Chapter Introductions for "Readings in Games and Information"

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PART I: THE RULES OF THE GAME

1. Philip Straffin, ``The Prisoner's Dilemma," *UMAP Journal.* 1: 101-103 (1980).

2. Albert Tucker, ``A Two-Person Dilemma," unpublished notes (May 1950).

3. John Nash, ``Equilibrium Points in n-Person Games," *Proceedings of the National Academy of Sciences, USA*. 36: 48-49 (January 1950).

4. John Nash,   ``Non-Cooperative Games," *Annals of Mathematics*, 54: 286-95 (September 1951).

5."To Ensure High Prices, Some Haulers Have Been Known to Break the Rules," Jeff Bailey, *Wall Street Journal*, p. A6 (8 November 1993).

6. "Cash Flow: 'Pay to Play' is Banned, but Muni-Bond Firms Keep the Game Going," *Wall Street Journal*, p. A1 (13 May 1998).

7. Sylvia Nasar, "School of Genius (Princeton, Fall 1948)," pp. 58-65 of *A Beautiful Mind,* New York: Simon and Schuster (1998).

8.Cartoon: Ratbert the Consultant. Dilbert, United Features Syndicate,(1997).

Two major themes of this chapter, and of my book *Games and Information*, and, indeed, of the entire field of game theory are the Prisoner's Dilemma and Nash equilibrium.

The Straffin and Tucker readings present the story of how the Prisoner's Dilemma came to be.   When I was working on the first edition of *Games and Information* in 1988, I wanted to be careful in my citations, but I found it hard to track down the origin of the Prisoner's Dilemma. I asked Lloyd Shapley, who was nearby at UCLA, and he told me to write to Albert Tucker, still alive and living in Princeton. Tucker referred me to this article, which was also reprinted in the *Two-Year College Mathematics Journal* (1983) 14: 229-230 along with an interview with Albert Tucker. Tucker was a friendly person; see also the oral history project he started at "The Princeton Mathematics Community in the 30's," June 24, 2000, http://www34.homepage.villanova.edu/robert.jantzen/princeton_math/pm06.htm, and Chapter 6 of Willam Poundstone, *Prisoner's Dilemma: John von Neumann, Game Theory, and the Puzzle of the Bomb*, New York: Doubleday (1992).

The story raises a profound question for the philosophy of science. Who discovered the Prisoner's Dilemma— Dresher and Flood, who came up with the payoff matrix, or Albert Tucker, who came up with the story? Should the contribution of any of the three be enough for tenure, if that were all the person had ever done? In any case, which   is more important, the matrix or the story?

The Prisoner's Dilemma is a game whose equilibrium can be found by either the idea of dominance or consistency of best responses. The second of these is the idea of Nash equilibrium. I tell my students that understanding Nash equilibrium is the most important thing to learn in a course on game theory. It is easy to memorize the definition, and to think that you understand the idea, but invariably I have questions on the midterm that rely on it and most students get the question wrong without even realizing why. All I can do is tell you that, and tell you that once you really know game theory you will realize why Nash's idea deserved a Nobel Prize. The two articles reprinted here are the publications that got him the prize.

Sylvia Nasar has written an excellent book on John Nash-- on his early successes, his insanity, and his subsequent life up to winning the Nobel Prize. I have included a chapter from it that is not about Nash directly, but

about the Princeton economics department which trained him. Princeton had one of the best mathematics department in the world in 1948. This is a good model for how a department should work. Note that the good qualities here described are no due to money, or fame, but to attitude. The worst college in the world could do the same. But attitude is often the hardest thing to acquire, and a scholarly attitude seems to be strongly correlated with scholarly talent. Why? A priori, I see no reason why a deparmtnet of morons could not have good coffee hours during which they fanatically discuss mathematics or economics, even if what they discuss is long division or the idea of a supply curve. They would enjoy themselves and increase their knowledge just as much as Nash and his colleagues, even if no new discoveries would be made for the wider world.

The two articles from the *Wall Street Journal* on garbage collection and municipal bond underwriting both are about Prisoner's Dilemma games. How? I will leave it to you. These are good stories on which to base the exercise of taking a verbal story and converting it to a formal game theory model by describing Players, Actions, Payoffs, and Information. They are also good for practice in finding Nash equilibria.

Finally, just to motivate you for the rest of the book, the Dilbert cartoon shows the easiest way to make money from game theory. But it raises good questions, too. Why do people hire consultants? How do they know which people to hire as consultants? Later chapters on information asymmetry will help you understand.

PART II: INFORMATION

9. Ian Ayres and Jeremy Bulow, ``The Donation Booth,'' *The Boston Review* , pp. 26-27 (December-January 1998).

10. Livy,"The Horatii and the Curiatii," *The Early History of Rome*, Section 1.23, A. Selincourt, translator, Harmandsworth, England: Penguin (1960).

11. Michael Rothkopf, , ``TREES-- A Decisionmaker's Lament,'' *Operations Research*, 28: 3 (January/February 1980).

12. Judith Lachman, ``Knowing and Showing Economics and Law, '' (A review of *An Introduction to Law and Economics*, A. Mitchell Polinsky (1983)) *Yale Law Journal*, 93: 1587, 1598-1605 (July 1984).

13. Cartoon: "All Those in Favor, Say 'Aye'," *The New Yorker Book of Business Cartoons*, edited by Robert Mankoff, Princeton: Bloomberg Press, 1998.

The Ayres and Bulow article illustrates one of the basic points of this chapter: information matters. They suggest that the key to campaign finance reform is not to change who is allowed to make contributions (the players) or how big a contribution can be (the actions) or who politicians can work for after they leave office (the payoffs), but just to change the information, leaving everything else the same. If the politician doesn't know you gave him the contribution, he won't do you any special favors. For a longer version of their idea, see Ian Ayres and Jeremy Bulow, "The Donation Booth: Mandating Donor Anonymity to Disrupt the Market for Political Influence," *Stanford Law Review,* 50: 837-891 (February 1998).

Ayres and Bulow's idea is similar to   the "Australian ballot".   This is the secret written ballot, introduced into the United States in the 19th century. The main argument was not that the ballot's secrecy would prevent harassment of the voter. What was it?   And why was the Australian ballot adopted, but we see no signs of any country adopting the Ayres and Bulow idea? Think about players, actions, and payoffs-- *cui bono*, or, as Rush Limbaugh likes to say, *follow the money*.

I include the story of the Horatii because it is the source for a good homework problem and also   shows how a story can be converted to a model.   How would you model this? Is everybody behaving rationally? It is possible to set a model up with everybody behaving rationally, albeit with imperfect information, or with the Curiatii being dim-witted and irrational. It is also quite possible to set it up with the Curiatii being dimwitted but nonetheless rational. For my own model, see this book's website at http://www.bus.indiana.edu/~erasmuse/book/_reader/gireader.htm.

The Rothkopf poem is a bit of humor from decision theory. As you can perhaps tell already, I think humor is an important part of learning game theory.   Even in   subjects less full of twists and paradoxes than game theory, humor is useful. As John Littlewood said, "A good mathematical joke is better, and better mathematics, than a dozen mediocre papers" (John Littlewood, *A Mathematician's Miscellany*, London: Methuen [1953]).   So rather than include another paper, I'll tell a joke:

One day a mathematician decided that he was sick of math. He walked down to the fire department and announced he wanted to be a fireman. The fire chief said, "You look dependable. I'd be glad to hire you, but first I have to give you a little test." He took the mathematician to an alley behind the firehouse where there was a dumpster, a spigot, a can of gasoline, and a hose. The chief said, "Suppose you were   walking in the alley to smoke a cigarette and you saw the dumpster   on fire. What would you do?"

The mathematician said, "Well, I'd hook up the hose to the spigot, turn the water on, and put out the fire."

The chief said, "That's great... perfect! The test isn't over, though, because we get some strange characters wanting to be firemen. What would you do if you were walking down the alley to smoke a cigarette and you saw the dumpster and gasoline, but the dumpster wasn't on fire?"

The mathematician puzzled over the question, looking for the trick. Finally, he said, "First, I'd light the dumpster on fire with the gasoline and my cigarette…."

The chief whistled. "I knew it! When PhDs show up wanting to be firemen, there's something wrong with them. So why would you light the dumpster on fire?"

The mathematician replied, "Well,   I couldn't figure out what the trick was in the question, but I knew there must be one. So I decided just to reduce the problem to one I'd already solved. I'm sorry it isn't a more elegant—does that mean I don't get the job?. (Adapted from a joke at David Shay, "Mathematicians," Www.geocities.com/CapeCanaveral/4661/, July 25, 1999.)

The cartoon is more humor.   It points to the importance of common knowledge. Would the managers behave the same way if they all knew what everybody's opinion was? What if everybody but the CEO knew everybody's opinions? How would you model this?

PART III: MIXED STRATEGIES

14. John McDonald and John Tukey (1949) ``Colonel Blotto: A Problem of Military Strategy,'' *Fortune*, p. 102 (June 1949).

15. ``Dutch Accountants Take on a Formidable Task: Ferreting Out `Cheaters' in the Ranks of OPEC,'' *Wall Street Journal,* Paul Hemp, p. 1 (26 February 1985).

16. "Shipping Price-Fixing Pacts Hurt Consumers, Critics Say," *Wall Street Journal*, Anna Mathews, p. A1 (7 October 1997).

17. George Stigler, ``The Conference Handbook,'' *Journal of Political Economy*, 85: 441-443 (April 1977).

18. Cartoon: "Very Guilty", Herman Unger, Universal Press Syndicate, (1988).

"Colonel Blotto games" from an entire class within game theory. The *Fortune* article shows one way of illustrating the payoffs from mixed strategies. You might find it instructive to try to set up the game other ways instead. Also, can you think of how to adapt this game to conflict between firms?

Auditing is not the same as using a mixed strategy. Why not? What problems might arise from the method the OPEC members use to try to discover if any of them are cheating on their agreement to limit oil output?   Can you think of any alternatives?

OPEC is a cartel made up of oil-producing countries, which is why it is exempt from the anti-trust laws of the U.S. and other countries.   Many countries, including the U.S., also exempt certain industries, especially sales of labor by labor unions. The article on ocean shipping cartels shows that even when cartels are legal, the price does not necessarily go to the monopoly price. Much depends on the particular industry.

I include Stigler's conference handbook for the reader's general education in how to do economic research. Thought it dates from 1977, most of the questions in it are still just as standard. Game theory adds a few more:

1. Is your equilibrium subgame perfect?
2. Did you take into account deviations using mixed strategies?
3. Why didn't you use out-of-equilibrium belief refinement [insert favorite here] to get rid of unreasonable equilibria?
4. Why did you use out-of-equilibrium belief refinement [insert speaker's refinement here], which gets rid of reasonable equilibria?
5. What happens with incomplete information?
6. Your model is too simple.
7. Your model is too complicated.
8. Is there even one market in the history of the world that fits the assumptions of your model?

The "Very Guilty" cartoon is about the discomfort of having a discrete instead of a continuous strategy set. In common law countries such as England and the United States the jury decides whether a criminal defendant is innocent or guilty but the judge decides what the penalty will be, taking the jury's decision as given.   Whether the jury is completely sure that the defendant is guilty and was able to decide in five minutes or whether the jury barely decided that he was guilty and took five days, the judge is supposed to impose the same penalty. Does this actually happen, though? What are the payoffs for the judge and jury? Will the judge really ignore the likelihood of guilt and concentrate on the heinousness of the crime, the past record of the criminal, and other such things that are supposed to determine the punishment? Will the jury really ignore the heinousness of the crime and concentrate on the likelihood of guilt? How else might a court be organized? Which way is best?

PART IV: DYNAMIC GAMES

19. Ernst Zermelo, ``On An Application of Set Theory to the Game of Chess,'' *Proceedings, Fifth International Congress of Mathematicians.* 2: 501-4 (1913). Translated by Ulrich Schwalbe and Paul Walker, pp. 8-10 of ``Zermelo and the Early History of Game Theory,'' University of Canterbury Economics working paper (14 August 1997).

20. Thomas Schelling, pp. 119-150 of Chapter 5 of *The Strategy of Conflict,* Cambridge, Mass: Harvard University Press (1960).

21. Martin Shubik (1954) ``Does the Fittest Necessarily Survive?'' pp. 43-46 of *Readings in Game Theory and Political Behavior* , edited by Martin Shubik, Doubleday: Garden City, New York (1954).

22. "Shooting the Bird's Eye," pp. 18-19 of *The Five Sons of King Pandu: The Story of the Mahabharata* , adapted from the Kisari Ganguli translation by Elizabeth Seeger, New York: William R. Scott (1967).

23. Cartoon: ``That's It? That's Peer Review?'' S. Harris. .

Existence of equilibrium is not a big concern in game theory once mixed strategies are admitted, since an equilibrium exists except in pathological cases.   Economists, however, frequently need to try to prove such things as existence of an equilibrium in pure strategies,   non-existence of asymmetric equilibria, or uniqueness of the equilibrium. Zermelo proves that in the game of chess, there is a best strategy.   More generally, in a finite game of perfect information, backwards induction shows that each player has a best strategy.

The best strategy might not be unique, though. In chess, for example, it may be that White is sure to win if he plays the correct strategy. If White does play that strategy, Black might as well play embarassingly and lose in 20 moves as play skillfully and lose in 100 moves. But I have assumed something about the payoffs in saying this. How would the game change if, instead, Black's payoff includes (a) a dislike of sitting in one place, (b) pride in showing his skill, or (c) personal hatred of White?

The game of chess continues to be popular despite Zermelo's Theorem because the theorem only establishes existence of an   optimal strategy, without characterizing it. It is like Hilbert's Hair Theorem. David Hilbert would say to his mathematics class in Gottingen, "Among the people now in this lecture hall, there is one who has the least number of hairs on his head." (He always got a laugh, because characterization was not actually so difficult in that special case, Hilbert himself being rather bald.) Howard Eves, *Mathematical Circles Squared*, p. 128, Boston: Prindle, Weber & Schmidt (1972).   A "constructive'' proof, on the other hand, would tell you how to find the person with the fewest hairs.

Thomas Schelling's 1960 book ought to be read by every   person as a requirement for obtaining a bachelor's degree from college. Although nontechnical, it conveys a large number of strategic ideas through clear writing and striking examples. It took twenty years before the profession caught up with the book's two big themes of precommitment and information transfer. This excerpt is just an appetizer for you. See also his *Arms and Influence*, New Haven: Yale University Press (1966), and *Micromotives and Macrobehavior*, New York: W. W. Norton (1978).

Martin Shubik's note on duelling is one of those papers better known than read, since it appeared in a book long out of print. Think how it could be applied to primary elections, political intrigue, and international diplomacy.

The Mahabharata is, with the *Ramayana*, one of the two great classic epics of India. You must imagine me as Drona and yourself as Arjuna, and think about the difficulty of bringing a situation down to its essentials when you choose the players, actions, payoffs, and information in a game. Think also of the mathematician Euler, who said, after going blind in one eye after extraordinary effort put into a particular proof, "Now I will have less distraction." Howard Eves, *In Mathematical Circles*, p. 48 of Volume II, Boston: Prindle, Weber and Schmidt (1969). The cartoon for this chapter, however, "That's it? That's peer review?" will remind us to be humble. Sometimes the arrow misses anyway.

PART V: REPEATED GAMES

24. Robert Axelrod & William Hamilton, ``The Evolution of Cooperation,'' *Science,* 211:1390-1396 (March 1981).

25. "This Tax Amnesty Will Only Work Once," *Wall Street Journal,* Robert Barro, p. 1 (7 August 1986).

26.   "Fare Warning: How Airlines Trade Price Plans," *Wall Street Journal*, p. B1 (9 October 1990).

27. Harry Roberts and Roman Weil, ``The University of Chicago. Starting Research Early,'' unpublished notes, University of Chicago Graduate School of Business (August 14, 1970)

28. Cartoon: ``Einstein Discovers that Time is Actually Money,'' Gary Larson.

Repeated games are important in economic transactions where it is hard to write enforceable contracts, but they are even more important for non-economic transactions, since writing contracts is much harder when money does not change hands. Axelrod and Hamilton apply the idea even to non-human transactions-- to animals and insects whose evolutionary strategies can be modelled as if they were rationally choosing strategies in a game. Robert Barro is   a macroeconomist, but his two best-known articles, on debt in an overlapping-generations model with bequests and on reputation in monetary policy, are both about repeated games. (Robert Barro, "Are Government Bonds Net Wealth?" *Journal-of-Political-Economy*, 82:1095-1117 [Nov.-Dec. 1974] and Robert Barro & David Gordon, "Rules, Discretion and Reputation in a Model of Monetary Policy," *Journal-of-Monetary-Economics*; 12:101-121[July 1983].) This newspaper piece is about the usefulness of ruining a reputation in the political sphere. But why does past behavior give any indication of future behavior? The last of the three readings on repeated games *per se* is in an economic context, airline pricing, and takes us back to the old problem of oligopoly pricing. It is yet another reminder that there can be no single model of oligopoly, because the institutional features of different markets-- the type of product and the marketing channels-- matter to pricing behavior.

The notes on dissertation writing by Robert and Weil are part of the unpublished lore that makes doing doctoral work at a top department so valuable. They have kindly given permission for us to make attending Chicago less valuable by publishing their notes here so that the rest of us can get the benefit of their wisdom. The lessons, of course, are valuable for research beyond dissertations too. The cartoon, "Einstein discovers that time is actually money," is relevant to discounting future payoffs. This is a profound idea. Why is the discount rate positive? Is it the price of time? Can you think of strategic situations where a player would rather receive income later rather than earlier?

PART VI: DYNAMIC GAMES WITH INCOMPLETE INFORMATION

29.   David Kreps, Paul Milgrom, John Roberts, and Robert Wilson,"Rational Cooperation in the Finitely Repeated Prisoners' Dilemma," *Journal of Economic Theory,* 27: 245-252 (1982).

30. Joseph Farrell, ``Cheap Talk, Coordination, and Entry," *Rand Journal of Economics*, 18: 34-39 (Spring 1987).

31. Nicholas Pileggi, *Wise Guy:Life in a Mafia Family*, pp. 267-269, New York: Simon and Schuster (1985).

32. Cartoon: "Say, I think I see where we went off..." *New Yorker.*

The discovery of how incomplete information could be incorporated into games resulted in a rush of important articles in the early 1980's. The "Gang of Four" was made up of David Kreps, Paul Milgrom, John Roberts, and Robert Wilson, who co-authored the included 1982 paper. All were prominent in the field, and had a very good year in 1982. The same issue of the *Journal of Economic Theory* which contained the   article on the repeated prisoner's dilemma   also included two papers showing   how the idea could be applied to well-known problems in industrial organization: David Kreps & Robert Wilson, "Reputation and Imperfect Information," *Journal-of-Economic-Theory*, 27: 253-279 (August 1982); and Paul Milgrom & John Roberts, "Predation, Reputation, and Entry Deterrence," *Journal-of-Economic-Theory*; 27: 280-312 (August 1982). Together, the group published four other important papers in the same year, David Kreps & Robert Wilson, "Sequential Equilibria," *Econometrica,* 50: 863-894 (July 1982); Paul Milgrom & Robert Weber, "A Theory of Auctions and Competitive Bidding," *Econometrica*; 50: 1089-1122 (September 1982);   Paul Milgrom & John Roberts, "Limit Pricing and Entry under Incomplete Information: An Equilibrium Analysis," *Econometrica*; 50:443-459 (March 1982); and Paul   Milgrom & Nancy Stokey, "Information, Trade and Common Knowledge," *Journal-of-Economic-Theory*; 26: 17-27. Be on the lookout for theoretical breakthroughs: a new tool makes for a rush of new applications, and such moments are not common.

 One of the puzzling phenomenon of games of incomplete information that was discovered around that time, but which is still not understood in a fully satisfactory way is "cheap talk", costless, nonbinding, statements that nonetheless can affect the equilibrium. Joseph Farrell's article lays out some of what can happen with cheap talk in a simple model of natural monopoly.

The excerpt from Nicholas Pileggi's *Wise Guy* (later made into the 1990 Scorsese/DeNiro movie *Goodfellas*) is about asymmetric information towards the end of a repeated game. The Mafia and other formalized criminal gangs rely heavily on repeated interactions, but the threat of violent termination of the relationship always hangs in the air. In this excerpt, the narrator of this true-crime book has been caught by the police trading in heroin, and the evidence against him is so overwhelming that he will go to prison many years unless he enters the Witness Protection Program and testifies against his Mafia associates. He intends to testify and disappear, but first he wants to collect some heroin and some debts. His associates see him released, and wonder whether to kill him. The rest of the book is equally gripping and contains many other insights into illegal business practices, as does Pileggi's other book, *Casino: Love and Honor in Las Vegas,* New York: Simon & Schuster (1995)*,* also made into a movie by Scorcese and DeNiro, in 1995.

The cartoon, "Say, I think I see where we went off...," is for comic relief after you pore over the Gang of Four paper. That paper is short, but dense, which makes it good material for the exercise of really trying to understand an intricate game theory proof. Usually even in my Ph.D. classes I do not go over difficult proofs, but I have used this one on occasion just to show an example of how to work through them.   Do remember the lesson of the cartoon in long proofs, though. If the author of the proof is working efficiently, any flaw in it is equally likely to be found in the

arithmetic as in the differential topology. That is because he should devote more effort to the hard parts, so that the marginal return to error checking is the same for the easy parts as the hard parts. If people do not understand this, though, then mistakes in the easy parts are more embarassing, which would alter the efficient allocation of effort.

PART VII: MORAL HAZARD

33. Joseph Farrell, ``Monopoly Slack and Competitive Rigor: A Simple Model, " MIT mimeo. (February 1983).

34. Ariel Rubinstein, ``An Optimal Conviction Expectation Regime for Offenses that May Have Been Committed by Accident," in *Applied Game Theory,* 406-413, Wurzburg: Physica-Verlag (1979)

35. .``Bonded Worker Is No Guarantee of a Perfect Job," *Wall Street Journal* , Teri Agins, p. 1 (30 September 1985).

36. Cartoon: "Look, Ted! We get paid the same as you but all we're doing is standing around and flicking our fingers." Dilbert, Scott Adams.

I am very glad for the chance to be the first to publish this important note by Joseph Farrell, which I know about because he was on my dissertation committee at MIT when he wrote it. Being a true scholar, he doesn't just write for publication—and, in fact, forgot that he wrote this note till I reminded him.   It uses the idea of moral hazard to address the important policy question of what is wrong with monopolies. In 1954, Arnold Harberger pointed out that the triangle allocative losses from monopoly are surprisingly small. (Arnold Harberger, "Monopoly and Resource Allocation," *American Economic Review, Papers and Proceedings*, 44: 77-87 [May 1954]). Gordon Tullock later pointed out that if firms compete to become or to preserve market power, the welfare losses become rectangles instead of triangles. (Gordon Tullock, ``The Welfare Costs of Tariffs, Monopolies, and Theft',' *Western Economic Journal*, 5: 224-232 [June 1967]. I think this is the "Stigler trapezoid" to which Farrell refers; George Stigler later wrote about it too   Yet another possible loss, however, is the loss in productive efficiency if for some reason a monopoly slacks off and prefers "the quiet life" to profit maximization. From the point of view of the shareholders, however, such slacking off is implausible. There is no reason the shareholders of a monopoly would be less willing than those of a competitive firm to keep costs down; indeed, the monopoly, with 100 percent market share, has more sales and less danger of imitation, so it actually has more incentive to reduce production cost. Farrell shows why despite this, the monopoly might be less efficient-- he brings the managers into the picture.

Ariel Rubinstein's article, published and well-known, but published in an obscure place, is also about disciplining agents, but in the context of crime. Here, the principal is the government and the agents are the citizens-- or, if you like, the principal is the citizens as a group and the agent is the citizen as an individual.   Courts do, in practice, punish repeat offenders much more severely, and Rubinstein's article cries out for empirical work following his theoretical line. Data is all around us. To get you started, here are some excerpts from my local newspaper.

Robert Shepard III, 25, Spencer: Found guilty of violating probation on 1997 convictions for two felony counts of conspiracy to manufacture methcathinone plus one felony count of residential burglary. Sentenced by Judge E. Michael Hoff to serve six years in prison previously suspended from his 1997 convictions, with credit for 32 days already served in jail.

Timothy D. Grow Jr., 47, Spencer: Pleaded guilty to felony conspiracy to deal cocaine in October 1998. Sentenced by Hoff to six years in prison with five years suspended, three days' credit for time already served in jail, and the rest on community corrections or house arrest; assessed $625 in court costs, public defender and drug fees.

Damon Robinson, 26, 1861 Oakdale Drive East, pleaded guilty to two counts of felony theft of two diamond rings and $200 cash from two women on April 30. Sentenced by Hoff to three years in jail, all suspended, and 1 1/2 years on probation with 100 hours of public restitution work on county road crew duty; assessed $200 restitution for the stolen cash plus $125 court costs.
(*The Bloomington Herald-Times*, excerpts from "Court News", p. A7 [3 August 1999])

How would you assess these penalties from the point of view of principal-agent theory?

People have come up with other institutions that lie in between the penalties of firing a manager and of putting a felon in prison. The *Wall Street Journal* article discusses one of these: bonds posted for misbehavior by workers or contractors. In the absence of any of these penalties, shirking can be expected, and this is the point of the finger-flicking Dilbert cartoon.

PART VIII: FURTHER TOPICS IN MORAL HAZARD

37. Adam Smith, *Wealth of Nations* on efficiency wages (1776)

38. "Examples of Plea Bargains". Excerpted from Eric Rasmusen, "Mezzanatto and the Economics of Self Incrimination," *Cardozo Law Review*, 19: 1541-1584 (May 1998).

39. "Unions Say Auto Firms Use Interplant Rivalry to Raise Work Quotas," *Wall Street Journal,* Dale Buss, p. 1 (8 November 1983).

40. Cartoon: "Dilbert, I want you to manage Wally's Project while he's on vacation in Aruba." Dilbert, Scott Adams.

Moral hazard is important enough to deserve two chapters. The excerpt from Adam Smith's *Wealth of Nations* is part of his discussion of why wages differ. He begins with obvious determinants such as the skill needed for the work, but eventually he comes to the reason in the passage here: that some jobs require extra trust, and if the worker is paid a higher wage, he will be more reluctant to abuse his trust for fear of losing his good wage. That is the idea of the efficiency wage.

The examples of plea bargains are taken from an article I wrote on a very specialized point of law: whether suspects should be allowed to bargain away their right under federal U.S. law to keep discussions with the police out of their trials if they cannot come to an agreement of the kind in the Pileggi book excerpted in Chapter 6. These agreements are often very one-sided. Why? The answer may help us to understand why many contracts between employers and workers or between companies and consumers are one-sided. It may have something to do with the fact that in all of these situations one side of the transaction has a valuable reputation, but the other does not.

The newspaper article on interplant rivalry is an example of a tournament. Does the situation of the auto unions remind you of cartels? Tournaments have much in common with product competition. What are the differences? The situation in the Dilbert cartoon, "The vacation in Aruba," is more complicated, but it, too has a tournament in the background. What are the players, actions, payoffs, and information in that game?

PART IX: ADVERSE SELECTION

41. George Akerlof, ``The Market for Lemons: Quality Uncertainty and the Market Mechanism,'' *Quarterly Journal of Economics*, 84: 488-500 (August 1970).

42. "Walter Bagehot" (pseudonym for Jack Treynor), ``The Only Game in Town,'' *Financial Analysts Journal*, 27: 12-14,22 (March/April 1971).

43. ``Are Advertisers Ready to Pay Their Viewers?'' *Wall Street Journal,* Bart Ziegler, p. B1 (14 November 1996).

44. Philip Davis, Reuben Hersh & Elena Marchisotto,"The Creation of New Mathematics: An Application of the Lakatos Heuristic," pp. 291-298 of *The Mathematical Experience*, Boston: Houghton-Mifflin (1981).

45. Cartoon: "Frank's Neurosurgery," Gary Larson, *The Far Side*.

George Akerlof may well win the Nobel Prize one of these days for his "Lemons" article. Published in 1970, it was first submitted in July 1967, to the *American Economic Review*, but was rejected there and at the *Review of Economic Studies* as trivial and at the *Journal of Political Economy* as unrealistic.   Joshua Gans and George Shepherd tell the story in "How Are the Mighty Fallen: Rejected Classic Articles by Leading Economists," *The Journal of Economic Perspectives*, 8: 165-179 (Winter 1994) and George Shepherd (Editor) *Rejected : Leading Economists Ponder the Publication Process*, Thomas Horton (1994). The Akerlof article is indeed a strange one, which is why it is worth including here. By the year 2000 we have better ways of presenting a model like this, but it is worth reading the original article for its insight into how an intelligent person first thought of this idea, and to view it outside the useful blinders we now employ. The article is a good example of what Robert Fogel once told me: "Only your home runs count." (For Old World readers: in the American game of baseball, a home run is achieved by swinging a wooden bat very hard-- a risky approach which usually leads to the utter failure known as a "strikeout".)

The Bagehot article is not as well known as it should be, and it is another example of an idea published long before its time. I came across it in a course taught by Fischer Black, who said that "Bagehot" was a pseudonym for Jack Treynor, one of the formulators of the CAPM theory of asset pricing. The idea in the paper gave rise to the market microstructure literature of the 1980's and 90's.

One solution to adverse selection is for the informed player, the agent, to pay the cost of informing the uninformed player, the principal. Advertising does this; the player trying to sell something pays the cost of providing information to potential buyers. But some cost does remain for the buyer: the cost of reading the advertising. The Wall Street Journal article on paying viewers shows how this final barrier can be removed.   Cybergold, whose homepage I have incluced, is hoping to make millions by paying millions of people for reading ads.   The *Far Side* cartoon, "Frank's Neurosurgery," on the other hand, shows how not to sell a product of unknown quality.   In the cartoon, how many causes to be suspicious about Frank's skills can you spot?

The remaining selection in this chapter, "The Creation of New Mathematics," is an internal dialog illustrating the creative process in mathematics, a process much the same as in economics.   Karl Popper proposed that scientific theorizing worked by proposing "falsifiable" theories, theories which had implications that could be tested so that if the theory failed the test it could be rejected. (Karl Popper, *The Logic of Scientific Discovery*, .New York, Basic Books[1959], first published in German as *Logik Der Forschung*, Vienna: Springer [1934].)   Milton Friedman is known for his influential application of the idea to economics in   "The Methodology of Positive Economics," pp. 3-46 of *Essays in Positive Economics*, Chicago: University of Chicago Press (1953). Imre Lakatos proposed a different

process, in which the theory itself is not fully formed until it is tested, and the theory evolves along with the testing. He published his views in the form of a dialog between a teacher and students discussing a mathematical theorem, with copious footnotes by Lakatos in his own person. (Imre Lakatos, *Proofs and Refutations: The Logic of Mathematical Discovery*. Cambridge: Cambridge University Press [1976].) The selection here is a short dialog in imitation of Lakatos.

PART X: MECHANISM DESIGN IN ADVERSE SELECTION AND MORAL HAZARD WITH HIDDEN INFORMATION

46. Jacob Gonik, ``Tie Salesmen's Bonuses to their Forecasts, " *Harvard Business Review*, 56: 116-123 (May/June 1978).

47. ``Car-Buying Services Can Save Money, Especially for Those Who Hate Haggling, " *Wall Street Journal* , Melinda Guiles, p. 1 (23 April 1985).

48. Hal Varian, "How to Build an Economic Model in Your Spare Time," from *Passion and Craft: Economists at Work*, edited by Michael Szenberg, University of Michigan Press (1999).

49. Cartoon: "Of course that's only an estimate..." Hoff, *New Yorker.*

The Harvard Business Review is, like the *Financial Analysts Journal*, a practitioner journal, a good place to find relatively nontechnical write-ups of research results that are useful for businessmen.   The article here shows how to use the idea of mechanism design to extract information from salesmen about the quality of their territories.   Bargaining is another common application for mechanism design, as in the Myerson-Satterthwaite model. A way to avoid having to rely on one's own bargaining skills is to hire an agent, which is the subject of the *Wall Street Journal* article for this chapter.   You may also find it interesting to read Ian Ayres' article on his car bargaining experiments, in which he gave testers a uniform algorithm to follow in trying to buy a particular type of car in order to discover the effect of the race and gender of customer and car salesman. Ian Ayres, ``Fair Driving: Gender and Race Discrimination in Retail Car Negotiations," *Harvard Law Review*, 104: 817-872 (February 1991). Cars seem to attract shady practices, perhaps because they are valuable, are owned by unsophisticated as well as sophisticated people, and they break down sooner or later. The cartoon,"Of course that's only an estimate..." points to a common difficulty in translating the messages of car mechanics.

Hal Varian is an excellent all-round economist best known for his doctoral textbook, *Microeconomic Analysis*, New York: W. W. Norton (1st edition 1978, Second edition 1987, Third edition, 1992). He surprised everyone by becoming the dean of Berkeley's School of Information Management and Systems (the library school), but it fits his research interest in information and his polymath character. If you find his essay appealing, try his website at Http://www.sims.berkeley.edu/~hal/.   His essay is perhaps the best of the many good essays on doing research in the excellent book, *Passion and Craft*.   Other favorites of mine are the essays by William Landes , Paul Krugman, and Avinash Dixit.

PART XI: SIGNALLING

50. Kyle Bagwell and Michael Riordan, "High and Declining Prices Signal Product Quality," *The American Economic Review.* 81: 224-239 (March 1991). (Just pp. 224-232 and 237-239.)

51. John Davis, ``The Argument of an Appeal," from *American Bar Association Journal*, 26: 895-909 (December 1940).

52. Cartoon: "Yes, But the Trouble Is, He Always Wears that Mysterious Smile,..." Hoff, *New Yorker*.

The classic article on signalling is Michael Spence, ``Job Market Signalling," *Quarterly Journal of Economics*, 87: 355-374 (August 1973). I have deliberately chosen not to include it in this collection because it is a confusing presentation of the idea of signalling and not particularly well written or stimulating. My aim in this book is not to include the most important papers-- of which this is certainly one-- but those which I think are still worth not only citing, but reading. The Spence article is roughly as important as the Akerlof "lemons" article which I did include, but Spence's article is more straightforward and conventional, and so more easily replaced by textbook presentation. Instead, I have included a much later article on signalling by Bagwell & Riordan which is only moderately well known, but which is well written and representative of the mature literature on signalling. The two authors are both well-respected members of the generation of economists just after Spence's.

The prospector cartoon captures the idea of signal-jamming. At the cost of a little effort to look goofy, our prospector conceals whether he made his big strike or not. Cartoons are much like models, seeking to capture the essence of a situation economically, stripping away non-essentials and needing the participation of the reader to be understood. As David Remnick says on page iii of his preface to *The New Yorker Book of Business Cartoons*, edited by Robert Mankoff (1998), "The best cartoons have about them a sense of effortlessness, as if they were pieces of found art. They seem so stark and simple, like a small bomb. The combination of ink drawing and a few words produce a kind of explosive release-- laughter-- and truth all at once. Something so simple must be near impossible to do. My colleagues and I routinely give lip service to the art of concision-- good taste dictates Flaubert over Hugo-- but what writer isn't always *hokking* an editor for more space? As a writer, I have been guilty of it. We are road hogs, forever trying to occupy the whole highway, and so when we see the magical effects the cartoonists get with their drawings and their combustible bits of language, we begin to wonder about our own failings, the grossness of our 10,000- and 20,000-word bloviations."

Can you construct a formal model of the situation in this cartoon? Could there be a pooling equilibrium in which *all* lawyers, good and bad alike, had to wear clown costumes? Before you laugh, ask yourself whether there could be a pooling equilibrium in which all lawyers, good and bad alike, had to wear silk cloths around their necks and carefully pressed suits.

My inclusion of the Davis article may strike you as odd. What is a sixty-year-old article from a practitioner law journal doing in a collection of readings in game theory? I include it because it turns out that arguing cases before the Supreme Court and presenting research before I.O. economists is much the same. The speaker has limited time, he must think about the audience and not about his paper, he must make technical arguments understandable, and he should realize that questions are more important than displaying every last one of his overhead slides. Before one worries about such subtleties as signalling. one must worry about simply being comprehensible.

PART XII: BARGAINING

53.   John Nash, ``The Bargaining Problem,'' *Econometrica*, 18:155-162 (April 1950).

54. Ariel Rubinstein, ``Perfect Equilibrium in a Bargaining Model,'' *Econometrica,* 50: 97-109 (January 1982).

55. ``UPS Faces More Than $1 Billion A Year in New Labor Expenses: Pact Calls for Substantial Pay Increases, Full-Time Jobs and A Union Pension Plan,'' *Wall Street Journal* , Douglas A. Blackmon, Martha Brannigan, Glenn Burkins and Laura Jereski, p. A3 (20 August 1997).

56. Cartoon: ``Whatever Happened to Elegant Solutions?'' S. Harris.

In   ``The Bargaining Problem,'' Nash invented the most important equilibrium concept in cooperative game theory, just as in the Chapter 1 papers he invented the most important one for noncooperative games. Try comparing the two, and see how different the style of approach is (such a comparison would make a good homework problem for a game theory course).   Everybody agrees that a 50-50 split is reasonable for pie division games, but the axiomatic approach of this article leaves economists such as myself dissatisfied.   Rubinstein's 1982 article arrives at the same pie division, but justifies it in the setting of a noncooperative game, a structural rather than a reduced-form model.

One of the objections to the axiomatic approach is that it assumes away some of the most important problems. The assumption that players arrive at an efficient solution rules out any delay in reaching a solution. Why, then, do we get strikes and wars? The United Paracel Service strike is interesting for two reasons. First, both UPS and the labor union were willing to incur real losses in delaying agreement. Why did UPS not give in immediately, rather than wait? Second, the disagreement was not simply over whether wages would be higher or lower. Rather, the negotiations were over many different issues, including contract length, management of pension funds, wages, and employment levels. The usual answer to why strikes occur is there is incomplete information, and costly delay is necessary for a player to signal his unwillingness to accept the other side's terms. These models, get very intricate very quickly, however, which is why ``Whatever Happened to Elegant Solutions?'' is an appropriate cartoon for this chapter.

PART XIII: AUCTIONS

57. Martin Shubik, ``The Dollar Auction Game: A Paradox in Noncooperative Behavior and Escalation," *Journal of Conflict Resolution*, 15: 109-11 (March 1971).

58. R. Preston McAfee and John McMillan, ``Analyzing the Airwaves Auction," *Journal of Economic Perspectives*, 10:159-170 (Winter 1996).

59. ``At Many Auctions, Illegal Bidding Thrives As a Longtime Practice Among Dealers," *Wall Street Journal*, Meg Cox, p. 1 (19 February 1988).

60. Cartoon: "The next item up for bid is the presidency of the United States..." Rogers,*Pittsburgh Post-Gazette*, 1999. United Features Syndicate.

Auctions are the opposite of bargaining: in an auction two players compete against each other, to the advantage of a player on the other side of the market. Other situations, however, are like auctions even though there is no "other side of the market". Shubik's dollar auction is a simple paradigm for this, useful for thinking about rent-seeking, patent races, and other tournaments. It also applies to arms races: see Barry O'Neill, "International Escalation and the Dollar Auction," *Journal of Conflict Resolution* 30:33-50 (1986). Shubik discusses the problem of collusion in the dollar auction, which for that particular auction is actually to the social good, except for the seller. In most auctions, however, collusion is as pernicious as in oligopolies. The antique market is an interesting example, because antique auctions have a mix of sophisticated repeat players-- the professional dealers-- and unsophisticated one-time players--direct consumers.

Governments have often used auctions in procurement and in selling securities, but economists have urged them to use auctions more in sales of natural assets and privileges. The FCC airwaves auctions are the result of decades of such urging. In the *Journal of Economic Perspectives* article, McAfee and McMillan describe the choice of auction rules and the bidding that resulted. The cartoon, "The next item up for bid is the presidency of the United States..." raises a good question for the economist: Why not? Tax farming-- the right to collect taxes-- has often been sold by government in past centuries. Seats on the boards of directors of corporations are effectively sold via shares' voting rights. So why not sell off what are now elected offices?

PART XIV: PRICING

61. Francis Edgeworth, "The Mathematical Economics of Professor Amoroso," *Economic Journal*, 30: 400-407 (September 1922).

62. Harold Hotelling, ``Stability in Competition," *Economic Journal*, 39: 41-57 (March 1929).

63. Avner Shaked, ``Existence and Computation of Mixed Strategy Nash Equilibrium for 3-Firms Location Problem," *Journal of Industrial Economics*, 31: 93-96 (September/December 1982).

64. ``Busting a Trust: Electrical Contractors Reel Under Charges That They Rigged Bids," Andy Pasztor, *Wall Street Journal,* p. 1 (29 November 1985).

65. Cartoon: "Isn't it great that we don't get any more pesky calls during dinner asking us to switch long-distance companies?" Rogers,*Pittsburgh Post-Gazette*, 1999. United Features Syndicate.

Francis Edgeworth was, as you might expect of a Victorian Englishman with the middle name "Ysidro", an unusually original thinker, much like George Akerlof. What he is best known for besides the Edgeworth box is the Edgeworth Paradox, that price competition between two firms with capacity constraints or upward sloping marginal cost curves can result in no equilibrium in pure strategies. He first wrote this up in a now-lost English version translated into Italian as ``La Teoria Pura del Monopolio," *Giornale degli Economisti* (1897), which was translated back into English as "The Pure Theory of Monopoly," pages 111-142 of Volume I of his *Papers Relating to Political Economy*, London: Macmillan (1925). Pages 117-121 of that article deal with the Edgeworth Paradox with capacity constraints, and much of the rest is concerned with the effect of taxes. I have chosen instead to include a 1922 version of the paradox, a numerical example with upward sloping marginal cost. Note that in both articles Edgeworth also considers the case of differentiated products.

Harold Hotelling, however, is the man who published the seminal article in the economics of differentiated products. Like Edgeworth, he made important contributions to both economics and statistics in a time when the fields were much more sharply differentiated than they are today. In economics, he is best known for "Stability in Competition," for the equally seminal ``The Economics of Exhaustible Resources," *Journal of Political Economy*, 39: 139-175 (1931), and for being Kenneth Arrow's dissertation advisor. See Adrian Darnell, "Harold Hotelling: 1895-1973," *Statistical Science*, 3:57-62 (February 1988) for an interesting view of a many-faceted scholar.

This classic paper, however, like a number of other classics, had a mistake. Can you find it? If not, look at pp. 323-334 of William Vickrey, *Microstatics*, New York: Harcourt, Brace and World (1964), or at Claude D'Aspremont, J. Gabszewicz, & Jacques Thisse, ``On Hotelling's `Stability of Competition', " *Econometrica*, 47: 1145-1150 (September 1979), which independently found the mistake, or Martin Osborne & Carolyn Pitchik, "Equilibrium in Hotelling's Model of Spatial Competition," *Econometrica,* 55: 911-922 (July 1987), which solves for the correct equilibrium as best as our current mathematics can manage.

Hotelling did not consider the case when three firms simultaneously choose their locations, though he mentions what happens when a third firm unexpectedly shows up after the first two have already fixed their locations. Perhaps he avoided that case because one of his points was that oligopoly can be more stable than Edgeworth thought, and with three firms choosing location, there is no equilibrium in pure strategies. In the *Journal of Industrial Economics* article that I have included here, however, Shaked, solves for the equilibrium in mixed strategies that does exist.

In thinking about pricing, it is important not to forget the importance of collusion, tacit or explicit. The article, ``Busting a Trust,'' is a reminder that despite the complexity of some antitrust cases like those involving Microsoft or Intel, the bread-and-butter of an antitrust agency is still simple price fixing and merger for market power. The cartoon, "Isn't it great…," makes the same point: consumers may complain about having too much choice between different deals or too many differentiated products, but too little choice is much worse.

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PART XV: ENTRY

66. Drew Fudenberg & Jean Tirole,"The Fat-Cat Effect, The Puppy-Dog Ploy, and the Lean and Hungry Look," *American Economic Review, Papers and Proceedings*, 74: 361-366 (May 1984).

67. "Drugs: Novel Heart-Drug Deal Protects Sales, Spurs Suit," *Wall Street Journal*; By Ralph T. King Jr., p. B1 (21 August 1998).

68. Eric Rasmusen, ``Aphorisms on Writing, Speaking, and Listening'

69. Cartoon: ``Henry and the Candy Shop,"   Carl Anderson, *Henry* 4-16-.

Models of entry by new competitors vary even more than models of pricing, and in ways that necessity forces on us. If different things happen in different situations in reality, then so must they in our models.   It is a pleasant surprise, therefore, when an article helps us to sort out existing models rather than creating new ones we must understand. Fudenberg and Tirole's "Fat Cat" paper is one of those. It appeared in the American Economic Association *Papers and Proceedings,* which has contained quite a number of influential short pieces like this over the years. These papers do not go through the usual submission procedure, but must, on the other hand, be short, and so they are a good occasion for top economists to try something unconventional.   The cartoon, "Henry and the Candy Shop," illustrates one of their points: entrants and incumbents alike may be better off not to be too greedy.

I commented in the last chapter that the basic tasks of antitrust is to stop price fixing and monopolistic mergers, rather than tougher problems like the Microsoft case. The article,   "Drugs: Novel Heart-Drug Deal…," is about one of those tougher problems. Innovation is one way to enter a market, but patents and the licensing arrangements that result from them can block entry.

I have included just one of my own papers, my ``Aphorisms on Writing, Speaking, and Listening". These are notes I have accumulated over my years teaching doctoral students and writing referee reports. I value the opportunity to include them here, not just for students, but so that mid-career economists will read them, reform their writing style, and write better papers for me to read. Please do!