Does cartel leadership facilitate collusion?

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Abstract

We discuss the implications of a Stackelberg sequence of play between a cartel and the fringe. We consider two different approaches to collusion: (i) one-stage static model and (ii) a multi-period oligopoly model. Our main result is that in the static model with quantity-setting firms a stable cartel only exist when cartel firms behave as a Stackelberg leader. It is also shown that in the supergame approach the cartel is always more easily sustained with the leadership than in the simultaneous-moves game. The opposite result is obtained in a price-setting supergame with differentiated products.

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1 Introduction

The analysis of cartel formation in oligopoly markets has a long tradition in the economic literature. One of the most widely accepted structures to characterize collusive behavior it that of a leader cartel. However, the effects of the leadership assumption on cartel success is often not discussed. We address this issue using two different approaches to collusion for an industry with quantity-setting firms. First, we analyze cartel stability in a static model using the concept of cartel stability by d'Aspremont, Jacquemin, Gabszewick and Weymark (1983) —henceforth, d'AJGW — where a cartel is stable if no firm inside the cartel finds it desirable to exit and no firm outside the cartel finds it desirable to enter. By their very nature, in a static model cartel members do not cheat on a cartel agreement since it is assumed that agreements are sustained through binding contracts. This may therefore, be viewed as a model of explicit or binding collusion. To the best of our knowledge the literature on static cartel stability has assumed cartel leadership (see for instance Donsimoni (1985), Donsimoni, Economides and Polemarchakis (1986) or Shaffer (1995).[1] We show that when the cartel does not behave as a leader with respect to the fringe no cartel is stable. The intuition is that firms have incentives to exit the cartel in order to free ride from the output reduction agreed by the cartel. On the other hand, the supergame-theoretic approach to collusion has focused on the problem of enforcement of collusive behavior (see for example the seminal paper by Friedman (1971)). In these models, seemingly independent but parallel actions among competing firms in an industry are driven to achieve higher profits. This is termed tacit or implicit collusion. Although the tacit collusion literature is immense, it has usually focused on the equilibrium that maximizes industry profits (see for example Rothschild (1999))[2] or to duopolies with product differentiation (see for instance Deneckere (1983), Rothschild

[1] Among the few exceptions that analyze the sequence of moves between a cartel and a fringe are Shaffer (1995) and Prokop (1999). Both papers discuss the reasonableness of this assumption in a static framework with homogeneous products. Their findings tend to support the assumption of a Stackelberg cartel.

[2] An exception is Posada (2001) who considers exclusively the leader cartel.

(1992) or Albæk and Lambertini (1999)). In the present paper we consider the general case where a subset of firms are assumed to collude while the remaining firms choose their output levels noncooperatively and compare the models with cartel leadership and simultaneous moves. We analyze a implicit collusion model using subgame perfect Nash equilibria —henceforth, SPNE— as solution concept and restricting strategies to grim trigger strategies. We obtain that the leader cartel is always more easily sustained than the cartel that simultaneously decide quantities with the fringe. Our results indicate thus that with quantity competition cartels tend to be more successful when the cartel is allowed to lead. The intuition is that since firms may have incentives to exit the cartel in order to free ride from the output reduction agreed by the cartel, the relatively higher profits of the cartel attract more firms out of the fringe into the cartel as compared with the case of simultaneous play. We prove then, that previous results on cartel stability and cartel sustainability with quantity competition are sensitive to the assumption of cartel leadership. We also test whether our results depend on the quantity competition and homogeneous products assumptions. We show that regardless the degree of product substitutability, the leader cartel is more easily sustained only when firms set quantities. On the contrary, we obtain that if the price competition assumption seems justified, cartel leadership hinders collusion.

The remainder of this paper is structured as follows. In section 2 we present the model and study cartel stability in a one-stage game and cartel sustainability in a multi-period oligopoly model. In section 3 we also consider differentiated products and price competition. We conclude in section 4. All proofs are grouped together in the appendix.

2 The model

We consider an industry with $N > 2$ firms, indexed by $i = 1, ..., N$. Each firm produces a quantity of a homogeneous product and for simplicity, it is assumed that the total production cost of the firms is equal to zero. We denote by q_i the output produced by firm i. The industry inverse demand is given by the piecewise linear function

$$p(Q) = \max(0, a - Q)$$

where $Q = \sum_{i=1}^{N} q_i$ is the industry output, p is the output price. We assume that one cartel is formed, in such a way that $K \leq N$ firms —henceforth, cartel firms— behave cooperatively so as to maximize their joint profits. The remaining $(N-K)$ firms constitute the fringe and choose their output in a non-cooperative way.

We denote by $\Pi^c(N,K)$ and $\Pi^f(N,K)$ the profit function of a cartel firm and that of a fringe firm respectively. We analyze two different variations of the model described above: (i) when cartel and fringe firms simultaneously choose quantities, and (ii) when cartel firms behave as a Stackelberg leader with respect to the fringe.

2.1 Cartel stability

In this subsection we consider a model of explicit collusion. When cartel firms behave as a Stackelberg leader with respect to the fringe, the game consists of three stages. In the first one the firms decide independently whether or not to be part of the cartel. In the second stage the cartel collectively sets the Stackelberg leader output, and in the third stage, the fringe sets it output. Conversely, when cartel and fringe firms simultaneously choose quantities we assume a two-stage game where once the cartel is formed all firms simultaneously produce. We predict, by backward induction, the number of firms that will join the cartel in the first stage of the game. To that extent, we focus on the standard stability such that no individual move is desirable. In particular, a number $0 < K \leq N$ of firms join the cartel if and only if

$$\Pi^c(N,K) \geq \Pi^f(N,K-1) \tag{1}$$

and

$$\Pi^f(N,K) \geq \Pi^c(N,K+1). \tag{2}$$

We note that these conditions are equivalent to the stability concept proposed by d'AJGW where no individual move is desirable and where firms hypothesize that no other firm will change its strategy concerning its membership in the cartel.[3] Apart from the degenerate case of $K = 1$, a cartel can be defined as internally stable if it is not profitable for a cartel member to defect to the fringe (condition (1)). Likewise, apart from the degenerate case of $K = N$,.a cartel is said to be externally stable if it is not profitable for a fringe firm to join the cartel (condition (2)).

Definition 1 *A cartel is said to be stable if it is both internally and externally stable.*

We can now state the following Proposition proved in the appendix.

Proposition 1 *When all firms simultaneously choose quantities, no cartel is stable. When the cartel behaves as a Stackelberg leader with respect to the fringe, a stable cartels exists if $N \geq 4$ and if $K \in [f(N), f(N)+1]$ where $f(N) = \frac{1}{4}(1 + 3N - \sqrt[2]{(N-2)N-7})$. If $N < 4$ the unique stable cartel is joint monopoly.*

When all firms simultaneously choose quantities, no cartel is stable because firms inside the cartel find it desirable to exit.[4] By contrast, a stable leader cartel contains just over half the firms in the industry since with the leadership, the relatively higher profits of the cartel attract more firms out of the fringe into the cartel as compared with the case of simultaneous play.

2.2 Cartel sustainability

In this subsection we consider an industry where firms play an infinitely repeated oligopolistic game. We assume that cartel firms collude in quantities over an infinite time horizon

[3] Thoron (1998) proves the correspondence between this stability concept and the Nash equilibria.

[4] We remark also the similarity with the result in Salant et al. (1983) that, with simultaneous play, mergers are generally not profitable. As in the cartel case, unprofitability comes from the fact that non-participant firms react to the merger (or cartel) by increasing their output. However, mergers can still be profitable if a sufficiently large number of firms are involved in the merger since the free-rider problem is alleviated by the reduction in the number of firms.

with complete information (i.e. each of the firms either fringe or cartel observes the whole history of actions) and discount the future using a discount factor $\delta \in (0,1)$. As in the previous subsection we consider two different cases (i) all firms simultaneously choose quantities and (ii) in every period the cartel anticipates the fringe and behaves as a Stackelberg leader with respect to the fringe. For simplicity, we restrict our attention to the case where each cartel firm is only allowed to follow grim trigger strategies, i.e., after any deviation at time t cartel firms revert to the relevant one-shot Nash equilibrium strategy. Regarding fringe firms, their optimal response consists of maximizing their current period's payoff. As shown by Friedman (1971), cartel firms colluding in each period can be sustained as a SPNE of the repeated game if and only if for given values of N, K and δ, the following condition is satisfied

$$\frac{\Pi^c(N,K)}{1-\delta} \geq \Pi^{ch}(N,K) + \frac{\delta\Pi(N)}{1-\delta} \tag{3}$$

where $\Pi^{ch}(N,K)$ denotes the profits attained by an optimal deviation from the collusive output, and $\Pi(N)$ denotes the Nash equilibrium profits. Evaluating condition (3) in terms of the return rate $r \equiv \frac{1-\delta}{\delta}$ results in $r \leq r^* \equiv \dfrac{\Pi^c(N,K) - \Pi(N)}{\Pi^{ch}(N,K) - \Pi^c(N,K)}$ which is the critical value below which a cartel member does not have incentives to deviate. Therefore, r^* can be seen as a measure of the cartel sustainability. An easy comparison reveals the following result.

Proposition 2 *The leader cartel is always more easily sustained than the cartel that simultaneously decide quantities with the fringe.*

In other words, it seems more plausible that a collusive quantity-setting industry is characterized by a cartel leadership. Intuitively, cartel profits are higher with leadership and furthermore the gains from chiseling are higher in the simultaneous decision game. Consequently, the game with cartel leadership is more effective in enforcing an agreement.

3 Extensions

In this section we test whether our results hinge on the assumption of quantity competition and homogeneous products by considering also differentiated products and price competition. To that extent, we assume that the industry produces non-spatial horizontally differentiated products such that the degree of differentiation between the products of any two firms is the same. Thus, the inverse demand function exhibits a Chamberlinian symmetry:

$$p_i = a - q_i - b \sum_{j \neq i} q_j$$

where p_i denotes the price of good i and q_j the quantity sold of good j. Alternatively, we can write the demand system as

$$q_i = \alpha - \beta p_i + \gamma \sum_{j \neq i} p_j$$

where $\alpha = \frac{a}{1+(N-1)b}, \beta = \frac{1+(N-2)b}{(1-b)(1+(N-1)b)}$ and $\gamma = \frac{b}{(1-b)(1+(N-1)b)}$.It is assumed $a, b > 0$ and $0 \leq b \leq 1$. The value range for b (the common degree of product substitutability) implies that the products are viewed as substitutes rather than complements and that the price of each product is more susceptible to changes on its own demand rather than changes on other product demand. When products are differentiated, the computation of cartel stability is intractable. However, numerical simulations can be conducted. We offer examples to analyze whether the results of the previous section regarding cartel stability extend to the heterogenous products case. The following tables show the unique stable cartel (K) for different values of N and b in four cases: quantity and price competition with leadership and simultaneous decision.

Quantity competition and cartel leadership

b\N	2	3	4	5	10	20
0.2	2	3	3	3	3	4
0.4	2	3	3	3	4	5
0.6	2	3	3	3	4	7
0.8	2	3	3	3	5	9

Simultaneous quantity competition

b\N	2	3	4	5	10	20
0.2	2	2	2	2	/	/
0.4	2	2	/	/	/	/
0.6	2	/	/	/	/	/
0.8	2	/	/	/	/	/

Price competition and cartel leadership

b\N	2	3	4	5	10	20
0.2	2	3	3	3	/	/
0.4	2	3	/	/	/	/
0.6	2	/	/	/	/	/
0.8	2	/	/	/	/	/

Simultaneous price competition

b\N	2	3	4	5	10	20
0.2	2	3	3	3	4	5
0.4	2	3	4	4	5	6
0.6	2	3	4	5	6	6
0.8	2	3	4	5	6	6

These tables indicate that with quantity competition the stable cartel always exists only when the cartel behaves as a Stackelberg leader. The reverse is true when firms compete in prices. It seems thus reasonable to suppose that the intuition behind Proposition 1 extends to the differentiated products case when firms compete in quantities and is reversed when firms compete in prices.

We can also analyze cartel sustainability extending the analysis of subsection 2.2 to price competition and differentiated products. Its is a standard exercise to obtain the critical values below which a cartel member does not have incentives to deviate in four different settings: a Cournot supergame where firms set quantities or a Bertrand supergame where they choose prices with cartel leadership or simultaneous decision between the cartel and the fringe.

Proposition 3 *In a Cournot supergame with differentiated products, the leader cartel is always more easily sustained than the cartel that simultaneously decide quantities with the fringe. In a Bertrand supergame with differentiated products, the leader cartel is always less easily sustained than the cartel that simultaneously decide prices with the fringe.*

Therefore, Proposition 2 carries over to a model with differentiated products. However, the implications on cartel sustainability derived in Proposition 2 do not carry over when firms compete in prices. This difference follows from the fact that reaction functions are upward sloping in price games but downward sloping in quantity games. With cartel leadership, the reaction of fringe firms reinforces the initial price increase that results from the cartel price and therefore the intuitions provided in the previous section are reversed when firms compete in prices.

4 Concluding comments

We have developed a theoretical framework to study how the sequence of play between the cartel and the fringe affects cartel stability and cartel sustainability. We show that using a standard stability concept, with quantity competition no cartel is stable unless the cartel is allowed to lead. Regarding cartel sustainability in a repeated game, we prove that cartel leadership only facilitates tacit collusion in a Cournot supergame where firms set quantities. Our findings suggest then that in a cartelistic industry, the Stackelberg model is more plausible than the simultaneous-move model if firms set quantities. Conversely, when firms choose prices cartel leadership hinders collusion. Therefore, antitrust authorities may be extremely wary to consider cartel leadership as a factor that facilitates collusion.

We note also that cooperation within a cartel is similar to the outcome of horizontal mergers in the absence of synergies, although unlike a cartel, a merger usually reduces the number of firms in the industry. Therefore, the present paper presents a contrasting result to the analysis of exogenous Cournot mergers in Salant, Switzer and Reynolds (1983), and confirms that the endogenization of the merger decision depends also on the sequence of moves within the firms.

The framework we have worked with is, admittedly, a particular one. To analyze real-world cases of cartels, firms' capacities or cost asymmetries should also be considered. Other natural questions are also which is the appropriate endogenous sequence of play between the cartel and the fringe and how the cartel could be able to impose its most preferred timing in a cartelistic model. We believe that those are subjects for future research.

Appendix

Proof of Proposition 1. When firms simultaneously choose quantities it can be easily proved that

$\Pi^c(N,K) = \frac{a^2}{K(N-K+2)^2}$ and $\Pi^f(N,K) = \frac{a^2}{(N-K+1)^2}$ It is immediate to see that internal stability holds if $\Pi^c(N,K) \geq \Pi^f(N,K-1) \Longrightarrow \frac{1}{K(N-K+2)^2} - \frac{1}{(N-K)^2} \geq 0$ which is true if $N \in [-2 - \frac{2}{1+\sqrt{K}} + K, -2 + \frac{2}{1+\sqrt{K}} + K]$ but this cannot hold if $K \leq N$. When the cartel behaves as a Stackelberg leader $\Pi^c(N,K) = \frac{a^2}{4K(N-K+1)}$ and $\Pi^f(N,K) = \frac{a^2}{4(N-K+1)^2}$. It can be easily verified that internal and external stability become $\frac{a^2(2K^2+(2+N)^2-K(5+3N))}{4K(1+N-K)(2-K+N)^2} \geq 0$ and $\frac{a^2(1+K(2K-1)+N(N-3K+1))}{4(1+K)(K-N)(1-K+N)^2} \geq 0$ respectively. If $N < 4$ external stability is never met unless $K = N$. In the later case, internal stability holds if $N \leq 4$. If $N \geq 4$ internal stability holds if $K \leq \frac{3}{4}N - \frac{1}{4}\sqrt{(N-2)N-7} + \frac{5}{4}$ and external stability holds if $K > \frac{1}{4}(1+3N-\sqrt{(N-2)N-7})$. Hence, it follows that since $(\frac{3}{4}N - \frac{1}{4}\sqrt{(N-2)N-7}+\frac{5}{4}) - \frac{1}{4}(1+3N-\sqrt{(N-2)N-7}) = 1$, stable cartel exists only when both conditions hold and that is for $K \in [f(N), f(N)+1]$ where $f(N) = \frac{1}{4}(1+3N-\sqrt{(N-2)N-7})$. ■

Proof of Proposition 2. It is easy to prove that the return rate defined in subsection 2.2 is obtained as $r_S^* = \frac{4K(K(3+2N)-K^2-(1+N)^2)}{(-1+K)(1+N)^2}$ and $r_L^* = \frac{4K(1-K+N)}{(1+N)^2}$ where subscripts S and L indicate respectively whether cartel and fringe firms simultaneously choose quantities or cartel firms behave as a Stackelberg leader. It is immediate to verify that $r_L^* - r_S^* = \frac{4K(N-K)}{(1+N)(-1+K)} > 0$. ■

Proof of Proposition 3. It is a straightforward exercise to calculate the return rates. We denote this return rates by r_S^B, r_L^B, r_S^C and r_L^C where C and B indicate respectively whether firms set quantities or choose prices

$$r_S^B = \frac{-4(1+b(N-2))(4-4K+4b(-4+4K+K^2+2N-3KN)+b^2(21+K^3-22N+5N^2+3K^2(2N-5)+K(-19+34N-11N^2))+b^3(K^3(N-2)+(N-3)^2(N-1)+K^2(14-11N+2N^2)+K(6-23N+16N^2-3N^3)))}{(K-1)(4+6b(N-2)+b^2(9-9N+2N^2))^2}$$

$$r_L^B = \frac{4(1-2b+bN)(2-3b+bK+bN)(2-5b+3b^2-bK+2b^2K+3bN-4b^2N-b^2KN+b^2N^2)}{(2-3b+Nb)^2(2-3b+2bN)^2}$$

$$r_S^C = \frac{4(4(K-1)+4b(2+(K-2)K-N)+b^3(N-1)^2-b^2(5+K^3+K^2(1-2N)+(N-6)N+K(N-1)(3+N)))}{(-2+b)^2(-1+K)(2+b(-1+N))^2}$$

$$r_L^C = \frac{4(-2+b(1+K-N))(-2-b(-3+b+K)+(-1+b)bN)}{(-2+b)^2(2+b(-1+N))^2}$$

We only have to check that $r_S^B - r_L^B = \frac{4bK(1+b(N-2))(N-K)}{(K-1)(2+b(N-3))(2+b(2N-3))} > 0$ and $r_S^C - r_L^C = \frac{4bK(N-K)}{(b-2)(K-1)(2+b(N-1))} < 0$. We note that r_S^B, r_L^B are valid only for the case where $K < N$ since otherwise when the cheating member deviates, the remaining demand of the cartel members may become negative. In this case the cheating firm maximizes its profits by reducing its price until the demand of the remaining cartel members is equal to zero. ■

References

-Albæk, S. and Lambertini, L., (1998). "Collusion in differentiated duopolies revisited". *Economics Letters 59 (1998), pp. 305–308.*

-d'Aspremont, C. Jacquemin, A., Gabszewick, J.J. and Weymark, J.A., (1983). "On the Stability of Collusive Price Leadership". *Canadian Journal of Economics 16 (1), 17-25.*

-Deneckere, R., (1983). "Duopoly supergames with product differentiation". *Economics Letters 11, 37–42.*

-Donsimoni, M.-P., (1985). "Stable Heterogenous Cartels". *International Journal of Industrial Organization 3(4), 451-467.*

-Donsimoni, M.-P. Economides, N. and Polemarchakis, H., (1986). "Stable Cartels". *International Economic Review 27, 317-327.*

-Friedman, J.W., (1971). "A Non-cooperative Equilibrium for Supergames". *Review of Economic Studies 28, 1-12.*

-Posada, P., (2001). “Leadership cartels in industries with differentiated products“. *University of Warwick Economic Research Paper No. 590.*

-Prokop, J., (1999). “Process of dominant-cartel formation“. *International Journal of Industrial Organization 17, 241–257.*

-Rothschild, R., (1992). “On the sustainability of collusion in differentiated duopolies”. *Economics Letters 40, 33–37*

-Rothschild, R., (1999). “Cartel stability when costs are heterogeneous”. *International Journal of Industrial Organization 17, 717-734.*

-Salant, S. Switzer, S. and Reynolds, R., (1983). “The Effects of an Exogenous Change in Industry Structure on Cournot-Nash Equilibrium”. *Quarterly Journal of Economics 98(2), 185-199.*

-Shaffer, S., (1995). “Stable Cartels with a Cournot Fringe”. *Southern Economic Journal 61, 744-754.*

-Thoron, S., (1998). “Formation of a Coalition Proof Stable Cartel”. *Canadian Journal of Economics 31, 63-76.*