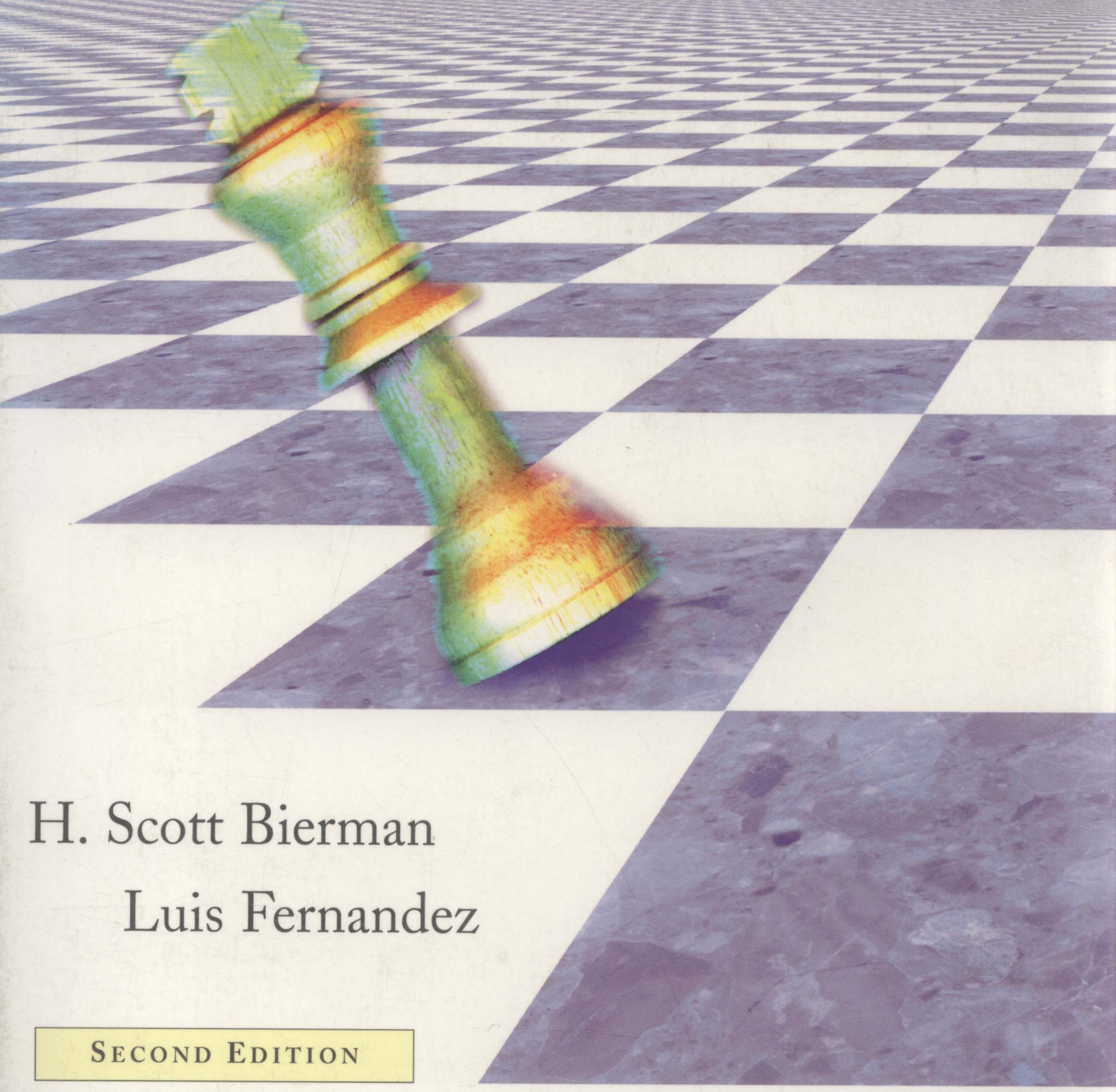

H. Scott Bierman
Luis Fernandez

SECOND EDITION

GAME THEORY

WITH ECONOMIC APPLICATIONS

Game Theory with Economic Applications

SECOND EDITION

江苏工业学院图书馆
藏书章

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Preface

Sophisticated use of game theory has become an integral part of economic graduate education. Yet, most undergraduate economics majors currently leave college with little knowledge of game theory beyond the Prisoner's Dilemma. *Game Theory with Economic Applications,* Second Edition, is designed to introduce undergraduates to the power of this new tool of economic analysis and can be read by any student who is comfortable with basic economic concepts and has taken a semester of differential calculus.

The book has five parts, each of which examines games that have a common informational structure. Each part begins with a core chapter in which equilibrium concepts and solution techniques are developed. The core chapters are followed by from one to five chapters of economic applications.

We have learned much since the publication of the first edition, not the least of which is how to better organize a game theory text. Although we have aimed this book at undergraduate economics majors, the book can be useful for anyone who wants to learn the language and ideas of game theory at an introductory level. Those readers familiar with the first edition will see major structural changes in the second. Yet, the emphasis remains on applying a relatively small set of game-theoretic tools to understand important economic phenomena.

In writing this book we have tried to avoid trivializing either the economics or the game theory. When the economics is made too trivial, an application often looks contrived and applicable to only a narrow set of circumstances. When the game theory is made too trivial, on the other hand, it is easy to lose sight of its role in the analysis. In each of the applications in this book both the game-theoretic and the economic foundations have been laid out in detail. Although we have provided fewer examples than other game theory texts, we have tried to be more detailed.

We have chosen examples from a wide range of fields so that students can see the power of game theory for studying economics. Applications can be found from labor economics, the economics of the public sector, international trade, natural resource economics, macroeconomics, corporate finance, banking, and, of course, industrial organization, to name a few. A student who makes it through

the book will not only learn a great deal of game theory but also will see a lot of modern economic modeling.

Instructors can use the book as a supplement for an Industrial Organization class by assigning Chapter 1 (Nash Equilibrium), Chapter 2 (Oligopoly), Chapter 6 (Subgame Perfect Equilibrium), and Chapter 9 (Repeated Games and Dynamic Competition). A more ambitious plan would also include Chapter 13 (Bayesian Nash Equilibrium), Chapter 15 (Perfect Bayesian Equilibrium), Chapter 19 (Limit Pricing and Entry Deterrence), and Chapter 20 (Cartel Enforcement).

Instructors who want to use the book as a supplement for a course in intermediate price theory will find this edition of the book far more congenial. After covering Chapter 1 (Nash Equilibrium), the instructor can choose up to four applications or move directly to Chapter 6 (Subgame Perfect Equilibrium).

Prerequisites

Most of the economics in the book can be understood by students who have taken only a Principles of Economics class. There are, however, a few applications where a previous course in Intermediate Microeconomics is very useful. Drafts of the second edition have been used at both Oberlin College and Carleton College to teach courses that did not have an Intermediate Microeconomics prerequisite, but the lack of that common background slowed down the pace of the class. Faculty teaching a course on game theory and economics for the first time will probably want to make Intermediate Microeconomics a prerequisite for the course.

When we began writing this text, we hoped that calculus would not be necessary. Alas, we were unable to write a book in which the economics was not horribly unrealistic without using differential calculus. There are simply too many examples in which the important decision variables are continuous and not discrete. Students are expected to know how to take derivatives of simple functions (i.e., polynomials and exponential functions) and to be able to use the chain rule.

Probabilistic and statistical concepts of expected value and variance are not used until Part III (Games with Uncertain Outcomes). Conditional probability is not used until Part IV, and Bayes' theorem is not used until Part V. We believe it is relatively easy to give students who have no previous exposure to probability or statistics the background they need so that they will not be at a disadvantage.

Changes to the Second Edition

NEW ORGANIZATION

In response to reviewers and adopters of the first edition, the structure of the book has changed significantly from that of the first edition. The book now begins with static games with complete information. This allows the instructor to start right away with the Prisoner's Dilemma and Battle of the Sexes without having

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to first cover decision theory and expected utility. The elimination of dominated strategies and Nash equilibrium are introduced in the first chapter along with best response functions. Instructors interested in using subsets of the book as a supplement for either an Industrial Organization class or a Microeconomics class should find this new organization much better than the first edition.

Dynamic games with complete information now appears in Part II (Dynamic Games with Complete Information). The emphasis is on the extensive form and the concept of subgame perfection. An extensively revised chapter on repeated games is the capstone of this portion of the book.

Part III introduces static and dynamic games with complete information but random outcomes. The expected utility hypothesis and mixed strategies are presented for the first time in the core chapter. Two application chapters involve moral hazard.

Games in which the players have incomplete information are examined in the last two parts of the book. Part IV looks at static games, and Part V looks at dynamic ones. The Harsanyi transformation and Bayesian updating are the principal theoretical concepts introduced here. Among the application chapters is a new one on the popular topic of auctions.

NEW CHAPTER CONTENT

Besides completely revamping the core chapters, all of the applications have been revised in the second edition with an eye toward emphasizing the power of game-theoretic analysis. For example, Chapter 2 (Oligopoly) has a new section on Bertrand games with capacity constraints, and Chapter 15 (Perfect Bayesian Equilibrium) presents Spence's model of education signaling. Users of the second edition will note two completely new chapters, Chapter 13 (Bayesian Nash Equilibrium) and Chapter 14 (Auctions).

To streamline the book, some of the application chapters in the first edition were removed based on feedback from adopters and reviewers. These chapters include Chapter 9 (Patents and Product Variety), Chapter 22 (Public Goods and Preference Revelation), and Chapter 25 (Durable Goods and Monopoly Power) from the first edition. Chapter 12 (The Coase Theorem) and Chapter 15 (The Use of Common Resources) in the first edition have been combined into Chapter 4 (Property Rights and Efficiency) in the second edition.

Nearly all of the application chapters have a new feature entitled Game Theory in Action, which discusses empirical evidence that either confirms or disconfirms the theoretical models. New exercises have also been added to most of the chapters.

An Overview

The book is divided into five parts corresponding to five different informational structures. Each part begins with a core chapter identifying the general character-

istics of games that will be analyzed in that part. This chapter carefully describes the equilibrium concepts that will be used in the application chapters that follow. The core chapters also introduce analytical methods (such as backward induction or the elimination of dominated strategies) that can be used to help solve the games in that part of the book. Concepts learned in the core are applied to carefully developed economic models. The applications have been designed both to reinforce the concepts and methods used in the core chapters and to show how game theory has modified the way we think about important economic issues and phenomena.

Part I (Static Games with Complete Information) introduces students to strategic form games and the fundamental solution concept of Nash equilibrium. In Chapter 1 (Nash Equilibrium) games are defined and Nash equilibrium and payoff matrices are introduced and then used to analyze a series of well-known games including the Prisoner's Dilemma and the Battle of the Sexes. Other concepts introduced include dominance, iterated dominance, and best response functions. Chapter 2 (Oligopoly) presents the historically important oligopoly models of Cournot and Bertrand. Chapter 3 (Strategic Trade Policy) explains the puzzling phenomenon of cross-hauling. This chapter also explains why a country might rationally enact an export subsidy and simultaneously engage in multilateral negotiations with other countries to make such subsidies illegal. Chapter 4 (Property Rights and Efficiency) looks at two ways in which property rights could affect economic behavior. The first model is the common resources model of an overfished fishery. The second is a model of pollution with high transaction costs in which the Coase theorem does not hold. A conclusion of that chapter is that tort law can be expected to have important efficiency implications even in a laissez-faire market economy. Part I concludes with a look at Voting Games (Chapter 5). The chapter begins with Arrow's impossibility theorem and concludes with a look at some so-called voting paradoxes.

Dynamic games with complete information are examined in Part II. Chapter 6 (Subgame Perfect Equilibrium) introduces the concepts of the extensive form and subgame perfection along with the solution procedure of backward induction. Chapter 7 (Bargaining) presents Ariel Rubinstein's model of alternating-offer bargaining over a trading surplus, starting from bargaining situations in which there is symmetric discounting and a fixed number of rounds. Chapter 8 (Time-Consistent Macroeconomic Policy) examines a highly stylized macroeconomic model with rational expectations in which in equilibrium the Federal Reserve Bank reaches neither its low inflation nor its high employment goals. Chapter 9 (Repeated Games and Dynamic Competition) reexamines the Cournot and Bertrand models of oligopoly in a world of repeated interactions. We show how cooperation can emerge in equilibrium in a strategic situation in which there are strong incentives for noncooperation.

Part III (Games with Uncertain Outcomes) extends Parts I and II by adding uncertainty. Chapter 10 (Uncertainty and Expected Utility) introduces the state-of-the-world approach to uncertainty. Utility maximization on the part of the players is replaced by expected utility maximization, and risk neutrality and risk

aversion are discussed. The two applications that follow are both moral hazard problems. Chapter 11 (Moral Hazard and Incomplete Insurance) shows how the inability to monitor risk avoidance by the policyholder can lead to underinsurance. Chapter 12 (Moral Hazard and Involuntary Unemployment) shows how the inability to monitor employee work effort can lead to involuntary unemployment.

Some of the most interesting theoretical work done by economists in the last twenty years has involved games in which players have private information. Such games are the subject of Parts IV and V. Part IV (Static Games with Incomplete Information) is completely new to the second edition. Chapter 13 (Bayesian Nash Equilibrium) shows how static games with incomplete information can be converted into games with complete but imperfect information, which then can be solved using the tools of Parts I to III. Chapter 14 (Auctions) begins with an extensive discussion of auction rules and the games they generate. It goes on to demonstrate the revenue equivalence theorem, the truth revelation property of Vickrey auctions when there are independent private values, and the phenomenon of the winner's curse when there are common values.

Although Part V (Dynamic Games with Incomplete Information) is the most challenging part of the book, we have structured it so that the most difficult material appears in the last two application chapters. Chapter 15 (Perfect Bayesian Equilibrium) takes the concept of Bayesian Nash equilibrium developed in Part IV and refines it. The refinement amounts to assuming that rational players use Bayes' theorem to update their beliefs whenever this is possible. These ideas are used to study Spence's seminal model of education signaling. Chapter 16 (Bargaining with Private Information) revisits the problem of bargaining using three examples. The chapter concludes by showing how costly strikes can reveal to the employer the worker's reservation wages. Chapter 17 (Corporate Takeovers and Greenmail) shows how management efforts to fight off a hostile takeover, such as by paying "greenmail," may be in the best interest of shareholders. Chapter 18 (Adverse Selection and Credit Rationing) examines the conditions under which a competitive market equilibrium can exist in which there are borrowers who cannot borrow "at any price." Chapter 19 (Limit Pricing and Entry Deterrence) provides a greatly simplified version of Milgrom and Roberts' model of entry deterrence and predatory pricing. We show how an incumbent firm may try to signal that it has a cost advantage over a potential entrant by charging a low price. Chapter 20 (Cartel Enforcement) concludes the book with Porter and Green's model of self-enforcing cartels and the necessity of occasional price wars to keep the members of the cartel honest.

It is our experience that getting through the entire book in a quarter or semester, even with well-trained and highly motivated students, is difficult, if not impossible. This provides the instructor with scope for choosing among the application chapters. Some application chapters, however, present material that is referred to later in the book and, hence, should not be cut. These include Chapter 2 (Oligopoly), Chapter 7 (Bargaining), and Chapter 9 (Repeated Games and Dynamic Competition). The other applications are independent of each other.

Instructor's Manual

An Instructor's Manual, including answers to the end-of-chapter problems, is available free of charge to instructors adopting the text.

Acknowledgments

The first edition of this book benefited from the advice and help of many people. The list has more than doubled with the second edition. We have been helped tremendously from adoptors who have freely offered useful advice and criticism. And we are indebted to reviewers of the second edition for hundreds of improvements, both large and small.

The initial impetus for the first edition of the book came from a summer workshop on game theory in the social sciences sponsored by the Alfred P. Sloan Foundation and directed by Professor Alan Taylor of Union College and Professor Steven Brams of New York University. Steven Brams, Samuel Goldberg at the Sloan Foundation, and our colleagues at Carleton College and Oberlin College encouraged us to develop and teach an undergraduate game theory course. The lecture notes from these courses provided the first draft of the book. A grant from the Dana Foundation to Professor Fernandez allowed him to spend a year visiting the Cowles Foundation at Yale University. We wish to thank William Brainard, William Nordhaus, and Peter Cramton for their many helpful suggestions and ideas.

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Brief Contents

Preface xv

PART I
Static Games with Complete Information 1

CHAPTER 1 Nash Equilibrium 3
CHAPTER 2 Oligopoly 32
CHAPTER 3 Strategic Trade Policy 60
CHAPTER 4 Property Rights and Efficiency 76
CHAPTER 5 Voting Games 98

PART II
Dynamic Games with Complete Information 119

CHAPTER 6 Subgame Perfect Equilibrium 121
CHAPTER 7 Bargaining 149
CHAPTER 8 Time-Consistent Macroeconomic Policy 167
CHAPTER 9 Repeated Games and Dynamic Competition 185

PART III
Games with Uncertain Outcomes 205

CHAPTER 10 Uncertainty and Expected Utility 207
CHAPTER 11 Moral Hazard and Incomplete Insurance 239
CHAPTER 12 Moral Hazard and Involuntary Unemployment 256

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PART IV
Static Games with Incomplete Information **272**

CHAPTER 13 Bayesian Nash Equilibrium 273

CHAPTER 14 Auctions 289

PART V
Dynamic Games with Incomplete Information **315**

CHAPTER 15 Perfect Bayesian Equilibrium 317

CHAPTER 16 Bargaining with Private Information 342

CHAPTER 17 Corporate Takeovers and Greenmail 371

CHAPTER 18 Adverse Selection and Credit Rationing 384

CHAPTER 19 Limit Pricing and Entry Deterrence 402

CHAPTER 20 Cartel Enforcement 424

Index 441

Contents

Preface xv

PART I
Static Games with Complete Information **1**

CHAPTER 1
Nash Equilibrium 3

1.1 INTRODUCTION, 3
1.2 AN EXAMPLE: THE OIL DRILLING GAME, 5
1.3 CHRONOLOGICAL TIME AND GAME TIME, 8
1.4 DOMINANT STRATEGY EQUILIBRIUM, 9
1.5 ITERATED DOMINANT STRATEGY EQUILIBRIUM, 13
1.6 NASH EQUILIBRIUM, 14
1.7 FOCAL POINT EQUILIBRIUM, 17
1.8 EVOLUTIONARY EQUILIBRIUM, 19
1.9 GAMES WITH CONTINUOUS STRATEGIES, 21
1.10 SUMMARY, 24
1.11 FURTHER READING,* 25
1.12 DISCUSSION QUESTIONS,* 26
1.13 NEW TERMS,* 26
1.14 EXERCISES,* 27
GAME THEORY IN ACTION: Game Theory in the News, 5

CHAPTER 2
Oligopoly 32

2.1 INTRODUCTION, 32
2.2 THE COURNOT GAME, 33
2.2.1 Isoprofit Curves and Best Response Functions, 35
2.2.2 Cournot-Nash Equilibrium, 38
2.2.3 Stronger Properties of the Cournot-Nash Equilibrium, 38

*These sections appear at the end of each chapter.

2.2.4 Experimental Evidence, 41
2.2.5 Perfect Competition as the Limiting Case of the Cournot Game, 43
2.3 THE BERTRAND GAME, 45
2.3.1 The Bertrand Game with Capacity Constraints, 46
2.4 CONTESTABLE MONOPOLY, 52
2.5 SUMMARY, 55
GAME THEORY IN ACTION: Avoiding the Prisoner's Dilemma, 42

CHAPTER 3
Strategic Trade Policy 60
3.1 INTRODUCTION, 60
3.2 IMPERFECT COMPETITION AND INTRAINDUSTRY TRADE, 61
3.3 EXPORT SUBSIDIES, 66
3.4 OPTIMAL EXPORT SUBSIDIES, 67
3.5 SUBSIDY WARS, 68
3.6 INCREASING RETURNS TO SCALE, 70
3.7 SUMMARY, 72
GAME THEORY IN ACTION: Strategic Trade Policy in Action: Voluntary Export Restraints on Automobiles, 71

CHAPTER 4
Property Rights and Efficiency 76
4.1 INTRODUCTION, 76
4.2 UNDEFINED PROPERTY RIGHTS AND FISHING, 77
4.3 WELL-DEFINED PROPERTY RIGHTS AND THE COASE THEOREM, 83
4.3.1 Resource Allocation by a Benevolent Dictator, 86
4.3.2 Resource Allocation When Property Rights Are Well Defined and Bargaining Costs Are Zero, 87
4.3.3 Resource Allocation When Property Rights Are Well Defined and Bargaining Costs Exist, 90
4.3.4 Bureaucracy versus the Market, 93
4.4 SUMMARY, 94
GAME THEORY IN ACTION: The Coase Theorem and Baseball, 93

CHAPTER 5
Voting Games 98
5.1 INTRODUCTION, 98
5.2 CHOOSING AMONG VOTING MECHANISMS, 99
5.3 MAJORITY RULE WITH TWO CHOICES, 101
5.4 PLURALITY RULE AND THE CONDORCET CANDIDATE, 104
5.5 A MODIFIED PLURALITY RULE: THE SINGLE TRANSFERABLE VOTE, 105
5.6 STRATEGIC VOTING WITH PLURALITY RULE, 109
5.6.1 The Naive Voting Model, 111
5.6.2 The Strategic Voting Model, 111
5.6.3 Other Equilibria, 113
5.6.4 A Concern: The Limits of Rationality, 114

5.7 SUMMARY, 115
GAME THEORY IN ACTION: Verdict Voting, 106

PART II
Dynamic Games with Complete Information 119

CHAPTER 6
Subgame Perfect Equilibrium 121

6.1 INTRODUCTION, 121
6.2 AN EXAMPLE: SOFTWARE GAME I, 122
6.2.1 Game Trees, 124
6.2.2 Strategies, 127
6.2.3 Information, 127
6.2.4 Outcomes and Payoffs, 127
6.3 NASH EQUILIBRIUM AND BACKWARD INDUCTION, 128
6.4 THREATS AND CREDIBLE THREATS, 131
6.5 SUBGAMES AND SUBGAME PERFECT EQUILIBRIUM, 133
6.6 A SECOND EXAMPLE: SOFTWARE GAME II, 135
6.7 DYNAMIC GAMES WITH CONTINUOUS STRATEGIES: THE STACKELBERG DUOPOLY GAME, 139
6.8 SUMMARY, 143

CHAPTER 7
Bargaining 149

7.1 INTRODUCTION, 149
7.2 BARGAINING WITHOUT IMPATIENCE, 150
7.3 BARGAINING WITH SYMMETRIC IMPATIENCE, 151
7.4 BARGAINING WITH ASYMMETRIC IMPATIENCE, 153
7.4.1 A General Model of Bargaining with Impatience, 154
7.5 EXPERIMENTAL EVIDENCE ON SEQUENTIAL BILATERAL BARGAINING, 158
7.6 A BARGAINING EXAMPLE: SHARING SUNK COSTS, 161
7.6.1 A More Specific Example, 162
7.7 SUMMARY, 164

CHAPTER 8
Time-Consistent Macroeconomic Policy 167

8.1 INTRODUCTION, 167
8.2 INFLATION, 168
8.3 A SIMPLE MACROECONOMIC MODEL, 169
8.3.1 Identities, 171
8.3.2 Actions and Order of Play, 172
8.3.3 Strategies, 173
8.3.4 Payoffs, 173

8.3.5 Equilibrium, 175
8.3.6 A Numerical Example, 177
8.4 ONE SOLUTION TO THE CENTRAL BANK'S PROBLEM: PRECOMMITMENT, 180
8.5 SUMMARY, 181
GAME THEORY IN ACTION: How Chairman Volker Changed Inflationary Expectations, 170
GAME THEORY IN ACTION: Optimal Central Bank Performance, 180

CHAPTER 9
Repeated Games and Dynamic Competition 185
9.1 INTRODUCTION, 185
9.2 EXAMPLE: DUOPOLY REVISITED, 187
9.3 FINITELY REPEATED GAMES, 191
9.4 A FIRST MODIFICATION: PRECOMMITMENT, 194
9.5 A SECOND MODIFICATION: DISCOUNTING THE FUTURE, 196
9.5.1 A "Noncooperative" Equilibrium, 198
9.5.2 A "Cooperative" Equilibrium, 198
9.5.3 And Now the Bad News: The Folk Theorem, 200
9.6 THE BERTRAND GAME REVISITED, 201
9.7 SUMMARY, 202
GAME THEORY IN ACTION: Cooperation in the Trenches of World War I, 193

PART III
Games with Uncertain Outcomes 205

CHAPTER 10
Uncertainty and Expected Utility 207
10.1 INTRODUCTION, 207
10.2 EXOGENOUS UNCERTAINTY IN STATIC GAMES, 208
10.3 EXOGENOUS UNCERTAINTY IN DYNAMIC GAMES, 209
10.4 ENDOGENOUS UNCERTAINTY IN STATIC GAMES, 215
10.5 THE EXPECTED UTILITY HYPOTHESIS, 220
10.6 THE EXPECTED UTILITY THEOREM, 224
10.7 ATTITUDES TOWARD RISK, 227
10.8 SUMMARY, 232

CHAPTER 11
Moral Hazard and Incomplete Insurance 239
11.1 INTRODUCTION, 239
11.2 INSURANCE IN THE ABSENCE OF MORAL HAZARD, 241
11.3 INSURANCE IN THE PRESENCE OF MORAL HAZARD, 244
11.4 WELFARE EFFECTS OF MORAL HAZARD, 252
11.5 GOVERNMENT RESPONSES TO MARKET FAILURE IN THE UNEMPLOYMENT INSURANCE MARKET, 253

11.6 SUMMARY, 253

GAME THEORY IN ACTION: The S&L Mess: Double Moral Hazard, 250

CHAPTER 12
Moral Hazard and Involuntary Unemployment 256

12.1 INTRODUCTION, 256

12.2 A SIMPLE MODEL OF MORAL HAZARD IN THE LABOR MARKET, 257

12.2.1 Moral Hazard and Incredible Promises, 263

12.3 COMPLETION OF THE MODEL: THE NECESSITY OF INVOLUNTARY UNEMPLOYMENT, 265

12.4 SUMMARY, 267

GAME THEORY IN ACTION: Did Henry Ford Pay Efficiency Wages?, 262

PART IV
Static Games with Incomplete Information 271

CHAPTER 13
Bayesian Nash Equilibrium 273

13.1 INTRODUCTION, 273

13.2 THE HARSANYI TRANSFORMATION, 275

13.3 MIXED STRATEGIES REINTERPRETED, 279

13.4 THE REVELATION PRINCIPLE AND GAME DESIGN, 282

13.5 SUMMARY, 284

CHAPTER 14
Auctions 288

14.1 INTRODUCTION, 288

14.2 A PRIMER FOR AUCTIONEERS, 292

14.3 AUCTIONS WITH PERFECT INFORMATION, 293

14.4 SEALED-BID AUCTIONS WITH INDEPENDENT PRIVATE VALUES, 297

14.4.1 An Example, 298

14.5 ORAL AUCTIONS WITH INDEPENDENT PRIVATE VALUES, 301

14.6 COMMON VALUE AUCTIONS AND THE "WINNER'S CURSE," 303

14.6.1 Our Example Revisited, 303

14.7 THE EFFICIENCY OF AUCTIONS, 305

14.8 SUMMARY, 306

14.13 APPENDIX: A GUIDE TO WORKING WITH UNIFORMLY DISTRIBUTED RANDOM VARIABLES, 312

GAME THEORY IN ACTION: Game Theorists Design a Historic Auction for the FCC, 290

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