



Collusion Theory: Where to Go Next?

LUÍS M. B. CABRAL

lcabral@stern.nyu.edu

Stern School of Business, New York University, 44 West 4th Street, New York, NY, 10012, USA

Abstract. This note comments on Feuerstein's (Feuerstein, Switgard, "Collusion in industrial economics: A survey," forthcoming in *Journal of Industry, Competition and Trade*, 2005) survey of collusion theory. I start by presenting evidence from a recent real-world collusion case: the lysine industry. Based on this, I point out a few areas where collusion theory can improve: (a) the problem of equilibrium choice (bargaining over each firm's share), which is especially important in asymmetric oligopolies; (b) the problem of equilibrium implementation, including in particular communication in an asymmetric information context; and (c) the relation between price wars and collusion. I conclude with a few notes on policy issues, namely leniency programs and cartel detection strategies.

Keywords: collusion, cartels, public policy

JEL classification: C720, K210, L120

Collusion theory has made significant progress in the past three decades. Feuerstein (2005) provides a very competent survey and summary of the main findings. Except for a few references that I will include below, there is little I would add to the survey as a survey. Instead, in this note I will make a few comments on possible future directions for collusion theory.

One aspect of collusion theory that is somewhat troubling is the disconnect between optimal collusion theory, simple (grim-strategy) collusion models, and real world firm behavior. Feuerstein (2005, p. 39) states that "Due to their complexity, optimal punishments and stick-and-carrot punishments are treated as a separate subject in the literature. In applications, grim trigger strategies are used." Based on relatively standard assumptions, optimal collusion theory predicts potentially complex equilibrium patterns that don't always match the behavior of most real world industries.¹ On the other hand, the restriction to grim strategies seems rather arbitrary and, once again, not particularly concordant with the behavior of real world industries and cartels.

Why this disconnect between optimal collusion theory and the cartels we actually observe? One possibility is that the computational costs involved in optimal agreements are too large. A second possibility is that subgame perfection is not the right equilibrium concept, and that some form of renegotiation proofness is required. Thirdly, in the real world the information constraints faced by firms are different from the ones normally assumed in collusion theory. An additional source of constraints is antitrust policy: an optimal collusion scheme may lead to such unusual price patterns that it would be easily

¹ Important contributions to optimal collusion theory include Abreu (1988), Abreu et al. (1990), Fudenberg et al. (1994) and, more recently, Sannikov (2004).

screened for investigation. Finally, much of collusion theory concerns the optimal solution for a symmetric cartel. In reality, however, cartel participants are different from each other (cost, production capacity, etc); and then the issue of which firm gets what is at least as important as the overall plan for the cartel.

All of this suggests that the way forward is to (a) understand what the real constraints on collusive behavior are; (b) work on a theory of optimal collusive behavior subject to these constraints. Hopefully the result will be a series of models that better describe the actual nature of tacit collusion and explicit price-fixing agreements. In the next sections, I offer a few suggestions in greater detail.

1. How does price-fixing actually work? The ADM case

Given the current disconnect between theory and anecdotal observation, I believe it makes sense to pay more attention to the actual working of tacit collusion and price-fixing agreements. Various authors have looked at crosssection cartel data sets and studied factors that lead to more successful cartels; see the interesting references cited and surveyed by Feuerstein (2005).² Still more interesting for our purpose is the detailed analysis of particular price-fixing agreements. For example, Porter (1983), Levenstein (1997), Genesove and Mullin (2001), look at legal cartels (legal at the time) for grain shipping, bromide and sugar, respectively. I will return to these later.

One case that I find particularly interesting is lysine, an industry dominated by Archer Daniels Midland Company (ADM) and a number of Japanese, Korean and European firms. This case is interesting for two reasons: (a) it's recent (the relevant cartel events took place during the 1990s); and (b) the wealth of detailed information is considerable (including FBI videotapes of actual cartel meetings). The events of the case are masterfully reported in Eichenwald (2000), a 600 page book from which I now summarize the main relevant points for collusion theory.³

As we will see, asymmetric information is prevalent at various levels in the case. To begin with, firms were not sure of their competitors' capacity levels. According to Eichenwald (2000), executives from ADM's Japanese competitors visited ADM's plant "so that they could learn whether the company was bluffing about its capacity" (Eichenwald, 2000, p. 67). Not that this stopped ADM from further bluffing: At one point, ADM's Mark Whitacre received a call from David Hoech, an industry consultant whose clients included several of ADM's competitors. In a confident, almost arrogant tone, Whitacre told Hoech that ADM had enough capacity and low enough cost to go into a price war. Whitacre's hope was that the information would eventually leak to ADM's competitors (see Eichenwald, 2000, p. 141).

Eventually, at a June 1992 meeting in Mexico, lysine competitors agreed on a price. But that didn't stop ADM from cheating. ADM was expected to produce 45 thou-

2 One additional reference of interest is Stocking and Watkins (1946).

3 See also Connor (2004), Lieber (2000).

sand tons. ADM's competitors suspected ADM was producing 50. In fact, its output level was 68.

The topic of lysine prices came up at a dinner meeting in Chicago between ADM and European executives. The latter complained about low prices and accused ADM of being responsible for it. ADM's Whitacre responded that "one can point a lot of fingers," and that the best thing to do was to find a solution to the problem.

His colleague Terry Wilson proposed a strategy according to which "each company reported sales numbers to the other producers. That way, competitors would know which company was pushing down prices by selling too much. That company would be allocated fewer sales for the following month. If the companies cooperated, everyone would receive a fair share and prices would hold" (Eichenwald, 2000, p. 155).

Specifically, the plan was that output figures would "be collected every month by the trade association. Lots of industries did that to legally learn the size of their markets. But, while the trade association could tell them the total, it would have to keep the individual production numbers for each company a secret. Sharing those numbers would almost certainly be illegal. That's where the scheme came in. No one would question why each company had collected monthly sales data if it was turned over to the association. Then secretly, the companies could swap the numbers among themselves to enforce the volume agreement. If one company sold more than it was allotted, it would be forced to purchase lysine from companies lagging behind. That would keep everyone on target," Wilson said (Eichenwald, 2000, p. 205).

2. From empirical observation to theory

There are several takeaways from studying a case like ADM. First, firms don't just come up with a cartel equilibrium solution. There are many possible equilibria, and an important phase in the collusion process is the negotiation about each firm's "cut." Incomplete information plays an important role here: each firm's capacity and cost levels, which determine their bargaining position, are private information.

A second important point is that an agreement is not just about price and output levels; it also includes the mechanism by which the agreement is to be implemented and maintained. In the lysine case, the idea was to share data on monthly production levels, with the agreement that if a firm were to exceed its quota in a given month it would compensate for it the next month, so as to reach the target quota by the end of the year.

Previous studies on the inner workings of cartels seem to corroborate this point. For example, Genesove and Mullin (2001) show that in the sugar cartel there was no explicit agreement about prices and output levels; rather, the agreement spelled out specific, detailed, rules (e.g., prices must be posted) to ensure cheating would be easy to detect.⁴

A third important point raised by the ADM case concerns price wars.⁵ The received theory sees price wars as an equilibrium phenomenon. Under perfect observability price

4 Genesove and Mullin (2001) go on to observe that "the theory ignores the inevitable incompleteness of collusive agreements [and] provides no role for rich communication within the agreement."

5 The following paragraphs are adapted from Section 8.2 of Cabral (2000).

wars are a threat that is never realized in equilibrium. Under imperfect observability, price wars do take place, even though cheating never occurs. Specifically, in the Green and Porter (1984) model all firms simultaneously enter into a price war when observed demand is low. In other words, cheating does not occur in a collusive agreement; and price wars, when they occur, form part of a coordinated enforcement process.

The reality of ADM shows that cheating does take place. Moreover, rather than equilibrium enforcement, price wars correspond to competitor retaliation or an attempt to improve a firm's bargaining position. Finally, the ADM example shows price wars that are initiated by one firm, not simultaneously by all firms.

Other industries corroborate the view of price wars beyond the role of equilibrium enforcement. According to Levenstein (1997), in the bromine cartel "severe price wars were part of a bargaining process, in which firms tried to force renegotiation to a new collusive equilibrium with a different distribution of rents." In her study of the airline industry, Busse (2002) suggests that price wars are initiated (unilaterally) by financially troubled firms.

Two other interesting instances of price wars relate to the newspaper industry. The first one is the 1993 British newspaper price war. This war was unilaterally initiated by the *Times*, which shortly before had been acquired by Rupert Murdoch. The *Times* price first dropped from 45 to 30p, then to 20p. Some rivals followed suit, some did not. After 18 months of price war, the *Times*' circulation had increased from 360,000 to more than 650,000; and prices returned to their initial level. A similar pattern took place in the 2000 New York tabloid price war. This war was unilaterally initiated by the *New York Post*, which again had been acquired by Murdoch shortly before.

This abundance of empirical observation begs for a better theory (or theories) of collusion and price wars. Some of this work is under way. For example, Athey and Bagwell (2001) characterize optimal collusive conduct among firms whose costs are subject to privately observed, i.i.d., cost shocks. They assume that firms may exchange messages (e.g., cost levels) but not side-payments. Given these assumptions, they show that the "optimal solution involves extensive use of 'market-share favors,' whereby individual firms are treated asymmetrically as a reward or punishment for past behavior." This reflects some of the patterns observed in the ADM case.

Athey and Bagwell (2004) extend their previous framework by considering the case when cost shocks are serially correlated. They show that, under some conditions, the optimal solution is to set price at a rigid level.⁶ This seems to square with the empirical evidence that prices are more rigid in concentrated industries (though this might occur for reasons other than collusion).⁷

Harrington and Skrzypacz (2005) consider a repeated game where market shares are perfectly observable but prices are not, an assumption that seems consistent with the facts of the lysine market. They show a surprising impossibility result: no collusion can

6 In particular, they require a large degree of serial correlation.

7 Athey et al. (2004) also provide a price rigidity result under i.i.d. shocks for collusive schemes that correspond to strongly symmetric equilibria. See also the related research by Compte (1998), Kandori and Matshushima (1998).

be sustained by symmetric punishments. In fact, under symmetric punishments a firm that cut price would increase the probability that its market share would go past the punishment threshold; but it would also decrease the probability that the rival's market share would go past that trigger, so that the net change in probability of punishment is zero. While no symmetric punishment equilibrium exists, there exists one with asymmetric punishments. These punishments involve transfers from the presumed deviator to the presumed innocent firms. This seems consistent with lysine as well as other price fixing cartels, such as citric acid and sodium gluconate.

Fershtman and Pakes (2000) consider a dynamic model with firm-specific investment and stochastic shocks. The model solves for collusive equilibria with endogenous entry and exit. If, due to adverse stochastic shocks, too many firms are close to exiting, then it may no longer be possible to maintain collusion: effectively, these firms discount the future more heavily, similarly to Busse's (2002) financially troubled airlines.

In Fershtman and Pakes (2000), each firm's state is public knowledge. This implies that price wars are initiated by all firms in tandem, whereas, as mentioned above, real-world price wars are frequently initiated by one firm only. In more recent work, Fershtman and Pakes (2005) relax the assumption of full-information, proposing instead a periodic mechanism that reveals each firm's private information (e.g., executives visit each other's plants, or financial statements are disclosed). As in the work of Athey and Bagwell (2001), private information leads to a richer environment that allows for more realistic behavior patterns. In particular, Fershtman and Pakes (2005) model the dynamics of endogenous renegotiation of collusion agreements in a way that matches some of the features of the lysine and bromide cases.⁸

The ADM and related examples suggest that reputation plays an important role in collusion, at least in tacit collusion. For example, a firm may benefit from a reputation to retaliate "hard" (whereas, in most of the literature, the nature of retaliation is part of the equilibrium that firms sign up to). Since costs and capacity levels are normally privately known, firms may also want to acquire a reputation for low cost and high capacity levels (witness the ADM and bromide cases).

This raises an interesting issue. For all its variety, most of the received collusion theory is based on bootstrap-type equilibria. Some models feature incomplete information, but still the basic mechanism is repetition and enforcement by the threat of a collective shift to a price war. In related economics areas, notably the economics of reputation and trust, Bayesian learning models such as Kreps and Wilson (1982), Milgrom and Roberts (1982), are at least as important as bootstrap models (see Cabral, 2005).

Why has the Bayesian learning approach played such a minor role in the collusion literature? Partly, I believe, because models are typically difficult to solve analytically. For these reasons, I think the recent work reviewed in the previous paragraphs represents a major step forward in the collusion literature.

⁸ From a methodological point of view, Fershtman and Pakes (2000, 2005) also make an important contribution to the numerical modelling of dynamic collusion games.

3. From theory to policy

Cartels exist. Cartels are generally considered bad, and as such should be prosecuted to the extent that is possible.⁹ Recent economics literature has focused on two possible avenues for public policy. The first one is a leniency program, that is, a series of incentives for a cartel participant to report the cartel's activities to the government. The second possible course of action is to detect cartel behavior and initiate an investigation of the suspect firms.¹⁰ Leniency programs are now in place both in the U.S. and Europe. Active screening and investigation is relatively less common (unlike other areas, such as insider trading or tax evasion).

One interesting aspect in this approach is the strategic interdependence between government actions and cartel actions. For example, a leniency program changes the game played by cartel members.¹¹ Likewise, the government agency's screening criteria are also likely to influence the (constrained) optimal cartel agreement.

Both examples in the previous paragraph show how government actions influence cartel behavior; but the opposite direction of causality must also be considered. For example, looking at the market for frozen perch, Abrantes-Metz et al. (2005) report that, immediately after the collapse of a cartel conspiracy, average price fell by 16%, while variance increased by 263%. Based on this drastic evidence, they propose a variance screen for detecting cartel behavior. But if variance were systematically used as a test to initiate an investigation, then conspiring firms would likely respond by adding some noise to the prices they set so as to reduce the probability of detection. Another example of a simple screen test to look for identical bids.¹² Still other possible screens can be found for the specific case of auctions.¹³ But the same caveat applies in these cases as well.

What is the right level at which to analyze these strategic interdependencies? Game theory would normally suggest some equilibrium notion such as Nash equilibrium. But this assumes that the government is a well-defined player, which is far from clear. Moreover, some of the relevant players, cartel buyers, are unlikely to be sufficiently sophisticated to detect cartel behavior consistent with a well-defined theory.¹⁴ Finally, cartel members are unlikely to be so sophisticated as to anticipate the government's policy. More likely, cartel members will react to, adapt to, government policy.

9 Fershtman and Pakes (2000) make the provocative point that, in a model with endogenous entry, equilibria with collusion may actually be welfare superior to equilibria without collusion. A related point was earlier made by Dewey (1979).

10 See Harrington (2005) for an excellent survey of cartel detection. One particularly promising area is detecting collusion in auctions. See Bajari and Ye (2003), Baldwin et al. (1997), Porter and Zona (1993, 1999) for leading contributions; and Porter (2005) for a survey.

11 See for example Baccara and Bar-Isaac (2005), Spagnolo (2000), in addition to the papers surveyed in Feuerstein (2005).

12 According to Scherer and Ross (1990, p. 267), in 1955, five companies submitted identical bids of \$108,222.58 for an order of 5,640 one hundred capsule bottles of antibiotic tetracycline. Abrantes-Metz et al. (2005, p. 2) report that, "in the 1970s . . . the U.S. Department of Justice formed an "identical bids" unit that investigated government procurement auctions in which identical bids were submitted. In six years, the unit failed to uncover a single conspiracy."

13 See Bajari and Ye (2003), Baldwin et al. (1997), Porter and Zona (1993, 1999).

14 Auctions provide a potential exception to this rule. As noted by Porter (2005), the auctioneer might re-design the auction rules in reaction to bidders' collusive behavior.

I don't know what the right answer is, though I think this is a relevant issue. In any event, I am convinced this research program, well surveyed by Feuerstein (2005), represents a major step forward in the literature. It realistically considers that, in addition to cheating by cartel members, there are a number of external constraints that condition the scope for collusion. It is also one of industrial organization's best claims to become an increasingly policy relevant field.

4. Conclusion

To summarize and answer the title question (where to go next), I think we need, to begin with, a better understanding of the inner workings of cartels and price fixing agreements. Secondly, we need a better model of price wars. Finally, when discussing public policy towards collusive agreements it is important to consider the interdependency between the various players.

The empirical evidence of particular cases suggests some of the ways this can be done. I look forward to reading new work in this exciting research area.

Acknowledgments

I am grateful to Rosa Abrantes-Metz, Kyle Bagwell, Heski Bar-Isaac, Meghan Busse, Cristian Dezsö, Chaim Fershtman, Luke Froeb, David Genesove, Joe Harrington, Rob Porter, Yuliy Sannikov, Giancarlo Spagnolo for comments on an earlier draft.

References

- Abrantes-Metz, R.M., Froeb, L.M., Geweke, J., and Taylor, C.T., A variance screen for collusion, FTC Bureau of Economics Working Paper No. 275, 2005.
- Abreu, D., "On the theory of infinitely repeated games with discounting," *Econometrica*, vol. 56, pp. 383–396, 1988.
- Abreu, D., Pearce, D., and Stacchetti, E., "Toward a theory of discounted repeated games with imperfect monitoring," *Econometrica*, vol. 58, pp. 1041–1064, 1990.
- Athey, S., and Bagwell, K., "Optimal collusion with private information," *Rand Journal of Economics*, vol. 32, pp. 428–465, 2001.
- Athey, S., and Bagwell, K., *Collusion with Persistent Cost Shocks*. Stanford and Columbia Universities, 2004, (unpublished).
- Athey, S., Bagwell, K., and Sanchirico, C., "Collusion and price rigidity," *Review of Economic Studies*, vol. 71, pp. 317–349, 2004.
- Baccara, M. and Bar-Isaac, H., *How to Organize Crime*. New York University, 2005.
- Bajari, P. and Ye, L., "Detecting collusion in procurement auctions," *Review of Economics and Statistics*, vol. 85, pp. 971–989, 2003.
- Baldwin, L., Marshall, R., and Richard, J.-F., "Bidder collusion at forest service timber auctions," *Journal of Political Economy*, vol. 105, pp. 657–699, 1997.
- Busse, M., "Firm financial condition and airline price wars," *Rand Journal of Economics*, vol. 33, pp. 298–318, 2002.

- Cabral, L.M.B., *Introduction to Industrial Organization*. MIT Press: Cambridge, MA, 2000.
- Cabral, L.M.B., *The Economics of Reputation and Trust*. New York University, 2005, (unpublished).
- Compte, O., "Communication in repeated games with private monitoring," *Econometrica*, vol. 66, pp. 597–626, 1998.
- Connor, J., "Global cartels redux: The amino acid lysine antitrust litigation," in Kwoka, J. and White, L. (eds.), *The Antitrust Revolution*, 4th ed. Oxford University Press: Oxford, 2004.
- Dewey, D., "Information, Entry, and Welfare: The Case for Collusion," *American Economic Review*, vol. 69, pp. 587–594, 1979.
- Eichenwald, K., *The Informant*. Broadway Books: New York, 2000.
- Fershtman, C., and Pakes, A., "A dynamic oligopoly with collusion and price wars," *Rand Journal of Economics*, vol. 31, pp. 207–236, 2000.
- Fershtman, C., and Pakes, A., "Finite state dynamic games with asymmetric information: A framework for applied work," Tel-Aviv and Harvard Universities, May 2005.
- Feuerstein, S., "Collusion in Industrial Economics: A survey," *Journal of Industry, Competition and Trade*, vol. 5 no. 3, pp. 161–196, 2005.
- Fudenberg, D., Levin, D., and Maskin, E., "The folk theorem with imperfect public information," *Econometrica*, vol. 62, pp. 997–1039, 1994.
- Genesove, D., and Mullin, W.P., "Rules, communication, and collusion: Narrative evidence from the sugar institute case," *American Economic Review*, vol. 91, pp. 379–398, 2001.
- Green, E., and Porter, R., "Noncooperative collusion under imperfect price information," *Econometrica*, vol. 52, pp. 87–100, 1984.
- Harrington, J.E. Jr., *Detecting Cartels*. Johns Hopkins University, 2005, (unpublished).
- Harrington, J.E. Jr. and Skrzypacz, A., "Collusion under Monitoring of Sales," *Stanford GSB Research Paper No. 1885*, 2005.
- Kandori, M., and Matshushima, H., "Private observation, communication and collusion," *Econometrica*, vol. 66, pp. 627–652, 1998.
- Kreps, D.M., and Wilson, R., "Reputation and imperfect information," *Journal of Economic Theory*, vol. 27, pp. 253–279, 1982.
- Levenstein, M.C., "Price Wars and Stability of Collusion: A Study of the Pre-World War I Bromine Industry," *Journal of Industrial Economics*, vol. 45, pp. 117–137, 1997.
- Lieber, J.B., *Rats in the Grain: The Dirty Tricks and Trials of Archer Daniels Midland*. Four Walls Eight Windows: New York, 2000.
- Milgrom, P.R. and Roberts, J., "Predation, reputation and entry deterrence," *Journal of Economic Theory*, vol. 27, pp. 280–312, 1982.
- Porter, R.H., "A Study of cartel stability: The joint executive committee, 1880–1886," *Bell Journal of Economics*, vol. 14, pp. 301–314, 1983.
- Porter, R.H., "Detecting collusion," *Review of Industrial Organization*, vol. 26, pp. 147–167, 2005.
- Porter, R.H., and Zona, D., "Detection of Bid rigging in procurement auctions," *Journal of Political Economy*, vol. 101, pp. 518–538, 1993.
- Porter, R.H., and Zona, D., "Ohio school milk markets: An analysis of bidding," *Rand Journal of Economics*, vol. 30, pp. 263–288, 1999.
- Sannikov, Y., *Games with Imperfectly Observable Actions in Continuous Time*. University of California: Berkeley, 2004.
- Scherer, F.M. and Ross, D., *Industrial Market Structure and Economic Performance*, 3rd ed. Houghton Mifflin: Cambridge, MA, 1990.
- Spagnolo, G., *Self-Defeating Antitrust Laws: How Leniency Programs Solve Bertrand's Paradox and Enforce Collusion in Auctions*, FEEM Working Paper 52.2000, 2000.
- Stocking, G.W. and Watkins, M.W., *Cartels in Action. Case Studies in International Business Diplomacy*. The Twentieth Century Fund: New York, 1946.