On Merger Profitability in a Network Industry: The Role of Merger-related Network Connectivity*

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Abstract

Focusing on the role of merger-related network connectivity, we consider the profitability of a horizontal merger in a quantity-setting game within a network industry. In particular, we demonstrate that the merger is profitable, given strong network externalities. Otherwise, the "merger paradox" arises.

Keywords: connectivity; fulfilled expectation; merger paradox; network externality; quantity-setting game

JEL Classification: D43; L12; L13; L41

1. Introduction

Theoretically, horizontal mergers are not profitable for insiders (participant firms), whereas they are for outsiders (nonparticipant firms), i.e., the well-known issue of the "merger paradox" emerges. Salant et al. (1983) demonstrate that horizontal mergers in the case of Cournot oligopoly are unprofitable unless at least 80% of the firms in the industry participate in the merger[1)]. That is, in Cournot oligopolistic competition, where a strategic substitutionary relationship arises between firms, the merger results in a contraction of the outputs of the merged firms. As a result, although the prices increase, the insiders lose, whereas the outsiders gain.

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1) See Levin (1990), who shows that there is a 50% threshold under some conditions.

Since the publication by Salant et al. (1983), many solutions have been proposed for the merger paradox. For example, one way to resolve the paradox is to introduce merger-related synergies and scale economies. Perry and Porter (1985) consider incentives to merge in the context of a Cournot quantity-setting oligopoly in a homogeneous product market and introduce merger-related efficiencies occurring through scale economies such as cost-saving synergies. Furthermore, based on general demand and cost functions, Farrell and Shapiro (1990) consider horizontal mergers in the case of Cournot oligopoly in a homogeneous product market. Assuming efficiencies created by scale economies or learning in the general model, they show the condition for lowering the prices and the effect on external welfare, which is the difference between the merger and the premerger total surplus, net of the profits of the insiders. Davidson and Ferrett (2007) find that insiders benefit, whereas outsiders are harmed, when exploiting R&D complementarities such as through research joint ventures. Miyagiwa and Wan (2016) also consider the merger paradox in the presence of R&D investments. Dong et al. (2016) show that the merger paradox is mitigated when capacity constraints are considered [2)].

In summary, to resolve the merger paradox, the previous theoretical models assume that there are merger-related efficiencies resulting from scale economies, synergies, and externalities on the supply side. In this paper, to consider the profitability of a horizontal merger in a network product and service market, we focus on the efficiency of merger-related network synergies on the demand side. Since the 1990s, waves of global mergers and acquisitions (M&A) have been observed in various industries, including telecommunications, Internet businesses, and traditional industries such as banking, railways, and airlines. These industries are commonly characterized as network markets. Their characteristics may imply that M&A in these industries may be profitable for the participants. Considering the strength of network externalities and the degree of connectivity among firms' services, we investigate the conditions for a profitable merger. In particular, we demonstrate that given the strong network externalities, if the degree of merger-related network connectivity is sufficiently large, a profitable merger arises.

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2) In this paper, we consider the "merger paradox" in a quantity-setting game, although we should examine the case of a price-setting (Bertrand) game, e.g., Deneckere and Davidson (1985), who show that the effect of a merger on profits is positive in Bertrand competition. Recently, Chen and Li (2018) considered a merger between two competitors in a Bertrand-Edgeworth model and find that the effects of a merger depend on the tightness of capacity constraints.

2. A Model

2.1. Preliminary

We develop a three-firm $\{i, j, k\}$ model in a network industry, where each firm provides a homogeneous product (service, hereafter) associated with network externalities. This implies that although the intrinsic properties of the services are identical among the firms (providers), the expected network size of each service is not necessarily the same. For example, consider telecommunications and Internet businesses. Although the intrinsic functions of their services are similar, the network sizes (e.g., the number of subscribers) and the degree of connectivity differ.

Applying the framework of Economides (1996), we assume the following linear inverse demand function for firm i's service:

$$p_i = A - q_i - Q_{-i} + N(S^e_{ih}), \quad (1)$$

where $Q_{-i} = q_j + q_k$ is the total level of the rival firms' services, A is the intrinsic market size, and q_i is the level of firm i's service. $N(S^e_{ih})$ is a network externality function of S^e_{ih}, which is the expected network size of firm i's service in the cases of premerger $(h = N)$ and merger $(h = M)$. We assume a linear network externality function, i.e., $N(S^e_{ih}) = nS^e_{ih}$, where $n \in [0, 1)$ represents the degree of a network externality. The expected network size of firm i's service is given by:

$$S^e_{ih} \equiv q^e_i + \phi_h Q^e_{-i}, \; h = N, M, \quad (2)$$

where $Q^e_{-i} = q^e_j + q^e_k$ is the total expected size of the rival firms' services, and $\phi_h \in \{0, \delta\}$, $0 \leq \delta \leq 1$, is the degree of firm i's connectivity with the other firms $\{j, k\}$ in the cases of premerger $(h = N)$ and merger $(h = M)$.

When considering a market with network externalities, we should note the role of consumer expectations. In employing the concept of a fulfilled expectation, we assume that consumers form expectations of network sizes before firms make their output decisions (e.g., Katz and Shapiro, 1985). Thus, when determining their outputs, the expected network sizes are given for the firms. That is, following the terminology of Hurkens and López (2014), we consider the case of passive expectations[3]. Furthermore, to simplify the analysis, we assume that the marginal cost to provide services is zero. In reality, low

3) We can derive the same results in the case of responsive expectations as in the case of passive expectations.

and even negligible marginal running costs are readily observed in telecommunications and Internet businesses.

2.2. Premerger: Non-cooperative Cournot competition

We consider the premerger case, where three firms non-cooperatively compete on quantities à la Cournot in the market ($h = N$). Based on equation (1), the profit function of firm i is expressed as:

$$\pi_i = \{A - q_i - Q_{-i} + N(S^e_{iN})\} q_i, \tag{3}$$

where $S^e_{iN} = q^e_i + \phi_N Q^e_{-i}$. The first-order condition (FOC) of profit maximization is given by:

$$\frac{\partial \pi_i}{\partial q_i} = p_i - q_i = A - 2q_i - Q_{-i} + N(S^e_{iN}) = 0. \tag{4}$$

At a fulfilled expectation, i.e., $q^e_i = q_i$, $q^e_j = q_j$, and $q^e_k = q_k$, we obtain:

$$A - (2-n)q_i - (1-n\phi_N)Q_{-i} = 0. \tag{5}$$

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

$$q_N = \frac{A}{2-n+2(1-n\phi_N)}. \tag{6}$$

Because it holds that $p_N = q_N$, based on equation (4), the profit in the premerger case is expressed as $\pi_N = (q_N)^2$.

2.3. Horizontal merger and merger-related network connectivity

As mentioned in the Introduction, industries such as telecommunications, Internet businesses, banking, electricity, airlines, and railways are usually characterized as network industries. In these industries, network externalities and connectivity between the services affect the behavior and decisions of firms [4]. Accordingly, we investigate the conditions under which firms have an incentive to merge, i.e., how the degree of network externalities and the level of connectivity affect the profitability of a merger.

Without loss of generality, we assume that a merger takes place between two firms $\{i, j\}$, denoted as an insider I, while firm $\{k\}$ is an outsider (O) in the market. This implies that the insider (merged) firm is composed of two divisions $\{i, j\}$, and can be re-

4) For example, we observe strategic alliances created by mergers in the airline industry (see Bilotkach and Hüschelrath, 2012).

ferred to as a multidivisional firm. In this case, equation (2) can be revised as follows: $S^e_{iM} = q^e_i + \phi_M q^e_j + \phi_N q^e_k$ and $S^e_{jM} = q^e_j + \phi_M q^e_i + \phi_N q^e_k$. Thus, the joint profit of the merged firm can be expressed as:

$$\Pi_M = \pi_i + \pi_j$$
$$= \{A - q_i - Q_{-i} + N(S^e_{iM})\} q_i + \{A - q_j - Q_{-j} + N(S^e_{jM})\} q_j. \qquad (7)$$

The profit of the outsider is given by:

$$\pi_O = \{A - q_k - Q_{-k} + N(S^e_{kN})\} q_k, \qquad (8)$$

where $S^e_{kN} = q^e_k + \phi_N(q^e_i + q^e_j)$. Based on equations (7) and (8), the FOCs for the insider and outsider firms, respectively, are given by:

$$\frac{\partial \Pi_M}{\partial q_i} = p_i - q_i - q_j = A - 2q_i - 2q_j - q_k + N(S^e_{iM}) = 0, \qquad (9)$$

$$\frac{\partial \pi_O}{\partial q_k} = p_k - q_k = A - 2q_k - Q_{-k} + N(S^e_{kN}) = 0. \qquad (10)$$

We also obtain the FOC in a similar manner to equation (9) with respect to service (division) j. At a fulfilled expectation, i.e., $q^e_i = q_i$, $q^e_j = q_j$, and $q^e_k = q_k$, because of equations (2), (9), and (10), we have the following equations:

$$A - (2-n)q_i - (2-n\phi_M)q_j - (1-n\phi_N)q_k = 0, \qquad (11)$$
$$A - (2-n)q_k - (1-n\phi_N)Q_{-k} = 0. \qquad (12)$$

Assuming a symmetric equilibrium, i.e., $q_i = q_j = q_I$ and $q_k = q_O$, equations (11) and (12) can be rewritten as:

$$A - \{2-n+(2-n\phi_M)\} q_I - (1-n\phi_N) q_O = 0, \qquad (13)$$
$$A - (2-n)q_O - 2(1-n\phi_N)q_I = 0. \qquad (14)$$

Thus, we derive the following fulfilled-expectation equilibrium in the merger case:

$$q_I = \frac{2-n-(1-n\phi_N)}{D} A, \qquad (15)$$

$$q_O = \frac{2-n-(1-n\phi_N)+\{1-n(\phi_M-\phi_N)\}}{D} A, \qquad (16)$$

where $D \equiv (2-n)\{2-n+(2-n\phi_M)\} - 2(1-n\phi_N)^2 > 0$.

2.4. Merger profitability and the role of merger-related network connectivity

Comparing the profits in the cases of premerger and merger, we examine how the degree of merger-related network connectivity affects the profitability of a merger and, thus, the incentive for a merger.

Let us define the following: $\Delta\Pi_M \equiv 2(\pi_I - \pi_N)$ and $\Delta\pi_O \equiv \pi_O - \pi_N$, where $\Pi_M = 2\pi_I$,

$\pi_I = 2(q_I)^2$, $\pi_O = (q_O)^2$, and $\pi_N = (q_N)^2$. Using equations (6), (15), and (16), we derive the following relationships:

(i) $\Delta\Pi_M > (<) 0 \Leftrightarrow (\sqrt{2}-1)\{2-n-2(1-n\phi_N)\}\{2-n-(1-n\phi_N)\}$
$-(2-n)\{1-n(\phi_M-\phi_N)\} > (<) 0.$

(ii) $\Delta\pi_O > (<) 0 \Leftrightarrow (1-n\phi_N)\{1-n(\phi_M-\phi_N)\} > (<) 0.$

(iii) $\pi_I > (<) \pi_O \Leftrightarrow (\sqrt{2}-1)\{2-n-(1-n\phi_N)\}-\{1-n(\phi_M-\phi_N)\} > (<) 0.$

For the subsequent analysis, we assume that $\phi_N = 0$ and $\phi_M = \delta$, which expresses the efficiency of merger-related network connectivity on the demand side. This assumption implies that in the case of premerger, i.e., non-cooperative Cournot competition in the market, the network systems of firms are independent of each other, whereas, in the case of a merger, the integrated company from the merger has an incentive to own a jointly common network and operating systems of their services and to improve their levels. Thus, it is natural to assume that the degree of connectivity increases as a result of a merger, compared with the premerger case. Given this assumption, because of the relationships (i), (ii), and (iii) shown above, we have the following lemma.

Lemma.

(i) $\Delta\Pi_M > (<) 0 \Leftrightarrow \delta > (<) \mathrm{N}(n)$,

where $\mathrm{N}(n) \equiv \dfrac{2(3-2\sqrt{2})+(5\sqrt{2}-6)n-(\sqrt{2}-1)n^2}{n(2-n)} (>0).$

(ii) $\Delta\pi_O > 0$, because $1-n\delta > 0$.

(iii) $\pi_I < \pi_O$, because $(\sqrt{2}-1)(1-n)-(1-n\delta) < 0$.

Therefore, based on Lemma (i), we present the following proposition.

Proposition.

Given strong network externalities, if the degree of merger-related network connectivity is sufficiently large, i.e., $\delta > \mathrm{N}(n)$ for $2-\sqrt{2} < n < 1$ the merger is profitable. Otherwise, the merger paradox arises.

Proof.

For the function $\mathrm{N}(n)$, the following relationship holds.

$$\mathrm{N}(n) > (<) 1 \Leftrightarrow (1-n)\langle 2(3-2\sqrt{2})-(2-\sqrt{2})n\rangle > (<) 0 \Leftrightarrow n < (>) 2-\sqrt{2} \approx 0.59.$$

Thus, we derive the following cases:

(a) If $0 \leq n < 2-\sqrt{2}$, then $\mathrm{N}(n) > 1$. Thus, $\delta < \mathrm{N}(n) \Rightarrow \Delta\Pi_M < 0$.

(b) If $2-\sqrt{2} < n < 1$, then $\mathrm{N}(n) < 1$. Thus, $\delta > (<) \mathrm{N}(n) \Leftrightarrow \Delta\Pi_M > (<) 0$.

■

Given relatively weak network externalities, i.e., $0 \leq n < 2-\sqrt{2}$, as in Salant et al. (1983), the merger paradox arises. Even if this is not so, if the merged firm cannot sufficiently improve the degree of connectivity, i.e., $0 \leq \delta < \mathrm{N}(n)$ the merger is unprofitable. However, often, horizontal mergers in information and communications industries, e.g., telecommunications and Internet businesses, including traditional airline and railway companies, occur not only in advanced countries but also in emerging countries. This may imply that the degree of network connectivity between the merged firms in these industries is sufficiently large.

Lemma (ii) shows that the merger externality on the profit of the outsider is positive. Furthermore, related to Lemma (iii), with respect to the joint profits of the merged firm and the profit of the outsider, we have the following: $\Pi_M > (<) \pi_O \Leftrightarrow 2q_I > (<) q_O$. Based on equations (15) and (16), we obtain the following:

$$1 \geq \phi_M \Rightarrow \sqrt{2}\, q_I \leq q_O \Rightarrow \Pi_M \leq \pi_O,$$

where $\Pi_M = \pi_O$ if and only if $\phi_M = 1$. Thus, unless the merged firm provides a perfectly connectible service, the joint profits are lower than the profit of the outsider. Therefore, it is preferable for the outsider that the other firms merge[5).

2.5. Endogenous choice of the merger-related network connectivity

We have assumed that $\phi_N = 0$ and $\phi_M = \delta$, where $1 \geq \delta \geq 0 = \phi_N$. In this subsection, we examine the case of endogenous choice of connectivity by the insiders. That is, the joint profits of the merged firm are given by $\Pi_M = 2\pi_I$ and $\pi_I = 2(q_I)^2$. Furthermore, using equation (5), the quantity is rewritten as: $q_I = \dfrac{1-n}{(2-n)\{2-n+(2-n\delta)\}-2}A$. In this case, because we obtain $\dfrac{dq_I}{d\delta} = q_I\dfrac{(2-n)n}{(2-n)\{2-n+(2-n\delta)\}-2} > 0$, it holds that $\left.\dfrac{d\Pi_M}{d\delta}\right|_{1 \geq \delta \geq 0} > 0$. Thus, the insiders choose the perfect connectivity (compatibility) de-

5) Gugler and Szücs (2016) empirically analyze the externalities of mergers and demonstrate that the return on assets of rival firms (outsiders) increases significantly after a merger.

gree, i.e., $\delta = 1$ [6]. Because the merged firm provides a perfectly connectible service, the joint profits of the merged firm and the profit of the outsider are equal, i.e., $\Pi_M = \pi_O$. Furthermore, the proposition is revised as follows:

Revised proposition.

Given strong network externalities, i.e., $2-\sqrt{2} < n < 1$, the merger is profitable.

3. Conclusion

In the models of Perry and Porter (1985), and Farrell and Shapiro (1990), it is assumed that there are merger-related synergies on the supply side, i.e., cost savings, and they demonstrate the profitability of a merger in a homogeneous product (service) market. In this paper, focusing on the role of merger-related network connectivity, which induces synergies on the demand side, we have considered merger profitability (incentives for a merger) in a homogeneous service market with network externalities. In particular, we have found that, given strong network externalities, if the degree of merger-related network connectivity is sufficiently large, a merger is profitable. In this case, there is a positive externality with regard to the profit of an outsider.

Our model is based on specific assumptions, as a three-firm model with linear functions and limited parameters. It would be useful to relax these assumptions to analyze general cases. For example, we have dealt with a homogeneous service market with network externalities. We should examine the profitability of mergers, extending the model to the case of a horizontally differentiated product and service market. Furthermore, we have not examined the effect of the merger on welfare. This is related to mergers and competition policies in network industries, including, but not limited to, telecommunications and Internet businesses. Thus, in future research, we intend to examine an optimal merger policy in network industries.

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6) Toshimitsu (2018) demonstrates that there is a unique subgame perfect equilibrium where collusive firms (insiders) decide to provide perfectly compatible products to maximize their joint profits.

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