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NETWORK EXTERNALITY ON RETAILER AND SUPPLIER PRICING STRATEGIES FOR COMPETITIVE PRODUCTS

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Abstract

Network externality, which affects the value of many high-tech and Internet-related products, may have a critical impact on firm strategies. This paper focuses on the strategy selection of various players in a channel structure. We design a sequential game among two suppliers and a retailer. In the developed game and model, we provide two optional strategies to the retailer, whereas suppliers can impact retailer strategies with their own pricing. We found that (direct) network externality typically had a positive effect on firms. More important, we conclude that when the degree of product network externality from a weak supplier reaches a certain scale, a relatively stable state of competition is facilitated, which is more profitable compared with a collusion strategy. Otherwise, the two suppliers can still maintain a competition relationship. However, a collusion strategy may be more profitable than competition in the second case. In this article, we recommend an acquisition strategy as a sustainable and reasonable collusion strategy.

Keywords: digital products, price strategy, network externality, competition, collusion.

1 INTRODUCTION

Retailers (e.g., Amazon, Jingdong, Walmart, and GameStop) sell similar products by various brands. Different suppliers offer these products (e.g., iPhone 5s and Samsung Galaxy S6). Certain digital and information products such as cellphones, online games, and music-sharing programs have network externality. In other words, consumer utility depends on both the product itself and the number of consumers who have joined the corresponding network (Katz and Shapiro 1985). Network externality is widespread and exists for various information sources and digital products (Tomak and Keskin 2008).

We investigate pricing and interaction strategies between retailers and suppliers for network externality. Previous related studies have focused on the product version of supplier products (Jing 2007), consumer behavior (Gupta and Mela 2008, Li et al. 2014), managers aggressiveness (Hahn et al. 2015), and sales channel selection problems (Liu et al. 2015) in network externality. Pricing problems have also been researched (Bensaid and Lesne 1996, Cabral et al. 1999). However, previous studies have rarely focused on retailer interactions with suppliers and interactions among suppliers. Specifically, the following topics must be investigated: how suppliers should manager the retailer creation of pricing plans; how suppliers affect one another; and whether suppliers should engage in collaboration. For example, Amazon sells many products of the same type, such as Apple and Samsung phones, Nikon and Canon SLR cameras, and Dell and Samsung ultrabooks. Different suppliers provide these goods. We investigate the pricing and competitive strategies of retailers and suppliers for goods similar to these products to reach an understanding of the overall market in the context of network externality. In addition, we aim to explain various merger phenomena.

We modeled two suppliers and one retailer in the market. The two suppliers offer two products with network externality. The two suppliers, with a potential asymmetric demand, supply products to the retailer in a local marketplace. The reservation price of consumer included intrinsic valuation and direct network externality. Using this model and a game-theoretic model, we find that network externality has a positive effect on product retail and wholesale prices; the impact is similar on retailer and supplier profit. We still consider a possibility that the supplier with an appealing wholesale price can gain retailer favour through pricing. Surprisingly, we discover that when the weaker supplier has an unfavorable network externality degree, a collusion strategy, which is superior to a competitive strategy, may enhance profits for each supplier. However, if the weaker supplier has a sufficient network externality degree, maintaining a competitive state with the stronger supplier may be more advantageous.

The remainder of this paper is organized as follows: Section 2 introduces the literature review; Section 3 presents our applied model; Section 4 details our analysis and the results; and finally, Section 5 offers a conclusion.

2 LITERATURE REVIEW

Previous studies have primarily investigated the “two-tier” customer-supplier market structure for pricing and product strategies; few studies have examined competition or cooperation strategies among suppliers. For example, Baake and Boom (2001) revealed that when a vertical differentiation product has the characteristics of network externality, the quality difference of the products not only alleviates price competition between manufacturers but also facilitates improved compatibility for the manufacturer’s creation of products. Bayer and Chan (2007) found an inverse relationship between product pricing and the past size of a product. In other words, a greater past product scale led to a lower market pricing for the product. Kim (2000) indicated that when the product has network externality, manufacturers achieve greater technological innovation. In this case, they prefer the incompatible strategy, and are more willing to reveal their technology content to the market.

Otherwise, the manufacturer with the lower innovation ability would prefer a full compatibility strategy, which facilitates further gains.

Numerous studies have also examined network externality in the competition and standardization process (Katz and Shapiro 1985, Heinrich 2014), implications of licensing (Economides 1996), dynamic pricing and inventory management (Yang and Zhang 2015), preannouncement behavior (Farrell and Saloner 1986), bundling sales (Gallaugher and Wang 2002, Ghosh and Balachander 2007, Prasad et al. 2010), and user loyalty (Li et al. 2014).

3 MODEL SETUP

We assume that two suppliers and a retailer exist in the market. Supplier i provides product i ($i=1$ or 2). Products 1 and 2 are imperfect substitutes for each other. The wholesale price is denoted as w_1 and w_2, whereas the marginal cost of each product is assumed to be 0. The retailer, which is a monopolist, decides the products' retail prices, P_1 and P_2; the suppliers as well as the retailer are profit-maximizing firms. Without loss of generality, the total market potential was normalized to 1 in this study.

In this study, purchasing decisions of consumers are based on maximizing consumer surplus. We assume that every consumer has only one unit demand. Without loss of generality, we assume that the mass of the consumer is one unit in the market. Each consumer offers a particular reservation price for a product in the market. According to Prasad et al. (2010), the two parts of product value are called intrinsic valuation and direct network externality. Therefore, with network externality, a reservation price is expressed as the sum of these two parts.

The intrinsic valuation of a product is referred to as the value to a particular consumer in the absence of any network. Let R_{ik} denote the intrinsic valuation of product i for consumer k. We assume that (R_{1k}, R_{1k}) is uniformly distributed on [0,1] $\times$ [0,1], and that R_{1k} and R_{1k} are independent of each other (Nalebuff 2004, Prasad et al. 2010). We use this approach to represent consumer heterogeneity. We use R_i to replace R_{ik} because the mass of the consumer is one unit. We represents direct network externality utility that consumers gain from product i as $n_i D_i$ (Padmanabhan et al. 1997, Economides 2000, Prasad et al. 2010). Parameter n_i represents the size of network externality for product i. Endogenous variable D_i is the market demand for product i. We thus assume that prospective consumers know the equilibrium demand of the market.

Consumer reservation price RP_i for product i is given by $RP_i = R_i + n_i D_i$. Thus, RP_i with constraint $n_i D_i \le RP_i \le 1 + n_i D_i$. The net utility gained by consumers from product i is given by

$$V_i = RP_i - P_i = R_i + n_i D_i - P_i. \tag{1}$$

Let $V_1 - V_2 \ge 0$; we can then derive this as

$$R_2 \le R_1 + m_1 - m_2, \tag{2}$$

where $m_i = n_i D_i - P_i$. In Inequality (2), the consumer is bound to choose product 1, because the consumer can obtain a higher utility from product 1 than from product 2. As shown in Figure 1, the gray area is consistent with the representation of D_1 in Inequality (2); the remaining area is D_2. The total market potential is one, and therefore,

$$D_1 + D_2 = 1. \tag{3}$$

Assumption 1 $0 \le m_1 - m_2 \le 1.$

Without loss of generality, here we suppose that $0 \le m_1 - m_2 \le 1$. If we assume that $-1 \le m_1 - m_2 \le 0$, this is the equivalent of switching the two products or suppliers, which does not affect the generality of the conclusion of our study. In addition, when $m_1 - m_2 > 1$ or $m_1 - m_2 < -1$, it is implied that $D_1 \equiv 1$ and $D_2 \equiv 0$ or $D_1 \equiv 0$ and $D_2 \equiv 1$, which is an unfavorable scenario. Therefore, this study investigates only the case of $0 \le m_1 - m_2 \le 1$, as shown in Figure 1. Consequently, the ordinate intercept of $R_2 = R_1 + m_1 - m_2$ is $m_1 - m_2 \in [0,1]$. Therefore, we can formulate the demand for each product from consumers as

$$\begin{cases} D_1 = 1 - (1 - m_1 + m_2)^2 / 2, \\ D_2 = (1 - m_1 + m_2)^2 / 2. \end{cases} \tag{4}$$

Lemma 1 $D_1 \ge 1/2, D_2 \le 1/2$.

After considering Eq. (3) and Figure 1, $D_2 \le 1/2, D_1 \ge 1/2$ can be determined. This study is based on this premise, on which we can consider that the two suppliers are asymmetric. Because $D_1 \ge D_2$, we can suggest that supplier 1 achieves a market advantage over supplier 2. In practice, most suppliers in a specific market are often asymmetrical, such as Apple and Samsung, China Mobile and China Unicom, and Twitter and Facebook. Therefore, we believe that such a premise may receive further attention in the future.

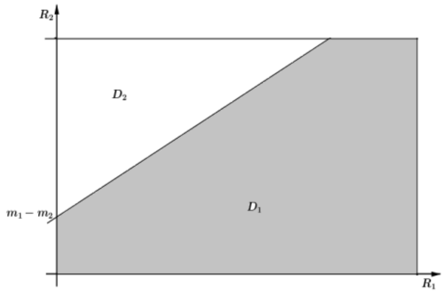

Figure 1. Consumer's demand on the two products.

In this study, the retailer and two suppliers play a timing game. An initial state before the game includes n_i and w_i ($i = 1$ or 2). According to this initial state, the retailer determines an optimal pricing. Therefore, with this strategy, the market has product demands D_1 and D_2. According to the retailer's pricing strategy, the suppliers are likely to adopt various alternative strategies. It should be emphasized that the interaction arises not only between the two suppliers and the retailer but also between suppliers 1 and 2.

For the retailer, the purpose is to maximize profit $\pi_R(P_1, P_2)$ as $\max_{P_1,P_2} \pi_R(P_1,P_2) = (P_1 - w_1)D_1 + (P_2 - w_2)D_2$. And for supplier i, the purpose is to maximize profit $\pi_i(w_i)$, shown as $\max_{w_i} \pi_i(w_i) = w_i D_i$. Then the following conclusions can be obtained. Unless indicated otherwise, all proofs of this paper are omitted due to the page limit but available from authors upon request.

Lemma 2 *The retailer has two alternative strategies, s_1 and s_2, where $s_1 = \{P_1 = n_1, P_2 = 1\}$; $s_2 = \{P_1 = n_1/2 + 1, P_2 = n_2/2 + 1\}$. When the retailer chooses strategy s_1, the corresponding market demand is $D_1 = 1, D_2 = 0$ and the profit is $\pi_R^1 = \pi(n_1, 1) = n_1 - w_1$, whereas when the retailer chooses strategy s_2, the corresponding product demand is $D_2 = 1/2, D_1 = 1/2$ and the profit is $\pi_R^2 = \pi(n_1/2 + 1, n_2/2 + 1) = 1 + (n_1 + n_2)/4 - (w_1 + w_2)/2$.*

Lemma 3 *Supplier 2 wants the retailer to choose policy* s_2 .

We can find with w_1 and w_2, the profit of the retailer increases (weakly) with n_1 and n_2 . Therefore, a retailer can benefit further from the increase in the size of network externality, but without incurring the excessive additional cost of price-pushing. By Lemma 2 and 3, we can also find that supplier 2 benefits from a larger n_2 and a small w_2, which is in line with s_2 .

4 ANALYSIS

We first identify the factors that affect the retailer and supplier's choice of strategy. Next, we investigate another strategy for the two suppliers. The results are presented in the following.

Proposition 1 *When* $3n_1 - n_2 \le 4 + 2w_1 - 2w_2$ *is satisfied, the retailer chooses policy* s_2 *; otherwise, the selected strategy is* s_1.

Let $\pi_R^2 \ge \pi_R^1$, and $3n_1 - n_2 \le 4 + 2w_1 - 2w_2$. Obviously, we can find that a larger n_i and a small w_i are supportive to policy s_i . From the demands of products in Lemma 2, we can suggest that policy s_i actually implies the retailer's preference to products. Retailer benefit more from a larger n_i and a small w_i if condition of s_i is satisfied. Particularly, under $3n_1 - n_2 \le 4 + 2w_1 - 2w_2$, if possible, the retailer even want to choose $D_2 = 1, D_1 = 0$. However, because of Lemma 1, the rational retailer must choose a maximum possible output for product 2, namely $D_2 = 1/2$. D_1 can only take a minimum of $1/2$. Under the existing conditions, supplier 2 has a price advantage over supplier 1. This creates an incentive when the retailer sells product 2, and supplier 2 is well equipped to divide the market demand evenly with supplier 1, even if they are asymmetric. Overall, this appears reasonable.

We present a discussion on the suppliers' pricing. Because of certain constraints involving market factors such as rivals, consumer endurance or sensitivity to price, and government intervention, to ensure the possibility of a sale, both w_1 and w_2 should follow an upper bound, denoted as $\varepsilon_1 > 0$ and $\varepsilon_2 > 0$. In other words, the wholesale price cannot be excessively high, even when the firm is a monopolist. Our result regarding $w_2 = w_1 - 3n_1/2 + n_2/2 + 2$ is achieved afterward, which is an indifference curve of w_1 and w_2 for the retailer, derived from the condition in Proposition 2. For simplicity, we assume that $t = 3n_1/2 - n_2/2 - 2$ in the result. Let t denote the network externality effect, and $w_1 - w_2 - t$ denote the wholesale price effect. The result is as follows.

Proposition 2 *If* $-3n_1/2 + n_2/2 + 2 \ge 0$ *(i.e.,* $t \le 0$ *), the retailer selects* s_2 *, after which* $w_1 = \varepsilon_1$ *and*

- *when* $\varepsilon_2 < -t$ *, then* $w_2 = \varepsilon_2$ *;*
- *when* $\varepsilon_1 \le \varepsilon_2 + t$ *, then* $w_2 = \varepsilon_1 - t$ *;*
- *when* $\varepsilon_1 > \varepsilon_2 + t \ge 0$ *, then* $w_2 = \varepsilon_2$ *;*

Intuitively, $t \le 0$ suggests that n_2 has reached a certain level, and that the network externality effect benefits supplier 2. In other words, n_2 is sufficiently high to facilitate a retailer choice of s_2 . Because supplier 2 has a substantially stronger motivation to urge the retailer to choose s_2 , a rational supplier 1 does not compete with supplier 2 in a price war. Because supplier 1 has a demand advantage, it can always set the highest and optimal price. This is similar to the case of Apple's market advantage with the iPhone. However, for a supplier with a weaker demand such as supplier 2, the case is complex. When ε_2 is extremely low ($\varepsilon_2 < -3n_1/2 + n_2/2 + 2$) or the wholesale price effect regarding ε_i is positive ($\varepsilon_1 - \varepsilon_2 - t > 0$), supplier 2 can set the highest price. Conversely, when the wholesale price effect regarding ε_i is negative ($\varepsilon_1 - \varepsilon_2 - t \le 0$), supplier 2 cannot set the highest price because ε_2 is too high; thus, the network externality effect (negative) is not strong. We found that a collusion strategy cannot be reached when $t \le 0$. In other words, if the network externality effect favors the weaker supplier, competition is more effective compared with collusion and the two suppliers only have the motivation to maintain s_2 .

Proposition 3 *If $-3n_1/2+n_2/2+2<0$ (i.e., $t>0$),*

- *when $\varepsilon_1 \le 2t$, the retailer selects s_1, and $w_1=\varepsilon_1$;*
- *when $\varepsilon_1 > 2t$ and $0<\varepsilon_2 \le \varepsilon_1 - t$, the retailer selects s_2 and $\{w_1=\varepsilon_1, w_2=\varepsilon_2\}$, or the suppliers adopt a collusion strategy as $\{w_1=\varepsilon_2+t, w_2=\varepsilon_2\}$ to have the retailer select s_1;*
- *when $\varepsilon_1 > 2t$ and $\varepsilon_2 > \varepsilon_1 - t$, the retailer selects s_2 , and $\{w_1=\varepsilon_1, w_2=\varepsilon_1 - t\}$ or the suppliers employ the collusion strategy of $\{w_1=\varepsilon_1, w_2>\varepsilon_1 - t\}$ to influence the retailer to select s_1.*

Intuitively, $t>0$ suggests that n_2 cannot reach a level at which $t \le 0$, whereby s_2 is unstable. The network externality effect benefits supplier 1. When w_1 cannot be priced too high (i.e., $\varepsilon_1 \le 2t$), such as in a price war, supplier 2 may be forced out of the market. Consequently, supplier 1 monopolizes the market at the expense of profits. When $\varepsilon_1 > 2t$, if the wholesale price effect of ε_i is positive (i.e., $\varepsilon_1 - \varepsilon_2 - t > 0$), the difference in tradeoff advantages between the two suppliers is minor. Therefore, the retailer prefers s2, and the suppliers employ the highest price strategy. However, if the wholesale price effect of ε_i is negative (i.e., $\varepsilon_1 - \varepsilon_2 - t \le 0$), the tradeoff favors supplier 1, which can set the highest price, whereas supplier 2 cannot. When $\varepsilon_1 > 2t$, if supplier 1 colludes with supplier 2 and employs a low-price strategy, each supplier may generate further profits. If the overall power disparity is strong between the two firms, an acquisition strategy is more profitable than is competition. In summary, for the collusion strategy, the two suppliers only have the motivation to maintain s_1. We also found that s_2 does not have to exist with $t>0$.

5 CONCLUSION

Although our study lacks empirical support, it is relevant to real-world markets for various reasons. First, if a positive network effect exists, a common goal among the retailer and suppliers is to attempt to boost the degree of that network effect. Second, for two products that are imperfect substitutes, if no significant difference exists in the degree of network externality, retailer sales for the two products revealed no significant difference, and are stable with each other. Furthermore, the suppliers also retain a relatively stable state of competition. We determined that a collusion strategy was inferior to a competitive strategy in improving the total profits for the suppliers; as in the real-world examples of Samsung and Apple cellphones, or Leica and Linhof cameras, the weaker firm can also gain a significant market share with an attractive network effect and a reasonable price. Third, if a weaker product such as product 2 has a lower network externality degree and an unappealing price, it has few advantages over a stronger product. For the weaker supplier in the market, it is rational to cooperate with the stronger counterpart. It is not uncommon for many small companies to desire acquisition by larger companies. Some examples include T-Mobile USA’s purchase of MetroPCS in 2013, Lenovo’s purchase of IBM PCD in 2004, and Electronic Arts’ (EA) 1991 purchase of Distinctive Software which once served Accolade, a main rival to EA and the 1998 purchase of Westwood. In reality, these acquisitions are ideal, and are similar to a collusion strategy, which may be more sustainable in an acquisition case than in an independent collusion case, according to our analytical results. Surprisingly, for a merger strategy, the weaker product can be regarded as a low-quality version, whereas the stronger product is regarded as a high-quality counterpart. Supplier profits rely on high-quality products, whereas the low-quality product version mainly improves the product network scale. This is relatively similar to the findings reported by Jing (2007).

Future research may aim to empirically validate the model. An investigation into the social welfare of various firm strategies is also warranted. Moreover, relaxing the premise that a consumer can buy only one product from two choices would prove fruitful.

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