Book Reviews

Competition, Conglomerates, and the Evolution of Cooperation

The Evolution of Cooperation. By Robert Axelrod. New York: Basic Books, 1984. Pp. x, 241. \$17.95.

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“Under what conditions will cooperation emerge in a world of egoists without central authority?”¹

The classical microeconomic model of inter-firm competition makes assumptions very similar to those of Darwinian biology.² “Survival of the fittest,” in fact, was a phrase coined not by Darwin but by Herbert Spencer, a vigorous proponent of laissez-faire capitalism.³ The ideal firm is egoistical—it possesses no altruistic instincts and is not concerned with the well-being of its “siblings” producing in the same market. Its sole objective might be described as “propagation”—increasing profits by increasing its market share or by expanding into new markets. A perfectly competitive firm never altruistically restricts its output to leave room for another firm’s production. Only the lower-cost (read “fitter”) producers survive.

Yet the antitrust casebooks are full of cooperative firms—firms that restrict production, fix prices, carve out exclusive territories, agree not to sell to certain buyers, rig bids for contracts, or share competitively useful information. Such cooperation among firms conflicts with the economist’s

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1. R. AXELROD, *THE EVOLUTION OF COOPERATION* 3 (1984) [hereinafter cited by page number only].

2. See generally E. WILSON, *ON HUMAN NATURE* (1978); E. WILSON, *SOCIOBIOLOGY: THE NEW SYNTHESIS* (1975) [hereinafter cited as E. WILSON, *SOCIOBIOLOGY*]; Smith, *The Evolution of Behavior*, *SCI. AM.*, Sept. 1978, at 176.

3. H. SPENCER, 1 *PRINCIPLES OF BIOLOGY* 444 (1864).

assumption of corporate egoism, just as cooperation within a species conflicts with the classical biologist's assumption of individual egoism. But perhaps somewhat better than economists, modern evolutionary biologists have begun to accept and explain the tenacity and ubiquitousness of seemingly altruistic behavior among egoists.⁴

In its social and biological dimension, the egoism-cooperation paradox has been the focus of research by Robert Axelrod, a political scientist and game theorist.⁵ Through an inspired, quasi-empirical study of a classical problem—the “Prisoner’s Dilemma”—Axelrod has revealed the essential behavioral characteristics that promote the evolution of cooperation and preserve cooperative structures once they have evolved.⁶ In *The Evolution of Cooperation*, Axelrod describes and extends that strikingly innovative research. Egoism, he shows, is neither inconsistent with nor antithetical to cooperation. Indeed, in a non-zero-sum world,⁷ group cooperation is almost inevitable because it is the best route to individual advancement.⁸

4. See E. WILSON, *SOCIOBIOLOGY*, *supra* note 2, at 120–29; E. WILSON, *THE INSECT SOCIETIES* (1971).

5. In part of the work, Axelrod collaborated with William D. Hamilton, an evolutionary biologist whose theories on the evolution of behavior have gained considerable prominence. See Smith, *supra* note 2, at 176, 178.

6. Much of his work has already been published and commented upon in several journals. See Axelrod & Hamilton, *The Evolution of Cooperation*, 212 *SCIENCE* 1390 (1981); Hofstadter, *Metamagical Themas*, *SCI. AM.*, June 1983, at 16, 20–26. It has attracted considerable attention, and won the 1981 Newcomb Cleveland Prize, awarded annually by the American Association for the Advancement of Science for “an outstanding paper published in *Science*.” For sources providing additional insight into the egoism-cooperation paradox, see R. DAWKINS, *THE SELFISH GENE* (1976); A. RAPOPORT, *TWO-PERSON GAME THEORY* (1966); A. RAPOPORT & A. CHAMMAH, *PRISONER’S DILEMMA* (1965); Hamilton, *The Genetical Evolution of Social Behavior*, 7 *J. THEORETICAL BIOLOGY* 1 (1964).

7. In a “zero-sum” game, such as poker, a player can gain only what others lose. The sum of the (signed) wins and losses in such a game is zero. In a non-zero-sum game, the sum of wins and losses need not equal zero. Such games are sometimes called “cooperative” games, since players can sometimes combine to produce better results for each than either could achieve on his own. See *infra* pp. 1148–1149 (describing potential for cooperation in “Prisoner’s Dilemma”).

8. The promotion of cooperation—or its suppression—is a fundamental problem that touches many disciplines. The Prisoner’s Dilemma has previously been used by social psychologists to study everything from the effects of westernization in Central Africa to aggression in career-oriented women. P. 28. Axelrod emphasizes his work’s relevance to evolutionary biology and recognizes that the lessons he has learned may be useful in other competitive settings such as international relations. See pp. 185–87. But the ramifications of his work are numerous and eclectic. *The Evolution of Cooperation* will be of lasting interest not only to Darwinian biologists, but to political scientists, lawyers, negotiators, politicians, and philosophers. This Review, which discusses the book primarily from the perspective of an antitrust lawyer, is only one of the many that could and should be written. Axelrod notes—but does not extensively develop—his work’s implications for the economic worlds of business and antitrust. Alluding briefly to collusive business practices, Axelrod simply states: “[O]n occasion, the theory will be used in reverse to show how to prevent, rather than to promote, cooperation.” P. 18.

I. IS COMPETITION ROBUST OR FRAGILE?

The efficiency of free enterprise is supposedly guaranteed by the unshakeable competitiveness of the "firm"—a supremely egoistic institution that strives for no one's advancement but its own. The free-marketeer believes that competition will not allow monopolies, cartels, consciously parallel behavior, and other cooperative arrangements among firms, to survive. In the language of the biologist, such arrangements are "evolutionarily unstable."⁹ Colluders defect; new entrants invade shared monopolies;¹⁰ in short, cooperating firms, like thieves, inevitably fall out, and for the same greedy reasons. Because firms can collect greater rewards by defecting from collusive agreements than by adhering to them, cooperation is fragile and unstable, competition robust and inevitable.

In analyzing all forms of anticompetitive behavior, the economist returns, again and again, to the competitive proclivities of the firm. The belief in firm competitiveness is grounded on a widely accepted psychoanalysis of the "typical" firm: The firm is both an egoist and an individualist. The ubiquitousness of these two character traits, it is thought, guarantees that many, perhaps most, markets will be competitive. The egoistic firm will seek to maximize its own profits without regard to possible adverse effects on others; the individualistic firm will set its strategies for competition without concern for the behavior of others.

Axelrod dramatically demonstrates that the two assumptions of egoism and individualism are independent—that the first can prevail while the second does not. Indeed, he shows that the two assumptions tend to be mutually exclusive when actors are baited with non-zero-sum rewards. While certain customary assumptions about firm micro-motives may be correct, the conclusions typically deduced about firm macro-behavior may be quite wrong.¹¹ In business, as in biology, competitive—not cooperative—behavior may be the rare beast, the less "fit" trait, the aberration destined for oblivion.¹²

9. See Smith, *supra* note 2, at 184. Smith defines an "evolutionarily stable strategy" as "a strategy with the property that if all members of a population adopt it, then no mutant strategy can invade the population." *Id.*

10. See R. BORK, *THE ANTITRUST PARADOX* 195-96 (1978); R. POSNER, *ECONOMIC ANALYSIS OF LAW* § 9.5, at 208 (2d ed. 1977).

11. Axelrod sets for himself the task of deducing consequences for the system as a whole from assumptions about individual motives, using a theory of cooperation. See p. 6 (citing Schelling, *Micromotives and Macrobehavior*, in *MICROMOTIVES AND MACROBEHAVIOR* (T. Schelling ed. 1978)).

12. This conclusion becomes more significant when the theory of the second best is taken into account. A stable system of pure competition and free consumer choice will lead to efficient allocations of factors. But if even one sector of the economy is non-competitive, the theory of the second best demonstrates that competition in other sectors is no guarantee of efficient resource allocation. Indeed, if one sector is monopolistic, we may do better to encourage all other sectors to be so as well. See generally Lipsey & Lancaster, *The General Theory of Second Best*, 24 *REV. ECON. STUDS.* 11 (1956)

Axelrod's research focuses on a paradigmatic problem of competition and cooperation—the "Prisoner's Dilemma." The Prisoner's Dilemma assigns to each of two actors a payoff that derives from the choices each makes in isolation. The dilemma posed by the problem is that the actors face an incentive structure which, if each acts in a superficially self-interested manner, will lead to a less favorable result than that achievable through cooperation. Cooperation appears unenforceable and therefore hazardous.

In its traditional formulation, the Prisoner's Dilemma involves two accomplices in crime, separated from each other, and each tempted to confess by an offer of leniency.¹³ The proposition given each makes it appear to the self-interested prisoner that he should confess: He will receive the heaviest sentence if he does not confess but his accomplice does, while he will receive only a moderate sentence if both confess. The dilemma derives from the fact that, if both confess, both will be punished more severely than if neither does.¹⁴

Shared monopolies are another form of the Prisoner's Dilemma. Consider, for example, a market served by only two, roughly identical, equally efficient producers. If both compete vigorously, they will expand their joint output to some socially "efficient" level, where their marginal costs of production (including a modest profit) equal the price they can command in the market at their joint level of production. Assume a firm competing under these conditions earns one unit of profit. This is, of course, a condition of "no cooperation" between the firms. The corresponding payoff is shown in the top left box of the Payoff Table on the following page.

Alternatively, suppose that (with or without overt collusion) both firms recognize that by restricting their production they can boost their profits. The public will be worse off, of course, but the firms will both do better. Assume the total monopoly profit available in this market is six, and that the firms split it equally.¹⁵ This yields the (three, three) entry in the bot-

(seminal article on theory of second best).

13. The Prisoner's Dilemma has been used to model other problems of legal interest. See, e.g., Birmingham, *Legal and Moral Duty in Game Theory: Common Law Contract and Chinese Analogies*, 18 BUFFALO L. REV. 99 (1968); Shubik, *A Game Theorist Looks at the Antitrust Laws and the Automobile Industry*, 8 STAN. L. REV. 594 (1956); Note, *Discovery Abuse Under the Federal Rules: Causes and Cures*, 92 YALE L.J. 352 (1982).

14. There are three essential characteristics of the Prisoner's Dilemma: (1) The game is not "zero-sum," see *supra* note 7; (2) The progression of payoffs, from highest to lowest and from the perspective of player A, is A confesses while B does not; both keep quiet; both confess; B confesses while A does not; (3) The sum of the rewards to both players when they pick different strategies must be less than the sum of the rewards to both players when they both keep quiet. This third condition guarantees that if two players get locked into a cycle in which each alternately defects and cooperates, and the two are always out of phase, they will do worse than if they always cooperate. This condition is especially important in an Iterated Prisoner's Dilemma, see *infra* pp. 115-56.

15. The example works no matter how the monopoly profit is allocated, so long as each firm gets some share. It is worth noting that monopoly is a non-zero-sum game regardless of how many pro-

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tom right of the Payoff Table. The “reward for mutual cooperation” is the sum of these payoffs—six.

The third possibility is that one firm “cooperates” while the other “competes.” After a no-competition understanding is reached, one firm “defects” by dropping its price a bit and expanding output. Two things happen. First, the defecting firm’s share of the monopoly profit rises—to five, say. Axelrod terms this payoff the “temptation.” Second, the cooperating firm is wiped out—it gets the “Sucker’s Payoff” of zero. The numbers (five, zero) add up, of course, to something less than six, the total monopoly profit available when both firms cooperate. If one firm is cheating, output must be somewhat higher than the optimum monopoly level, and profits somewhat lower.

Here is the completed Payoff Table:

PAYOFF TABLE

Firm 1	Firm 2	
	Competes	Cooperates
Competes	(1,1)	(5, 0)
Cooperates	(0,5)	(3,3)

This Payoff Table has all the features essential to the Prisoner’s Dilemma.¹⁶

There is, however, one important difference between the classical formulation of the Prisoner’s Dilemma and the firms-market dilemma. The prisoner is presented with his dilemma only once, while firms operating in the same market have repeated opportunities to watch, listen, and learn.

Another market example—competitive bidding—illustrates the point. In the game theorist’s terminology, this is the “Iterated Prisoner’s Di-

ducer firms serve a market. The entry of additional firms into the market never changes the total amount of monopoly profit to be earned through cooperation, though it does, of course, reduce each firm’s share of that windfall. Monopoly is good for producers because firms do not collect from each other, but from an external source—buyers.

16. The essential features are:
(1) *The game is not zero-sum.* If both firms cooperate, for example, they both do better, in absolute (though not in relative) terms, than if both compete. Total profits are greater if both cooperate.
(2) *Competing (alone) is best; cooperating (together) is second best; competing (together) is next best; cooperating (alone) is worst.* A firm that can persuade its rival to “cooperate” while it “competes” earns five units of monopoly profit; mutual cooperation earns each only three units. Mutual competition is still worse—profits drop to one. Worst of all is being suckered—your profit is then zero. This progression of preferred strategies is at the heart of the Prisoner’s Dilemma.
(3) *The Temptation plus the Sucker’s Payoff is less than the Joint Reward for Cooperating.* In the Payoff Table, the Joint Reward for Cooperating is three plus three, that is, six. The Temptation (five) and the Sucker’s Payoff (zero) obviously add up to only five.

lemma." Consider again a two-firm market. Your firm and mine frequently bid on the same contracts. In placing any particular bid we both estimate our cost of fulfilling the contract, both prepare a secret bid, and both understand that the low bid wins. We are rather similar firms, about equally efficient. In honest bidding, success will depend only on the vagaries and uncertainties of estimating costs. What bidding strategy should we adopt?

First, we can both compete to the fullest. We make our best, honest estimates of our costs and bid accordingly. Our payoffs will be a normal profit—two units, say, per winning bid. Each of us will win about half the time, so the expected payoff from this strategy is one. Alternatively, we might reach a tacit or explicit understanding that we will both inflate our estimated costs by ten percent. We will each continue to win contracts about half the time, and profits for both of us will soar. If, on the average contract, the winning bidder now makes a profit of six expected units, profits per bid submitted will rise to three. But we are both tempted to defect. If I can persuade you to pad your costs by ten percent, while I pad mine by only seven percent, I will do even better. On each contract the profit will be only five, but I will win almost every bid. My average profit per bid will be about five; yours, unfortunately, will drop to zero. Our expected returns will again look just like the Payoff Table.

But the Iterated Prisoner's Dilemma is different because the game does not end after one bid. I defect first, while you hold the line at ten percent padding. In short order you realize that something is seriously wrong—I'm winning every bid. You adjust your bidding. I respond, and before we know it, we are once more competing to the hilt. Because each of us is selfish, our collusive agreement unravels. How sad. Had we both cooperated, we both would have done much better. And we knew that all along! What went wrong?

II. THE VIABILITY OF COOPERATION

The Evolution of Cooperation explains "what went wrong." The short answer is that cooperation among egoists does not break down as easily as the example implies.

Axelrod's findings are so startling that their acceptance requires a description of his method. In 1979, Axelrod conducted a round-robin tournament that, in its conception at least, would have warmed the heart of a social Darwinist.¹⁷ The game was Iterated Prisoner's Dilemma, played to the following delightfully simple rules.

17. The tournament's results were first published in Axelrod, *Effective Choice in the Prisoner's Dilemma*, 24 J. CONFLICT RESOLUTION 3 (1980); Axelrod, *More Effective Choice in the Prisoner's*

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To enter, you submit a “strategy” (in the form of a computer program) for playing Prisoner’s Dilemma. Your task is to decide whether you will “compete” or “cooperate” each time you play. You will play against every other entrant, not once, but hundreds of times in succession. At the beginning you will know nothing about your rivals’ strategies. But in the second and subsequent encounters with each other player, you may take into account how he behaved in any or all of your previous meetings. In each encounter, you will earn a payoff determined by your move, your opponent’s move, and the payoffs listed in the Payoff Table. Your tournament score is cumulative—the sum of all the payoffs you earn in all your encounters with all opponents. Any strategy is allowed, including “flipping a coin.” But you cannot spy on your opponents’ programs, sign advance agreements, or announce in advance how you plan to play.¹⁸

Axelrod’s first round was played by fourteen game theorists—Prisoner’s Dilemma professionals, if you will. Each player met every other—as well as a clone of itself and a program called “Random,”¹⁹ whose inspired strategy was to flip a coin at every move—two hundred times in a row.²⁰ Total payoffs earned were chalked up, and the fourteen strategies (and Random) were ranked according to their relative success.

Before I describe the results of the first round, I invite you to map out your own strategy for success. Will you cooperate blindly? Opponents may soon catch on and start to compete. That doesn’t look promising; no one can afford to be a lone price-fixer or contract-padder in a world of aggressive competitors. How about being a cut-throat competitor—adopting an “always compete” strategy? That’s certainly better than

Dilemma, 24 J. CONFLICT RESOLUTION 379 (1980).

18. As Axelrod puts it:

There is no mechanism available to the players to make enforceable threats or commitments There is no way to be sure what the other player will do on a given move There is no way to change the other player’s payoffs Under these conditions, words not backed by actions are so cheap as to be meaningless. The players can communicate with each other only through the sequence of their own behavior.

Pp. 11–12.

19. Axelrod places the names of the strategies all in capital letters, a convention not followed here.

20. The first round had an announced length of 200 moves. This gave rise to certain “end-game” strategies exploited in several programs. Axelrod explains the principle behind them:

[T]wo egoists playing the game *once* will both choose their dominant choice, defection, and each will get less than they both could have gotten if they had cooperated. If the game is played a known finite number of times, the players still have no incentive to cooperate. This is certainly true on the last move since there is no future to influence. On the next-to-last move neither player will have an incentive to cooperate since they can both anticipate a defection by the other player on the very last move. Such a line of reasoning implies that the game will unravel all the way back to mutual defection on the first move of any sequence of plays that is of known finite length.

P. 10 (citations omitted). This problem was corrected in the second round of the tournament, described *infra* pp. 1154–55. In that round, the length of each game between a pair of players was determined probabilistically, with a 0.00346 chance of the game ending after each move. This yielded an expected length of 200 moves for each game. Pp. 42, 217 n.5.

being a solitary cooperator. But again, your opponents are likely to catch on, and you will earn none of those large monopoly profits. Perhaps the secret is to feel out each opponent in the first few moves, compete now and again to see how he responds, then modify your own strategy accordingly. The Payoff Table, after all, clearly shows that the way to win is to defect first, not last, to compete without being competed against, never to be suckered. Once you've worked out an opponent's strategy, you'll find a way to lure him into cooperating just when you're about to defect. Yes, this approach sounds promising, though somewhat complicated. It may be difficult to program, but it should win.

It didn't. The strategy that won Axelrod's first tournament was Tit for Tat, an almost unbelievably simple scheme.²¹ On the first encounter with any particular opponent, Tit for Tat cooperates. In every subsequent encounter, Tit for Tat makes the move its opponent made in the immediately preceding encounter between the pair. If you defected last time, Tit for Tat will defect this time. If you cooperated last time, Tit for Tat will cooperate this time. There are no exceptions, no other wrinkles.²² "Never defect first; if suckered by the opponent's defection, retaliate in equal measure." This is Tit for Tat's maxim of life.

Tit for Tat's success seems especially surprising when one examines its reasonably typical encounter with a strategy called Joss.²³ Joss used the Tit for Tat scheme, but threw in a random, "unprovoked" defection ten percent of the time. If you cooperated last time, Tit for Tat would always cooperate on this move; Joss would usually (nine times out of ten) cooperate on this move. If you defected last time, both Joss and Tit for Tat would always defect this time.²⁴

When Tit for Tat and Joss went head to head, perfect cooperation prevailed until Joss threw in its first unprovoked defection. On the next move, Joss reverted to "cooperate" while Tit for Tat responded with a defection. For a while Joss and Tit for Tat slugged it out, alternately defecting and cooperating, always out of phase. Then Joss threw in its second random defection (when, according to the cycle, it was due to "cooperate") and that was the end. On that and all subsequent moves both players defected—the breakdown of trust was complete.²⁵ The free-market faithful would have been pleased.

In the head-to-head competition, Joss did slightly better than Tit for Tat. Joss defected first, and that gave it a slight edge; all prior and subse-

21. Tit for Tat won the first tournament with 504.5 points. The second-place finisher earned 500.4 points.

22. P. 20.

23. This strategy was submitted by a Swiss mathematician, Johann Joss.

24. P. 36.

25. Pp. 36-37.

quent pairs of moves between Joss and Tit for Tat washed out. Another blow for competition! Yet Tit for Tat won the tournament. Joss's random defections caused cooperation to break down when it played with others as well. Tit for Tat elicited cooperation from other opponents more consistently than Joss did, and this more than made up for Joss's persistent one-on-one, pyrrhic "victories." In fact, a strategy of "always compete" will "beat" (or at worst, tie) every other competitor individually, yet do much less well, overall, than Tit for Tat, which "loses" to every other player.²⁶ Tit for Tat steadily racks up high cumulative scores while losing. The game is horribly counter-intuitive.

In non-zero-sum games, however, the best strategies need not—probably do not—"beat" each individual opponent. This is the first, and perhaps most enduring lesson of the Iterated Prisoner's Dilemma. Winners promote cooperation, persistently but prudently, and share in the larger rewards generated thereby.

Three characteristics of the Tit for Tat strategy reflect this lesson and account for the program's success. First, Tit for Tat never defects first. Axelrod calls such a characteristic "niceness." The top eight finishers in Axelrod's first tournament were nice; none of the bottom seven were.²⁷

Second, Tit for Tat understands that the nice risk being exploited.²⁸ If its opponent defected last time, Tit for Tat defects this time. Tit for Tat is, in Axelrod's terms, "retaliatory,"²⁹ because "it immediately defects after an 'uncalled for' defection from the other."³⁰ Strategies less retaliatory than Tit for Tat—those willing to overlook a defection if an atmosphere of trust had already developed—did less well.³¹

Finally, Tit for Tat gives only one tit for one tat—it is, according to Axelrod, "forgiving." "Of all the nice [strategies], the one that scored lowest was also the one that was least forgiving."³² It never forgave—once cheated, it would retaliate until the bitter end of its encounter with that opponent.

26. A moment's reflection shows that Tit for Tat *never* "wins" a one-on-one exchange. Tit for Tat is never the first to cheat, and never cheats more often than its opponent. Since the *only* way to score more points than your direct opponent is to cheat more often than you are cheated on, Tit for Tat never "beats" anyone. By the same token, an "always cheat" strategy can never be "beaten" in a head-to-head encounter; such a strategy would nevertheless have fared very badly in Axelrod's tournaments.

27. P. 33.

28. Axelrod explains: "The nice [strategies] did well in the tournament largely because they did so well with each other But what happened if there was a defection? Different [strategies] responded quite differently, and their response was important in determining their overall success." Pp. 35–36.

29. P. 44.

30. *Id.*

31. P. 46.

32. P. 36.

Axelrod's first tournament thus taught the value of being nice, retaliatory, and forgiving. These character traits, it seems, assure success in Prisoner's Dilemma—at least when you compete in an environment populated by thirteen other game theorists, a clone of yourself, and a random number generator.

With the first tournament completed and the lessons learned and published, Axelrod ran the second. The sixty-two entries in this round included new strategies submitted by all first-round participants and by many others as well³³—university professors from eight different academic disciplines, professional game theorists, one ten-year-old, and others from around the world. Before they submitted their programs, all entrants were given a detailed analysis of the results of the first round—a complete description of the winning Tit for Tat strategy and an explanation of the value of being nice, retaliatory, and forgiving. Entrants were free to use any strategy and to take full advantage of the lessons learned in the first round.

The strategies submitted ranged from the trivial to the highly complex. Tit for Tat was entered again—by the same University of Toronto philosophy professor³⁴ who submitted it in the first round. The computer whirled, the strategies played, and a short while later the results emerged.

Tit for Tat won again. It beat out Tit for Two Tats and other strategies that proved too forgiving. It beat out strategies written specifically to best Tit for Tat—they turned out to be too exploitative in this new environment. The extreme forgivers were taken advantage of too often; the extreme exploiters lost too much ground and goodwill testing out their opponents and trying to outwit them. The nice, mildly provokable, mildly forgiving, pedestrian Tit for Tat did best.

Axelrod offers this explanation of Tit for Tat's stunning triumph.

Part of [Tit for Tat's] success might be that other [players] anticipate its presence and . . . do well with it. Doing well with Tit for Tat requires cooperating with it, and this in turn helps Tit for Tat. Even [players whose strategy is] . . . to see what they could get away with, quickly apologize to Tit for Tat. Any [strategy] which tries to take advantage of Tit for Tat will simply hurt itself. Tit for Tat benefits from its own nonexploitability because three conditions are satisfied:

1. The possibility of encountering Tit for Tat is salient.

33. P. 41. One entrant was the evolutionary biologist John Maynard Smith, whose work I have cited *supra* note 2. His strategy was Tit for Two Tats, which defects only after two consecutive defections by an opponent. Smith's strategy would have won the first tournament, if it had been entered, but came in 24th in the second. Pp. 46–47.

34. Anatol Rapoport, Professor of Psychology and Philosophy, University of Toronto. Some of Rapoport's writings on the Prisoner's Dilemma are cited *supra* note 6.

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2. Once encountered, Tit for Tat is easy to recognize.
3. Once recognized, Tit for Tat's nonexploitability is easy to appreciate.³⁵

Of the top fifteen finishers in the second tournament, all but one (which ranked eighth) were nice. Overall, niceness correlated very strongly with good performance in the second round, just as it did in the first.³⁶

Based on the results of the second tournament Axelrod identified a fourth character trait as a crucial complement to niceness, provocability, and forgiveness—"clarity."

[T]oo much complexity can appear to be total chaos. If you are using a strategy which appears random, then you also appear unresponsive to the other player. If you are unresponsive, then the other player has no incentive to cooperate with you. So being so complex as to be incomprehensible is very dangerous.³⁷

And so, after two rounds, niceness, provocability, forgiveness, and clarity had proved essential to success. Other qualities had not.

III. CONSCIOUS PARALLELISM AND ANTITRUST

Firms have played Prisoner's Dilemma far longer than game theorists, and have witnessed more "rounds" in which winners and losers were counted. This leads me to believe that the instability of cartels and the inevitability of competition within oligopolies and contract-rigging consortiums may be only myths. Of course, firms in the real world may behave more like the losers in Axelrod's tournaments, letting their competitive instincts get the better of their rational self-interest. But I doubt it.

There are differences, I recognize, between complex reality and simple models such as the Prisoner's Dilemma. Most importantly, in economic competition, more than two firms usually operate in the same market. Firms face what game theoreticians call the "*n*-person Prisoner's Dilemma,"³⁸ a problem more complicated than that studied by Axelrod. If the game involves five players in each play, rather than two, the dilemma is less difficult. Surely one of the five will defect, so you should too. Diog-

35. Pp. 53-54.

36. Pp. 43-44, 113-14.

37. P. 122.

38. See M. OLSON, *THE LOGIC OF COLLECTIVE ACTION* 43 (1965); M. TAYLOR, *ANARCHY AND COOPERATION* 81-83 (1976); Hardin, *Collective Action as an Agreeable n-Prisoners' Dilemma*, 16 *BEHAV. SCI.* 472 (1971); Hardin, *The Tragedy of the Commons*, 162 *SCIENCE* 1243 (1968); Schelling, *Hockey Helmets, Concealed Weapons, and Daylight Saving: A Study of Binary Choices with Externalities*, 17 *J. CONFLICT RESOLUTION* 381 (1973).

enes, after all, had difficulty finding even one honest man in the streets of Athens.

Not so fast. In a one-time confrontation, the multiple Prisoner's Dilemma is unresolvable, just as the two player game seems to be.³⁹ There is no opportunity to learn anything about your cohorts' patterns of conduct, or to influence them by your own. But if the game is played often enough, players can still learn. Axelrod is somewhat equivocal on this point: "It is possible that the results from pairwise interactions will help suggest how to undertake a deeper analysis of the *n*-person case as well, but that must wait."⁴⁰ Yet he does not hesitate to apply the tournaments' lessons to problems involving multiple actors—trench warfare in World War I,⁴¹ political deals in Congress,⁴² and international relations.⁴³

Nevertheless, Axelrod's multi-actor examples all involve pairwise confrontations. The *n*-person Prisoner's Dilemma is different—or at least more difficult. The key difficulty is determining which player defected, and then focusing retaliation accordingly. The honest policemen of the cartel must be able to punish the defectors without hurting the colluders, or the several colluders must find some way to act in unison. It is hard to guess how easy this is in a typical concentrated oligopoly or in an international cartel with its larger numbers of actors. But successful players of a Prisoner's Dilemma with pairwise confrontations must overcome similar uncertainties. Because of the greater complexity of the *n*-person Prisoner's Dilemma, however, one would assume that cooperation in the multi-actor setting develops more slowly and erodes more easily.⁴⁴

A second important qualification in applying the lessons learned in Axelrod's tournaments concerns the "best strategy" for Prisoner's Dilemma and its variants. There is none. Tit for Tat is not the ultimate, best, or otherwise optimal strategy, even in the simple world of Prisoner's Dilemma. The quality of a strategy depends entirely on the quality of the "environment"—the strategies adopted by the other players. If, for example, you play only with unresponsive players, players whose strategies ignore the way you behave, your best strategy is always to compete. Another illustration appeared in a slightly modified replay of the first round

39. Axelrod and many others, including the participant using TIT FOR TAT in Axelrod's tournament, insist that this is the one time that the Prisoner's Dilemma is unresolvable.

40. P. 216 n.3.

41. Pp. 73-87.

42. Pp. 5-6.

43. Pp. 157-168.

44. See P. AREEDA, *ANTITRUST ANALYSIS: PROBLEMS, TEXT, AND CASES* 292 (2d ed. 1974) ("cheating" is most readily detected and thus least likely to occur where price fixing occurs in highly concentrated markets); Hay & Kelley, *An Empirical Survey of Price Fixing Conspiracies*, 17 J.L. & ECON. 13, 26-27 (1974) (price fixing "is most likely to occur and endure when numbers [of sellers] are small, concentration is high and the product is homogeneous").

of the tournament. Axelrod discovered that Tit for Two Tats (two defections required to provoke a retaliation) and two other strategies would have done better in the first round than Tit for Tat, had they been entered. They were entered in the second round—and there did worse. The “environment” had changed, and so had the “best” strategies. Thus, a Tit for Tat business strategy is no riskless guarantee of monopoly dividends.

With these qualifications flagged, let us return to our “psychoanalysis” of the firm. Are firms egoists? I’ll grant the assumption. Are they individualists? Probably not. Competitive business is a game of Iterated Prisoner’s Dilemma. That game, as we have seen, rewards the promotion of trust (being nice, forgiving, and clear) and learning through experience (being retaliatory). In a world of repetitive encounters, where each competitor faces the same opponents and makes the same types of choices time and time again, competitiveness is a poor strategy for success. An egoistical player cooperates not despite his egoism, but because of it—he recognizes that individualism is contrary to self-interest in a non-zero-sum world. Smart egoists discard autonomy as an expensive and unnecessary luxury.

Which brings me to the antitrust laws. What do they have to say about Tit for Tat-type strategies? Though the question is open, it appears that Tit for Tat operates quite legally.⁴⁵

As a threshold matter, Tit for Tat schemes independently. Direct contacts between competitors are often illegal⁴⁶—but Tit for Tat never initiates or responds to any. The antitrust laws generally do not allow competitors to carve up markets by product line, geography, or otherwise⁴⁷—but Tit for Tat, like a good competitor, takes on all comers. It may be illegal for firms to publish price lists,⁴⁸ or otherwise to exchange indirectly information about their marketing strategies⁴⁹—but Tit for Tat speaks only

45. See generally Turner, *The Definition of Agreement Under the Sherman Act: Conscious Parallelism and Refusals to Deal*, 75 HARV. L. REV. 655, 660–72 (1962) (arguing that antitrust laws should not condemn firms’ consciously parallel interdependent pricing decisions made in response to market conditions); Posner, *Oligopoly and the Antitrust Laws: A Suggested Approach*, 21 STAN. L. REV. 1562, 1563–78 (1969) (maintaining that illegal tacit collusion should entail conscious decision to act in consideration of competitor’s expectations).

46. See *Kiefer-Stewart Co. v. Joseph E. Seagram & Sons*, 340 U.S. 211 (1951); see also Rahl, *Price Competition and the Price Fixing Rule—Preface and Perspective*, 57 NW. U.L. REV. 137 (1962) (examining scope of per se rule against price fixing).

47. *United States v. Topco Assoc.*, 405 U.S. 596, 612 (1972); *United States v. Addyston Pipe & Steel Co.*, 85 F. 271 (6th Cir. 1898), *aff’d* 175 U.S. 211 (1899).

48. See *United States v. American Linseed Oil Co.*, 262 U.S. 371, 389–90 (1923); *American Column & Lumber Co. v. United States*, 257 U.S. 377, 410–11 (1921); Note, *Antitrust Liability For an Exchange of Price Information—What Happened to Container Corporation?*, 63 VA. L. REV. 639 (1977).

49. See *United States v. Foley*, 598 F.2d 1323, 1331–35 (4th Cir. 1979), *cert. denied*, 444 U.S. 1043 (1980); *Esco Corp. v. United States*, 340 F.2d 1000, 1008 (9th Cir. 1965). But see *United States v. General Motors Corp.*, 1974 Trade Cas. (CCH) ¶ 75,253, at 97,671 (E.D. Mich. 1974) (“The public announcement of a pricing decision cannot be twisted into an invitation or signal to conspire; it

through the consistent clarity of its actions. Tit for Tat is an expert promoter of interdependent thinking, not a back-room conspirator.

'Combination,' as used in the Sherman Act,⁵⁰ is a broad term with little historical content. A "combination in the form of trust or otherwise" could be read to embrace interdependent thinking of the type fostered by Tit for Tat market strategies.⁵¹ The courts, however, have had a great deal of trouble in coming to grips with the idea. In a much-quoted passage, Justice Clark once wrote that "'conscious parallelism' has not yet read conspiracy out of the Sherman Act entirely."⁵² But the Court has also stated that "an unlawful conspiracy may be and often is formed without simultaneous action or agreement on the part of the conspirators."⁵³ The legality of conscious parallelism has been debated at length in two major law review articles that reach quite different conclusions.⁵⁴ Where all this leaves us is anybody's guess. But an antitrust action brought against Tit for Tat would seem to have, at best, dubious prospects for success.

IV. PROMOTING AND SUPPRESSING COOPERATION

A. *Behavior*

For antitrust lawyers, the first lesson of Axelrod's tournament is a negative one: The absence of direct communication between firms does not foreclose cooperation.⁵⁵ A capacity to observe the conduct of one's rivals is the only type of communication really needed. Cooperation is promoted, first and foremost, by meaningful patterns of behavior.

This conclusion highlights the importance of clarity. In Axelrod's second tournament, the only program to do worse than Random was one non-random program so complicated that it appeared completely unre-

is instead an economic reality to which all other competitors must react.").

50. 15 U.S.C. §§ 1, 3 (1982).

51. For a case giving "combination" an unexpectedly broad reading, see *Albrecht v. The Herald Co.*, 390 U.S. 145, 149-50 (1968) (publisher's hiring agent to solicit customers away from carrier who had violated contract terms, and giving those customers to another carrier, constituted "combination" between publisher, solicitor, and new carrier).

52. *Theatre Enters. v. Paramount Film Distrib. Corp.*, 346 U.S. 537, 540 (1954).

53. *Interstate Circuit v. United States*, 306 U.S. 208, 227 (1939) (citations omitted); *see also* *American Tobacco Co. v. United States*, 328 U.S. 781, 809 (1946) ("It is not the form . . . or the particular means used, but the result to be achieved that the statute condemns.").

54. Compare *Turner*, *supra* note 45 (arguing that the conscious parallelism resulting from oligopolistic interdependence should not, in itself, be considered unlawful under the Sherman Act) with *Posner*, *supra* note 46 (taking issue with *Turner*'s view of oligopolistic interdependence and arguing that section 1 of the Sherman Act should apply to that collusion).

55. "The fact that cooperation based upon reciprocity can emerge and prove stable suggests that antitrust [courts] should pay more attention to preventing the conditions that foster collusion than to searching for secret meetings among executives of competing firms." P. 180.

sponsive. Such opaque behavior promotes competition; clear conduct promotes interdependence.

Several courts have recognized as much. Conspiracy has been inferred, in part, from “artificial” product standardization. “Delivered pricing,” designed to clarify the prices charged, is a venerable tradition of uncertain legality.⁵⁶ Vertical price restraints imposed by wholesalers on their independent dealers are suspect because such restraints may aid inter-wholesaler collusion by clarifying cooperative wholesaler conduct that dealers’ price-cutting might otherwise obscure.⁵⁷

Yet it remains difficult to infer “conscious parallelism” from objective behavioral criteria. The mere fact of parallel behavior is uninformative—cut-throat competition leads to parallel pricing as surely as does an intent to cooperate.⁵⁸ And viewed individually, at least, Tit for Tat’s character traits seem ingenuous.

Being retaliatory cannot by itself be illegal. The fiercest competitor can also be provoked. Parallel cuts in price or improvements in the quality of a product are as likely to attend bitter competition as they are to attend cooperation nurtured by a Tit for Tat strategy. Unless we inquire into underlying motives, a firm’s retaliatory behavior tells us nothing about the legality of its conduct.

“Forgiving” business strategies may also be pursued by honest competitors. Competitors may, for example, provoke a firm into competing at unrealistic levels—meeting a low bid, or a low price in some particular geographic area—from which it must retreat by return to “nicer” (higher) prices because it recognizes that the lower ones are simply not sustainable. This looks like forgiveness, but the underlying motive may be desperation: The “forgiving” firm certainly hopes that its competitors will follow suit, but also realizes that, if it does not, it is doomed.⁵⁹

56. *Compare In re Plywood Antitrust Litig.*, 655 F.2d 627 (5th Cir. 1981) (finding plywood manufacturers guilty of per se violation of Sherman Act for conspiring to maintain “delivered” pricing scheme), *cert. dismissed sub noms.* *Weyerhaeuser Co. v. Lyman Lamb Co. and Georgia-Pacific Corp. v. Lyman Lamb Co.*, 103 S. Ct. 3100 (1983), *with* *Boise Cascade Corp. v. FTC*, 637 F.2d 573 (9th Cir. 1980) (finding defendant not guilty on same facts).

57. *See Continental T.V. v. GTE Sylvania*, 433 U.S. 36, 51 n.18 (1977). In contrast, non-price vertical restraints are much less likely to foster cooperation effectively.

58. All firms, for example, will charge the same price if they are competing to the hilt; they may raise their prices in simultaneous response to price increases in supply markets; they may all decline to deal with a less attractive supplier, or insist on dealing with the same more attractive one; their markets may gain the semblance of exclusive territories because of cost advantages associated with geographical location or their familiarity with the locale.

59. *Cf. Ambook Enters. v. Time, Inc.*, 612 F.2d 604, 615 (2d Cir. 1979) (in oligopolistic market, downward price move would be followed by competitors), *cert. dismissed*, 448 U.S. 914 (1980); *United States v. Borden Co.*, 111 F. Supp. 562, 579–80 (N.D. Ill. 1953) (parallel conduct, without agreement, sufficient to establish violation of Sherman Act), *aff’d in relevant part*, 347 U.S. 514 (1954). The recent pattern of slashing and raising prices in the airline industry, coupled with heavy losses on almost all sides, illustrates the point. Viewed narrowly, the pattern of cutting prices responsively, and then raising them again in the apparent hope that others will follow, looks nice and

Niceness—the refusal to be the first to defect—provides the most unambiguous evidence of intent to promote cooperation. Niceness consists of foregoing competitive opportunities, but it too is a difficult barometer to read. Courts have occasionally seized on action against self interest,⁶⁰ or its absence,⁶¹ as a touchstone for testing allegations of interdependent conduct. But not all conduct against self-interest is “nice.” A vigorous competitor may sacrifice short-run profits to attract new customers or stimulate business.⁶² This may be against short-term self-interest, but it is unmistakably not “nice.” A firm’s vigorous attempt to attract new business is not likely to promote cooperative responses from its rivals, who stand to lose in business what the first firm gains.⁶³

Retaliatory or forgiving conduct, viewed in isolation, is thus of little help in attempting to distinguish conduct intended to elicit cooperative behavior. Niceness, though a good abstract gauge of conduct intended to foster cooperation, is difficult to identify in practice. Yet in a game of Prisoner’s Dilemma, Tit for Tat is recognizable because its overall pattern of conduct is so distinct. Tit for Tat is an *integrated* strategy, characterized by four dimensions of behavior—niceness, responsiveness to provocation, readiness to forgive past competitive transgressions, and clarity in implementing these three substrategies. The cycle of niceness, provocation, and a return of cooperation is the unmistakable signature of a Tit for Tat strategy. It is this pattern that courts must search for to identify consciously parallel actors.

B. *Psychology*

The simple patterns of behavior that promote cooperation are only the table manners of interdependence. Axelrod also discusses the deeper psy-

forgiving. But if prices are slashed to levels below marginal cost, raising them again is a bid for survival as much as for a similar response.

60. See *Ambook Enters.*, 612 F.2d at 614 (summary judgment inappropriate because defendants “offered no evidence to show what legitimate business advantage, save continuity and fear of reprisal, inhered” in their parallel conduct).

61. See, e.g., *Venzie Corp. v. United States Mineral Prods. Co.*, 521 F.2d 1309, 1314 (3d Cir. 1975) (“The absence of action contrary to one’s economic interests renders consciously parallel business behavior ‘meaningless, and in no way indicates agreement.’”) (quoting *Turner*, *supra* note 45, at 681); *Delaware Valley Marine Supply Co. v. American Tobacco Co.*, 297 F.2d 199, 204–05 (3d Cir. 1961) (notwithstanding evidence “sufficient to support a finding by a jury of conscious parallelism,” directed verdict for defendant partly because of absence of any action contrary to self interest), *cert. denied*, 369 U.S. 839 (1962).

62. P. AREEDA, *supra* note 44, at 231–32.

63. Cf. *FTC v. Lukens Steel Co.*, 454 F. Supp. 1182, 1198 (D.D.C. 1978) (buyer’s informing bidder of competing bidder’s lower bid was not against buyer’s self-interest, because action intended to induce matching low bid). Antitrust plaintiffs have, on occasion, attempted to make something of the fact that a defendant rejected a plaintiff’s offer in favor of a less attractive one from another customer. See *Lamb’s Patio Theatre v. Universal Film Exchs.*, 582 F.2d 1068 (7th Cir. 1978); *Milgram v. Loew’s, Inc.*, 192 F.2d 579, 583 (3d Cir. 1951), *cert. denied*, 343 U.S. 929 (1952).

chology of cooperation. He proposes four maxims for living happily, or, as he more modestly puts it, maxims for “how to do well in a durable iterated Prisoner’s Dilemma.”⁶⁴

1. *Don’t be envious.* We are accustomed to think in terms of zero-sum enterprises. In these ventures we think ordinarily, not cardinally—the benchmark of the success of your performance is the failure of your opponent’s. That point of view must be discarded in non-zero-sum games such as Prisoner’s Dilemma. “People tend to resort to the standard of comparison that they have available—and this standard is often the success of the other player relative to their own success. This standard leads to envy. And envy leads to attempts to rectify any advantage the other player has attained.”⁶⁵

How big a role envy plays in the psyche of corporate strategists is hard to say. I suspect that in young and burgeoning enterprises it may be a powerful force; in older, more mature, and more stable industries, envy may disappear. In any event, egoism, which we have granted the firm all along, is not the same as envy. A pure egoist is not concerned with the relative success of his collaborators; he focuses on his own advancement in absolute, not relative, terms.

2. *Don’t be the first to defect.* The single best predictor of success in Axelrod’s tournaments was niceness. Some of the non-nice rules were very sophisticated; they still did badly. Tester, for example, tried an initial defection, then quickly “apologized” (by cooperating for several moves) if the opponent retaliated.⁶⁶ Tranquilizer cooperated for a dozen or so moves, hoping to lull opponents into a stupor of niceness, then began defecting with increasing frequency until the retaliations became too costly. But neither strategy did particularly well—both lost too much ground when playing against readily provokable strategies like Tit for Tat.⁶⁷

3. *Reciprocate both cooperation and defection.* Tit for Tat is amazingly robust—it does very well in a wide variety of different environments. It suffers little in a world peopled with meanies; it is quickly embraced by the nice; it cannot be lulled, tranquilized, or tested into doing something stupid. Its incredibly simple strategy is very good at discriminating (not consciously, but reactively) between the good, the bad, and the ugly—the nice, the mean, and the random.⁶⁸ The cornerstone of this dis-

64. P. 110.

65. P. 111 (footnote omitted).

66. P. 44.

67. Pp. 45–46.

68. Axelrod notes a minor qualification. In an environment where the main danger is unending mutual recrimination triggered by an early defection, a strategy somewhat more forgiving than Tit for Tat would be superior. P. 120. But, of course, when the main danger is exploitation by non-nice strategies, forgiveness is costly. *Id.* If you know your environment, you can refine your strategy. Oth-

criminating strategy is reciprocity. With a modest presumption of niceness, and a strong policy of reciprocating both good and evil, Tit for Tat reaps all the benefits of cooperation, yet cannot be excessively exploited.

4. *Don't be too clever.* Some of the most sophisticated entries in Axelrod's tournaments did very badly. They failed for one of two reasons. Some were just too complicated, and appeared unresponsive. The best strategy against an unresponsive player, a player who completely ignores what you do, is always to compete. A strategy so complicated that it elicits that response from others is doomed to do badly. Other clever strategies failed because they were not clever enough. No one ever is "clever enough" in Prisoner's Dilemma. As Axelrod put it,

it does not pay to be clever in modeling the other player if you leave out the reverberating process in which the other player is adapting to you, you are adapting to the other, and then the other is adapting to your adaptation and so on. This is a difficult road to follow with much hope for success.⁶⁹

C. *Structural Changes*

For those unable to master Tit for Tat, there are other ways of adjusting Prisoner's Dilemma to make it easier to win or lose.

1. *Different Payoffs.*⁷⁰ A treble-damage penalty for cooperating can change the payoff table significantly. If the probability of being assessed treble damages is high enough, then the expected net reward for cooperating will fall below the reward for competing, and competition will become the unconditionally preferred strategy.

Would single damages be enough?⁷¹ The answer is not altogether clear. Certainly the hierarchy of payoffs⁷² would not be changed by imperfectly enforced single damages, so one essential aspect of the dilemma would remain. But the sum of the Temptation plus the Sucker's Payoff might come to exceed the Joint Reward of Cooperation (reduced by the expected collusion penalty), and this would upset the applecart. When the cycle of alternately suckering everyone else, and then being suckered by them in return, becomes more attractive than cooperating and paying the collusion penalty, competition becomes favored.

erwise, Tit for Tat represents an excellent compromise.

69. P. 121.

70. P. 133.

71. A bill now before Congress would allow trial judges to reduce treble-damage antitrust awards to amounts equal to, or on occasion lower than, the plaintiff's "unrecovered actual damages." H.R. 2244, 98th Cong., 1st Sess. § 3 (1983). See 129 CONG. REC. E1473 (daily ed. Apr. 11, 1983) (statement of Rep. Rodino).

72. See *supra* note 16.

The structure of a market itself may discourage cooperation. When the rewards of joint cooperation are only slightly greater than those of competition, and the cost of being suckered as a “lone” cooperator is high, a Tit for Tat strategy may be too risky ever to get started. If even one defection by a co-producer will be catastrophic, Tit for Tat-type strategies may never be tried.

Finally, if an industry is innovative, and innovation is suitably rewarded, competition may be (or, equally well, may *appear* to be) more rewarding than cooperation. Oligopolies, it has been observed, are characterized by a lack of innovation. It is sometimes suggested that the complacent life of oligopoly is the cause of this stagnation,⁷³ but cause and effect may, in fact, be quite the reverse. A mature industry in which innovation is rare favors cooperation because it is obvious to all that the rewards of competition are limited. This suggests, somewhat surprisingly, that one way to undermine shared monopolies is to award limited exclusive monopolies—to grant patents, protect trade secrets, and take other steps to increase the rewards of competition.

2. *Kinship*. If you share sufficiently in the other player’s gain, the short-term reward for competing in Prisoner’s Dilemma disappears, and cooperation becomes unconditionally favored.⁷⁴ It seems obvious that cooperation is inevitable when a Prisoner’s Dilemma player values the other player’s gain as much as his own. The rule of *United States v. Yellow Cab Co.*⁷⁵ therefore becomes particularly ineffectual. Members of the same corporate family operating within the same market are required by *Yellow Cab* to comply with the antitrust laws: “[T]he common ownership and control of the various corporate appellees are impotent to liberate the alleged combination and conspiracy from the impact of the [Sherman] Act.”⁷⁶ A wholly owned subsidiary can unlawfully “combine” with its parent,⁷⁷ just as two subsidiary corporations owned by the same parent can conspire together illegally.⁷⁸ Whether or not it makes sense as a matter of economic policy to insist on the managerial autonomy of affiliated

73. See J. SCHUMPETER, *CAPITALISM, SOCIALISM & DEMOCRACY* 81–106 (1983).

74. Pp. 96–97; cf. R. FISHER & W. URY, *GETTING TO YES* 58–83 (1981) (“Invent Options for Mutual Gain”).

75. 332 U.S. 218 (1947).

76. *Id.* at 227. See P. AREEDA, *supra* note 44, at 319–22 (discussing “intraenterprise conspiracy”). A number of courts, perhaps troubled by the anomaly of faulting intra-family cooperation, have watered down the *Yellow Cab* rule. See *Knutson v. Daily Rev.*, 548 F.2d 795, 802 n.5 (9th Cir. 1976), *cert. denied*, 433 U.S. 910 (1977) (related corporations not entirely immune from § 1 of Sherman Act). The Supreme Court will be taking another look at the problem of intra-family collusion in the 1983 term. *Copperweld Corp. v. Independence Tube Corp.*, 691 F.2d 310 (7th Cir.), *cert. granted*, 103 S.Ct. 3109 (1983).

77. *Perma Life Mufflers v. International Parts Corp.*, 392 U.S. 134, 141–42 (1968).

78. *Kiefer-Stewart Co. v. Joseph E. Seagram & Sons.*, 340 U.S. 211, 215 (1951).

corporations,⁷⁹ it is naive to believe that this autonomy can in fact exist when related corporations operate in the same market. When two players of Prisoner's Dilemma are members of the same corporate family, Tit for Tat-type cooperation is inevitable.

3. *Central Authority*. There is no better way to promote cooperation than to have a third party watch over and direct the conduct of both players.⁸⁰ The authority figure must have power to discipline any player who competes, and ideally should communicate freely with each so that instances of competition may be reported. One such arrangement exists when a wholesaler distributes products through several independent dealers. *Dr. Miles Medical Co. v. John D. Park & Sons Co.*,⁸¹ announced a per se prohibition on this type of "vertical" policing by wholesalers. Likewise, a cartel with one very large producer, capable of punishing or rewarding others, is likely to be especially stable.

4. *The Shadow of the Past*. Why are manufacturers of cereals and canned goods willing to cut prices only with generically packaged products? Why is non-price competition so prevalent among oligopolists, while oligopolistic prices themselves are rigid?⁸² Why are trade associations eager to compile historical price data for distribution to their members? Axelrod's book suggests the answer.

Anything that clarifies what a player did in *preceding* moves promotes the evolution of cooperation. A player who wishes to encourage cooperation in others, while competing himself, will make every effort to cloud and complicate his own competitive conduct: "The ability to recognize the other player from past interactions, and to remember the relevant features of those interactions, is necessary to sustain cooperation. Without these abilities, a player could not use . . . reciprocity and hence could not encourage the other to cooperate."⁸³ Or, as Profesor Areeda argues: "[With] secret bidding and made-to-order goods, oligopolistic coordination will be very unlikely indeed. This is a particular and strong illustration of a more

79. Compare P. AREEDA, *supra* note 44, at 320-21 (suggesting that subsidiary should not be considered able to "combine" with parent) with Note, *Intra-Enterprise Conspiracy Under Section 1 of the Sherman Act: A Suggested Standard*, 75 MICH. L. REV. 717 (1977) (proposing test based upon degree of managerial control exercised by parent over subsidiary).

80. 220 U.S. 373 (1911). *But see* Continental T.V. v. GTE Sylvania, Inc., 433 U.S. 36 (1977) (non-price vertical restraints are judged by rule of reason and are not per se illegal). The Supreme Court recently declined to reexamine the per se prohibition against vertical price restraints. *Monsanto Co. v. Spray-Rite Servs. Corp.*, 104 S. Ct. 1464 (1984).

81. See P. SAMUELSON, *ECONOMICS* 484 (11th ed. 1980) ("oligopolists particularly love to shift rivalry and competition into dimensions other than price").

82. P. 139; *see also* Smith, *supra* note 2, at 184 (evolution of cooperative behavior in animals is possible only if "individuals can recognize other individuals and remember their past behavior").

83. P. AREEDA, *supra* note 44, at 213.

general proposition: Uncertainty about rivals' behavior may force each oligopolist to act more like a perfect competitor."⁸⁴

Antitrust courts have had no trouble condemning announcements of *future* price changes, product standards and so on. But they have been much less hostile to inter-firm sharing of *past* pricing information, apparently on the assumption that knowledge of past conduct contributes little to future cooperation.⁸⁵ A Tit for Tat strategist, however, relies *entirely* on the record of past conduct—not because that record has any predictive value, but because it is needed for well-timed retaliation. Restrained retaliation, Tit for Tat demonstrates, is a key to promoting the reciprocation of cooperation. The essentially per se prohibition of data dissemination within oligopolies, established in *United States v. Container Corp. of America*,⁸⁶ is therefore quite reasonable.

5. *The shadow of the future*.⁸⁷ Players soon learn to be nice to a Tit for Tat strategist because they learn that Tit for Tat repays meanness. The effectiveness of Tit for Tat depends on the promise of future encounters between the players: "[I]f the other player is not likely to be seen again, defecting right away is better than being nice."⁸⁸ Conversely one way to increase the importance of the future is to make interactions more durable. The longer firms remain in the same markets, the greater the value of cooperation.

An obstacle to cooperation however, is that future gains are usually discounted to arrive at their present value. Tit for Tat works only if the present value of future encounters is sufficiently large.⁸⁹ Thus, another way to increase the value of the future is to make interactions more frequent. "A good way to increase the frequency of interactions between two given individuals is to keep others away . . . [F]irms in a congenial industry try to keep out new firms that might upset the cozy restraints on competition that have grown up in the restricted industry."

Somewhat unexpectedly, one implication of this analysis is that when interest rates are high—that is, when the present value of future earnings is low—cooperation will be undermined. It also implies that the goals of antitrust may be best served if the managers of corporate America focus

84. See *Maple Flooring Mfrs. Ass'n v. United States*, 268 U.S. 563 (1925); *Tag Mfrs. Inst. v. FTC*, 174 F.2d 452 (1st Cir. 1949); cf. P. AREEDA, *supra* note 44, at 230 ("[P]ast transactions give each firm but little assurance on how his rivals will bid today.").

85. 393 U.S. 333 (1969).

86. The phrase is Axelrod's. P. 126.

87. P. 115.

88. Cf. P. AREEDA, *supra* note 44, at 230 ("If transactions are relatively infrequent, each firm will have less fear of rival imitation or retaliation because an observed transaction may simply not be comparable to the next transaction occurring much later amidst substantially altered market circumstances.").

89. P. 130.

on short-run profits and this year's balance sheet. A longer-term view may encourage desirable capital investment and product development but it will also foster inter-firm cooperation.

V. THE EVOLUTION OF COOPERATION

A. *The Conglomerate Oligopolist*

Although Axelrod never makes the point, his work demonstrates an important difference between the garden-variety Iterated Prisoner's Dilemma, and the game he actually organized, which might be called a "round-robin" Iterated Prisoner's Dilemma. In Iterated Prisoner's Dilemma, two players meet each other many times in succession. In the round-robin version of the game, many different opponents face each other, one-on-one, many times; a player's cumulative score against all opponents is what counts.

As already noted, Tit for Tat invariably "loses" one-on-one confrontations. Nevertheless, Tit for Tat "wins" when its aggregate performance against many opponents is assessed. This is profoundly important.

All commentators recognize that the performance of isolated oligopolies is indeterminate.⁹⁰ In some instances, oligopolies work "well" for the participating, cooperating firms; in many others, price or non-price competition develops and erodes profits.⁹¹ Any oligopoly may contain a basically well-meaning but slightly erratic Joss, whose occasional defections ruin the *entente cordiale* for all. Thus, in any particular oligopoly, a nice oligopolist may not fare especially well.

But if Tit for Tat is used as the firm-wide strategy by a conglomerate with products in several oligopolistic markets, facing a correspondingly broad spectrum of opposing strategies, then that conglomerate's chances of success improve considerably. The advantage of a cooperative strategy to a conglomerate oligopolist is likely to be much greater than to a firm operating in a single oligopoly.

Like so many others in the world of Prisoner's Dilemma, this conclusion may seem counter-intuitive. But consider how the advantages of cooperation increase in the three variants of Prisoner's Dilemma. In a one-shot game, with its single test of good will, the Prisoner's Dilemma is unresolvable. Cooperation simply cannot be said to be a superior strategy to competition. In the single-opponent Iterated Prisoner's Dilemma, cooperation already begins to look much better. Rivals, if they are smart

90. See P. SAMUELSON, *supra* note 82, at 484 ("The richness of possible outcomes [of oligopolistic behavior] would exhaust a specialized book on the subject.").

91. Non-price competition may take the form of non-nice advertising, research, and other avenues. See *id.*

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enough, will recognize that their well-being depends more on the long-term pattern of their relations than on the outcome of any single bid. But even in this setting, cooperation has its hazards: Unrequited cooperation may cost money or customers that will never be recouped. The round-robin Iterated Prisoner's Dilemma offers the most attractive habitat for the would-be cooperator—a variegated one occupied by many different opposing strategies. Here a conglomerate can afford to be—indeed, will do best by being—a consistently cooperative oligopolist, provided there are at least a few others like it in a few of the oligopolistic markets in which the conglomerates operate.⁹²

In one of the few “business” examples included in the book, Axelrod notes:

[S]uppose a business school teacher taught a class of students to initiate cooperative behavior in the firms they join, and to reciprocate cooperation from other firms. If the students did act this way, and if they did not disperse too widely (so that a sufficient proportion of their interactions were with other members of the same class), then the students would find that their lessons paid off.⁹³

Axelrod even supplies an illustrative calculation. If the payoffs resemble our Payoff Table, and each move is discounted to ninety percent of the previous move, a large conglomerate firm needs to have only *five percent* of its interactions in shared monopolies populated by like-minded firms to make an across-the-board Tit for Tat strategy pay off.⁹⁴

B. *Survival of the Fittest*

The most interesting and original aspect of Axelrod's research is his third, “ecological” tournament, which neatly sidestepped what Paul Samuelson described as “[a] century of theorizing by economists about what Mind A thinks Mind B will do if B thinks A will do such-and-such.”⁹⁵ Axelrod recognized that it is less important to speculate about which types of strategies will be *tried* than to determine which will *prevail* in the long run.

92. A cooperative business strategy is promoted not by increasing the number of its contacts with a few firms that it already meets frequently but by increasing the number of different strategies that it meets. Tit for Tat does especially well not when it encounters the same few opposing strategies many times, but when it encounters a variety of *different* strategies many times. Cf. M. GREEN, *THE CLOSED ENTERPRISE SYSTEM* 27–28 (1972) (the existence of many points of market contact between corporate strategists promotes interdependent behavior of conglomerates).

93. P. 65.

94. *Id.*

95. P. SAMUELSON, *supra* note 81, at 482 n.3, (citing J. VON NEUMANN & O. MORGENSTERN, *THE THEORY OF GAMES AND ECONOMIC BEHAVIOR* (3d ed. 1953)).

To answer this question, Axelrod structured his third tournament on a simple, "ecological" principle: "[W]hatever is successful is likely to appear more often in the future."⁹⁶ The first round of the ecological tournament was played by the sixty-two entries of Axelrod's second tournament—a varied group comprising the benign and malign, and most of the spectrum in between. In each subsequent round of the ecological tournament, the field was changed to reflect the outcome of the preceding round: Each strategy was replicated in proportion to its score in the previous round. A player's score in each round thus measured its "fitness" to survive and propagate into the next round. The outcome of each round changed because the "fitness" of a strategy depends on its environment.

Natural selection takes time, of course. Axelrod observed that some players thrived in early rounds by being highly predatory—feeding on their non-retaliatory colleagues—but suffered later when all the dodos were gone and only the warier remained. As Axelrod puts it: "[D]oing well [against strategies] that do not score well themselves is eventually a self-defeating process . . . [N]ot being nice may look promising at first, but in the long run it can destroy the very environment [the non-nice strategy] needs for its own success."⁹⁷

After one hundred "generations" a clear winner of the ecological tournament had emerged—Tit for Tat, of course. There were by that stage more Tit for Tats than any other species, and Tit for Tat's rate of growth was the highest.⁹⁸ In short, Tit for Tat gradually but inexorably took over the world, with other cooperative strategies not too far behind.

Axelrod thus demonstrated that the evolution of cooperation is, at least in the world of Prisoner's Dilemma, unstoppable. A primordial soup, dominated by hostile competitors but seeded with only a small cluster of nice cooperators, will evolve into a cooperative Utopia. The Tit for Tats thrive in their occasional encounters with each other, and lose little ground in their encounters with unresponsive or cut-throat competitors.

In other carefully manipulated tournaments, Axelrod also found that a world initially full of Tit for Tats cannot be invaded by a few unenlightened competitors. The Tit for Tats soon expel the intruders. Again, Tit for Tat does well when it encounters its clones or cousins, and loses little when it stumbles across a more predatory (less nice) beast. In short, the cooperators always prevail.

Imagine now a world of many markets, each occupied by several firms, all of which always compete. One fine day a "mutant" manager of a firm in one market adopts a Tit for Tat strategy. The firm does not fare well.

96. P. 169.

97. P. 117.

98. P. 51-53.

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Its initial attempt at cooperation is rebuffed; thereafter, consistent with sound Tit for Tat principles, it always competes. "A world of 'meanies' can resist invasion by anyone using any other strategy—provided that the newcomers arrive one at a time."⁹⁹ Unfortunately, the Tit for Tat Co.'s one-time attempt at niceness is costly; its balance sheet for the year in which it first attempts to be nice will not look good. The mutant manager will be fired.

But suppose, instead, that some day a market comes to be dominated by a small cluster of Tit for Tat planners, yourself included. No one will be fired here; in due course you and your colleagues grow fat on your shared monopoly profits. Perhaps you will think of expanding. But what can a Tit for Tat strategist do? Any attempt to expand market share in a shared monopoly would not be nice.¹⁰⁰

Conglomerate expansion is surely the answer. Start up business in a different market, or, if you feel especially lazy, buy one. You will find a use for those accumulated oligopoly profits, gratify your empire-building instincts, and if you are reasonably careful you will not run afoul of the antitrust laws, which are not greatly concerned with conglomerate expansion.

Most of the time you will find conglomerate expansion disappointing—new markets will not usually be hospitable to a Tit for Tat strategist. Your corporate children, just like biological ones, often will not live up to expectations.¹⁰¹ But every now and again, you and other Tit for Tat firms will move simultaneously into the same new market, and there your cooperative progeny will flourish. And in the fullness of time they will have children of their own, who will expand into new markets It's like an invasion of the body-snatchers.

And about as incredible? Having read Axelrod's book, I'm not so sure. The first thing to remember is that Tit for Tat, that master of cooperation, is not complicated: Cooperation can evolve among simple minds. As Axelrod puts it:

There is no need to assume that the players are rational. They need not be trying to maximize their rewards. Their strategies may sim-

99. P. 63.

100. In a one-market oligopoly, a managerial strategy that places a premium on growth cannot be reconciled with one that is nice. One firm's expansion within the market will almost inevitably be at the expense of another's. It may, on occasion, be possible for a firm to stimulate consumer demand, and thereby to expand without directly injuring other firms in the market. But even when that is possible, an oligopolist must worry that efforts to stimulate demand may be perceived as non-nice attempts to encroach on another's market share. Advertising, product changes, coupons, refunds, and so on, are not likely to be viewed by one's colleagues in the market as entirely benign.

101. To be more precise, the progeny of a cooperative parent will do unusually well only if they are born into a world in which cooperation continues to be advantageous.

ply reflect standard operating procedures, rules of thumb, instincts, habits, or imitation The actions that players take are not necessarily even conscious choices There is no need to assume deliberate choice at all.¹⁰²

Moreover, a successful Tit for Tat strategist need not be a saint. A Tit for Tat player may be perfectly egoistic, so long as it remembers the value of cooperation. It may be voraciously acquisitive, so long as it expands into markets other than those it already occupies. It may even be mildly envious of the success of other firms, so long as it recognizes that it cannot afford to be the first to compete. The only thing a Tit for Tat strategist may not be is *so* envious of other firms' successes that it will sacrifice its own gross profits in an attempt to best competitors. The possibility of conglomerate expansion gives free rein to a firm's acquisitiveness while allowing it to preserve peaceful harmony within its shared monopolies.¹⁰³

VI. CONCLUSION

The world of business is complicated—much more complicated than I have acknowledged here. Axelrod would certainly be the first to admit it. And yet, the Prisoner's Dilemma cannot be dismissed simply because it is simple: "It is the very complexity of reality which makes the analysis of an abstract interaction so helpful as an aid to understanding."¹⁰⁴

For antitrust lawyers, Axelrod's research should perhaps serve a cautionary role rather than a predictive one. The ascendant view these days seems to be that antitrust is not as important as had heretofore been thought. Axelrod's book should unsettle this complacency. That firms are greedy does not ensure that they will compete; quite the contrary may be true. Competition does not inevitably emerge triumphant; cooperation is hardy, not fragile.

102. P. 18 (citation omitted).

103. This suggests that one strategy for fighting oligopolies might be to bottle up successful oligopolists' greed. If firms are acquisitive, and if conglomerate expansion is forbidden, firms may end up forgoing cooperation and attempting to expand within their own markets. Intra-market expansion is, in markets with stable consumer demand, a zero-sum game (my market gain is your loss) in which trust is not likely to flourish.

104. P. 19.