}
\]

Therefore, the retailer’s decision problem is

\[
\max_{p^r_1} \pi^r_1(p^r_1)
\]

Similarly, the e-tailer faces a problem of deciding the retail price \( p^e_1 \) to maximize profit. In this strategy, the e-tailer’s profit, which is also a function of \( p^e_1 \), denoted as \( \pi^e_1(p^e_1) \), is

\[
\pi^e_1(p^e_1) = p^e_1 D^e(p^r_1, p^e_1) - w_1 D^e(p^r_1, p^e_1) \tag{5}
\]

The first term is sales revenue, and the second term represents the e-tailer’s purchasing cost. Then

\[
\pi^e_1(p^e_1) = (p^e_1 - w_1) (\alpha - p^r_1 + \beta p^e_1 + \gamma v^e) \tag{6}
\]

Therefore, the e-tailer’s decision problem is

\[
\max_{p^e_1} \pi^e_1(p^e_1)
\]

After a discussion of the retailer and e-tailer’s optimal retail price, we get the following proposition:

Proposition 1. With manufacturer’s pricing strategy I, the retailer’s optimal retail price \( p^r_1 \) and e-tailer’s
optimal retail price \( p_1^r \) satisfy \( p_1^r = \frac{\alpha + w_1}{2 - \beta} + \frac{\gamma v}{2 + \beta} \), and
\( p_1^{e_r} = \frac{\alpha - w_1}{2 - \beta} - \frac{\gamma v}{2 + \beta} \).

This proposition means that both the retailer and e-tailer have unique optimal retail prices with manufacturer’s pricing strategy I.

3.2 The manufacturer’s problem

The manufacturer faces an issue to determine a wholesale price \( w_1 \) that maximizes his expected profit. The manufacturer’s profit, denoted as \( \pi^m_1(w_1) \), is \( \pi^m_1(w_1) = (w_1 - m)D^r(p_1^r, p_1^{e_r}) + (w_1 - m)D^e(p_1^r, p_1^{e_r}) \) 

The first term denotes the profit gained from retail channel and the second term represents the profit gained from the e-tail channel. Then
\[
\pi^m_1(w_1) = (w_1 - m)(\alpha - p_1^r + \beta p_1^{e_r} + \gamma v) + (w_1 - m)(\alpha - p_1^{e_r} + \beta p_1^r - \gamma v) \]

Therefore, the manufacturer’s decision problem is
\[
\max_{w_1} \pi^m_1(w_1) \]

The manufacturer’s optimal wholesale price can be presented by the following proposition:

**Proposition 2** With manufacturer’s pricing strategy I, the manufacturer’s optimal wholesale price is
\[
w_1 = \frac{m}{2} + \frac{\alpha}{2(1 - \beta)} \]

From (4), (6), (10) and propositions 1 and 2, we find that the supply chain’s entire profit with manufacturer’s pricing strategy I is \( \pi^w_1 = \pi^r_1(p_1^r) + \pi^e_1(p_1^{e_r}) + \pi^m_1(w_1) = (p_1^r - w_1)(\alpha - p_1^{e_r} + \beta p_1^r + \gamma v) - \frac{\gamma v^2}{2} + (p_1^{e_r} - w_1)(\alpha - p_1^{e_r} + \beta p_1^r + \gamma v) + (w_1 - m)(\alpha - p_1^{e_r} + \beta p_1^r - \gamma v) \)

That is,
\[
\pi^u_1 = (p_1^{e_r} - m)(\alpha - p_1^{e_r} + \beta p_1^r + \gamma v) - \frac{\gamma v^2}{2}
\]

We take into account the effect of service level \( v \) on the retailer, the e-tailer and the manufacturer’s pricing decision with manufacturer’s pricing strategy I. For this, we have the following proposition.

**Proposition 3** With manufacturer’s pricing strategy I, \( p_1^r \) increases and \( p_1^{e_r} \) decreases in \( v \), and \( w_1 \) is constant in \( v \).

Proposition 3 indicates that with the value-added service provided by retailer increased, the retailer will set higher retail price, the e-tailer will set lower retail price, and the manufacturer’s wholesale price is changeless.

Below, we discuss the effect of unit manufacturing cost \( m \) on the manufacturer’s pricing decision and profit, the retailer and e-tailer’s retail price decision and their profits, and the entire supply chain’s profit with manufacturer’s pricing strategy I. We gain the following proposition.

**Proposition 4** With manufacturer’s pricing strategy I, \( p_1^r, p_1^{e_r} \) and \( w_1 \) all increase in \( m \), \( \pi^r_1(p_1^r), \pi^e_1(p_1^{e_r}) \), \( \pi^m_1(w_1) \) and \( \pi^w_1(p_1^r) \) all decrease in \( m \).

From this proposition, we know that with manufacturer’s pricing strategy I, the increase in unit manufacturing cost \( m \) will lead to a decrease in the unit sales profit. Therefore, the manufacturer will set a higher wholesale price, the retailer and e-tailer will set a higher retail price and purchase less quantities of product from the manufacturer, which will be detrimental to the profit of retailer, e-tailer and manufacturer.

4. Manufacturer’s Pricing Strategy II

With manufacturer’s pricing strategy II, the sequence of events is as follows: the manufacturer acting as the market leader moves first and sets different wholesale prices \( w^*_1 \) and \( w^*_2 \) to retailer and e-tailer according to their service level to optimize its own profit; then the retailer and e-tailer observe \( w^*_1 \) and \( w^*_2 \), and follow Nash’s equilibrium to determine their optimal retail price.

4.1 The mixed channels’ problem

The retailer faces a problem to decide a retail price \( p^r_2 \) that maximizes his/her expected profit. The retailer’s profit which is an one-variables function of \( p_2^r \), denoted as \( \pi^r_2(p_2^r) \), is
\[
\pi^r_2(p_2^r) = p_2^r D^r(p_2^r, p_2^e) - w^*_2 D^e(p_2^r, p_2^e) - c(v) \]

The first term is sales revenue. The last two terms correspond to the retailer’s purchasing cost and value-added service cost, respectively. Then
\[
\pi^r_2(p_2^r) = (p_2^r - w^*_2)(\alpha - p_2^r + \beta p_2^e + \gamma v) - \frac{\gamma v^2}{2}
\]

Therefore, the retailer’s decision problem is
\[
\max p_2^r \pi^r_2(p_2^r)
\]

Similarly, the e-tailer faces a problem of defining the retail price \( p_2^e \) to maximize profit. In this strategy, the e-tailer’s profit which is also an one-variables function of \( p_2^e \), denoted as \( \pi^e_2(p_2^e) \), is
\[
\pi^e_2(p_2^e) = p_2^e D^e(p_2^r, p_2^e) - w^*_2 D^e(p_2^r, p_2^e) \]

The first term is sales revenue, and the second term represents purchasing cost. Then
\[
\pi^e_2(p_2^e) = (p_2^e - w^*_2)(\alpha - p_2^r + \beta p_2^e + \gamma v)
\]

Therefore, the e-tailer’s decision problem is
\[
\max p_2^e \pi^e_2(p_2^e)
\]
On the basis of a discussion of the retailer and e-tailer’s optimal retail price, we get the following proposition:

**Proposition 5** With manufacturer’s pricing strategy II, the retailer’s optimal retail price \( p^*_2 \) and e-tailer’s optimal retail price \( p^*_e \) satisfy
\[
\begin{align*}
\frac{2y_v + w^*_e - w^*_2}{2(2 - \beta)} \quad & \text{and} \quad \frac{2y_v + w^*_e - w^*_2}{2(2 - \beta)} \quad & \text{From this proposition, we know that there exist unique optimal retail prices for both the retailer and e-tailer in response to manufacturer’s pricing strategy II.}
\end{align*}
\]

**4.2 The manufacturer’s problem**

The manufacturer must decide a wholesale price to maximize his/her expected profit. The manufacturer’s profit, denoted as \( \max \pi^m(w^*_2, w^*_e) \), is
\[
\pi^m(w^*_2, w^*_e) = (w^*_2 - m)D^r(p^*_2, p^*_e) + (w^*_e - m)D^e(p^*_2, p^*_e) \quad (18)
\]

The first term is the manufacturer’s profit from retailer, and the second represents the manufacturer’s profit from e-tailer. Then
\[
\pi^m(w^*_2, w^*_e) = (w^*_2 - m)(\alpha - p^*_2 + \beta p^*_e + yv) + (w^*_e - m)(\alpha - p^*_2 + \beta p^*_e - yv) \quad (19)
\]

Therefore, the manufacturer’s decision problem is denoted as
\[
\max_{w^*_2, w^*_e} \pi^m(w^*_2, w^*_e)
\]

With regard to the manufacturer’s optimal wholesale price, we get the following proposition:

**Proposition 6** With manufacturer’s pricing strategy II, the manufacturer’s optimal wholesale price is
\[
w^*_2 = \frac{\alpha}{2} + \frac{m}{2(1 - \beta)} \quad \text{and} \quad w^*_e = \frac{\alpha}{2} + \frac{m}{2(1 - \beta)} - \frac{yv}{2(1 - \beta)}
\]

This proposition means that with manufacturer’s pricing strategy II, the manufacturer will set a higher wholesale price to retailer than the wholesale price to e-tailer.

From (13), (15), (19) and propositions 5 and 6, we obtain the supply chain’s entire profit with manufacturer’s pricing strategy II as
\[
\begin{align*}
\pi^a_{\text{II}}(p^*_2, p^*_e) &= \pi^m(w^*_2, w^*_e) + \pi^a_m(w^*_2, w^*_e) = (p^*_2 - w^*_2)(\alpha - p^*_2 + \beta p^*_e + yv) + (w^*_2 - m)(\alpha - p^*_2 + \beta p^*_e - yv) \quad (20)
\end{align*}
\]

**4.3 Sensitivity analysis**

In the following calculations, the effect of service level \( v \) on the supply chain decisions and profit is taken into account to obtain the retailer, the e-tailer and the manufacturer’s pricing decision on the basis of manufacturer’s pricing strategy II. This gives the following proposition.

**Proposition 7** With manufacturer’s pricing strategy II, \( p^*_2 \) and \( w^*_2 \) increase in \( v \), \( p^*_e \) and \( w^*_e \) decrease in \( v \).

This proposition indicates that with the value-added service provided by retailer increased, the retailer will set higher retail price, the manufacturer will set higher wholesale price to retailer accordingly; the e-tailer will set lower retail price, and the manufacturer will set higher wholesale price to e-tailer in the same way.

Below, we will take into consideration the effect of unit manufacturing cost \( m \) on the supply chain decisions and profit and obtain manufacturer’s decision on pricing strategy and profit, the retailer and e-tailer’s decision on retail price and their profit, and the entire supply chain’s profit on the basis of manufacturer’s pricing strategy II. This gives the following proposition.

**Proposition 8** With manufacturer’s pricing strategy II, \( p^*_2, p^*_e, w^*_2 \) and \( w^*_e \) all increase in \( m \); \( \pi^a_m(p^*_2), \pi^a_m(p^*_e), \pi^a_m(w^*_2), \pi^a_m(w^*_e) \) and \( \pi^a_m \) all decrease in \( m \).

Proposition 8 suggests that with manufacturer’s pricing strategy II, an increase in unit manufacturing cost \( m \) will lead to higher retail price and wholesale price and a decrease in the unit sales profit, and as a consequence the retailer and e-tailer will order lesser quantities of product, which will be detrimental to the profit of retailer, e-tailer and the manufacturer.

**5. Manufacturer’s Pricing Strategy III**

With manufacturer’s pricing strategy III, the sequence of events is as follows: the manufacturer acting as the market leader and sets the wholesale price \( w^*_2 \) according to retailer’s service level and applies it to the e-tailer, that is, \( w^*_2 = w^*_e \); then, the retailer and the e-tailer observe \( w^*_2 \) and determine their optimal retail price in accordance with Nash’s equilibrium.

**5.1 The mixed channels’ problem**

The retailer faces a problem to decide a retail price \( p^*_2 \) that maximizes his expected profit. The retailer’s
profit which is an one-variables function of \( p_3^r \), denoted as \( \pi_3^r(p_3^r) \), is
\[
\pi_3^r(p_3^r) = p_3^r D'(p_3^r, p_3^e) - w_3^r D''(p_3^r, p_3^e) - c(v)
\] (21)

The first term is sales revenue. The last two terms correspond to the retailer’s purchasing cost and value-added service cost, respectively. Then
\[
\pi_3^r(p_3^r) = (p_3^r - w_3^r)(\alpha - p_3^e + \beta p_3^e + \gamma v) - \frac{k v^2}{2}
\] (22)

Therefore, the retailer’s decision problem is
\[
\max \pi_3^r(p_3^r)
\]

Similarly, the e-tailer faces a problem of defining the retail price \( p_3^e \) to maximize profit. In this strategy, the e-tailer’s profit which is an one-variables function of \( p_3^e \), denoted as \( \pi_3^e(p_3^e) \), is
\[
\pi_3^e(p_3^e) = p_3^e D'(p_3^r, p_3^e) - w_3^e D''(p_3^r, p_3^e)
\] (23)

The first term is sales revenue, and the second term represents the e-tailer’s purchasing cost. Then
\[
\pi_3^e(p_3^e) = (p_3^e - w_3^e)(\alpha - p_3^e + \beta p_3^e - \gamma v)
\] (24)

Therefore, the e-tailer’s decision problem is
\[
\max \pi_3^e(p_3^e)
\]

On the basis of a discussion of the retailer and e-tailer’s optimal retail price, the following proposition is presented:

**Proposition 9** With manufacturer’s pricing strategy III, the retailer’s optimal retail price \( p_3^r \) and e-tailer’s optimal retail price \( p_3^e \) satisfy \( p_3^r = \frac{\alpha + w_3^r}{2 - \beta} - \frac{v}{2 + \beta} \) and \( p_3^e = \frac{\alpha + w_3^e}{2 - \beta} - \frac{\gamma v}{2 + \beta} \)

5.2 The manufacturer’s problem

The manufacturer must decide a wholesale price to maximize his expected profit according to the retailer’s service level. The manufacturer’s profit from retailer, denoted as \( \pi_3^m(w_3^r) \), is
\[
\pi_3^m(w_3^r) = (w_3^r - m)D'(p_3^r, p_3^e) \]

The first term is the manufacturer’s unit profit from retailer, and the second represents the retailer’s demand. Then
\[
\pi_3^m(w_3^r) = (w_3^r - m)(\alpha - p_3^r + \beta p_3^r + \gamma v) \] (28)

Therefore, the manufacturer’s decision problem is denoted as
\[
\max \pi_3^m(w_3^r)
\]

With regard to the manufacturer’s optimal wholesale price, the following proposition is developed:

**Proposition 10** With manufacturer’s pricing strategy III, the manufacturer’s optimal wholesale price is
\[
\begin{align*}
\frac{w_3^r - m}{2} + \frac{\alpha}{2(1 - \beta)} + \frac{(2 - \beta)\gamma v}{2(1 - \beta)(2 + \beta)}.
\end{align*}
\]

Because \( w_3^r = w_3^r \), the manufacturer’s profit from e-tailer, denoted as \( \pi_3^m(w_3^e) \), is
\[
\pi_3^m(w_3^e) = (w_3^e - m)D'(p_3^r, p_3^e) \]

Then we get the manufacturer’s profit from mixed retailer and e-tailer channels, denoted as \( \pi_3^m(w_3^r, w_3^e) \), is
\[
\pi_3^m(w_3^r, w_3^e) = (w_3^r - m)(\alpha - p_3^r + \beta p_3^e + \gamma v) + (w_3^e - m)(\alpha - p_3^e + \beta p_3^e - \gamma v)
\] (29)

From (22), (24), (29) and propositions 9 and 10, we obtain the supply chain’s entire profit with manufacturer’s pricing strategy III as \( \pi_3^v = \pi_3^r(p_3^r) + \pi_3^m(w_3^r, w_3^e) = (p_3^r - w_3^r)(\alpha - p_3^e + \beta p_3^e + \gamma v) - \frac{k v^2}{2} \)

**Proposition 11** With manufacturer’s pricing strategy III, the manufacturer’s optimal wholesale price is
\[
\begin{align*}
\frac{w_3^r - m}{2} + \frac{\alpha}{2(1 - \beta)} + \frac{(2 - \beta)\gamma v}{2(1 - \beta)(2 + \beta)}, \text{ if } \frac{1}{2} \leq \beta < 1, \text{ and decrease in } v; \text{ if } \beta = \frac{1}{2}, \text{ is constant in } v; \text{ if } 0 < \beta < \frac{1}{2}, \text{ is increase in } v.
\end{align*}
\]

Proposition 11 indicates that with the value-added service provided by retailer increased, the retailer will set higher retail price; if the pricing competition between the two channels is higher, the e-tailer will set higher wholesale price. However, the e-tailer’s retail price will changeless; if the pricing competition between the two channels is lower, the e-tailer will set lower retail price. This proposition is departure from our normal knowledge on price competition.

Below, we will investigate the effect of unit manufacturing cost \( m \) on the manufacturer’s decision on pricing strategy and profit, the retailer and e-tailer’s decision on retail price and their profits, and the entire supply chain’s profit with manufacturer’s pricing strategy III. This gives the following proposition.

**Proposition 12** With manufacturer’s pricing strategy III, \( p_3^r, p_3^e \) and \( w_3^r \) all increase in \( m \); \( \pi_3^r(p_3^r), \pi_3^m(p_3^e), \pi_3^m(w_3^r, w_3^e) \), and \( \pi_3^m \) all decrease in \( m \).
This proposition means that with manufacturer’s pricing strategy III, an increase in unit manufacturing cost \( m \) will lead to higher retail price and wholesale price and a decrease in the unit sales profit, and as a consequence the retailer and e-tailer will order lesser quantities of product, which will be detrimental to the profit of retailer, e-tailer and the manufacturer.

From propositions 4, 8 and 12, we know that an increase in unit manufacturing cost \( m \) will hurt the retailer’s, e-tailer’s, manufacturer’s and the entire supply chain’s profit with either manufacturer’s pricing strategy I, II or III.

6. Manufacturer’s Pricing Strategy IV

With manufacturer’s pricing strategy IV, the sequence of events is as follows: the manufacturer acting as the market leader and sets the wholesale price \( w^* \) according to e-tailer’s service level to optimize its own profit and applies it to the retailer, that is, \( w^* = w^*_2 \); then, the retailer and the e-tailer observe \( w^* \) and determine their optimal retail price in accordance with Nash’s equilibrium.

6.1 The mixed channels’ problem

The retailer faces a problem to decide a retail price \( p^*_q \) that maximizes his/her expected profit. The retailer’s profit which is an one-variables function of \( p^*_q \) is

\[
\pi^*_q(p^*_q) = p^*_qD^r(p^*_q, p^*_1) - w^*_qD^e(p^*_q, p^*_1) - c(v)
\]

The first term is sales revenue. The last two terms correspond to the retailer’s purchasing cost and value-added service cost, respectively. Then

\[
\pi^*_q(p^*_q) = (p^*_q - w^*_q)(\alpha - \beta p^*_q + \gamma v) - \frac{\kappa v^2}{2}
\]

(32)

Therefore, the retailer’s decision problem is

\[
\max_{p^*_q} \pi^*_q(p^*_q)
\]

(33)

Similarly, the e-tailer faces a problem of defining the retail price \( p^*_e \) to maximize profit. In this strategy, the e-tailer’s profit which is an one-variables function of \( p^*_e \) is

\[
\pi^*_e(p^*_e) = p^*_eD^r(p^*_e, p^*_1) - w^*_eD^e(p^*_e, p^*_1)
\]

(34)

The first term is sales revenue, and the second term represents the e-tailer’s purchasing cost. Then

\[
\pi^*_e(p^*_e) = (p^*_e - w^*_e)(\alpha - \beta p^*_e + \gamma v)
\]

(35)

Therefore, the e-tailer’s decision problem is

\[
\max_{p^*_e} \pi^*_e(p^*_e)
\]

On the basis of a discussion of the retailer and e-tailer’s optimal retail price, the following proposition is presented:

**Proposition 13.** With manufacturer’s pricing strategy IV, the retailer’s optimal retail price \( p^*_q \) and e-tailer’s optimal retail price \( p^*_e \) satisfy

\[
p^*_q = \frac{\alpha + w^*_q}{2} + \frac{\nu v}{2 + \beta} \quad \text{and} \quad p^*_e = \frac{\alpha + w^*_e}{2} - \frac{\nu v}{2 + \beta}
\]

From Proposition 1, 5, 9 and 13, we can directly gain the following Corollary:

**Corollary 1** \( p^*_q > p^*_e \).

Corollary 1 means that the retailer will always set higher retailer price than the e-tailer with every manufacturer’s pricing strategy. It is very clear that the retailer will provide value-added service and will spent more cost. From the customers’ point of view, it is reasonable to expect that the price on the retail channel is higher because of the added value.

**Remark 1** The retailer’s optimal retail price is always higher than the e-tailer’s optimal retail price.

6.2 The manufacturer’s problem

The manufacturer must decide a wholesale price to maximize his expected profit according to the e-tailer’s service level. The manufacturer’s profit from e-tailer, denoted as \( \pi^m_{\pi^e}(w^*_e) \), is

\[
\pi^m_{\pi^e}(w^*_e) = (w^*_e - m)D^r(p^*_e, p^*_1)
\]

(36)

The first term is the manufacturer’s unit profit from e-tailer, and the second represents the e-tailer’s demand. Then

\[
\pi^m_{\pi^e}(w^*_e) = (w^*_e - m)(\alpha - \beta p^*_e + \gamma v)
\]

(37)

Therefore, the manufacturer’s decision problem is denoted as

\[
\max_{w^*_e} \pi^m_{\pi^e}(w^*_e)
\]

With regard to the manufacturer’s optimal wholesale price, the following proposition is developed:

**Proposition 14** With manufacturer’s pricing strategy IV, the manufacturer’s optimal wholesale price is

\[
w^*_e = \frac{m}{2} + \frac{\alpha}{2(1 - \beta)} - \frac{\nu v}{2(2 + \beta)}
\]

(38)

Because \( w^*_e = w^*_e^* \), the manufacturer’s profit from e-tailer, denoted as \( \pi^m_{\pi^e}(w^*_e^*) \), is

\[
\pi^m_{\pi^e}(w^*_e^*) = (w^*_e^* - m)D^r(p^*_e^*, p^*_1^*) = (w^*_e^* - m)(\alpha - p^*_e^* + \beta p^*_e^* + \gamma v)
\]

(39)

Therefore, the manufacturer’s decision problem is

\[
\max_{w^*_e^*} \pi^m_{\pi^e}(w^*_e^*, w^*_e^*)
\]

On the basis of the discussion of the retailer and e-tailer’s optimal retail price, the following proposition is presented:
strategy II or IV, therefore
strategy IV. This gives the following proposition.
Proposition 15: With manufacturer’s pricing strategy IV, if \( 0 < \beta < \frac{1}{2} \), \( p^*_4 \) increases in \( v \); if \( \frac{1}{2} < \beta < 1 \), \( p^*_4 \) decreases in \( v \); \( p^*_3 \) and \( w^*_3 \) all decrease in \( v \).

Proposition 15 indicates that with the value-added service provided by retailer increased, the e-tailer will set lower retail price and the manufacturer will set lower wholesale price. However, the retailer’s retail price depends on the pricing competition factor between the two channels. That is, if the pricing competition factor between the two channels is lower, the retailer will set higher retail price; if the pricing competition between the two channels is middling, the retailer’s retail price will changeless; if the pricing competition between the two channels is lower, the retailer will set higher retail price.

Below, we will discuss the effect of unit manufacturing cost \( m \) on the manufacturer’s decision on pricing strategy and profit, the retailer and e-tailer’s decision on retail price and their profits, and the entire supply chain’s profit with manufacturer’s pricing strategy IV. This gives the following proposition.

Proposition 16 With manufacturer’s pricing strategy IV, \( p^*_4, p^*_3, \) and \( w^*_3 \) all increase in \( m \); \( \pi^*_3(p^*_4), \pi^*_3(p^*_3), \pi^*_w(w^*_4, w^*_3), \) and \( \pi^*_w \) all decrease in \( m \).

This proposition means that with manufacturer’s pricing strategy IV, an increase in unit manufacturing cost \( m \) will lead to higher retail price and wholesale price and a decrease in the unit sales profit, and as a consequence the retailer and e-tailer will order lesser quantities of product, which will be detrimental to the profit of retailer, e-tailer, manufacturer and the entire supply chain’s profit.

Remark 2 The increase in unit manufacturing cost \( m \) will lead to higher retail price and wholesale price, and hurt all the retailer, e-tailer, manufacturer and the entire supply chain’s profit.

7. Discussion

In this section, we discuss the effects of different manufacturer’s pricing strategies on the retailer, e-tailer and the entire supply chain. In terms of the relationship between the manufacturer’s optimal wholesale prices with different pricing strategies, we have the following proposition.

Proposition 17. \( w^*_4 > w^*_2 > w^*_1 > w^*_2 > w^*_4 \).

From this proposition we know that, the manufacturer’s optimal wholesale price is highest with pricing strategy III, and is lowest with pricing strategy IV.

With regard to the optimal retail price with different pricing strategy, we have the following proposition.

Proposition 18. \( p^*_3 > p^*_2 > p^*_1 > p^*_3, p^*_3 > p^*_4 > p^*_5 > p^*_4 \).

This proposition indicates that the retailer’s and e-tailer’s optimal retail price both is highest with manufacturer’s pricing strategy III and lowest with manufacturer’s pricing strategy IV. The retailer’s optimal retail price with manufacturer’s pricing strategy II is higher than the case with manufacturer’s pricing strategy I, whereas the e-tailer’s optimal retail price with manufacturer’s pricing strategy II is lower than the case with manufacturer’s pricing strategy I.

From proposition 17 and 18, we obtain the following remark.

Remark 3 The manufacturer’s optimal whole price, the retailer’s optimal retail price and the e-tailer’s optimal retail price are all highest with pricing strategy III and are all lowest with pricing strategy IV.

With regard to the manufacturer’s optimal profit, we have the following proposition.

Proposition 19. \( \pi^*_w(w^*_3, w^*_4) > \pi^*_1(w^*_4) > \pi^*_2(w^*_3, w^*_4) = \pi^*_3(w^*_4, w^*_3) = \pi^*_w(w^*_4, w^*_3) \).

This proposition implies that, with pricing strategy II, the manufacturer will gain the highest profit, so the manufacturer should prefer to adopt pricing strategy II.

With regard to the retailers’ optimal profit, we have the following proposition.

Proposition 20. \( \pi^*_3(p^*_4) > \pi^*_1(p^*_1) > \pi^*_2(p^*_2) = \pi^*_3(p^*_3), \pi^*_2(p^*_4) = \pi^*_3(p^*_4) > \pi^*_1(p^*_1) > \pi^*_2(p^*_2) \).

From this proposition, we find that with pricing strategy IV, the retailer will gain a highest profit, so the retailer expects the manufacturer to adopt pricing strategy IV. On the other hand, the e-tailer will gain a highest profit with pricing strategy II or IV, therefore
from the view of the e-tailer, he expects the manufacturer to adopt pricing strategy II or IV.

With regard to the entire supply chain’s profit, we have the following proposition.

Proposition 21. $\pi_1\pi_2 > \pi_3\pi_4 > \pi_5\pi_6 > \pi_7\pi_8$.

This proposition indicates that, with manufacturer’s pricing strategy I, the entire supply chain’s profit is higher than that with manufacturer’s pricing strategy II and III; with manufacturer’s pricing strategy IV, the entire supply chain’s profit is higher than that with manufacturer’s pricing strategy III.

From the previous discussion, we make the following remarks:

Remark 4: With pricing strategy II, the manufacturer will gain a highest profit and he dominates the supply chain, so the manufacturer would adopt pricing strategy II. At the same time, with pricing strategy II, the e-tailer will also gain a highest profit, but the retailer will gain a lowest profit.

8. Conclusion

In this paper, we have investigated manufacturer's pricing strategies in a two-echelon supply chain that comprises one manufacturer and two competing channels: a retailer and an e-tailer. The manufacturer acting as the market leader and sets a wholesale price to two competing channels who face price and service dependent demand. The manufacturer may use one of the four pricing strategies: (1) negotiating with retailer and e-tailer simultaneously according to their service level and setting one wholesale price that applied to both retailer and e-tailer (Strategy I); (2) negotiating with retailer and e-tailer separately according to their service level and setting different wholesale prices to the retailer and e-tailer (Strategy II); (3) negotiating only with retailer and set the wholesale price according to the retailer’s service level, then applies it to the e-tailer (Strategy III); (4) negotiating only with e-tailer and set the wholesale price according to the e-tailer’s service level, then applies it to the retailer (Strategy IV). We built the game theory model and derived retailer, e-tailer’s optimal retail price and their optimal profit and the manufacturer’s optimal wholesale price and optimal profit corresponding to different pricing strategies. In summary, our results are as follows:

1. With pricing strategy II, the manufacturer will gain a highest profit and he acts as the market leader, so he would adopt pricing strategy II. At the same time, with pricing strategy II, the e-tailer will also gain a highest profit, but the retailer will gain a lowest profit.

2. With pricing strategy III, the manufacturer’s optimal whole price, the retailer’s optimal retail price and the e-tailer’s optimal retail price are all higher than other pricing strategies. On the contrary, with pricing strategy IV the manufacturer’s optimal whole price, the retailer’s optimal retail price and the e-tailer’s optimal retail price are all lower than other pricing strategies.

3. From the view of retailer, pricing strategy IV is the best strategy and pricing strategy II or III is the worst strategy. On the other hand, from the view of e-tailer, pricing strategy II or IV is the best strategy and pricing strategy III is the worst strategy.

4. The increase in unit manufacturing cost m will lead to higher retail price and wholesale price, and hurt the retailer, e-tailer, manufacturer and the entire supply chain’s profit.

5. The retailer’s optimal retail price is always higher than the e-tailer’s optimal retail price. It is very clear that the retailer will provide value-added service and will spent more cost. And this is reasonable from the customer’s view to expect that the price on the retail channel is higher because of the added value.

Similar to any other model previously published in the literature, the present model is based on a set of assumptions, for example, our model assumed competition between two channels and one manufacturer. For simplicity, the demand is deterministic price and service level dependent demand. An interesting extension of this study is to include stochastic demand in the model. Incorporating competition between manufacturers might be another interesting extension and might require a new set of models.

References


