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Tacit collusion and its welfare effect in a network product market

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Abstract

Based on a horizontally differentiated duopoly model with network externalities, and focusing on the role of compatibility between products, we demonstrate the conditions under which collusive behavior improves social welfare. In particular, if the degree of a network compatibility effect upgraded by collusive agreement is sufficiently large, collusion increases consumer surplus compared with noncooperative Cournot competition.

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1. Introduction

The analysis of cartel behavior (or market concentration) and its effect on market performance in oligopoly is a theoretical issue in industrial organization, as well as a public (competition and antitrust) policy concern. There is a consensus that collusive agreement, i.e., monopolization, reduces welfare and should be forbidden.

Recently, many studies have analyzed collusion and market concentration in the context of markets influenced by the progress of information and communication technologies, in which network externalities and compatibility between products and services exist. [1] In network industries (e.g., telecommunications, smartphones, application software, operation systems, and Internet services), compatibility and standardization of products and services are important for both providers and users of such products. Compatibility (interoperability and interconnectivity) is a characteristic of products and services that interact with other products and services to enhance performance for users.[2]

Focusing on network externalities and compatibility, the recent literature has considered whether market concentration plays a role in sustaining collusion (Lambertini, et al., 1998; Pal & Scrimitore, 2016; Rasch, 2017; Song & Wang, 2017). Currently, market concentration or monopolization is observed in various forms (e.g., cartels, collusive agreements, mergers and acquisitions, and joint ventures), including in network industries, such as telecommunications and Internet services.

The cited papers above mainly consider the sustainability (stability) of collusion by introducing an infinitely repeated game. Pal and Scrimitore (2016) examine the case of oligopoly, with firms competing on quantities in a homogeneous product market. Song and Wang (2017) analyze the case of a horizontally differentiated duopoly competing in quantity. Rasch (2017) addresses the case where firms collude on prices in a Hotelling-type market.

In this paper, we consider the effect of collusion on social welfare and the sustainability of collusion. The welfare effect was not analyzed in the literature mentioned above. We appreciate that introducing a common standard to make products and services compatible (connectable and interoperable) is an important consideration with network externalities; therefore, we focus on the role of compatibility where collusive behavior is involved. That is, with respect to collusive behavior in our model, we assume the following: (i) the output level is determined through a cooperative decision that involves maximizing joint profits; and (ii) the level of compatibility (standardization between the products) is upgraded compared with the case of noncooperative competition.[3]

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[1] Since the 1990s, waves of domestic and global mergers and acquisitions (M&A) have been observed in various industries, including telecommunications, internet businesses, banking, airlines, and railways. For example, we observe strategic alliances created by M&A in the airline industry (Bilotkach & Hüschelrath, 2012).

[2] Estimating network effects and compatibility in the Polish mobile market, Grajek (2010) finds strong network effects. Furthermore, Gandal (1995) empirically analyzes complementary network externalities in PC software markets, in which users need to exchange data files between spreadsheets and database management systems.

[3] Toshimitsu (2018) considers an endogenous choice of compatibility levels in the case

Given these assumptions, we demonstrate that collusive behavior improves social welfare, compared with the case of noncooperative Cournot competition if the level of compatibility between the products under the collusive agreement is sufficiently large, given the existence of a stronger network externality. In this case, the collusion is stable.

2. The Model

2.1 Preliminary

We develop a duopoly model (i.e., involving two firms, i and j) in a network industry, where each firm provides a horizontally differentiated product with network externalities. Applying Economides's (1996) framework, we assume the following linear inverse demand function of firm i's product:[4]

$$p_i = A - q_i - \gamma q_j + N(S_i^e), \tag{1}$$

where A is the intrinsic market size of product i, q_i is the output of firm i, and $\gamma \in (0,1)$ represents the level of product substitutability. $N(S_i^e)$ is the network externality function, where S_i^e represents the expected network size of firm i's product. We assume a linear network externality function, $N(S_i^e) = nS_i^e$, where $n \in [0,1)$ represents the level of a network externality. Furthermore, based on the formulations of Shy (2001) and Chen and Chen (2011), the expected network size of product i is given by:

$$S_i^e \equiv q_i^e + \phi_k q_j^e, \quad k = C, N, \tag{2}$$

where $\phi_k \in [0,1]$ denotes the level of product i's compatibility (connectivity and interoperability) with the other firms' product j, and subscript C (N) denotes the case of collusion (noncooperative Cournot competition).

Considering the concept of a fulfilled expectation, we assume that consumers develop expectations for network sizes before the firms make their output decisions, i.e., consumers have *ex ante* expectations (Katz & Shapiro, 1985; Economides, 1996).[5]

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of Cournot duopoly. Multiple equilibria are present in the case of noncooperative decisions (i.e., an imperfect compatibility and a perfect compatibility). However, in the case of collusive decisions, where both firms cooperatively determine the compatibility levels to maximize the joint profits, there is a unique equilibrium (i.e., a perfect compatibility). Thus, considering this result, we assume that the level of compatibility in the case of collusion is higher than that in the case of noncooperative Cournot competition.

[4] To derive equation (1), we assume that a representative consumer has the following quadratic utility function with network externalities.

$$U(q_i, q_j) = A(q_i + q_j) - \frac{1}{2}(q_i^2 + q_j^2) - \gamma q_i q_j + N(S_i^e)q_i + N(S_j^e)q_j,$$

where the expected network sizes, i.e., S_i^e and S_j^e, are given for the representative consumer who decides on the amount of consumption.

[5] Toshimitsu (2017) examines the case of consumers' *ex post* expectations, under which

Thus, when deciding the output level, the expected network sizes are given for the firms.

For the analysis, we make the following assumptions:

(i) $1 \geq \phi_C > \phi_N \geq 0$.

(ii) $n > \gamma$.

Assumption (i) implies that the level of compatibility in the case of collusion is larger than that in the case of noncooperative Cournot competition, i.e., the level of compatibility between the products is upgraded because of collusion (collusive agreement).[6] Assumption (ii) implies a strong network externality. Otherwise, we obtain the same results as the related literature that analyzes collusion in the case of Cournot oligopoly (e.g., Song & Wang, 2017). Furthermore, we assume that production costs are zero, because we observe low and even negligible marginal running costs in a network industry, e.g., Internet businesses.

2.2 Noncooperative Cournot competition

We consider the initial situation where the firms noncooperatively compete on quantities à la Cournot in the market. Based on equation (1), the profit function of firm *i* is given by:

$$\pi_i = \{A - q_i - \gamma q_j + N(S_i^e)\} q_i. \tag{3}$$

The first-order condition (FOC) of profit maximization is given by:

$$\frac{\partial \pi_i}{\partial q_i} = p_i - q_i = A - 2q_i - \gamma q_j + N(S_i^e) = 0. \tag{4}$$

At the point of a fulfilled expectation, i.e., when $q_i^e = q_i$ and $q_j^e = q_j$, given equations (2) and (4), we obtain the following:

$$A - (2-n)q_i - (\gamma - n\phi_N)q_j = 0. \tag{5}$$

Assuming a symmetric equilibrium, i.e., $q_i = q_j = q_N$, we derive the following fulfilled expectation Cournot equilibrium:

$$q_N = \frac{A}{2 - n + (\gamma - n\phi_N)}, \tag{6}$$

where $n\phi_N$ denotes the level of a network compatibility effect in the case of noncooperative Cournot competition. As it holds that $p_N = q_N$, based on equation (4), the profit in the case of noncooperative Cournot competition is expressed as $\pi_N = (q_N)^2$.

2.3 Collusion

We examine the case of collusion where each firm determines the output to maximize the following joint profits:

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consumers develop their expectations for network size after firms decide their outputs. The main results derived in this paper do not change in the case of consumers' *ex ante* expectations.

[6] See footnote 3. Furthermore, we implicitly assume that there are nil or negligible costs involved in increasing the level of compatibility between the insiders' products.

$$\begin{aligned}\Pi_C &= \pi_i + \pi_j \\ &= \{A - q_i - \gamma q_j + N(S_i^e)\}q_i + \{A - q_j - \gamma q_i + N(S_j^e)\}q_j.\end{aligned} \tag{7}$$

Equation (7) implies that a multiproduct monopoly determines the output of products *i* and *j* to maximize its profit. The FOC is given by:

$$\frac{\partial \Pi_C}{\partial q_i} = p_i - q_i - \gamma q_j = A - 2q_i - 2\gamma q_j + N(S_i^e) = 0. \tag{8}$$

At the point of a fulfilled expectation, i.e., when $q_i^e = q_i$ and $q_j^e = q_j$, given equations (2) and (8), we obtain the following:

$$A - (2-n)q_i - (2\gamma - n\phi_C)q_j = 0. \tag{9}$$

Assuming a symmetric equilibrium, i.e., $q_i = q_j = q_C$, we derive the following collusive fulfilled expectation equilibrium:

$$q_C = \frac{A}{2 - n + (2\gamma - n\phi_C)}, \tag{10}$$

where $n\phi_C$ denotes the level of a network compatibility effect in the case of collusion. In particular, both firms ensure standardization of their products under collusive agreements, so that the level of compatibility rises, compared with the case of noncooperative Cournot competition. Furthermore, using equation (8), because the collusive price is expressed as $p_C = (1+\gamma)q_C$, the profit in the case of collusion is given by $\pi_C = (1+\gamma)(q_C)^2$.

Taking equations (6) and (10), we obtain the following relationship:

$$q_C > (<) q_N \Leftrightarrow n(\phi_C - \phi_N) > (<) \gamma. \tag{11}$$

Equation (11) indicates that if the net level of a network compatibility effect, i.e., $n(\phi_C - \phi_N)$, is larger than the level of product substitutability, the output in the case of collusion is larger than that in the case of noncooperative Cournot competition.

Suppose that there is no network externality, i.e., either $n = 0$ or $\phi_C = \phi_N$. In this case, as is well known, collusion reduces output but increases prices compared with those in the case of noncooperative Cournot competition. Furthermore, even with a positive network externality, these well-known results hold in Song and Wang (2017), in which it is assumed that product substitutability is equal to compatibility, i.e., that $\gamma = \phi_C = \phi_N$, as expressed in the notation of our model. However, given a strong network externality based on assumption (ii), if the level of compatibility in the case of collusion is sufficiently large, collusive outputs do not necessarily decrease compared with those in the case of noncooperative Cournot competition. For example, we suppose perfectly compatible products under collusion (i.e., $\phi_C = 1$) and incompatible products under noncooperative Cournot competition (i.e., $\phi_N = 0$). Then, it holds that $q_C > q_N$.

With respect to profits, we derive the following relationships:

$$\pi_C > (<) \pi_N \Leftrightarrow \left(\sqrt{1+\gamma} - 1\right)\{2 - n + (\gamma - n\phi_N)\} + n(\phi_C - \phi_N) - \gamma > (<) 0.$$

If $n(\phi_C - \phi_N) \geq \gamma$, then it holds that $\pi_C > \pi_N$. The above relationship can also be expressed as:

$$\pi_C > (<) \pi_N \Leftrightarrow \Gamma(\gamma) + \left[(1+\phi_C) - \sqrt{1+\gamma}(1+\phi_N)\right]n > (<) 0, \tag{12}$$

where $\Gamma(\gamma) \equiv \left[\sqrt{1+\gamma}(2+\gamma)-2(1+\gamma)\right] > 0$ and $1 > n > \gamma > 0$. Regarding equation (12), even with $n(\phi_C - \phi_N) < \gamma$, if $\dfrac{1+\phi_C}{1+\phi_N} \geq \sqrt{1+\gamma}$, then it holds that $\pi_C > \pi_N$. Furthermore , if $\dfrac{1+\phi_C}{1+\phi_N} < \sqrt{1+\gamma}$, equation (12) can be rewritten as:

$$\pi_C > (<) \pi_N \Leftrightarrow \mathrm{N}(\gamma, \phi_C, \phi_N) > (<) n, \tag{13}$$

where $\mathrm{N}(\gamma, \phi_C, \phi_N) \equiv \dfrac{\Gamma(\gamma)}{\sqrt{1+\gamma}(1+\phi_N)-(1+\phi_C)} > 0$. Therefore, if $\mathrm{N}(\gamma, \phi_C, \phi_N) > n$, then the firms have an incentive to collude.

We summarize the results analyzed above regarding the outputs and profits in the cases of collusion and noncooperative Cournot competition as Lemma 1.

LEMMA 1
(i) If $n(\phi_C - \phi_N) \geq \gamma$, it holds that $q_C \geq q_N$ and $\pi_C > \pi_N$.
(ii-a) If $n(\phi_C - \phi_N) < \gamma$ and $\dfrac{1+\phi_C}{1+\phi_N} \geq \sqrt{1+\gamma}$, it holds that $q_C < q_N$ and $\pi_C > \pi_N$.
(ii-b) If $n(\phi_C - \phi_N) < \gamma$ and $\dfrac{1+\phi_C}{1+\phi_N} < \sqrt{1+\gamma}$, it holds that $q_C < q_N$ and $\mathrm{N}(\gamma, \phi_C, \phi_N) > (<) n \Leftrightarrow \pi_C > (<) \pi_N$.

Lemma 1 (i) implies that market concentration resulting from collusion does not necessarily negatively affect market performance. Lemma 1 (ii-b) is similar to Song and Wang (2017), in which product substitutability is assumed to be equal to compatibility, i.e., $\gamma = \phi_C = \phi_N$.

2.4 The stability of collusion
Here, we examine whether the firms have an incentive to deviate from collusion. Without loss of generality, we assume that firm *i* deviates from collusion, given that firm *j* decides the collusive output level, i.e., $q_i = q_D$ and $q_j = q_C$, where subscript *D* implies deviation. In this case, the profit function can be represented by:

$$\pi_D = \left\{A - q_D - \gamma q_C + N(S_D^e)\right\} q_D, \tag{14}$$

where $S_D^e \equiv q_D^e + \phi_D q_M^e$.

We assume that $\phi_C > \phi_D \geq \phi_N$. This implies that the level of compatibility decreases if firm *i* deviates from collusion, but the level of compatibility is at least equal to that in the case of noncooperative Cournot competition. That is, we implicitly assume that the collusive agreement is such that if firm *j* observes the deviation of firm *i*, it is immediately possible for firm *j* to reduce the level of compatibility of the product. For example, firm *j* can change the common network system under the collusive agreement to a different system.

The FOC of profit maximization is:

$$\frac{\partial \pi_D}{\partial q_D} = p_D - q_D = A - 2q_D - \gamma q_C + N(S_i^e) = 0. \tag{15}$$

When expectations are fulfilled, i.e., when $q_D^e = q_D$ and $q_C^e = q_C$, we obtain the following:

$$A - (2-n)q_D - (\gamma - n\phi_D)q_C = 0. \tag{16}$$

Substituting equation (10) into equation (16), we derive the following output in the case of deviation.

$$q_D = \frac{\{2-n+\gamma-n(\phi_C-\phi_D)\}A}{(2-n)\{2-n+(2\gamma-n\phi_C)\}} = \frac{\{2-n+\gamma-n(\phi_C-\phi_D)\}}{2-n}q_C. \tag{17}$$

Given equations (10) and (17), we obtain the following:

$$q_C > (<) q_D \Leftrightarrow n(\phi_C - \phi_D) > (<) \gamma. \tag{18}$$

As it holds that $p_D = q_D$, the profit in the case of deviation is expressed as $\pi_D = (q_D)^2$. Thus, with respect to the profits in the cases of collusion and deviation, we derive the following relationship:

$$\pi_C > (<) \pi_D \Leftrightarrow \left(\sqrt{1+\gamma}-1\right)(2-n) + n(\phi_C - \phi_D) - \gamma > (<) 0.$$

The above relationship can be rewritten as:

$$\pi_C > (<) \pi_D \Leftrightarrow -\Gamma_D(\gamma) + \left[(\phi_C - \phi_D) - \left(\sqrt{1+\gamma}-1\right)\right]n > (<) 0, \tag{19}$$

where $\Gamma_D(\gamma) \equiv \left[(2+\gamma) - 2\sqrt{1+\gamma}\right] > 0.$

If $\phi_C - \phi_D \leq \sqrt{1+\gamma} - 1$, then it holds that $\pi_C < \pi_D$. Thus, the firm has an incentive to deviate from collusion because the difference in the level of compatibility is small between the cases of collusion and deviation. Conversely, if $\phi_C - \phi_D > \sqrt{1+\gamma} - 1$, equation (19) can be rewritten as:

$$\pi_C > (<) \pi_D \Leftrightarrow n > (<) \mathrm{N}_D(\gamma, \phi_C, \phi_D), \tag{20}$$

where $\mathrm{N}_D(\gamma, \phi_C, \phi_D) \equiv \dfrac{\Gamma_D(\gamma)}{(\phi_C - \phi_D) - \left(\sqrt{1+\gamma}-1\right)} > 0.$ If $\mathrm{N}_D(\gamma, \phi_C, \phi_N) > (<) n$, the firm will (not) deviate from the collusion.

Taking equations (18) and (19), regarding the incentive to deviate from the collusion, we present Lemma 2.

LEMMA 2

(i) If $n(\phi_C - \phi_D) \geq \gamma$, it holds that $\pi_C > \pi_D$. Thus, the firms do not have an incentive to deviate from collusion.

(ii-a) If $n(\phi_C - \phi_D) < \gamma$ and $\phi_C - \phi_D \leq \sqrt{1+\gamma} - 1$, it holds that $\pi_C < \pi_D$. Thus, the firms have an incentive to deviate from collusion.

(ii-b) If $n(\phi_C - \phi_D) < \gamma$ and $\phi_C - \phi_D > \sqrt{1+\gamma} - 1$, it holds that $n > (<) \mathrm{N}_D(\gamma, \phi_C, \phi_D) \Leftrightarrow \pi_C > (<) \pi_D$. Thus, the firms do not have (do have) an incentive to deviate from collusion if $n > (<) \mathrm{N}_D(\gamma, \phi_C, \phi_D)$.

Lemma 2 (i) and (ii-b) imply that, for firms to sustain collusion, it is necessary that the level of compatibility in the case of collusion and the level of a network externality are sufficiently large. Furthermore, in view of Lemma 2 (ii-a) and (ii-b), given that $n(\phi_C - \phi_D) < \gamma$, if either $\phi_C - \phi_D \leq \sqrt{1+\gamma} - 1$ or $\phi_C - \phi_D > \sqrt{1+\gamma} - 1$, and $n < \mathrm{N}_D(\gamma, \phi_C, \phi_D)$, the collusion is not sustainable. However, as Pal and Scrimitore (2016), Rasch (2017), and Song and Wang (2017) show, assuming an infinitely repeated Cournot game with a trigger strategy punishment, we demonstrate that there exists a certain value of discount factor composed of the parameters (i.e., γ, ϕ_C, ϕ_D) that makes the collusion sustainable.

3. The Effect of Collusive Behavior on Social Welfare

We consider the effect of collusive behavior on social welfare and, in particular, consumer surplus. In a related study, Hüschelrath and Müller (2014) examine the consumer welfare effect of mergers in airline networks, i.e., the price effects of the America West Airlines–US Airways merger completed in 2005. They empirically demonstrate that the merger led to a net increase in consumer welfare. Taking equation (1), consumer surplus in each equilibrium is given by $CS_k \equiv (1+\gamma)(q_k)^2$, where $k = C, N$.[7] Thus, given equations (6) and (10), we derive the following relationship directly:

$$CS_C > (<) CS_N \Leftrightarrow q_C > (<) q_N \Leftrightarrow n(\phi_C - \phi_N) > (<) \gamma. \tag{21}$$

Therefore, based on Lemmas 1 (i) and 2 (i), and equation (21), we obtain the following key result:

PROPOSITION 1
If $n(\phi_C - \phi_N) > \gamma$, then the firms have an incentive to collude. In this case, the firms do not have an incentive to deviate from collusion. The collusion increases consumer surplus and, thus, social welfare, compared with the case of noncooperative Cournot competition.

Proposition 1 implies that collusion in a network industry does not necessarily reduce the resulting welfare level if the level of a network compatibility effect under collusion is sufficiently large, given a strong network externality. However, prices rise compared with those in noncooperative Cournot competition. In this sense, collusion may not be procompetitive, even though consumer surplus increases because of a strong network externality. In contrast, if $n(\phi_C - \phi_N) < \gamma$, then the effect of collusion on consumer surplus is always negative. This case is similar to the result in the literature that considers collusion with network externalities (e.g., Song & Wang, 2017).

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[7] Using the utility function in footnote 4, consumer surplus is defined as:

$$CS(q_i, q_j) \equiv U(q_i, q_j) - p_i q_i - p_j q_j = \frac{1}{2}\left(q_i^2 + q_j^2\right) + \gamma q_i q_j.$$

Thus, we obtain $CS_k = (1+\gamma)(q_k)^2$, where $k = C, N$.

4. Concluding Remarks

In this paper, assuming that the level of compatibility is upgraded due to collusion—in other words, that greater standardization between products and services occurs under collusion compared with the case of noncooperative competition—we considered collusive behavior and its effect on consumer surplus and social welfare. We demonstrated that collusion improves social welfare if the level of compatibility in the case of collusion is sufficiently large, given that a network externality is strong. In this case, the collusive output levels are larger than those of noncooperative Cournot competition. We may observe collusive behavior by firms in airlines, telecommunications, and Internet services markets. However, such collusive behavior does not necessarily reduce social welfare if the level of compatibility between the products and services of the collusive firms is sufficiently large.

Our result has some limitations because our duopoly model is based on specific assumptions and linear functions. In future research, we intend to discuss more general cases, relaxing the assumptions and extending the model to oligopolistic competition. For example, we must consider the presence of outsiders to the collusion between firms in the case of oligopoly. Furthermore, we have assumed the exogenously given level of compatibilities in the cases of noncooperative Cournot competition and collusion. Thus, we should consider endogenous decisions regarding the level of compatibilities.

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