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Collusion in a differentiated duopoly with network externalities

Ruichao Song [a], Leonard F.S. Wang [b,*]

[a] Research Institute of Economics and Management, Southwestern University of Finance and Economics, Chengdu, China

[b] Wenlan School of Business, Zhongnan University of Economics and Law, Wuhan, China

HIGHLIGHTS

- Conventional wisdom is that collusion between firms will be destabilized when they produce closer substitutes of products.
- We show that in the presence of strong network externalities, this result no longer holds.
- Collusion becomes more sustainable for closer substitutes of products under relatively strong network externalities.

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ABSTRACT

Conventional wisdom is that collusion between firms will be destabilized when they produce closer substitutes of products. We show that, in the presence of strong network externalities, this result no longer holds, and collusion becomes more sustainable for closer substitutes of products under relatively strong network externalities.

1. Introduction

As generally argued, the common interest of firms would be to maximize joint profits by restricting output to the monopoly level. However, this outcome is not easy to reach without enforcing agreement and unless collusion is seen to be sustained in a given industry. Researchers in industrial organizations contribute a lot to understanding how the mechanisms of collusion work and whether demand-side or cost-side factors support the sustainability of collusion. In this paper, we aim to examine the sustainment of collusion in a differentiated duopoly with network externalities.

In an important paper on collusive behavior with product heterogeneity, Deneckere (1983) derived some basic results on the ability to maximize profits jointly in repeated Cournot and Bertrand duopolies. The model is simple, in that demand is linear and symmetric marginal costs are assumed to be constant.[1] An increase in the degree of product differentiation has two opposite effects on the ability to collude: deviation becomes less profitable, as it is more difficult to attract consumers of the rival firm by decreasing the price; however, the punishment will be less severe. In particular, Deneckere (1983) showed that, for a quantity-setting supergame, the first effect dominates and sustaining collusion becomes more difficult with an increasing degree of substitutability. Recently, Pal and Scrimitore (2016), demonstrated that, in an infinitely repeated Cournot game with trigger strategy punishment, the relationship between market concentration and collusion sustainability depends on the strength of network externalities. Their analytical result is derived in the absence of product differentiation.

* Correspondence to: Wenlan School of Business, Zhongnan University of Economics and Law, 182# Nanhu Avenue, East Lake High-tech Development Zone, Wuhan 430073, China.

E-mail addresses: songruichao@qq.com (R. Song), lfswang@gmail.com, lfswang@saemfan.org (L.F.S. Wang).

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[1] More works on the collusion behavior in the Cournot or/and Bertrand infinitely repeated game can be found in Abreu (1988), Chang (1991), Lambertini and Sasaki (2001), Østerdal (2003), and Matsumura and Matsushima (2012).

In this paper, we extend the analysis and show that, in an infinitely repeated Cournot game with trigger strategy punishment, the collusion will become more sustainable for closer substitutes of the products under network externalities.

2. The model

We assume that there are two firms producing differentiated goods with positive consumption externalities n and constant marginal cost of production, $c \geq 0$. Following Hoernig's original specification (2012), which is then used in Pal (2014), Bhattacharjee and Pal (2014), and Pal (2015),[2] the utility function of the representative consumer is given by $U\left(q_i, q_j; y_i, y_j\right) = m + \frac{\alpha(q_i+q_j)}{1-\gamma} - \frac{q_i^2+2\gamma q_i q_j+q_j^2}{2(1-\gamma^2)} + n\left(\frac{(y_i+\gamma y_j)q_i+(y_j+\gamma y_i)q_j}{1-\gamma^2} - \frac{y_i^2+2\gamma y_i y_j+y_j^2}{2(1-\gamma^2)}\right)$,[3] $i, j = 1, 2$, $i \neq j$, where m denotes the consumption of all other goods, q_i is the quantity of firm i's output, y_i is the consumer's expectation regarding firm i's total sales, and $\alpha > 0$, $0 < \gamma < 1$ and $0 \leq n < 1$ are preference parameters. The parameter γ indicates the degree of product differentiation, with a smaller γ corresponding to a higher degree of product differentiation. The parameter n indicates the strength of network effects, and $n = 0$ corresponds to the case of non-network goods.

From the utility function, we derive inverse and direct demand function for good i,

$$p_i = \frac{\alpha}{1-\gamma} - \frac{q_i + \gamma q_j}{1-\gamma^2} + \frac{n\left(y_i + \gamma y_j\right)}{1-\gamma^2}, \quad (1)$$

$$q_i = \alpha + n y_i - p_i + \gamma p_j. \quad (2)$$

The profit of firm i is given by

$$\pi_i = p_i q_i - c q_i, \quad (3)$$

where c denotes marginal cost for both firms and $0 < c < \frac{\alpha}{1-\gamma}$, so that consumers' highest valuation of the good is larger than is the marginal cost.

Following Katz and Shapiro (1985) and Hoernig (2012), we consider that consumer's expectations satisfy 'rational expectations' in the equilibrium, and, thus, we assume the following holds true in the equilibrium,

$$q_i = y_i, \qquad q_j = y_j. \quad (4)$$

3. The results and analysis

3.1. Monopoly

First if a collusion is achieved, the joint payoff is $\pi^M = \pi_i^M + \pi_j^M$, which is maximized at

$$q_i^M = q_j^M = \frac{\alpha - c(1-\gamma)}{2-n}, \qquad p_i^M = p_j^M = \frac{\alpha + c(1-\gamma)(1-n)}{(1-\gamma)(2-n)}. \quad (5)$$

The collusion payoff is

$$\pi_i^M = \pi_j^M = \frac{(\alpha - c(1-\gamma))^2}{(1-\gamma)(2-n)^2}. \quad (6)$$

3.2. Cournot competition

In Cournot competition, firm i independently decides q_i to maximize its payoff in Eq. (3), given q_j, y_i, y_j. Solving firm i's problem, we obtain its quantity reaction function (RF_i^C)[4]

$$q_i = \frac{(1+\gamma)[a - c(1-\gamma)]}{2} - \frac{\gamma}{2} q_j + \frac{n}{2}\left(y_i + \gamma y_j\right). \quad (7)$$

Solving RF_i^C, RF_j^C and using the 'rational expectations' condition in Eq. (4), we obtain the Cournot–Nash equilibrium output and profits,

$$q_i^{CN} = q_j^{CN} = \frac{(1+\gamma)[a - c(1-\gamma)]}{2+\gamma-n(1+\gamma)}, \quad (8)$$

$$\pi_i^{CN} = \pi_j^{CN} = \frac{(1+\gamma)[a - c(1-\gamma)]^2}{(1-\gamma)[2+\gamma-n(1+\gamma)]^2}. \quad (9)$$

3.3. Incentive to collude

The incentive condition for a collusion to be obtained is that the collusion payoff exceeds the competition payoff, i.e.,

$$\pi_i^M > \pi_i^{CN} \Rightarrow n < 1 - \sqrt{\frac{1}{1+\gamma}} = \hat{n}_I^C(\gamma), \quad (10)$$

$$\text{or,} \ \gamma > \frac{1}{(1-n)^2} - 1 = \hat{\gamma}_I^C(n). \quad (11)$$

It is easy to check that (a) $\hat{n}_I^C(\gamma) \in (0, 1)$ and $\frac{d\hat{n}_I^C(\gamma)}{d\gamma} > 0$, $\forall \gamma \in (0, 1)$, and (b) $\hat{\gamma}_I^C(n) \in (0, 1)$ for $n \in [0, 1 - \frac{1}{\sqrt{2}})$ and $\frac{d\hat{\gamma}_I^C(n)}{dn} > 0, \forall n \in (0, 1)$. As is depicted in Fig. 1, for combinations (n, γ) lying below the curve $n = \hat{n}_I^C(\gamma)$, we have $\pi_i^M > \pi_i^{CN}$. The collusion incentive condition implies that (a) it is always more profitable for firms to collude when there is no network effect, i.e., $\pi_i^M > \pi_i^{CN}$, if $n = 0$, and (b) firms may have no incentive to collude unless network externalities are sufficiently weak and this incentive condition is more likely to be satisfied for closer substitutes. In other words, the incentive condition implies that, for a network goods duopoly to pursue a collusion, their products must exhibit sufficiently high substitutability, i.e., $\gamma > \frac{1}{(1-n)^2} - 1$, and this critical value increases with the strength of network externalities.

Proposition 1. *In a duopoly with network externalities, a certain level of product substitutability is necessary for firms to benefit from collusion rather than Cournot competition. The stronger the network externalities, the higher the required degree of substitutability.*

Notice that (a) when network externalities are sufficiently strong ($n > 0.293$), no collusion can be obtained; (b) when the duopoly produces homogeneous products (i.e., $\gamma = 1$), collusion is only possible when the network is weak, which is consistent with Pal and Scrimitore (2016).

This result is different from Deneckere (1983), in which, without considering network effects, sustaining collusion becomes more difficult with an increasing degree of substitutability. The intuition goes as follows.

According to Eq. (2), due to network externalities, an increase in the expected output of own product will shift the firm's

[2] As the specification of Hoernig (2012) and other related papers, technical compatibility is not the issue considered in this paper.

[3] We thank the referee pointing out that the utility function is not defined for $\gamma = 1$, i.e. the homogeneous case, and providing an alternative specification. Nevertheless, please see that in the following passage that our conclusion, based on the current utility function, is extendable to the homogeneous case.

[4] SOCs for maximization and stability conditions are satisfied.