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Tacit collusion and market concentration under network effects

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HIGHLIGHTS

- We consider infinitely repeated competition in a Cournot oligopoly with network effects.
- We find that the number of firms must be sufficiently large for firms to have the incentive to collude.
- We demonstrate that the relationship between market concentration and collusion sustainability depends on the strength of network effects and the number of firms.
- Under certain circumstances, higher market concentration can make collusion unstable.

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ABSTRACT

In an infinitely repeated Cournot game with trigger strategy punishment, we demonstrate that the relationship between market concentration and collusion sustainability depends on the strength of network externalities. The latter is shown to interact with the number of firms and to affect the profitability of cooperation *vs.* competition, which delivers the result, challenging conventional wisdom, that lower market concentration can make collusion more stable.

1. Introduction

Cartel prosecution is at the core of competition policy and the understanding of cartel behavior in oligopoly markets is a major concern in Industrial Organization. Studies on tacit (or non-cooperative) collusion provides a game-theoretic foundation of cartel stability.[1] By modeling firm interactions as a infinitely repeated game, collusive behavior emerges as a sub-game perfect Nash equilibrium, provided that the discount factor of future firm payoffs is large enough. Literature following such a dynamic approach basically recognizes that market concentration facilitates collusion (Levenstein and Suslow, 2006).[2] Although the Chicago School viewed collusion as highly unstable in both concentrated and unconcentrated industries, and unlikely to raise antitrust concern (Brozen, 1977; Posner, 1979), a negative relationship between the number of firms in a market and cartel success is also supported by empirical evidence (Fraas and Greer, 1977; Davies et al., 2011, among others) and by experimental evidence (Huck et al., 2004; Fonseca and Normann, 2008).[3]

This paper examines the role of market concentration in sustaining collusion when consumers' preferences exhibit network

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1 See Martin (2006) for a distinction drawn between collusion as the outcome of a non-cooperative game and the antitrust concept of collusion.

2 As asserted in Levenstein and Suslow (2006, p. 44); 'cartels are much more likely to succeed in concentrated industries than in less concentrated ones'; and moreover: 'industry concentration makes collusion easier both by simplifying the coordination issues and by increasing firms' gains from collusion'.

3 Using a static approach in a Cournot model in which any enforcement problem is ruled out, Selten (1973) also shows that a small number of competitors determines a tendency towards cooperation.

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externalities (or network effects), namely when their utility increases as market gets larger. The latter have been shown to have relevant implications for economic analysis and antitrust enforcement:[4] indeed, they can represent a source of firm success and market power in network industries, such as telecommunications and utilities, and play a considerable role in the process of technology adoption and decision-making on network goods' pricing, compatibility and connectivity. The impact of cross network effects on platforms' incentives to collude in a two-sided market is examined in the working papers by Ruhmer (2011) and Boffa and Filistrucchi (2014). While in the latter the presence of network effects is shown to induce firms to charge, on one side of the market, prices above the two-sided monopoly price as a means to sustain collusion, in the former increasing network effects makes collusion harder to sustain by positively affecting the gains from collusion to a lesser extent than the gains from deviation. With the exception of the two above-mentioned works, research on cartel stability under network effects is still scarce. The present paper contributes to such research by studying the conditions for collusion stability in a Cournot oligopoly with network effects, when collusion is enforced *via* a trigger strategy (Friedman, 1971). We demonstrate that firms' incentives to collude depend on the strength of network externalities, the latter interacting with the number of firms in making collusion more or less stable as market becomes more concentrated. In particular, we find that, unless the strength of network externalities is very low, the possibility for collusion to be stable increases (decreases) with the number of firms when the latter is sufficiently low (high).

2. The model

We consider that there are k firms producing homogeneous network goods. Each firm incurs constant marginal(average) cost of production $c(\geq 0)$. Firms either compete in terms of quantities or form a grand coalition. The market demand function is assumed to be as follows

$$p = a + n\sum_{i=1}^{k} y_i - \sum_{i=1}^{k} x_i, \tag{1}$$

where p denotes price and x_i denotes the quantity of the good produced by firm i $(i = 1, 2, \ldots, k)$. y_i denotes the consumers' expectation regarding firm i's sales. $a(>c)$ and $n \in [0, 1)$ are demand parameters. Note that $\frac{\partial p}{\partial(\sum_{i=1}^{k} y_i)} = n$, i.e., if $n > 0$, the marginal willingness to pay for the good increases with the increase in consumers' expectation regarding total sales of all firms, since outputs of different firms are compatible and form one network. Thus, higher value of n indicates stronger network externalities. $n = 0$ corresponds to the case of non-network goods.

2.1. Cournot competition

Solving firm i's profit maximization problem under Cournot competition, $Max_{x_i}\,\pi_i = (a + n\sum_{j=1}^{k} y_j - \sum_{j=1}^{k} x_j - c)x_i$ $(i = 1, 2 \ldots k)$, we get the quantity reaction function $x_i = \frac{1}{2}(a - c - \sum_{j=1, j\neq i}^{k} x_j + n\sum_{j=1}^{k} y_j)$. Following Katz and Shapiro (1985), we solve for the Nash equilibrium satisfying the *rational expectations* condition that expected sales equal the actual sales in equilibrium, i.e. $y_i = x_i$. We thus obtain firm i's Cournot equilibrium output and profits as follows:

$$x_i^{CN} = \frac{a-c}{1+k(1-n)} \tag{2}$$

$$\pi_i^{CN} = \frac{(a-c)^2}{(1+k(1-n))^2}; \quad i = 1, 2 \ldots k. \tag{3}$$

2.2. Collusion

Maximization of industry profits π with respect to firm i's output can be written as $Max_{x_i}\,\pi = (a+n\sum_{j=1}^{k} y_j - kx_i - c)kx_i$ $(i = 1, 2 \ldots k)$, under the assumption that firms share the market (and thus industry profits) equally. From the first order condition of this problem, $a+n\sum_{j=1}^{k} y_j - 2kx_i - c = 0$, and by applying the rational expectations condition $y_i = x_i$, we get firm i's equilibrium collusive output and profits which are, respectively,

$$x_i^{CC} = \frac{a-c}{k(2-n)} \tag{4}$$

and $$\pi_i^{CC} = \frac{(a-c)^2}{k(2-n)^2}; \quad i = 1, 2, \ldots, k. \tag{5}$$

2.3. Incentive to collude

A firm has an incentive to collude, if its profit under collusion is greater than its Cournot profit, i.e., if

$$\pi_i^{CC} > \pi_i^{CN} \Rightarrow \frac{(k-1)(a-c)^2\left(k(1-n)^2 - 1\right)}{k(2-n)^2(1+k(1-n))^2} > 0$$
$$\Rightarrow n < 1 - \frac{1}{\sqrt{k}} = \hat{n}_I(k). \tag{6}$$

Clearly, $\hat{n}_I(k) \in (0, 1)$ and $\frac{\partial \hat{n}_I(k)}{\partial k} > 0, \forall k \in [2, \infty)$. It implies that, in non-network goods oligopoly $(n = 0)$, a firm always has an incentive to collude regardless of the number of firms in the industry. On the contrary, in network goods oligopoly there does not exist any incentive to collude, unless network externalities are sufficiently weak $(n < \hat{n}_I(k))$ — a condition that is more likely to be satisfied if there are more firms in the industry. The dashed curve in Fig. 1 depicts $n = \hat{n}_I(k)$ in kn-plane. For each (k, n) combination lying below (above) the dashed curve $n < (>)\hat{n}_I(k)$ and, thus, collusive profit is greater (less) that Cournot profit. It follows that, for it to be profitable for firms to collude, there must be more than a critical number $(1/(1-n)^2)$ of firms in the industry — such a critical number being increasing in the strength of network effects.[5]

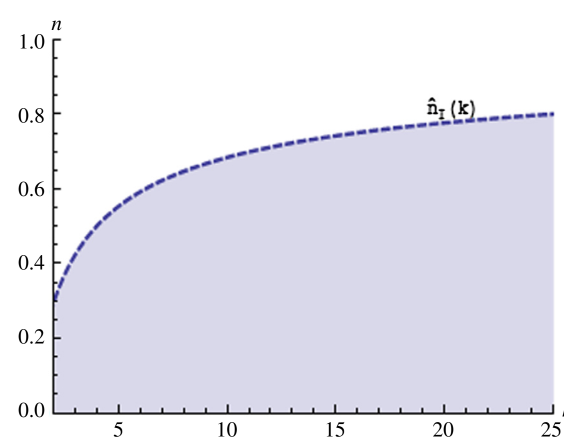

Fig. 1. Collusion incentive.

[4] See Shy (2011) for a recent survey on the economics of network effects and Economides (2009) for an analysis of antitrust issues in network industries. See also Birke (2009) for an empirical literature review in the field, and Devetag (2003) and Ruffle et al. (2015) for experimental evidence on the concept of critical mass in network markets.

[5] Note that condition (6) implies $k > 1/(1-n)^2$.