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Distribution Channel Management in the Internet Age: Equilibrium and Social Welfare

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Abstract

Using a spatial competition model, this paper considers the conditions under which a monopoly manufacturer will introduce an e-channel, and its effect on consumer surplus and social welfare. We find that the e-channel will be introduced only if the transportation cost is high and the delivery cost is low. Second, if only some of the consumers buy the good from the retail outlets and the delivery cost is certainly high, the introduction will not decrease any consumer's surplus and the Pareto efficiency can be realized. Third, the social welfare will be improved when the delivery cost is low.

JEL: L11, L22

Keywords: Internet distribution channel, delivery cost, distribution channel management

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1. INTRODUCTION

The rapid development of information technology has let to widespread use of the internet. Consequently, the number of online transactions (also referred to as electronic commerce or e-commerce) has increased significantly since the mid-1990s. According to “An Investigation of Current Status and Market Size of Electronic Commerce (EC) during the fiscal year H18” conducted by the Ministry of Economy, Trade and Industry, the Japanese e-commerce market was worth 152 trillion yen in 2006. Furthermore, the share of consumer segment of e-commerce (BtoC) in total retail sales was 2.03% in Japan and 4.37% in the U.S.

There are two types of retailers in the consumer goods e-commerce market; pure e-retailers who only sell the goods online and retailers who sell the goods both online and offline. In recent years, the number of retailers who sell goods both online and offline has increased dramatically[1]. In this paper, we use the term “e-retailer” to refer to both regardless of whether or not they own a real outlet. Moreover, we try to clarify how a manufacturer should construct his distribution channel in a setting where conventional outlet retailer (i.e., retailers who do not sell the goods online) and e-retailer coexist and the impact the manufacturer’s behavior exert on consumer surplus and social welfare.

Preceding model analyses on the competition between e-retailers and conventional outlet retailers include Balasubramanian (1998), Cheng and Nault (2007) etc[2]. Chiang, Chhajed, and Hess (2003), Kumar and Ranran (2006), and Nakayama (2007) discuss over distribution channel management from the viewpoint of a manufacturer. Chiang et al. (2003) and Kumar and Ranran (2006) largely concentrate on the factors necessary for the introduction of an e-channel, but ignore the impact of such introduction on social welfare. Nakayama (2007) addresses the possibility that the introduction of an e-channel would worsen welfare by assuming that the manufacturer's wholesale price for the outlet retailer remains constant before and after the introduction. Since this case does not appear enough, we drop the above assumption and try to reconsider the necessary conditions for the introduction of an e-channel along with the welfare effects of such introduction.

We find that, first, the manufacturer will introduce an e-channel only if the consumer's transportation cost is high and e-retailer's delivery cost is low. Second, if all the consumers buy the good from the retail outlets, the introduction of an e-channel will decrease the consumer surplus. On the other hand, if only some of the consumers buy the good from the retail outlets and the delivery cost is certainly high, the introduction will not decrease any consumer's surplus. Third, the introduction of an e-channel will lead to improvements in social welfare only when the delivery cost is low. Finally, the introduction of an e-channel can be Pareto efficient even if the delivery cost is certainly high.

The remainder of this paper is organized as follows. In the next section, we present the model and analyze the situation where only outlet retailers exist. In section C, we elaborate the necessary conditions for the introduction of an e-channel by the manufacturer when the e-channel is available. In section D, we explain the effects of the introduction on consumer surplus and social welfare. A brief summary and the experimental implication are presented in section E.

2. MODEL

Consider a linear city model of length 1 where the consumers are uniformly distributed with unit density. In this city, a single manufacturer produces a good with zero marginal cost and sells it through two outlet retailers denoted by i (i = 0, 1) that are located at points 0 and 1, respectively. The increasing popularity of the Internet enables the manufacturer to sell the goods directly to the consumers over the Internet. However, a constant delivery cost T is applicable for each unit sold[3].

The surplus of a consumer whose location is given by $x \in [0, 1]$ when buying one unit of the good from either outlet retailer i or the e-retailer is as follows:

(1-1) $$v_0 = u - p_0 - t\,x,$$

(1-2) $$v_1 = u - p_1 - t\,(1 - x), \text{ and}$$

(1-3) $$v_e = u - p_e,$$

where v_i (v_e) denotes the surplus from retailer i (e-retailer); u is the reservation price which is assumed to be identical for all consumers for the purpose of simplicity; p_i is retailer i's retail price, and p_e is the e-retailer's retail price that is inclusive of T; and $t/2$ is the constant transportation cost per unit distance. If a consumer does not make any purchase, his surplus is assumed to be zero. Assume that if and only if $\max\{v_0, v_1, v_e\} \geqq 0$ holds, the consumer will buy at most one unit of the good from the retailer who offers the highest consumer surplus.

Consider a two-stage game. In the first stage, the manufacturer decides whether or not to sell products on line and sets the wholesale price. In the second stage, taking the manufacturer's decisions for given, each retailer sets his own price simultaneously. In this section, we analyze the situation where only conventional outlet retailers exist; the situation wherein both conventional retailers and e-retailers coexist will be discussed in the next section.

First, let us start our analysis with the consumer's selection problem when only two conventional retailers exist in the market. From (1), if we denote that

$$v_0 = 0 \rightarrow x_0 \equiv \frac{u - p_0}{t},$$
$$v_1 = 0 \rightarrow x_1 \equiv \frac{t + p_1 - u}{t},$$
$$v_0 = v_1 > 0 \rightarrow x^* \equiv \frac{p_1 - p_0 + t}{2t}.$$

Then, the consumer's decision problem is represented as follows:

if $x \leqq \min\{x_0, x^*\} \equiv \hat{x}_0$, purchase from retailer 0;

if $x \geqq \max\{x_1, x^*\} \equiv \hat{x}_1$, purchase from retailer 1;

if $x_0 < x < x_1$, do not make any purchase.

In this situation, for any given p_1, retailer 0's demand function is given by[4]

$$(2) \qquad q_0 = \hat{x}_0 = \begin{cases} 0 & \text{if} \quad u < p_0, \\ \dfrac{u - p_0}{t} & \text{if} \quad 2u - p_1 - t \leq p_0 \leq u, \\ \dfrac{p_1 - p_0 + t}{2t} & \text{if} \quad p_1 - t \leq p_0 < 2u - p_1 - t, \\ 1 & \text{if} \quad p_0 < p_1 - t. \end{cases}$$

Therefore, the inverse demand function is as follows:

$$p_0 = \begin{cases} u - tq_0 & if \quad 0 < q_0 \le \dfrac{t + p_1 - u}{t}, \\ p_1 + t - 2tq_0 & if \quad \dfrac{t + p_1 - u}{t} < q_0 \le 1. \end{cases}$$

The inverse demand curve refracts at point P^k ($q_0^k = (t + p_1 - u)/t$, $p_0^k = 2u - p_1 - t$). Therefore the marginal revenue function is derived as

$$MR^+ = u - 2tq_0 \qquad if \quad 0 < q_0 \le \frac{t + p_1 - u}{t},$$
$$MR^- = p_1 + t - 4tq_0 \qquad if \quad \frac{t + p_1 - u}{t} < q_0 \le 1.$$

It is discontinuous at q_0^k. By substituting the value of q_0^k in the above formulas, we can obtain the two ends of discontinuity as follows:

$$mr^+ = u - 2(t + p_1 - u) = 3u - 2t - 2p_1$$

$$mr^- = p_1 + t - 4(t + p_1 - u) = 4u - 3t - 3p_1.$$

Retailer 0's inverse demand and marginal revenue curve are illustrated in FIGURE 1[5].

(insert FIGURE 1 here)

Conventional Retailer's Decision Problem

Given p_1, retailer 0 determines his profit maximization price p_0. If the wholesale price w is higher than mr^+, we obtain retailer 0's decision problem using the demand function (2):

$$\text{Max } y_0 = (p_0 - w)q_0 = \frac{(p_0 - w)(u - p_0)}{t}, \quad \text{w.r.t. } p_0 \text{ for given } w.$$

From the maximization condition $dy_0/dp_0 = 0$, the retail price is derived as

(3-1) $$p_0 = \frac{u+w}{2}.$$

We calculate retailer 1's price p_1 in the same way (see TABLE 1).

(insert TABLE 1 here)

In this case, the market area of the two retailers separate with each other and some consumers are unable to make any purchase from either of the two retailers. We define this situation as the "separation equilibrium" (as in FIGURE 2), which is realized if

(3-2) $$mr^{+} = 3u - 2t - (u + w) < w \rightarrow u - t < w,$$

when the retail price is $p^{S}=(u+w)/2$. S indicates the situation that the separation equilibrium has been realized.

(insert FIGURE 2 here)

Next, if $mr^{-} \leqq w \leqq mr^{+}$ and the "kinked equilibrium" (see FIGURE 2) is realized, retail price (and sales) is set equal to p_0^{k} $(=2u-p_1-t)$. Since numerous solutions exist for any given p_1, we suppose a symmetrical equilibrium ($p_0 = p_1$) for simplicity[6]. Hence, the retail price is $p^{K}=u-t/2$ (K indicates the situation that the kinked equilibrium has been realized). Note that in this equilibrium, every consumer purchases if

(4) $$mr^{-} \leqq w \leqq mr^{+} \rightarrow 4u - 3t - 3p_1 \leqq w \leqq 3u - 2t - 2p_1 \rightarrow u - \frac{3t}{2} \le w \le u - t.$$

Finally, if $w < mr^{-}$ and the "competitive equilibrium" (see FIGURE 2) is realized, retailer 0's profit maximization problem is given as

$$\text{Max } y_0 = (p_0 - w)q_0 = \frac{(p_0 - w)(p_1 - p_0 + t)}{2t} \quad \text{w.r.t. } p_0 \text{ for given } p_1 \text{ and } w.$$

Since $dy_0/dp_0 = 0$, retailer 0's best-response function is derived as

$$p_0(p_1) = \frac{w + t + p_1}{2}.$$

Retailer 1's best-response function is obtained as $p_1(p_0)=(w+t+p_0)/2$ such that the retail price is $p^C=w+t$ (C indicates the situation that the competitive equilibrium has been realized). Every consumer also makes a purchase in this equilibrium if

$$(5) \qquad w < mr^{-} \rightarrow 4u - 3t - 3(w + t) < w \rightarrow w < u - \frac{3t}{2}$$

Manufacturer's Decision Problem

Taking retailers' action as given, the manufacturer sets his profit- maximization wholesale price w in the first stage. Since the two retailers are symmetrical, we omit the subscript i in this section so as to avoid any misunderstanding.

First, when the separation equilibrium is realized if $u–t<w$, the manufacturer's decision problem is derived from the 2nd row of TABLE 1 as follows:

$$\text{Max } \pi^S = 2wq = \frac{w(u - w)}{t} \quad \text{w.r.t. } w \quad \text{s.t. } u - t \le w \le u.$$

Since $d\pi^S/dw = (u - 2w)/t = 0$, the wholesale price is set as $w^S = u/2$. The equilibrium is satisfied if

$$(6) \qquad u - t < w^S = \frac{u}{2} \rightarrow u < 2t.$$

Further, the sales for each retailer are calculated as $q^S = u/(4t) < 1/2$. All possible solutions for this situation are listed in TABLE 2 for reference.

(insert TABLE 2 here)

Second, when the kinked equilibrium is realized if $u–3t/2 \leqq w \leqq u–t$, the manufacture's decision problem is derived from the 3rd row of TABLE 1 as follows:

$$\text{Max } \pi^K = 2wq^K = w \quad \text{w.r.t. } w \quad \text{s.t. } u - \frac{3t}{2} \le w \le u - t.$$

Since $d\pi^K/dw = 1 > 0$, the wholesale price is set as $w^K = u–t$ (the upper bound of the domain $[u - 3t/2, u - t]$).

Finally, when the competitive equilibrium is realized if $w < u–3t/2$, the manufacture's decision problem is derived from the 4th row of TABLE 1 as follows:

$$\text{Max } \pi^C = 2wq^C = w \quad \text{w.r.t. } w \quad \text{s.t. } 0 \le w \le u - \frac{3t}{2}.$$

Since $d\pi^C/dw = 1 > 0$, the wholesale price is set as $u–3t/2$. However, since $w < u–3\, t/2$, the optimal w^C does not exist in this equilibrium[7].

On comparing the manufacturer's profits under the separation and kinked equilibrium when $u<2t$, we get

$$\pi^S - \pi^K = \frac{u^2}{4t} - (u - t) = \frac{(2t - u)^2}{4t} > 0.$$

Consequently, the separation equilibrium is chosen. If $u > 2t$ and the separation equilibrium is not realized, the kinked (and not the competitive) equilibrium is chosen. We thus deduce our first proposition as follows.

Proposition 1: If $u < 2t$, the manufacturer sets the wholesale price as $w^S = u/2$ and the separation equilibrium is realized. If $u > 2t$, the wholesale price is set as $w^K = u–t$ and the kinked equilibrium (and not the competitive) equilibrium is realized.

The intuition behind this proposition is as follows. In this case, note that the manufacturer's payoff is calculated by multiplying the wholesale price and the retail sales volume. When the consumer's transportation cost is high, it is more profitable for the manufacturer to set a high wholesale price, as this will lead to a higher retail price and will induce the two retailers to sell the good to only some of the consumers. On the other hand, when the transportation cost is sufficiently low, it is profitable to sell the good to all consumers. This is so because in this case, the manufacturer's payoff is higher and increases with wholesale price. Therefore, the wholesale price is set at the upper bound of the range $[u–3t/2, u–t]$. However, any wholesale price below $u–3t/2$ will never be chosen because then, the reduction in retail price caused by the competition between the retailers will not lead to any expansion in retail sales. In other words, retail sales will remain constant (=1) in both kinked and competitive equilibrium. Therefore, in this model, the manufacturer will never choose a competitive equilibrium.

3. INTRODUCTION OF AN E-CHANNEL

In this section, we consider the manufacturer's channel management problem when both conventional and e-retailers coexist. Since the delivery cost is included in the e-retail price, $p_e > T$, and therefore, if $u < T$, no consumer would buy the good from the e-retailers because $p_e > u$. Therefore, we assume that

(7) $$T < u.$$

Additionally, for simplicity, we suppose that the number of e-retailers in the market is more than one[8]. Therefore, as a result of Bertrand competition among the e-retailers, the e-retail price is set by[9]

(8) $$p_e = w_e + T.$$

For $p_e \leqq u$ to hold,

(9) $$w_e \leqq u - T$$

From the consumer's utility function given in (1), we denote x_1^e by

$$v_1 = v_e \rightarrow x_1^e \equiv \frac{t + p_1 - p_e}{t}.$$

If $p_e \geqq p_1 + t$, then $v_1 \geqq v_e$. In this case, no consumer would purchase the good from e-retailers; hence, we assume that $p_e < p_1 + t$ (as in FIGURE 3) so as to ensure that $x_1^e > 0$.

(insert FIGURE 3 here)

Conventional Retailer's Decision Problem

Taking p_1 and p_e as given, the retailer 0's demand function can be written as

(10) $$q_0 = \hat{x}_0 = \begin{cases} 0 & if \quad p_e < p_0, \\ \dfrac{p_e - p_0}{t} & if \quad 2p_e - p_1 - t < p_0 \leq p_e, \\ \dfrac{p_1 - p_0 + t}{2t} & if \quad p_1 - t < p_0 \leq 2p_e - p_1 - t, \\ 1 & if \quad p_0 \leq p_1 - t. \end{cases}$$

Further, retailer 0's inverse demand function is

$$p_0 = \begin{cases} p_e - tq_0 & \text{if} \quad 0 < q_0 \le \dfrac{t + p_1 - p_e}{t} \\ p_1 + t - 2tq_0 & \text{if} \quad \dfrac{t + p_1 - p_e}{t} < q_0 < 1 \end{cases}$$

which kicks at ($q_0^{ke} = (t+p_1-p_e)/t$, $p_0^{ke} = 2p_e - p_1 - t$). The marginal revenue function is derived as

$$\begin{aligned} MR^+ &= p_e - 2tq_0 && \text{if} \quad 0 < q_0 \le \frac{t + p_1 - p_e}{t} \\ MR^- &= p_1 + t - 4tq_0 && \text{if} \quad \frac{t + p_1 - p_e}{t} < q_0 < 1, \end{aligned}$$

which is discontinuous at q_0^{ke}. By substituting the value of q_0^{ke} in the above formulas, we can obtain the two ends of discontinuity as follows:

$$mr^+ = p_e - 2(t + p_1 - p_e) = 3p_e - 2t - 2p_1$$

$$mr^- = p_1 + t - 4(t + p_1 - p_e) = 4p_e - 3t - 3p_1.$$

To ensure that e-retailers' sales are positive, we assume that $w > mr^+$[10]. Retailer 0 sets his profit maximization price p_0 as per the demand function given in (10). Therefore, the decision problem is

$$\text{Max} \;\; y_0 = (p_0 - w)q_0 = \frac{(p_0 - w)(p_e - p_0)}{t} \quad \text{w.r.t. } p_0 \;\; \text{for given } w \text{ and } p_e.$$

Since $dy_0/dp_0 = 0$, the retail price response function is calculated as

(11-1) $$p_0(p_e) = \frac{p_e + w}{2}.$$

The proper retail sales and payoff functions are as follows:

(11-2) $$q_0(p_e) = \frac{p_e - w}{2t}$$

(11-3) $$y_0(p_e) = \frac{(p_e - w)^2}{4t}.$$

We can also derive the response functions for retailer 1 in the same format if

(11-4) $$mr^+ = 2p_e - w - 2t < w \;\rightarrow\; p_e - t < w.$$

If not, e-retailers will make no sales.

Manufacturer's Decision Problem

In the first stage, the manufacturer sets the wholesale prices for conventional outlet retailers and e-retailers to maximize his profit. From (8), (9) and (11), we get the decision problem as follows:

(12) $$\begin{aligned} &\text{Max } \pi^N = w(q_0 + q_1) + w_e(1 - q_0 - q_1) = w_e + \frac{(w_e - w)(w_e + T - w)}{2t} \\ &\text{w.r.t. } w \text{ and } w_e \\ &\text{s.t. } \quad w_e \le u - T \quad \text{and} \quad w_e + T - t < w. \end{aligned}$$

N indicates the situation that the e-channel is introduced. Here, it must be noted that a transaction may occur between conventional retailers and e-retailers when $w_e \neq w$ [11]. To avoid such arbitration, the manufacturer must set a uniform wholesale price for all the retailers. By assuming $w = w_e$ and substituting the same in the second constraint of (12), we get the constraint $T < t$ that contains no variable. Therefore, the manufacturer's decision problem can be rewritten as

$$\text{Max} \quad \pi^N = w_e \qquad \text{w.r.t. } w_e \qquad \text{s.t.} \qquad w_e \leqq u - T.$$

Since $d\pi^N / dw_e = 1 > 0$, the wholesale prices are set as follows (see TABLE 2):

(13) $$w_e^N = w^N = u - T.$$

By comparing π^N with π^K when the kinked equilibrium is realized, we get $\pi^N -$

$\pi^K = u–T–(u–t) = t–T$. Therefore, the manufacturer will introduce the e-channel if $T < t$, and will not if $T > t$. Similarly, when the separation equilibrium is realized ($\pi^N – \pi^S = u–T–u^2/(4t)$), the manufacturer introduces the e-channel if $u – u^2/(4t) > T$.

Proposition 2: When the kinked equilibrium is realized in the second stage, the manufacturer introduces an e-channel if $T<u$ and $T<t$. When the separation equilibrium is realized, the manufacturer will introduce an e-channel even if the delivery cost is certainly high ($t < T < u–u^2/(4t)$).

Note that when the kinked equilibrium is realized, since the volume of sales will remain constant before and after the introduction, the decision problem (whether or not to introduce) depends only on the wholesale price level. When $T<t$, the wholesale price after the introduction is higher ($w^N=u–T>u–t=w^K$), and it is profitable to introduce the e-channel. However when the separation equilibrium is realized, the introduction of the e-channel will enable the consumers who were not making any purchase before to buy the good from the e-retailers; this has a positive effect on the expanding of retail sales. Therefore, even if the wholesale price w^N is lower than w^S when T is certainly high ($w^N=u–T<u/2=w^S$, *if* $2T>u$), it is still profitable for the manufacturer to introduce an e-channel.

In fact, according to an investigation conducted by the Ministry of Economy, Trade and Industry in 2007, the electronic commerce (EC) rate (i.e., the share of online transactions in the total number of transactions) of hotel registration and ticket sales in Japan was 2.18% (market size about 508 billion yen) in 2006. This can be attributed to the effect of a low delivery cost T that arises from a relatively low uncertainty in the quality of the concerned commodities (hotel services and tickets).

4. ECONOMIC WELFARE

In this section, we analyze the impact of the introduction of an e-channel on consumer surplus and social welfare.

Impact on Consumer Surplus

We define the consumer surplus CS as

$$CS = (u - p_e)q_e + 2\int_0^Z (u - p - tz)dz,$$

where z denotes the distance between a consumer and a conventional retail outlet, and Z denotes the size of the market area of each outlet. The first term of the above formula is the aggregated consumer surplus when the consumers buy the good from e-retailers; the second term is the consumer surplus when they buy from conventional retailers.

By comparing the consumer surplus before and after the introduction, we get

$$CS^N - CS^K = \frac{(T^2 - t^2)}{4t} < 0.$$

Consumer surplus decreases after the introduction when $T < t$, and

$$CS^N - CS^S = \frac{T^2}{4t} - \frac{u^2}{16t} = \frac{(2T - u)(2T + u)}{16t}.$$

Consumer surplus increases only if T is certainly high ($2T > u$).

Proposition 3: When the kinked equilibrium is realized, the introduction of an e-channel decreases the consumer surplus. On the other hand, the consumer surplus will not decrease if the separation equilibrium has been realized in the second stage and the delivery cost is certainly high ($2T > u$).

The first half of the above proposition is easy to understand if we note that after the introduction of the e-channel, (1) there is a zero surplus for consumers who buy the good from e-retailers and (2) there is an increase in the conventional retailer's price. In fact, when the kinked equilibrium is realized, the constraint $T < t$ leads to the following being held:

$$p^K = u - \frac{t}{2} < u - \frac{T}{2} = p^N.$$

The increase in the conventional retailer's price reduces his market area and the consumer surplus.

The second half of the proposition claims that when the efficiency of the e-channel is low in terms of delivery cost (i.e., the delivery cost is high), the introduction of an e-channel by a monopoly manufacturer increases consumer surplus. This seemingly paradoxical claim can be explained as follows. First, when the separation equilibrium is realized in the second stage before the e-channel is introduced, the conventional retailer's price is set high to compensate for the double margin issue. After the introduction, the wholesale price for e-retailers is set as $w_e^N = u - T$, which decreases as T increases. Under the arbitration prevention condition of $w_e^N = w^N$, when T is high enough, the wholesale price for conventional retailers w^N must to be set equal to the wholesale price for e-retailers w_e^N, which leads to a lower outlet retail price. When $2T > u$, we have

$$p^S = \frac{3u}{4} > u - \frac{T}{2} = p^N.$$

The decrease in the conventional retailer's price expands the market area of each outlet from $u/(4t)$ to $T/(2t)$. For the consumers who continue making purchases from conventional retailers even after the introduction, the surplus increases as the conventional retailer's price decreases. The expansion of the conventional retailer's market area provides the consumers who make fresh purchases from conventional retailers with a positive surplus. Additionally, a zero surplus from e-retailers does not translate into any decrease in consumer surplus as before the introduction of an e-channel, e-retailers did not exist and made no sales. Therefore, we can say that though the e-channel is less efficient in terms of a high delivery cost, the introduction does not decrease any consumer's surplus. Because the delivery cost T is high, the conventional retailer's price remains low and his market area increases. Conversely, when the delivery cost is low, a high conventional retailer's price decreases consumer surplus.

Impact on Social Welfare

Social welfare (gross surplus) is defined as the sum of the manufacturer's and retailer's profits and consumer surplus. Since the wholesale and retail price levels do not affect the gross surplus, we define social welfare as

$$TS = u(q_0 + q_1 + q_e) - Tq_e - 2\int_0^Z tzdz$$

The first term is the consumer's consumption utility; the second, delivery cost; and the third, transportation cost.

By comparing social welfare when the kinked equilibrium is realized, we get

$$TS^N - TS^K = u - T + \frac{3T^2}{4t} - (u - \frac{t}{4}) = \frac{(3T-t)(T-t)}{4t}.$$

Since $T < t$, we get

$$TS^N \gtreqless TS^K, \quad if \quad T \lesseqgtr t/3.$$

If the delivery cost T is relatively lower than the transportation cost t, the introduction of an e-channel will improve social welfare.

Next, supposing the separation equilibrium is realized, we get

$$TS^N - TS^S = u - T + \frac{3T^2}{4t} - \frac{7u^2}{16t} = u - T - \frac{u^2}{4t} + \frac{3(2T-u)(2T+u)}{16t}.$$

Since $u–T–u^2/(4t) > 0$, we conclude that even when the delivery cost is certainly high ($T > u/2$), the introduction of the e-channel improves social welfare.

Proposition 4: When the kinked equilibrium is realized, social welfare is improved with the introduction of an e-channel only if the transportation cost is high and delivery cost is low ($T < t/3$). However, when the separation equilibrium is realized, the introduction will improve social welfare even when the delivery cost is certainly high ($2T > u$).

The first half of the above proposition makes a valid claim that social welfare will improve if the e-channel is introduced when its efficiency is higher than that of the conventional distribution system. However, the second half states a more interesting fact that even when the efficiency of the e-channel is certainly low, the introduction of an e-channel will still improve social welfare.

The intuition can be explained as follows. When the separation equilibrium is realized, there are two ways in which the introduction can affect welfare. One is increased retail sales—consumers who before the introduction would not make any purchase, buying the good from e-retailers. This has a positive effect on social welfare. A high transportation cost t (which indicates that the number of consumers who made no purchase is large) and low delivery cost T (which implies that the surplus of thee consumers who buy the good from e-retailers, given by $u–T$, is high) make the effect on social welfare more pronounced. The other way in which the introduction of an e-channel affects social welfare is the change in the size of the conventional retailer's market area. After the introduction, if the conventional retailer's price is high ($2T < u$), the market area of the conventional retailer reduces from $u/(4t)$ to $T/(2t)$; this results in waste in terms of transportation/delivery cost. In other words, some consumers will shift from conventional retailers to e-retailers, and will, thus, have to bear a higher delivery cost T (as compare to the transportation cost ($T/2$) they had to bear before the introduction of the e-channel). This has a negative effect on social welfare. However, when T is sufficiently high ($2T > u$), the conventional retailer's market area expands from $u/(4t)$ to $T/(2t)$. Further, in this case, the consumers who buy from e-retailers would not make purchases before the introduction of the e-channel. This eliminates waste and increases social welfare.

Herein, the underlying logic can also be explained in the following way. First, we define $a \equiv T/t$ and $b \equiv u/(2t)$ (as in FIGURE 4),where $0 < a$, $b < 1$ (this is as supposed in this model). From the above definition, we get $T = at$ and $u = 2bt$. Then the effect of the introduction on social welfare when the separation equilibrium is realized can be expressed as

$$TS^N - TS^S = 2bt - at + \frac{3(at)^2}{4t} - \frac{28(bt)^2}{16t} = 4t(8b - 4a + 3a^2 - 7b^2).$$

Further, for $t > 0$, if we denote $g\ (a, b) \equiv 8b–4a+3a^2–7b^2$, $TS^N \lessgtr TS^S$ *iff* $g(a, b) \lessgtr 0$. The function $g\ (a, b)$ is convex on a and concave on b and holds an saddle point at (2/3, 4/7).

From the introduction condition of $u–u^2/(4t)–T > 0$, we get

$$h(a, b) \equiv 2b - b^2 - a > 0 \ \Rightarrow \ 1 - (1 - a)^{1/2} < b < 1 + (1 - a)^{1/2}.$$

Here, since $1+(1–a)^{1/2} > 1$, the parameter range within which the manufacturer can introduce an e-channel when the separation equilibrium is realized is $D = \{1–(1–a)^{1/2}, 0 < a < 1, 0 < b < 1\}$. The loci that lie within D and satisfy $g\ (a, b)$ are derived as

$$b = \frac{4 \pm \sqrt{16 - 28a + 21a^2}}{7}.$$

However, since

$$1 - \sqrt{1 - a} > \frac{4 - \sqrt{16 - 28a + 21a^2}}{7},$$

$b = [4–(16–28a+21a^2)^{1/2}]/7$ does not lie within D. Therefore,

$$TS^N \lessgtr TS^S \quad if \quad b \gtrless \frac{4 + \sqrt{16 - 28a + 21a^2}}{7}$$

holds within D.

(insert FIGURE 4 here)

As discussed above, by keeping the other parameters constant, we can observe that when the delivery cost T is sufficiently low, social welfare increases with the introduction of an e-channel because the positive effect of the growth in retail sales surpasses the waste encountered in terms of transportation/delivery cost. When T is moderately high, both the positive and negative effects are diminished. However, if T very high, the negative effect is eliminated while the positive effect is only further diminished; this, therefore, does lead to improvements in social welfare.

Finally, from Proposition 3 we have that the consumer surplus does not decrease after the introduction of the e-channel if $2T>u$. By comparing the profits of conventional retailers at this time, we get

$$y^S = \frac{u^2}{16t} < \frac{T^2}{4t} = y^N .$$

This shows that the conventional retailer's profit increases with the introduction of an e-channel. At the same time, although the e-retailer's profit is zero, technically, there has been no decrease in the profit after the introduction because before the introduction, the e-retailers did not exist (i.e., profit is zero). Furthermore, a monopoly manufacturer will never introduce an e-channel if it is not profitable. Therefore, when $2T > u$, the introduction of an e-channel is Pareto efficient. If $2T > u$ is expressed by $a > b$, Pareto efficiency can shown in Figure 4.

Proposition 5: When the separation equilibrium is realized, the introduction of the e-channel is Pareto efficient if $2T > u$.

5. CONCLUSION

This paper considers the conditions under which an e-channel can be introduced and the impact of the introduction on consumer surplus and social welfare from the viewpoint of a manufacturer. From Proposition 1, we know that when only conventional retailers exist and the consumer's transportation cost is high (low), the manufacturer will set his wholesale price such that the separation equilibrium (kinked equilibrium) will be realized at the retailing stage. If the separation equilibrium is realized, some consumers are unable to make any purchase. Further, as show in Proposition 2, the increasing popularity of the Internet implies that the manufacturer will introduce an e-channel only if consumer's transportation cost is high and e-retailer's delivery cost is low. This is obvious given that in this case, the e-channel will be much more efficient than the market where only conventional retailers exist.

Proposition 2 provides a good explanation as to why Japan's EC rate is much lower than that of the U.S. Although the U.S. is 20 times larger than Japan in terms of land area, the number of conventional retail outlets per unit area in Japan is remarkably higher. Consequently, in Japan, the distance between outlets is shorter and the constant transportation cost t per unit distance (between the outlets) is lower as compared to the delivery cost T. As a result, a significantly higher percentage of consumers continue buying from conventional retailers. In this situation, future estimates of increases in online sales are lower and also the incentive for a manufacturer to introduce an e-channel is smaller.

When the kinked equilibrium is realize, the introduction of an e-channel decreases the consumer surplus as follows. First, the e-retail price is set equally to the reservation price and consequently, the surplus of consumers who make purchase from e-retailers is zero. Further, the rise in e-retail price leads to a sharp increase in the outlet retail price. Therefore, the surplus of consumers buying the good from the conventional retail outlets decreases after the introduction. However, this conclusion strongly depends on the supposition that there is a monopoly manufacturer. Consumer welfare can be improved by decreasing the e-retail price if many manufacturers exist in the market. On the other hand, when the separation equilibrium is realized, consumer surplus increases even when the delivery cost is certainly high. Because the wholesale price for e-retailers w_e^N $(=u-T)$ decreases as T increases, under the arbitration prevention condition of $w_e^N = w^N$, when T is high, the manufacturer has to set the wholesale price for the conventional retailers as the same low as w_e^N. Resultantly, this lower outlet retail price increases the consumer surplus. As presented in Proposition 3, this lead to an interesting conclusion in that none of any consumer's surpluses decreases even when a less efficient e-channel is introduced by the monopoly manufacturer for profit maximization. However, the manufacturer will not introduce an e-channel if it is not profitable; this implies that the manufacturer and consumers share a mutual interest in this case.

The first half of Proposition 4 is very obvious given that the introduction of an e-channel will improve social welfare if it is more efficient than the existing market system where only conventional retailers exist. However, when the separation equilibrium is realized and delivery cost is certainly high, the introduction leads to consumers, who before its introduction would not make any purchase, buying the good from e-retailers. Profits from these new sales cover the losses incurred because of the transportation/delivery cost and social welfare is improved. Finally, because the outlet retailers' profits also increase, as stated by Proposition 5, even when the efficiency of the e-channel is certainly low, the introduction of an e-channel by a monopoly manufacturer is still Pareto efficient.

In this paper, we suggest a benchmark model to analyze the conditions under which an e-channel can be introduced along with the impact of its introduction on consumer surplus and social welfare. With regarded to the future research direction, first, we would like to study the outcomes of allowing the conventional retailers to relocate their outlets after the introduction. Second, we would like to study a market where there is competition between two or more manufacturers. Finally, we intend to study the effects of allowing the conventional outlet retailers to sell online as well.

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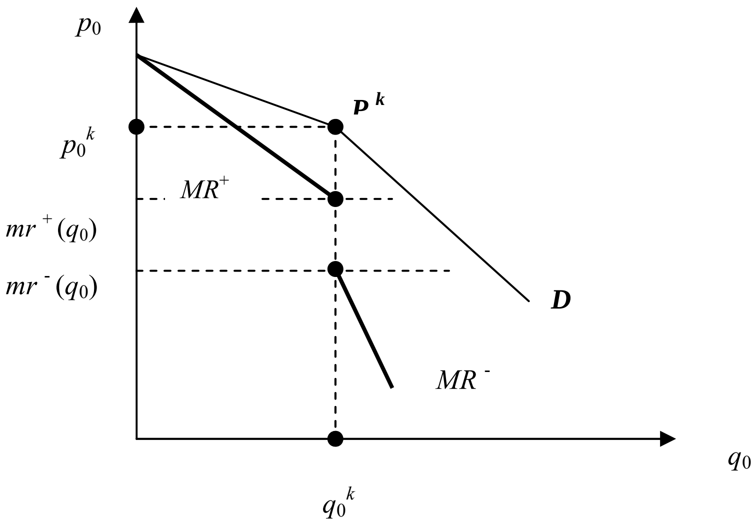


Figure 1   The Inverse Demand Curve of Outlet Retailer 0

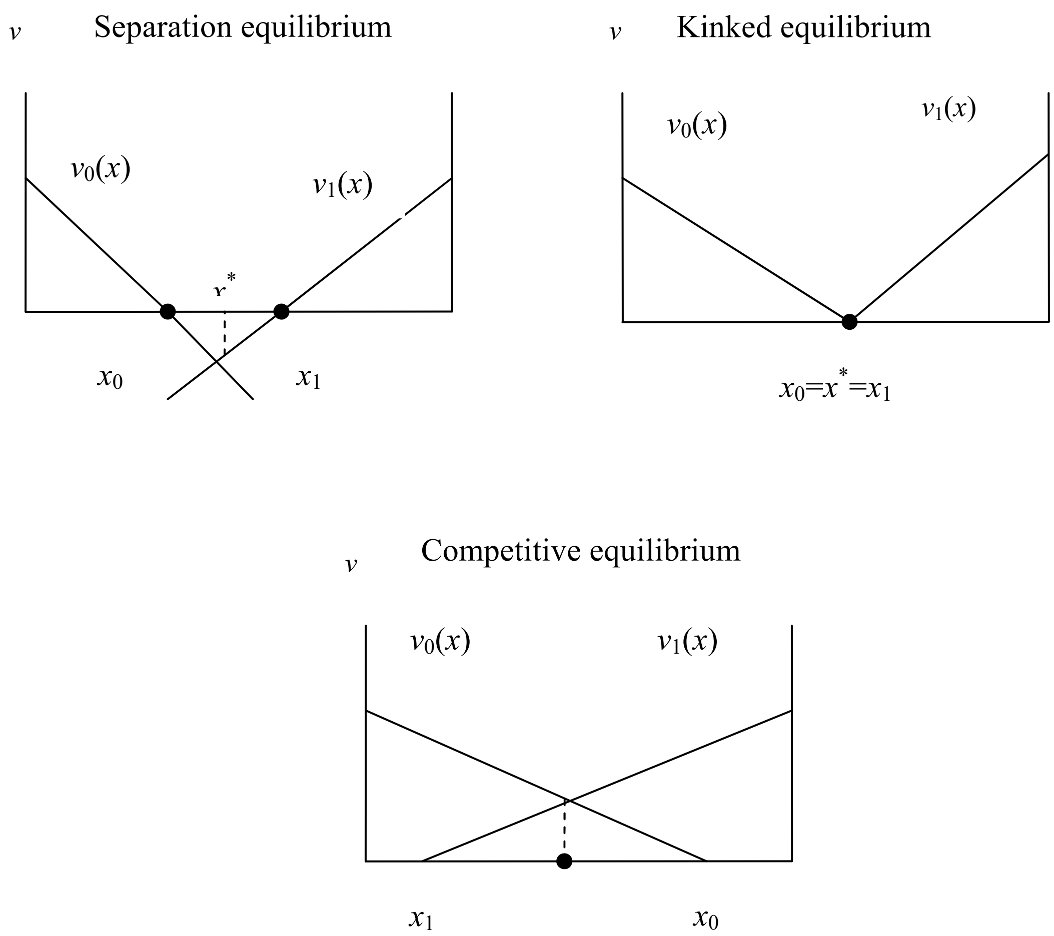
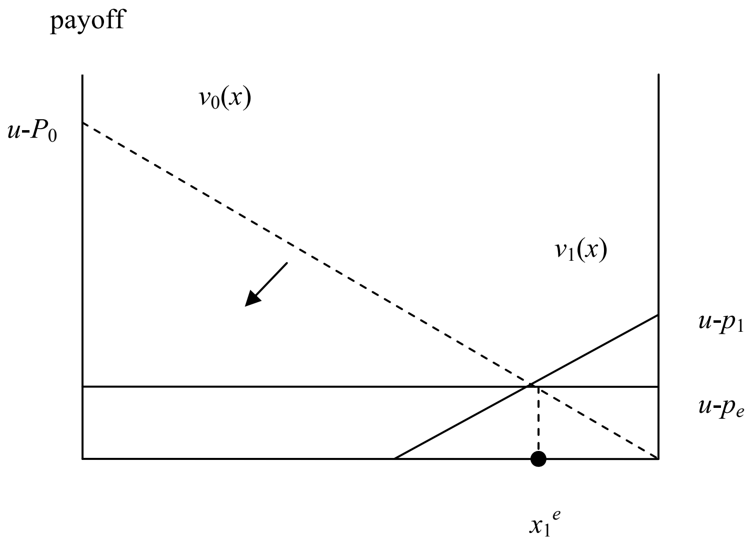


Figure 2　3 types of equilibrium

	Separation	Kinked	Competitive
p	$(u+w)/2$	$u-t/2$	$w+t$
q	$(u-w)/(2t)$	$1/2$	$1/2$
y	$(u-w)^2/(4t)$	$(2u-t-2w)/4$	$t/2$
condition	$u-t < w$	$u-3t/2 \leqq w \leqq u-t$	$w < u-3t/2$

Table 1 Solutions for the 2nd Stage



If the outlet 0 set his retail price lower than P_0, then e-retailer's sales would be zero.

Figure 3 The market segment when the e-channel is available

	Before the introduction		After the introduction
	Separation(S)	Kinked(K)	
w	$u/2$	u-t	u-T
w_e	---	---	u-T
p	$3u/4$	u-$t/2$	u-$T/2$
p_e	---	---	u
q	$u/(4t)$	1/2	$T/(2t)$
q_e	---	---	$(t$-$T)/t$
π	$u^2/(4t)$	u-t	u-T
y	$u^2/(16t)$	$t/4$	$T^2/(4t)$
y_e	---	---	0
CS	$u^2/(16t)$	$t/4$	$T^2/(4t)$
TS	$7u^2/(16t)$	u-$t/4$	u-T+$3T^2/(4t)$
Condition	$u < 2t$	$u > 2t$	$u > T$, $t > T$ (Kinked) $T < u$-$u^2/(4t)$ (Separation)

Table 2　Solutions for the first stage

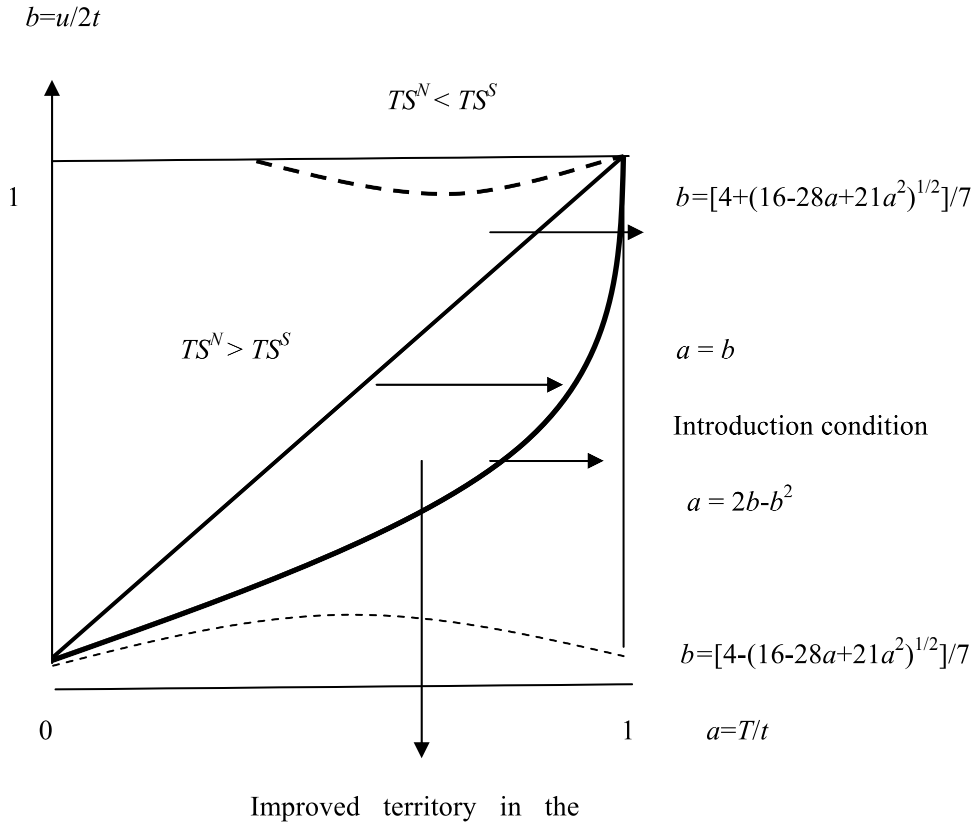


Figure 4 The change on social welfare with the introduction

when Separation equilibrium is realized

[1] Rakuten is one of the general merchandise retailers who only sell their products online. Department stores such as Takashimaya, Yiseten, and Mistukoshi, and large specialized stores such as Muruzen, Kinokuniya, and Shinseido are examples of retailers who sell their products both online and offline.

[2] A number of preceding researches have used the empirical approach. For example, Brynjolfsson and Smith (2000) analyzed the American books/music CDs market; Degeratu, Rangaswamy, and Wu (2000) studied the food and grocery market; Lynch and Ariely (2000) analyzed consumer action by constructing an online wine market simulation; Clemons, Hann, and Hitt (2002) researched the online air-ticket market; Brynjolfsson, Hu, and Smith (2003) argued the impact of the assortment of online bookstores on consumer surplus; and Morton, Zettelmeyer, and Risso (2001) studied the automobile market. Furthermore, Morita and Nishimura (2002) analyzed the use of websites by Japanese consumers before the purchase of an automobile.

[3] E-retailers are unlike conventional retail outlets, and consumers may feel naive and insecure when making a purchase from e-retailers. This disutility may arise from the fact that the delivery is not immediate or from quality concerns as physical inspection of the actual purchased good is not possible. T can also be explained as the cost arising from such disutility (for reference, one can see Aiura (2007), which deals with a similar issue). For the purpose of the embodiment, we simply consider T as a delivery cost in this paper.

[4] The last line in equation (2) indicates the situation in which all the consumers make their purchase from retailer 0 and retailer 1 losses his market completely. We assume that this never occurs.

[5] If we assume that $q_1=1-\hat{x}_1$, the same theory can be applied to retailer 1.

[6] Such symmetrical equilibrium can be realized by territorial restriction, wherein the manufacturer sets the center of the market as the boundary for each outlet retailer.

[7] If $w = u-3t/2$, the manufacturer's payoff will be $\pi^C = u-3t/2 < u-t = \pi^K$.

[8] In the situation where a franchise fee can not be levied, the manufacturer prefers to deal with

multiple retailers to avoid the double-margin issue if the manufacturer is able to determine the number of e-retailers it has to deal with.

[9] Equation 8 is derived by the zero-profit condition $y_e = (p_e - T - w_e)q_e = 0$.

[10] If $mr^+ \leqq w \leqq mr^-$, the kinked equilibrium is realized, and if $w < mr^-$, the competitive equilibrium is realized. As mentioned in the previous section, since all consumers buy the good from the outlet retailers, sales of e-retailers are zero (see FIGURE 3).

[11] In the case where retailers see the good(s) both online and offline, the retailers can always move the inventory meant for online sales to their retail outlets. If such arbitration does take place, the delivery cost is supposed to be lower owing to the economics of scale. For simplicity, we assume that this delivery cost is zero.