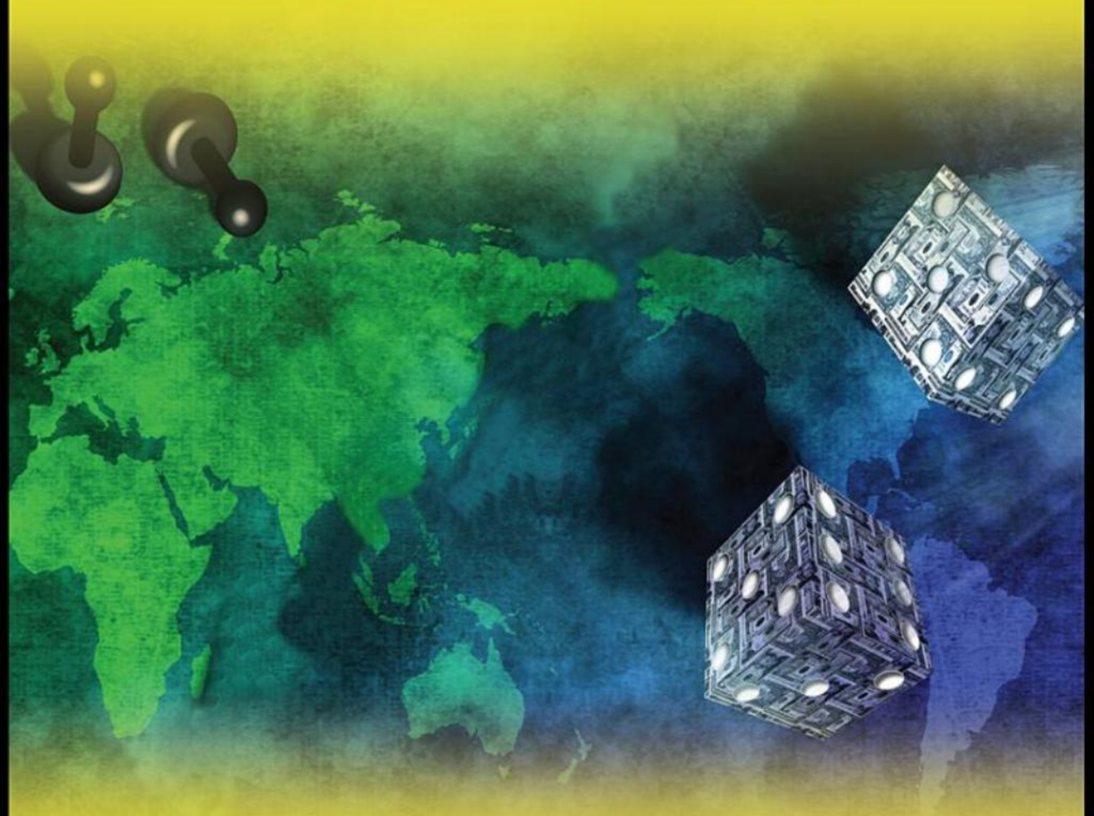
APPLIED GAME THEORY AND STRATEGIC BEHAVIOR



ILHAN KUBILAY GEÇKIL
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To my mother, Hacer Bilhan-Geçkil, and my father, Ali Geçkil, who have dedicated their lives to education.

IKG

To my mother, Marilyn Mencotti Anderson, and my father, William Cowles Anderson, for their love and guidance.

PLA

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Chapter 4 A Theory of Strategic Value

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Preface

You need to learn the rules of the game. And then you have to play better than anyone else.

Albert Einstein

Purpose of this Book

The purpose of this book is to demonstrate the use of game theory techniques to address practical issues in business, applied economics, and public policy; as well as to demonstrate the benefits of strategic thinking that incorporates uncertainty about the behavior of other parties.

Studying game theory often requires trudging through arcane and often daunting mathematics. Of course, some mathematics are necessary to establish such a theory formally. However, as strategic analysis is practical and useful, game theory should be practical and useful, too.

Instead of providing pure theory, this book concentrates on the practical applications of theory. Applications we present in this book will show how to build a model in an interactive decision-making environment in order to analyze real-world problems. Through these applications, we will discuss various economic and game theory concepts, including static and dynamic games, complete and incomplete information sets, asymmetric information, and dominant and dominated strategies.

It is our aim to show how game theory can be used in real life, not just in mathematical models. We want to get game theory out of the box, and into the business world.

Our Approach

In this book, we introduce various games and outline the process of modeling game theory questions while thinking strategically. Since the intention of this book is to explore real-world applications of game theory, we will introduce the core concepts within examples and case studies taken from the business world and our consulting work, including examples from the automotive industry, the beer, wine, and spirits industry, and government regulation. Game theory provides us with powerful analytical models for different types of consulting projects, including valuation projects, antitrust matters, and projects regarding mergers and acquisition.

Upon completing the book, an active reader should be able to improve his strategic thinking, define the game, and model the games with payoffs and probabilities. With such tools, some readers will "play the game," execute the model, and find strategically sound decisions.

In keeping with our practical approach, we use software and other tools as helpful devices throughout the book. We include sample problems that are illustrated using newly developed software applications, which may prove useful to a portion of our readers. These include applications developed using the mathematical software MATLAB, graphics software Microsoft Visio, and spreadsheet software such as Microsoft Excel.[1] All of the spreadsheet applications, and at least some of the vector-processing applications in MATLAB, could be created using other software products.

We include many applications using newly developed software that supports the construction of game theory models in clear and visual diagrams. At the same time, these software algorithms calculate the outcomes of the game, based on the decisions made throughout the game. MATLAB codes are included at the end of these games for the benefit of the reader. Illustrations of extensive form games developed in Microsoft Visio as well as the normal form of games are also provided to the reader. However, no specific software is required for this study.

1. MATLAB is a trademarked product of The MathWorks. Microsoft Visio and Excel are trademarked products of Microsoft Corporation.

Organization of Book

We introduce a brief history of game theory in Chapter 1. Readers will find the development of the field and introduction of key game theory concepts and inventions.

If a reader does not have any interest in the history of game theory, we recommend jumping to Chapter 2, where we introduce game theory concepts and strategy. In that chapter, we show how to illustrate a game, introduce the rules of the game, key concepts, as well as strategy and strategic behavior in game theory.

Chapter 3 introduces two well-known games: the Prisoner's Dilemma, and the Battle of the Sexes, as well as solutions to those games. We model them with MATLAB, a mathematical programming software. We also introduce a sample game of dominated strategies modeled in a MATLAB environment.

Chapter 4 through Chapter 9 demonstrate real-world cases involving strategic environments and game-theoretic models. In these chapters, we show how to analyze strategic problems by using game theory concepts and models.

Chapter 4 discusses the theory of strategic value. We explain the relationship between business value and strategy, firm objectives, valuation concepts, and state and control variables for firms. Chapter 5 is a dynamic game of incomplete information between a global brewer and national importer in the U.S. beer industry. Chapter 6 discusses a consolidation trend in the wine and spirits industry as well as market power.

Chapter 7 develops a game demonstrating strategic actions and responses of key players in a regulatory game revolving around the Corporate Average Fuel Economy (CAFE) standards. Chapter 8 analyzes strategies available to players in the auto industry crisis of 2008. Finally, Chapter 9 discusses using game theory in law and provides strategic discussion on antitrust claims filed against Microsoft in the late 1990s.

Our Appreciation

We were assisted by a number of individuals during the two years in which we worked on this book. We would like to thank them for their support and help, especially Justin Eli, Luke Olson, and Onur Yavuz. Special thanks also goes to Mehmet Oztan, who helped us develop the MATLAB codes for Chapter 3. We also want to thank Jay P. Choi, Shashi Kumar, Tom Walton, and Scott Watkins. Finally, we wish to thank Robert B. Stern, Michele A. Dimont, Marsha Pronin, Katy Smith, and Samantha White of Taylor & Francis Group.

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Chapter 1 A Brief History of Game Theory

Why Study Games?

The field known as "game theory" was invented in the last century by mathematicians and economists as a tool to analyze both economic competition and political conflicts. The fundamental insight of game theory was to apply the logic of games—in which players compete against each other using strategy, tactics, and effort—to events in real life.

Most games played for entertainment and recreation involve two persons (or two teams) competing directly against each other. Checkers, chess, football, judo, and squash, and thousands of other formalized contests are examples of games in which there are two players or teams. Most of these games have only one winner after played.

Originally, theorists focused on *strictly competitive* or *two-person zero-sum* games. In these games, cooperation is pointless since the goals of the players are necessarily at odds; if one player prefers a certain outcome, the other player will not prefer it.

Furthermore, the setting for the game is typically a one-time competition, in which the actions of players in the past do not affect the current competition at all.

This construction of a game works quite well in many game situations, and is a powerful tool for the development of much of modern game theory. However, it is unsatisfactory as a model for the majority of economic, business, or political applications. In real life, there are usually more than two parties involved in a market, and the contest or opportunity to execute some type of strategic decision happens repeatedly.

Thus, broader types of games have been codified in game theory, and will be discussed in this book.

Rapid Discoveries in the Twentieth Century

Despite the shortcomings of simple *two-person zero-sum* games, the theorists that began studying this type of contest only about a half century ago have produced a number of important discoveries. These developments have dramatically broadened the application of game theory to situations in real life.

Key Conceptual Developments in Early Years

A short history of the development of game theory would include the following significant developments in early years:[1]

- The *extensive (or tree) form* of a game, introduced by John Von Neumann in 1928, which presents a systematic description of the game as well as the rules of the game, specifying how players move, information they possess at the time they move, how probabilities affect the game, and the payoff to each player at the end of the game.
- The definitions of a *strategy*, *strategic behavior*, and *strategic actions* of a player in a game, related to the other players' moves, strategies and tactics.
- The *normal form (or matrix form)* of a game. Given strategies for each of the players, the normal form of a game demonstrates outcomes and payoffs for each player.

  The formulation of a game into a matrix structure is one of the most powerful tools developed by game theory pioneers. This form helps the decision maker to

1. This history is based on R.J. Aumann's essay "Game Theory," in *The New Palgrave, A Dictionary of Economics*, Volume 2, Edited by John Eatwell, Murray Milgate, and Peter Newman, The Macmillan Press Limited, 1987, 1991, pages 460-479.

   The early history of game theory is largely accepted, however, the importance of more recent developments is debated among the practitioners and by new theorists, and our selection of developments in the past twenty years is therefore somewhat subjective.

realize that other players in the game are also making decisions, so that no outcome is the result of an isolated decision.

- The concept of *mixed* or *randomized* strategy. This strategy enables the player to choose a probability for each strategy in a set of pure strategies, rather than play a pure strategy. Often, a pure strategy is dominated by such a strategy. When a player uses a mixed strategy, the payoff to the player at the end of the game becomes the expected payoff.
- The concept of *individual rationality*, where the actions of players are consistent and led by their utility maximizing preferences. *Utility theory* suggests that economic agents, e.g., consumers, act in a way to maximize their utility, their overall happiness when they make a decision among different choices.
- Different types of information concepts, such as *perfect information*.

  The concept of *perfect information* means that there are no moves occurring simultaneously and that all information within the game is *common knowledge*; that is, the information is known by every player of the game and that each player is aware that the information is public.
- *The mini-max theorem*. In a two-person zero sum game, if a player reduces the other player's payoff, he will be increasing his own, i.e., one's loss is another's gain. Because each player cannot improve his position in respect to utility, this strategy is the *optimal* strategy.

Pioneers of Game Theory and Advancement of the Field

In 1944, John Von Neumann and Oskar Morgenstern published the *Theory of Games and Economic Behavior.* It established the economic and mathematical basis for the field we now call "game theory." Von Neumann and Morgenstern established the field that economic and social questions can often be described as mathematical models of *suitable games of strategy.* The book covered various applications of game theory to economics and introduced techniques such as backward induction.

The games analyzed by Von Neumann and Morgenstern are *one-shot* games. Players play these games only once. They do not meet again after the game is played. If this assumption does not hold, the analyst should consider the *repeated game* as a single-player game, which is played just once (Savage defined this principle in 1954).

The method of Von Neumann and Morgenstern has become the standard of later applications of game theory. One takes an economic or business problem, formulates it as a game, finds the game theoretic solution, then translates the solution into economic or business terms.

During the 1950s, game theory developed dramatically, when John Nash developed game theory tools and concepts for general *non-cooperative theory* and *cooperative bargaining theory.* He introduced what is now called the "Nash equilibrium" of a strategic game in 1951. In a Nash equilibrium, each player's strategy maximizes his payoff assuming that the other players are doing the same.

In 1950, *Strategy in Poker, Business and War* by John McDonald was published. McDonald's book was one of the first to demonstrate the use of strategy in real-world environments and how game theory could be applied to business and not just games.

Lloyd Shapley brought *conditional games* to game theory and defined the specifics of the conditional games. The emergence of stochastic and other dynamic games further expanded the generalization of game theory. Games played in multiple stages are called *dynamic*, including stochastic games and repeated games. Repeated games model the psychological side of a continuous relationship, including the concepts of threats and rewards (promises).

D.B. Gillies and John Milnor developed the first *continuous* game theoretical models. Harold Kuhn contributed to the field with his work on behavior strategies.

Melvin Dresher and Merrill Flood of the RAND Corporation developed the structure of the prisoner's dilemma. However, it was mathematician Albert Tucker who formalized the game using prisoners, sentences and payoffs, and who famously named it. The RAND Corporation would go on to start its center for game theoretic research in Santa Monica in the 1950s.

The first textbook on game theory, *Introduction to the Theory of Games*, was published in 1952 by John Charles C. McKinsey. The book was published when game theory was still in its infancy, and thus did not cover many aspects of the field that are well known today. However, it did cover basic terminology and the topics and theories well accepted at that point in time.

In the same year, the University of Michigan along with the Ford Foundation sponsored "Design of Experiments in Decision Processes." This was the first experimental economics conference covering design and lab parameters and the behavior of players.

Game theory continued to branch out. In 1955, it was applied to philosophy by British philosopher R. B. Braithwaite in his book *Theory of Games as a Tool for the Moral Philosopher.* In the book, Braithwaite demonstrates how game theory can be used to arrive at moral and ethical decisions.

The introduction of repeated games occurred in the late 1950s. During this period, the emphasis of game theory moved to cold war strategies. Kuhn, Kissinger, and Schelling contributed to the field while developing cold war strategies. Another important development in the field in the late 1950s is the use of the *Folk Theorem* to show the solid relationship between repeated and cooperative games.

In 1957, another masterpiece of game theory, *Games and Decisions*, by R. Luce and H. Raiffa, was published. Luce and Raiffa determined that it was unrealistic in game theory to have designed games where players are assumed to have full knowledge of the rules and payoffs of the game. “Each player … is fully aware of the rules of the game and the utility functions of each of the players… this is a serious idealization which only rarely is met in actual situations.”[2] John C. Harsanyi built off this idea and later developed games with incomplete and asymmetric information to overcome this problem. Along with Nash’s work, Luce and Raiffa’s book allowed game theory to begin reaching a wider audience.

In 1960, *The Strategy of Conflict* by Thomas Schelling was published. Schelling introduced the *focal point* concept, also known as the Schelling point. The focal point is the solution where players in the lack of communication take the most strategic action to receive the highest payoff.

Harsanyi introduced cooperative games in 1966—games in which commitments such as contracts, agreements, threats, and promises are enforceable. A game is considered non-cooperative if commitments between players are not possible. Before Harsanyi’s contribution, analysts in the field considered cooperative games to be a type of non-cooperative games, because the extensive form of a game allows negotiation and enforcement mechanisms.

In 1969, D.K. Lewis formalized the *common knowledge* assumption, which had been implicitly assumed earlier by Luce and Raffio and other game theorists. Lewis defined *common knowledge* as the idea that players all know the rules of the game, each player’s utility function, and know that each player is aware that each player is aware, and so on.

The common knowledge assumption is one of the most important assumptions of game theory. Whether the game-theoretic model is cooperative or non-cooperative, with complete or incomplete information, the model must assume common knowledge.

In 1972, the *International Journal of Game Theory* was first published covering game theory, its applications, and the discussion around current research at the time. The journal continues to be published today. It was founded by Oskar Morgenstern.

In 1973, Harsanyi introduced the idea of explicit randomization in game theory. He discovered the pure strategy outcome remains unaltered in a game where each player’s payoffs are allowed to randomly shift by a small amount and the new payoffs are known only to the player to whom they apply.

2. Luce, Duncan, and Howard Raiffa. *Games and Decisions, Introduction and Critical Survey.* Wiley, 1957, p. 49.

In 1974, Robert Aumann introduced the *correlated equilibrium*, whereby players' strategies in a game are based on their observations and common information available within the game.

Game theory continued to expand. In the 1970s it was even applied to biology by John Maynard Smith in his work on evolutionary stable strategy (ESS). ESS intertwined the evolutionary behavior of animals and the game theory. ESS is used today in biology, anthropology, psychology, and political science.

Game Theory's Evolution during the Last Three Decades

After game theory was established by great mathematicians and economists as a field, the last quarter of the twentieth century and early 2000s witnessed dramatic evolution of the field. Most of the economists who specialized in game theory have been interested in pure theory questions rather than applications of the theory. However, in other fields, such as psychology, biology, genetics, and politics, scholars have used game theory and game theoretical approaches for the problems in their own fields. Some of the recent historical work and developments in game theory are summarized below.

In 1981, Elon Kohlberg published *Some Problems with the Concept of Perfect Equilibria*, which formally introduced the idea of forward induction, which could be used similarly to backward induction.

In 1982, "Sequential Equilibria" by David Kreps and Robert Wilson was published in *Econometrica*. Kreps and Wilson refined the Nash equilibrium for games in extensive form. They proposed that not only do players have a strategy, but players also have a sensible belief in their actions.

In 1984, David Pearce and Douglas Berheim independently introduced the idea of rationalizability in their papers *Rationalizable Strategic Behavior* and *the Problem of Perfection*; the idea concerned rational players and their approach to the choice of strategies. *The Evolution of Cooperation* by Robert Axelrod was published in 1984. Axelrod explored the idea that under certain conditions selfish economic agents would cooperate. Axelrod famously used computer simulations in 1980s in game theory.

In 1986, Elon Kohlberg continued to use forward induction, which he introduced in 1981 with his publication *Some Problems with the Concept of Perfect Equilibria*. Kohlberg worked with Jean-Francois Merterns and in 1986, they published *On the Strategy Stability of Equilibria*, where they addressed the refinement of the Nash equilibrium in normal form.

In 1988, *A General Theory of Equilibrium Selection in Games* by John Harsanyi and Reinhard Selten was published. Harsanyi and Selten provided a general theory of the selection among equilibria and the rational parameters necessary for a player to choose a specific equilibrium point for any non-cooperative or cooperative game.

In 1989,the journal *Games and Economic Behavior* (GEB) was first published. It is one of the leading journals in economics and game theory.

Game theory continued to reach a wider audience, particularly in the field of economics itself. In 1990, *A Course in Microeconomic Theory* by David Kreps was published. It was the first microeconomics book to include extensive discussion of game theory with conventional microeconomic theory.

In 1994, *Game Theory and the Law* by Douglas Baird, Robert Gertner and Randal Picker was published. The book is generally viewed as the first to apply fundamental frameworks of game theory such as dilemma and coordination games, and Nash equilibrium to the field of law.

Recognition

Game theory has been appreciated by academicians, and rewarded by universities and other academic institutions, particularly in the field of economics. In the last decade, a few game theory pioneers have been lauded with the Nobel Prize in Economic Science: John Harsanyi, John Nash, and Reinhard Selten (1994); and Robert J. Aumann and Thomas C. Schelling (2005).

Other economists who have greatly contributed to the field have also won the Nobel Prize in recent years. In 2002, behavioral and experimental economist Vernon Smith was awarded the Nobel Prize in Economics "for having established laboratory experiments as a tool in empirical analysis."[3]

In 2007, three economists, Roger Myerson, Leonid Hurwicz, and Eric Maskin, were awarded the Nobel Prize in Economics "for having laid the foundations of mechanism design theory," with game theory structure and its design.[4]

With these recognitions have come an explosion of academic research in the area, and many published works describing an enormous range of competitive and cooperative strategic situations in game theory concepts.

3. "The Prize in Economics Press Release," The Royal Swedish Academy of Sciences, October 9, 2002.
4. "The Prize in Economics Press Release," The Royal Swedish Academy of Sciences, October 15, 2007.

Chapter 2 Strategy and Game Theory Concepts

Thus, what is of supreme importance in war is to attack the enemy's strategy.

Sun Tzu

Game theory uses economic and mathematical tools to solve decision-making problems. Avinash Dixit and Barry Nalebuff describe game theory briefly as "the branch of social science that studies strategic decision-making."[1] Even though the many decades of work by economists and mathematicians provide sufficient credits for it to be called a science, the authors of this book consider game theory to be as much an art, as a field of science.

As an interactive decision-making environment, game theory offers valuable tools for solving strategy problems in everyday life and in the business world. Game theory has been used for determining cold war strategies, establishing merger and acquisition strategies, picking Supreme Court judges, as well as measuring the market power of firms.

Game theory is not just theory—it is a field practiced by young boys and girls as well as world leaders. However, in the past it has been taught either as a difficult

1. Dixit, Avinash K., Barry J. Nalebuff, *Thinking Strategically: The Competitive Edge in Business, Politics and Everyday Life*, W. W. Norton & Company, 1991, p. 2.

mathematical exercise, or as a separate field without much practical application. In this book, we provide practical uses of game theory.

Game Theory, Strategy, and Strategic Behavior

A game-theoretic model is an environment where each decision-maker's actions interact with those of others. In general, behavior that involves such interactive decision-making is called *strategic*, and the set of actions and moves by each player with respect to others, given the rules of the game, is called *strategy.*

Human beings have behaved strategically since the dawn of time. Indeed, some definitions of "intelligent" life begin with the ability to think in a manner that could be described as "strategic." Many of the classic game theory models—such as the "prisoner's dilemma" and various nuclear war scenarios—involve multiple players whose actions affect others, and whose fate literally depends on the others' actions as well as their own. In this book, we will concentrate on more down-to-earth scenarios, involving the relatively mundane affairs of businessmen and women, policymakers, investors, and consumers.

Many business strategies are short or long-term plans to achieve certain goals. The ultimate goal for most business managers is sustainable profitability, and thus creation of stockholder value. Of course, having a strategy is not enough to achieve this goal; a company must provide the goods and services in a manner that its customers find acceptable. However, with the wrong strategy, a business will suffer in the long run, and often disappear. With the right strategy, a business can often successfully position itself in its competitive environment, given the behavior of consumers, the competition, as well as the market. For the business manager, elements for a good strategy include understanding one's strengths and capitalizing on them; understanding one's weaknesses and making them strengths; and understanding how strategic behavior will affect the short- and long-term outlook for the company.

More on Strategic Behavior and Strategy

We will consider "strategic" behavior as behavior serving the self-interest of the person, based on the person's own subjective evaluation of likely events and the possible actions of other players; with the potential rewards and risks being considered over single or multiple period(s). According to Schelling: "A strategic move is one that influences the other person's choice, in a manner favorable to one's self, by affecting the other person's expectations on how one's self will behave."[2] *Palgrave's Dictionary of Economics* defines strategic behavior as: "An agent is said to act strategically when in choosing an action it takes into account the dependence of the

2. Schelling, Thomas, *The Strategy of Conflict*, Harvard University Press, Cambridge, Mass., 1960, p. 160.

other agents' actions on its behavior."[3] Most of the strategic behaviors we will analyze in this book fit into these definitions. Any person playing checkers, common card games, sports games such as football and baseball, or interviewing for a job fulfills the criteria in these definitions.

Note that strategic behavior is more than simply maximizing utility with defined prices and commodities (we discuss *consumer behavior* and *utility theory* in the following pages). Consider, in the standard one-period neoclassical economics model, a consumer's choice among different commodities to purchase, given that consumer's preferences and the prices that prevail in the market. This is an economic decision but not a strategic decision. Indeed, it is an economic decision that is the basis for microeconomics in a purely competitive market. However, it is not a strategic decision. Because strategic behavior involves considering the *future consequences* of the actions of *more than one person*. Thus, it is different than the standard microeconomic study of consumers and producers.

Game Theory and Strategic Behavior in Business

Strategic behavior occurs regularly among executives, managers and investors in business. The life of these individuals is replete with situations in which they must decide to enter into new markets, launch new products, invest now or lose the opportunity to invest, purchase an item whose future use is uncertain, and make pricing and purchasing decisions. In each of these situations, the person confronts not only uncertainty about future states of nature (such as prices, interest rates, and incomes), but also uncertainty about actions that other persons will take (such as competitors, workers, suppliers, and government agencies). Using any of the definitions of "strategy" introduced above, this behavior is called "strategic behavior."

The advantages of game theory in applied work are clear. The formal structure of game theory models forces each player to consider the actions of others when picking their strategy. The extensive or normal forms of the game (which we will describe in the following pages in this chapter) lay out the information that each player knows when he is choosing his move. Simply laying out the structure provides significant benefit to a decision-maker.

Given these advantages, game-theoretic models are very powerful tools for analyzing firm decisions. Most of business world scenarios can be modeled as dynamic games with multiple stages, in which one player may respond to the moves of his opponent. In such a world, firms act strategically in each stage, based on the information available at the current time.

3. Harrington, Joseph E., "Strategic Behavior and Market Structure," in *The New Palgrave, A Dictionary of Economics*, Volume 4, Edited by John Eatwell, Murray Milgate, Peter Newman, The Macmillan Press Limited, 1987, 1991, p. 513.

Consumer Behavior, Utility Theory, and Game Theory

One of the most important assumptions of game theory since its inception is that economic agents are rational players. As a rational player, a consumer's goal in real life is to maximize his well-being, i.e., utility. Likewise, in game theoretical models, we assume that rational players act to maximize their utility. Utility within such models have been represented by the payoffs at the end of the game. Before further discussing game theory and building game-theoretic models, let us discuss consumer behavior and utility theory briefly.

Utility is an indicator of a person's overall happiness or well-being. Consumers make choices to maximize their utility (their happiness). We use the concept of consumer preferences to understand consumer behavior. We assess consumer preferences by utility, even though actually measuring utility is practically impossible. To model consumers' preferences, we use utility functions. Utility functions are tools for assigning a number to consumption bundles of consumers. "Bundle" here represents any combination of consumer goods or services. Because a utility function is based on preferences, to construct a utility function, we usually assign *ordinal* numbers for consumers' preferences. More-preferred bundles get assigned larger numbers than less-preferred bundles, based on the order of preferences.We discuss utility functions below.

Economists say a bundle (x_1, x_2) is preferred to a bundle (y_1, y_2) if and only if the utility of (x_1, x_2) is larger than the utility of (y_1, y_2). Symbolically, (x_1, x_2) is preferred to (y_1, y_2) if and only if $u(x_1, x_2) > u(y_1, y_2)$. This assumption is very important; it is called an axiom of utility theory.

We can assign different measures of utility to different bundles of goods. Let us assume that the consumer prefers X to Y and Y to Z. We can assign utilities as we want, as long as U(X) > U(Y) > U(Z). See the table below:

TABLE 2.1 Examples of Assigning Utilities to Different Bundles

Bundle	**X**	**Y**	**Z**
U_1	100	10	1
U_2	5	3	2
U_3	1	0	-1

There are infinite ways for assigning ordinal utility measures to bundles of goods and services, because only the ranking (order) of utilities is important. If you multiply these assigned measures by a positive number, you still have the same order.

Let us say U(X) = 3, U(Y) = 2, and U(Z) = 1, so
U(X) > U(Y) > U(Z)

For example, multiplication by 2 does not change the preference order:

U(X') = 3×2 = 6,
U(Y') = 2×2 = 4, and
U(Z') = 1×2 = 2; therefore,

U(X') > U(Y') > U(Z')

Cardinal Utility

For some utility theories, the magnitude of utility is important. These are called "cardinal utility theories." Cardinal utility theory asserts that the level, as well as the order, of utility gained from a bundle of goods and services is significant. For example, a common cardinal utility theory implies that one prefers a specific bundle at least three times more than another if he is willing to pay three times as much for that bundle.

Choice Behavior and Game Theory

In game theory, *choice behavior* is determining whether one bundle or another will be preferred. In our game theory models, we consider which strategy brings greater utility. The utility levels of preferences, and the knowledge of how much larger the utility is, are significant for the game-theoretic models.

Utility Functions and Game-Theoretic Models

Some game-theoretic models require a *utility function*. A utility function maps the utility of a bundle of goods and services to a real number.

Some examples of utility functions are listed below:

- $u(x_1, x_2) = x_1x_2$
- $u(x_1, x_2) = ax_1 + bx_2$
- $u(x_1, x_2) = \max\{ax_1, bx_2\}$

The first example above is a multiplicative function, in which to have 16 units of utility requires 4 of each bundle, or 8 of bundle x_1 and 2 of bundle x_2, or 1 of bundle x_1 and 16 of bundle x_2. The other examples are additive and maximum functions.

How do we use utility functions for our game-theoretic models? Let us say at some point in a game a player needs to pick a strategy from the strategy set A={*A1*, *A2*}. The player knows that strategy *A1* will lead him to 2 units of bundle x_1 and 3 units of bundle x_2; and strategy *A2* leads him to 5 units of bundle x_1 and 1 unit of bundle x_2. Assuming that his utility function is $u(x_1, x_2) = x_1x_2$, he would prefer the first strategy. By choosing *A1*, he will get 6 units of utility; and by choosing *A2*, he will get 5 units of utility. We expect a rational player under these circumstances to choose strategy *A1*.

Utility Theory and Payoffs

In the early chapters of the book, we present payoffs in numerical form, so the student of game theory can concentrate on the structure of the game. In the real world, properly constructing the payoff matrix is a critical, and often difficult, step. This difficulty arises from the fact that a person's utility is rarely defined by any one-dimensional measure, such as a price, quantity, or size, of a cash payment.

Game-Theoretic Models and Illustration

As we described in the previous section, game theory models describe strategic interaction among many players. We assume that players make rational decisions to maximize their expected utility.

The interdependence of the players' decisions is the foundation of game theory. Game theory models often exhibit a social science corrollary to a fundamental principle of physics: Every action has a reaction. These interactions arise in two ways: sequential and simultaneous.

Sequential interaction refers to each player taking action in a sequence of turns. During a player's turn, he or she is aware of the actions taken in previous turns. Furthermore, each is aware that his current action(s) will affect later actions of the other player(s), as well as his future action(s) during the game.

The second kind of interaction is simultaneous. Simultaneous interactions occur when players take actions concurrently, in ignorance of the others' current actions. It is important to note that while players do not know the specific actions of the other players, they are aware of each other in simultaneous games.

The Payoff Matrix and Tree Diagram

To analyze sequential-move and simultaneous-move games, we introduce two different illustrations: (1) the payoff matrix, and (2) the tree diagram.

Suppose that two players are in a simple game. Player I has two options, choosing *X* or choosing *Y*; Player II has the same two options as well, *X* and *Y*. Let us assume they decide their moves simultaneously. If player I picks *X* and player II picks *Y*, player I gets \$10; player II gets \$5. If player I picks *Y* and player II picks *X*, player I gets \$5; player II gets \$10. If both pick *X*, player I gets \$2, and player II gets \$8. Finally, if both pick *Y*, each gets \$3.

How do we show this game for our analysis? In game theory, we often show this type of game with a *payoff matrix*. Below is the payoff matrix of the game just described above:

TABLE 2.2 Illustration of a Sample Payoff Matrix

		Player II	
		X	*Y*
Player I	*X*	(2, 8)	(10, 5)
	Y	(5, 10)	(3, 3)

We discuss this game later in this chapter, when we introduce dominant and dominated strategies. Our purpose here is to show how to construct a payoff matrix of a game. The payoff matrix illustration in game theory is also called the "normal form" of the game.

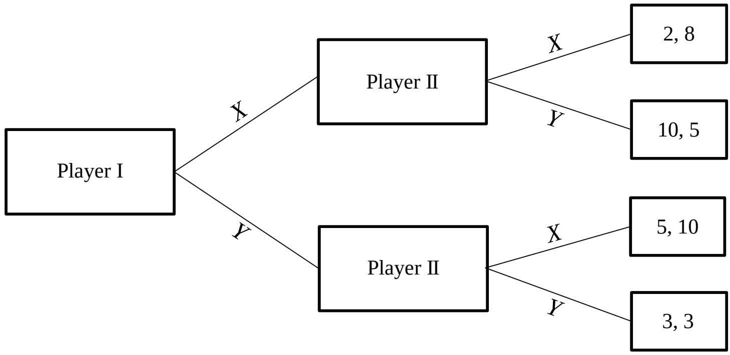
A tree diagram is another very powerful tool for illustrating and analyzing games, especially games in which players act sequentially. A common depiction of possible outcomes over time, and one that we will use repeatedly, is called a "tree," "event tree," or "decision tree." Such a device combines the time aspect, and the logical and sequential connections among decision-makers and events.

The tree starts at a specific point in time, which conveniently can be drawn as a single point in a two-dimensional space. From that point, "branches" of the tree emerge. Each such branch terminates into another "node." At each "node" of the tree, an event occurs such as a decision, random occurrence, or receipt of information. This event then causes the tree to branch into different outcomes at the next time step.

For a better conceptual understanding, let us make one change in the game illustrated in Table 2.2, "Illustration of a Sample Payoff Matrix." Instead of assuming that the players in this game move simultaneously, we assume they move sequentially. Let us say player I moves first, and player II follows him. In sequential move games, players observe the other players' future moves and use them in assessing their best current move. This is known as "backward induction," that is, *look ahead and reason back.*

Tree diagrams, generally used for sequential or the non-simultaneous games, are also called "decision trees," or the *extensive form* of the game. Figure 2.1 below shows the decision tree illustration of the game described above.

FIGURE 2.1 Tree Diagram of a Sample Game



Strategic Thinking and Simultaneous- and Sequential-Move Games

In sequential-move games, the current course of action taken by the player is based on his expectation of what the other players' future strategy and action will be. A player typically thinks, "if I choose this course of action, the other player will take that course of action, therefore I should do this," and so forth.

In contrast, simultaneous-move game interaction can be more difficult for players. This is because players must guess what the other player is anticipating at the moment, and respond accordingly, as well as anticipate how these actions affect future outcomes of the game. For simultaneous-move games, a player may try to think of more combinations of his and other players' actions.

Rules of the Game

The nature of a game theoretical model is determined by the rules, just like the rules determine sports games or parlor games. We will first describe the key rules of any game.

- *Players.* How many players do we have in a game? Are their interests matching or conflicting?
- *Information.* What information does each player possess? Do they have *complete, symmetric,* or *perfect* information regarding each other's actions and payoffs? What are the moving sequences of players?
- *Actions or Strategies.* What actions or strategies are the players allowed to have? What are the specifics of interaction between players? Are they allowed to communicate?
- *Payoffs.* What are the possible outcomes for each player? What is the utility or expected utility for each player at the end of the game for every action they are allowed to have?

Players

In game theory, players are rational economic agents who make decisions with a well-defined set of actions and strategies. We assume that their goals are to maximize their utility or expected utility. *Rational* characteristics for the players in game-theoretic models are implicitly assumed for every game we analyze in this book.[4] Unless explicitly stated, we adopt the classical assumption that players maximize their utility by maximizing their payoffs in a game.

In our sample game depicted in Table 2.2, we have two players: player I and player II. Both players have the same set of actions: $\{X, Y\}$. Player I and player II share the similar goal in this game as in other game-theoretic models: to maximize their payoff at the end of the game.

Information

Information is the knowledge each player has about the game. The information set may include the number of players, each player's set of actions, strategies, payoffs, and the moving sequence. Players in a game possess some sort of information set; they might have *perfect* or *imperfect* information, *complete* or *incomplete* information, *symmetric* or *asymmetric* information. We will define these concepts below.

Another important implicit assumption of game theory is that the structure of the game is common knowledge: that is, players know how many players are in the game, their moving sequence, either simultaneous or non-simultaneous, and the set of actions or strategies available to each player when he or she moves.

In our sample game described in Table 2.2, both players know that the game is a two-player simultaneous-move game. Both players know each one of them has the same set of actions *X* and *Y*. In addition, they possess the information of each other's payoffs. For example, player I knows if he picks X from his set of actions, and player II picks X as well from his set of actions, his outcome will be 2 and player II's outcome will be 8. Player I also knows that player II knows the set of actions and player I's payoffs. Player I knows that player II knows that player I knows player II's set of actions and payoffs, and so on.

In the game illustrated in Figure 2.1, both players know the game is a non-simultaneous two-player game. They possess the information about the moving sequence, and when each moves. Each player also knows his and the other player's payoffs.

4. Adam Brandenburger and Barry Nalebuff define rationality in their book *Co-opetition* as "...a person is rational if he does the best he can, given how he perceives the game (including his perceptions of perceptions) and how he evaluates the various possible outcomes of the game." (p. 61).

We have three main categories for the information structure of a game :

1. Perfect vs. imperfect information,
2. Complete vs. incomplete information, and
3. Symmetric vs. asymmetric information

Perfect vs. Imperfect Information

Perfect information means that no moves are simultaneous, and each player knows the sequence of moves and where players move. The game we described in Figure 2.1, "Tree Diagram of a Sample Game," is an example of a game with perfect information.

All simultaneous-move games are games of imperfect information. An incomplete or asymmetric information game is also a game of imperfect information. We discuss these concepts further below.

Complete vs. Incomplete Information

In a game of incomplete information, there are some uncertainties about the actions of players, the moving sequence of the game, or the payoffs. For instance, some players choose from their set of actions randomly. A game of incomplete information might include probabilities at some of the nodes in the game. A game of incomplete information is also a game of imperfect information.

Symmetric vs. Asymmetric Information

In a game of symmetric information, players have the same elements in their information sets, including the sequence of the game, where each player chooses an action, and the end nodes. Otherwise, a game is called a "game of asymmetric information." In asymmetric information games, players have different information regarding each other's moves or payoffs.

Set of Actions and Strategies

In a game, each player has an action set that includes their possible moves or strategies. Players determine their strategies based on the information available to them at the beginning of the game and at each node.

For example, in the games described in Table 2.2 and illustrated in Figure 2.1, players I and II have the same action sets: $\{X, Y\}$. Each player chooses between actions X and Y.

Payoffs

Payoffs are what players receive at the end of the game. The nature of games is that the payoffs differ depending on the actions of the players. We often visualize the possible payoffs in a payoff matrix.

For example, the payoff matrix of player I in Table 2.2 is:

$$\begin{bmatrix} 2 & 10 \\ 5 & 3 \end{bmatrix}$$

The figures in each row show player I's payoffs if he picks the specific action that row represents. For instance, the first row above shows that if he chooses *X* from his action set, he will get either $2 or $10, based on his opponent's decision.

The payoff matrix of player II in Table 2.2 is:

$$\begin{bmatrix} 8 & 5 \\ 10 & 3 \end{bmatrix}$$

For player II, the figures in each column are his payoffs based on his choices. The first column shows that if he chooses X, he will get either $8 or $10 based on player I's decisions.

Strategy and Equilibrium

A "strategy" is an order of moves determined in advance of some events by an individual player. A strategy can, and often does, depend on the action of other players, random events, and particular payoffs available to a specific player. In games where there are more than one move for each player, a "strategy" is different than an "action." In general, players decide what action to take by using a strategy.

Dominant and Dominated Strategies

We can define two characteristics that apply to some strategies in specific games, based on the likely outcome for the player.

If any player follows a *dominant strategy*, the player will get the best possible payoff regardless of what the other player(s) will do. A dominant strategy is the *optimal* strategy for a player no matter what the other player(s) does (do). To illustrate dominant strategies, recall the game described in Table 2.2, "Illustration of a Sample Payoff Matrix."

TABLE 2.3 First Sample Game

		Player II	
		X	*Y*
Player I	*X*	(2, 8)	(10, 5)
	Y	(5, 10)	(3, 3)

If player I picks action X, player II gets $8 by picking *X*, and $5 by *Y*. So *X* is a better strategy for player II, if player I chooses *X*. If player I picks *Y*, player II gets $10 by choosing *X*, and $3 by choosing *Y*. Again, *X* is a better strategy for player II. Regardless of player I's choice, player II is better off by choosing *X* from his set of available actions. Choosing *X* is the *dominant strategy* for player II in this game.

There is no dominant strategy for player I in this game. By using our payoff matrix, readers should be able to quickly determine that the best move for player II depends on what player I does. (If player II picks *X*, player I is better off by picking *Y*; if player II picks *Y*, player I is better of by picking *X*).

Dominated Strategies

Just as a dominant strategy is a strategy that is better than any other strategy a player can choose from his set of actions, a dominated strategy is a strategy that is worse than another strategy available for the player. In a game with rational players, players can be expected to play their dominant strategies (if they have any) and avoid their dominated strategies.

In our sample game described in Table 2.2, choosing *Y* is a dominated strategy for player II. However, player I does not have a dominated strategy.

Equilibrium

An *equilibrium* in game theory is defined as a stable outcome, based on the payoffs received by players at the end of the game. We call it stable because after players settle on an equilibrium point with their payoffs, they have no incentive to deviate from that point. When we have an equilibrium point in a game, we call that the *solution* of the game.

Dominant Strategy Equilibrium

In most classic sports and parlor games, there is no strategy that is dominant. For example, following centuries of play—including decades of the availability of computer software—no chess strategy has emerged that wins every time.

However, in some games, players either have dominant strategies, or learn their best strategies over time and begin to play them repeatedly. This creates the potential for an equilibrium position among multiple players.

Does our sample game discussed above have an equilibrium? We need to analyze the payoff matrix of players and their set of actions to find out if our game has an equilibrium and equilibrium payoff.

We showed above that there is no dominant or dominated strategies for player I, and that *X* is the dominant strategy for player II. For player II, it does not matter what player I picks in this game. He picks *X* regardless of player I's move. Assuming player I is a rational player, he knows that player II picks *X*, regardless of how he moves, that is, both players know that player II picks *X*. Based upon this information, our sample game becomes:

TABLE 2.4 Reduced Form of the First Sample Game

		Player II
		X
Player I	*X*	(2, 8)
	Y	(5, 10)

The normal form of the game illustrated in Table 2.4 is called *reduced form*. Let us analyze the reduced form of the game: If player I picks *X*, his payoff is $2; if he chooses *Y*, his payoff is $5. Therefore, he is better off by picking *Y*.

Equilibrium strategies for players in this game are *Y* for player I and *X* for player II. We say (*Y*, *X*) = (5, 10) is the equilibrium of this game.

It is possible that every player in a game has a dominant strategy. Similarly, it is also possible that no player has a dominant strategy. If there is a dominant strategy for each player, then we have a *dominant strategy equilibrium* for that game. If there is a dominant strategy for only one player, we have a dominant strategy equilibria in a 2-player game. If it is an n-player game, we may or may not have a dominant strategy equilibrium.

Nash Equilibrium

We do not have dominant strategy equilibria in all games. Let us review the game depicted below.

TABLE 2.5 Sample Game with No Dominant Strategy

		Player II	
		C	*D*
Player I	*A*	(2, 2)	(1, 3)
	B	(4, 2)	(0, 1)

We have two players, with two options in their feasible action sets in this game. Player I's action set includes *A* and *B*; Player II's action set contains moves *C* and *D*. We assume that this is a simultaneous-move game and each player knows the other player's action set and payoff matrix, as well as the simultaneous nature of the game.

If player II picks *C*, player I is better off by picking *B*, [4 > 2]; if player II picks *D*, player I's best choice is *A*, [1 > 0]. The same reasoning demonstrates that player II chooses *D* if player I picks *A*, [3 > 2], and *C* if player 1 picks *B*, [2 > 1].

In this game, neither player has a dominant strategy. Their rational moves depend on each other's moves. Hence, there is no dominant strategy equilibrium in this game. However, we have two equilibria (*B*, *C*) and (*A*, *D*), and we call each of these equilibria *Nash equilibrium*.

In a two-player simultaneous-move game, we call a pair of strategies a *Nash equilibrium*, if player I's choice is optimal based on player II's choice, and player II's choice is optimal based on player I's choice.

If a game is a non-simultaneous (sequential) game, the first mover has the advantage and is able to dictate an equilibrium. However, in a simultaneous-move game, we do not have such an attribute. The game described in Table 2.5 is a simultaneous-move game where neither player knows the other's move until they both act. So players make a decision based on expectations. Both players have the same information in respect to the payoff matrix. If they have rational expectations about the other player's moves, they reach the Nash equilibria, (*B*, *C*) and (*A*, *D*) in this case.

Do Nash equilibria exist in every game? The answer is no. See the simultaneous-move game depicted below.

TABLE 2.6 Sample Game with No Dominant Strategy or Nash Equilibria

		Player II	
		C	*D*
Player I	*A*	(2, 2)	(-1, 3)
	B	(1, 2)	(0, 1)

If player II picks *C*, player I is better off by choosing *A*; if player II picks *D*, player I gets better off by choosing *B*. If player I picks *A*, player II chooses *D*, otherwise he chooses *C*.

This game does not have a dominant strategy for each player nor a dominant strategy equilibrium. Furthermore, we do not have a Nash equilibrium for this game.

Note on Dominant Strategy Equilibrium and Nash Equilibrium

Even though dominant strategy equilibria are stable, players do not have a dominant strategy in every game. The Nash equilibrium occurs in a broader spectrum of games.

A game has a Nash equilibrium if there exists a set of strategies such that each player optimizes his utility given the other players' actions. A Nash equilibrium is quite stable, because no player has an incentive to deviate from his *Nash strategies*.

Recall that in game theory, we implicitly assume players are rational agents. The Nash equilibrium is dependent upon individual rationality more than the dominant strategy equilibrium. The equilibrium outcomes in the Nash equilibrium depend not only on every player's own rationality as in the dominant strategy equilibrium, but also on other players' rationality.

Subgame Perfect Nash Equilibrium

Subgame is a smaller portion of a game starting at a specific node of an entire game. From that point, the subgame emerges and continues to the end of the whole game.

We call an equilibrium a *subgame perfect Nash equilibrium*, if every subgame of the entire game has a Nash equilibrium based on players' strategies.

Mixed Strategies; Repeated Games

In all the payoff matrices of games shown above, we have concentrated on "pure strategies"; that is, players making one choice and playing the game with that choice only. If games are played more than once (with the same rules), we call them *repeated* games. In such cases, it is possible for players to change their strategies. Players are even allowed to randomize their strategies.

In the game depicted in Table 2.5, "Sample Game with No Dominant Strategy." let us assume that player I picks *A* 70% of the time and *B* 30% of the time. This type of strategy is called a *mixed strategy.*

If a player has such a mixed strategy, the equilibrium of the game changes. Let us reintroduce our sample game here:

TABLE 2.7 Sample Game with No Dominant Strategy

		Player II	
		C	*D*
Player I	*A*	(2, 2)	(1, 3)
	B	(4, 2)	(0, 1)

We assumed that both players I and II have the information about players I's mixed strategy of choosing *A* 70% of the time and *B* 30% of the time. For simplicity, let us assume player II does not randomize his strategies.

Player II's *expected payoffs* of the new game becomes 2 for choosing *C*, $[(2 \times 0.7) + (2 \times 0.3) = 2]$, and 2.4 for choosing *D*, $[(3 \times 0.7) + (1\times 0.3) = 2.4]$.

The games shown up to this point have always had a Nash equilibrium in mixed strategies.

Maximin Strategy

What strategies are available to players who face payoffs that vary according to their opponent's actions? One classic strategy is called the *maximin*.

The maximin strategy pertains to a two-person zero-sum game. If a player (player I) attempts to take action(s) to reduce the other player's (player II) payoff, player II will take the action(s) that will give him the maximum minimum payoff. It should be noted that since most games are not *zero-sum games*, the maximin strategy is often not applicable.[5]

5. Maximin strategy and behavior is also known as the minimax criterion (theorem). The minimax theorem was proved by John von Neumann in 1928. In a two-person zero-sum game, if one player reduces the other player's payoff, he will be increasing his own, i.e., one's loss is another's gain. Von Neumann concluded that the minimum of the maximum payoff is equal to the maximum of the minimum payoff. Because each player cannot improve his position in respect to utility, this strategy is the (minimax) equilibrium.

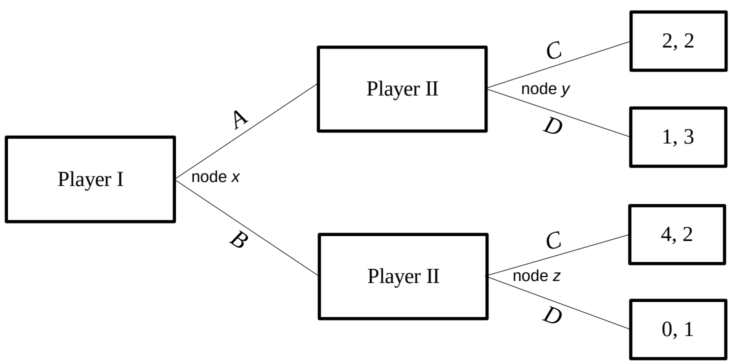
Sequential Games and Problem Solving

All of the games analyzed thus far in this section, "Strategy and Equilibrium," are simultaneous-move games. Let us consider sequential games.

Let us revisit the game described in Table 2.5, "Sample Game with No Dominant Strategy." Recall that game was a simultaneous-move game and had two Nash equilibria.

This time we assume that this game is a non-simultaneous-move (sequential) game, and player I moves first. We also assume that both players know the sequence of their moves. The extensive form (decision tree form) of this sequential game is illustrated below. See Figure 2.2, "Extensive Form of the Sample Game of Table 2.7 with Sequential Moves,"

FIGURE 2.2 Extensive Form of the Sample Game of Table 2.7 with Sequential Moves

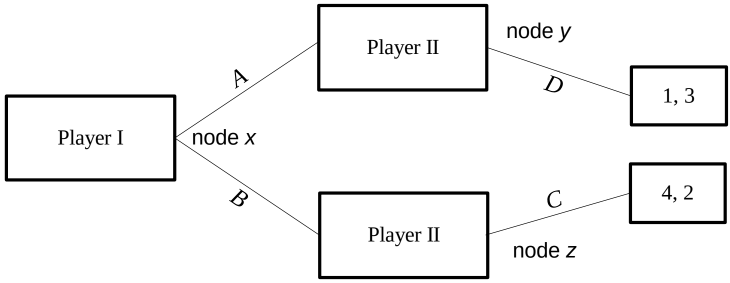


We utilize backward induction to solve this game. We have nodes *x*, *y* and *z* in the decision tree illustrated above. At node *x*, player I chooses between *A* and *B*. If player I picks *A*, player II needs to choose between *C* and *D* at the node *y*; if player I picks *B*, player II chooses between *C* and *D* at the node *z*.

With backward induction, we start analyzing the game at the end of the game. If the game reaches node *y*, player II chooses either *C* or *D*. If he chooses *C*, he gets $2; if he chooses *D*, he gets $3. As a rational player, he chooses *D* at the upper arm of the tree.

If the game reaches node *z*, player II picks *C* by using the same reasoning, [2 > 1]. By using backward induction, player I has the reduced form of the game as illustrated in Figure 2.3:

FIGURE 2.3 Reduced Extensive Form of the Game

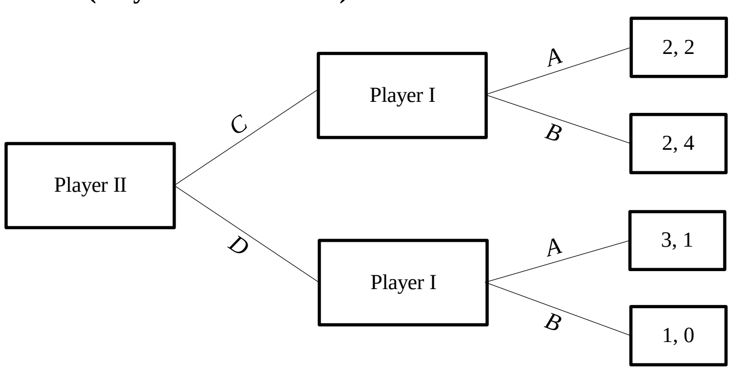


Player I knows that if he picks *A*, he gets $1; otherwise he gets $4. By using backward induction, player I chooses *B*, and forces player II to pick C and gets $4. The equilibrium outcome of the game in this case is (*B*, *C*).

In this non-simultaneous game, moving first gives player I a *first-mover advantage*. It is important to note that by changing the sequence of the players' moves, we have a different equilibrium for this game. As we indicated above, rules and information are very important in game theory, as changing the rules will often change the outcome of the game.

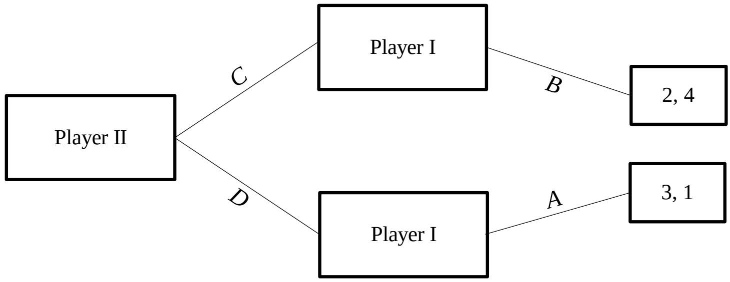
Let us change the sequence of players, and see what would happen. If player II moves first in the game described above, we have the extensive form of the game as illustrated in Figure 2.4:

FIGURE 2.4 Extensive Form of the Sample Game of Table 2.7 with Sequential Moves (Player II Moves First)



Note, in this case, that first figure in the payoff vectors belongs to player II. By using backward induction, we have the reduced form of the game as illustrated in Figure 2.5:

FIGURE 2.5 Reduced Extensive Form of the Game (Player II Moves First)



By choosing *D* at the beginning of the game, player II becomes better off, [3 > 2].

Note that when player I moves first, the equilibrium outcome of the game is (*B*, *C*); when player II moves first, the equilibrium outcome of the game is (*A*, *D*).

Complex Games and Games by Categories

Up to this point, we have only shown two-person *static* games. In real life, games are more complex than we have presented in the early pages. We used simple games to illustrate game theoretic concepts; we now make the games complex.

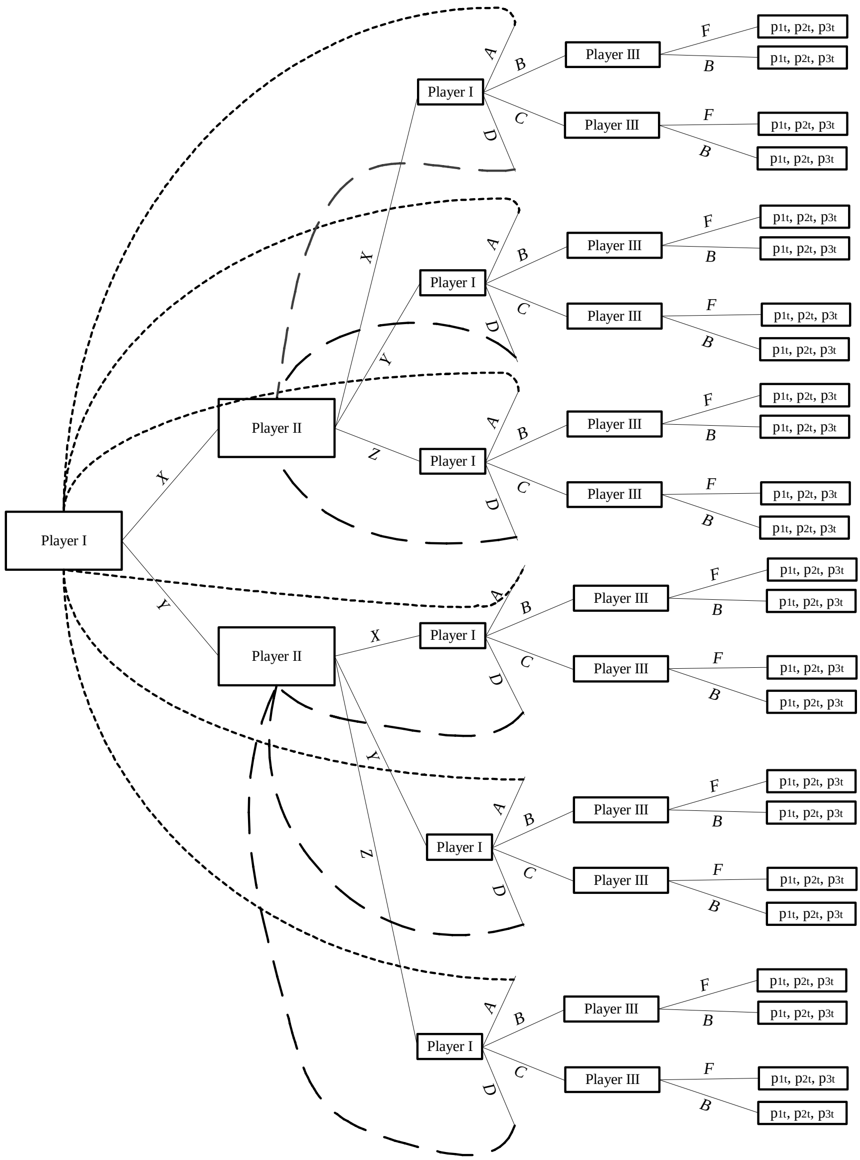
n-Person Games

The games we illustrated in Table 2.2, "Illustration of a Sample Payoff Matrix." and Figure 2.1, "Tree Diagram of a Sample Game," involve two players with two elements in their action sets. The game is supposed to be played once. As they have been presented thus far, each player moves once, and the game is not repeated again.

Let us readdress the game illustrated in Figure 2.1 and build from it a complex game. First, let us summarize this new sequential-move game with perfect information. In this new game, instead of two players, we assume there are three players. In this revised game, player I still has two potential actions at the beginning of the game, *X* and *Y*. Player II has actions *X*, *Y*, and *Z*. Player I has the second move in our new game, with an action set of {A, B, C, and D}. If player I picks B or C at his second move, player III has to move; otherwise player III does not have a play in this game. Player III's action set is {F, B}. The game ends after player III's move. If player I picks D at his second move, the game goes back player II, and player II chooses between actions X, Y, and Z again. Finally, if player I picks A at his second move, the game repeats itself.

Figure 2.6 shows the extensive form of this complex game:

FIGURE 2.6 Complex Version of the Game Illustrated in Figure 2.1



The game illustrated above has three players. There are games with no certain number of players. We call games with more than two players, n-person games where n can be 3, 4 or more. Economists and mathematicians have used advanced techniques to analyze n-person games and find equilibria for this type of games. In such games, the rules of the game, information set, and actions available are very important, just as in two-person games.

In n-person games, *power* is the key element for the outcome of the game. We define power here as the ability to affect the outcome of a situation to one's favor. In a game, this can be seen as who will win the game, given the power each player has to affect future outcomes such as play during the game, as well as the final outcome, the winner of the game. Power might have different forms in game theory: market power, product power, power due to connections, or power from information.

For complex games, a forward looking approach is a very powerful analytical tool. You should ask where you end up after multiple moves. By utilizing a forward looking method, a player can assess what kind of position he will be in after several moves.

Some games are complex because of the high number of strategies available to players. A player needs to assess each strategy carefully, as well as his opponent's. The normal form of a two-person game with multiple strategies provided in Table 2.8 is an example of such a game. In this game, player P has nine strategies and player Q has six strategies.

TABLE 2.8 Complex Game with Many Strategies

		Player Q					
		A	*B*	*C*	*D*	*E*	*F*
Player P	*i*	(p_1, q_1)	(p_1, q_2)	(p_1, q_3)	(p_1, q_4)	(p_1, q_5)	(p_1, q_6)
	ii	(p_2, q_1)	(p_2, q_2)	(p_2, q_3)	(p_2, q_4)	(p_2, q_5)	(p_2, q_6)
	iii	(p_3, q_1)	(p_3, q_2)	(p_3, q_3)	(p_3, q_4)	(p_3, q_5)	(p_3, q_6)
	iv	(p_4, q_1)	(p_4, q_2)	(p_4, q_3)	(p_4, q_4)	(p_4, q_5)	(p_4, q_6)
	v	(p_5, q_1)	(p_5, q_2)	(p_5, q_3)	(p_5, q_4)	(p_5, q_5)	(p_5, q_6)
	vi	(p_6, q_1)	(p_6, q_2)	(p_6, q_3)	(p_6, q_4)	(p_6, q_5)	(p_6, q_6)
	vii	(p_7, q_1)	(p_7, q_2)	(p_7, q_3)	(p_7, q_4)	(p_7, q_5)	(p_7, q_6)
	viii	(p_8, q_1)	(p_8, q_2)	(p_8, q_3)	(p_8, q_4)	(p_8, q_5)	(p_8, q_6)
	ix	(p_9, q_1)	(p_9, q_2)	(p_9, q_3)	(p_9, q_4)	(p_9, q_5)	(p_9, q_6)

Different Categories of Games

Zero-Sum Games vs. Non-Zero-Sum Games

In zero-sum games, one player's gain is another player's loss. In other words, in zero-sum games, the sum of the payoffs of all players should be zero. For example, chess, poker, and most sports games like basketball are zero-sum games. In a two-player poker game, if one player wins $100, the other player loses $100. In a chess game, one player wins the game, only if the other player loses the game. Zero-sum games are also called *constant-sum games*.

Most of the games in real life and the business world are not zero-sum games. In non-zero-sum games, all players could win or lose together. For example price wars between firms are non-zero-sum games. All players might lose in such a game. In most of the business partnerships and international trade, we have a *win-win* situation, that is, all parties might gain from the partnership or trade.

In zero-sum games, players have no common interests. However, in non-zero-sum games, players have common and conflicting interests.

Static vs. Dynamic Games; Repeated Games

Earlier in the chapter, we went over some sample games, such as the game illustrated in Table 2.3, "First Sample Game." and demonstrated the game with a payoff matrix. Most of the games we illustrated above are static, one shot games. In real life, most of the games are played more than once. Play may unfold differently with a sequential game; that is where the players play the game more than once consecutively.

We call this type of game *dynamic*. Repeated games are dynamic. An example of a real life dynamic game would be one where firms set prices periodically. In dynamic games, unlike static games, players observe other players' behaviors, modify their strategies accordingly, and develop reputations about their own behavior.

Cooperative vs. Non-Cooperative Games

A game can be cooperative or non-cooperative by nature. This categorization is important for understanding the behaviors, objectives, and strategies of the players.

A game in which players are allowed to cooperate with each other on a joint strategy is called a "cooperative game." In cooperative games, agreements, commitments and threats are binding and enforceable. An example of a cooperative game is a bargaining game between parties in a transaction (some sort of merger or acquisition) over the value of a target company.

A game in which players are not allowed to cooperate or negotiate on a contract is called a "non-cooperative game." In these games, commitments are not enforceable.

Other Key Game Theory Concepts

There are some other key game theory concepts we would like to bring to our readers' attention here, before we start working on applications.

Threats and Rewards (Promises)

In game theory, players can achieve a strategic advantage through the *response rule*. A response rule sets one's action(s) as a response to another's action(s). Response rules are prevalent in our daily lives. A manager telling an employee he will get a raise if he exceeds his sales plan for the year is a simple example of a response rule. The response rule can be defined in two ways: threats and rewards. Threats and promises are essentially the same; both are messages that players can send to each other to affect the other player in choosing a certain action. With a threat, failure to cooperate results in some type of negative payoff. With a reward or promise, cooperation results in some type of positive payoff.

Both threats and rewards themselves can be defined further, generally as compellent or deterrent. A compellent threat is meant to induce action from another, while a deterrent threat is meant to prevent future action from another.

An example of a Cold War-era deterrent threat was the threats by the U.S. to respond with nuclear weapons if the Soviet Union attacked an allied country. Such a deterrent threat existed for several decades with the North Atlantic Treaty Organization (NATO), attempting to deter the Soviet Union from any type of attack or invasion of Western Europe.

Credibility

The *credibility* of the threat or promise is very important. If the threat or promise looks fundamentally unrealistic, then the threat or promise is not credible. The Cold War threat of NATO responding with nuclear force if the Soviet Union did invade Western Europe, while not an ideal situation, was certainly a credible threat.

Sample Game with Threats

Let us look at threats and rewards in a simple game. Suppose that there are two players and each player owns a similar type of business selling a good. Player I has just begun selling a new version of the same good. Player II continues to sell the previous version of the good. The payoff matrix illustrated in Table 2.9, "A Sample Game of Non-Credible Threat." shows that both players will have higher revenue if player I charges more. Many consumers will still buy the good from player I even if player II charges the low price, because player I is selling the newer version. However, if player I charges the low price, player II will also have to charge the low price to make a profit (otherwise player II will make zero profit).

Player I is the player who has the most power, because its pricing will have the most impact within the game. Player I could threaten player II to try to influence him to charge a high price, threatening that if he does not, player I will charge the low price.

However, this threat is not credible because player I will be greatly worse off, with much lower payoffs if player II charges the lower price. Therefore, player II's threat is not credible.

TABLE 2.9 A Sample Game of Non-Credible Threat

		Player II	
		High Price	*Low Price*
Player I	*High Price*	(5, 4)	(4, 5)
	Low Price	(1, 0)	(0.5, 1)

The Threat as a Strategy

Threats and rewards are strategic moves. Threats and rewards must be credible to influence the behavior of others. For this reason, smart players often display a pattern of fulfilling threats and promises throughout the game.

When a player needs to offer a reward, he should not promise more than necessary to influence behavior. Likewise, threats should not be too big. Threats and promises of disproportionate scale can undermine the reputation of a player.

Games of Chance: Uncertainty and Risk

In game theory, chance and uncertainty are very important concepts. In some games, nature determines if one player is a winner or loser, and how much he wins. These are games of chance, such as rolling a pair of dice. Games of chance might be one-player games. In these games, nature affects the payoffs of the player based on his choices.

Games of chance involve either risk or uncertainty, or both. In a game of chance involving risk, a player knows the probabilities of nature's response, such as tossing a coin. When a football game begins, the referee will flip a coin to decide which team will receive the ball first. Each team's captain is present with one of them calling out either heads or tails. The captain who makes the call knows that the chance of getting tails is 50%, and the chance of getting heads is also 50%.

In a game of chance involving uncertainty, a player does not know the probabilities of nature's response. For instance, the weather is key to the farming of crops and the agriculture industry; however, there is no certainty from one season to the next on how the weather will be. If a grape farmer sees that preliminary weather crop reports indicate that a dry season or some kind of drought is ahead, he may decide to plant less that season or perhaps just as much as he originally planned. There is no way to tell what will happen.

Another real world example would help in understanding uncertainty. Often in the past homeowners would purchase a fixed-price home heating oil contract during the summer for the upcoming winter season. One reason was to save money, as historically the price of heating oil usually increased during the winter. While many homeowners purchase these types of contracts, the price of heating oil rising is not certain. Indeed, many bought contracts as usual in 2008 at varying prices. The recession, which was not in full swing by the summer, would later affect heating oil prices causing them to fall sharply by the end of December.

Some games involve both chance and strategy, such as backgammon. Note that even in pure chance games, by randomizing a player can develop a strategy.

Uncertainty is not only brought by nature, but also other players in the game. For instance, if a player randomizes his strategies in a game, other players are left with uncertainties regarding their opponents' moves.

In this book, we concentrate only on games with two or more players. One-player games against nature are not the subject of this book. Since our goal is to analyze strategic behavior and strategy, we concentrate on interactive decision-making environments, which involve two or more players.

Chapter 3 Modeling Games with Computer Software and Experimenting Games

In this chapter, we introduce modeling techniques using computer software. First, we review two games that are commonly described in many game theory textbooks, as well as a sample game of dominated strategies. The purpose here is to model games by using key game theory concepts introduced in the last chapter.

The games discussed in this chapter are presented in the simplest form. Each can be extended to more generalized situations such as imperfect information games and repeated games. Basic forms of these games are modeled using MATLAB here, and are illustrated by Visio.

A common assumption in game theory is that a player is concerned with maximizing his individual utility function. He is unconcerned with another player's utility. This is clearly an abstraction of actual human behavior.

A game is ultimately defined by its form, not by the story behind the game. This is important to keep in mind, so that the reader does not get lost in unimportant details.

Prisoner's Dilemma

In this classic game, two players, prisoner I and prisoner II, have been arrested on suspicion of committing a crime. The law enforcement officers put them in separate rooms. Each prisoner must independently make the decision whether or not to confess his crime without knowing his partner's actions.

The law offers both prisoners the following deal. If one prisoner denies the crime and remains quiet, while the other confesses, then the law will reward the confessor by letting him go free, while the law will punish the prisoner who does not confess by sending him to jail for 10 years. If both prisoner I and prisoner II confess, the law puts the prisoners away for 5 years. Finally, If both of the prisoners cooperate and do not confess, the law will have little evidence and can only charge each with a minor violation resulting in one year in jail.

This situation can be seen clearly in the payoff matrix below:

TABLE 3.1 Normal Form of the Classic Prisoner's Dilemma Game

		Prisoner II	
		Confess	*Deny*
Prisoner I	*Confess*	(–5, –5)	(0, –10)
	Deny	(–10, 0)	(–1, –1)

Prisoner's dilemma game analyzed here is a two-player simultaneous-move game. Prisoner I and prisoner II have the same set of actions: {*Confess*, *Deny*}. Each player has a perfect information set. Each player knows the simultaneous nature of the game, each other's action set, and payoffs.

Analysis

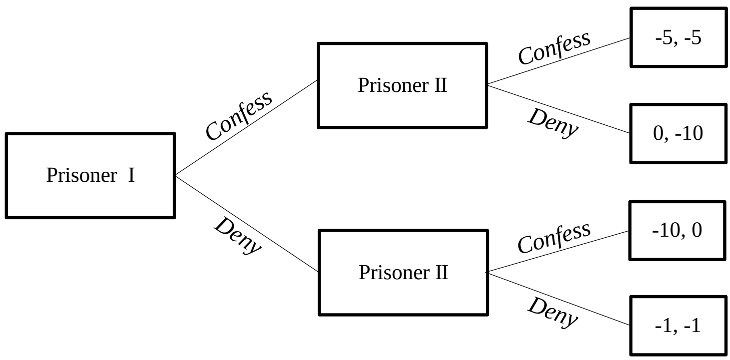
Each player has two strategies: confess, and do not confess (deny). In this game, the prisoners may cooperate with one another by denying, or may defect by confessing. If prisoner I cooperates and does not confess, he will only be in jail for one year if prisoner II also does not confess, but will go away for 10 years if his partner confesses.

On the other hand, if prisoner I confesses and prisoner II does not, prisoner I goes free. If he confesses along with his partner, prisoner I is in a better situation than if he cooperates while his partner denies. The same reasoning applies to prisoner II.

Since each prisoner will be better off by defecting regardless of the choice made by his partner, both prisoner I and prisoner II will choose to confess. In game theory terminology, *Confess* is a *strictly dominant strategy* for both players. Since both players have a dominant strategy, we have a dominant strategy equilibrium for the prisoner's dilemma game.

Figure 3.1 below shows the tree diagram illustration of the game. Please note that prisoner's dilemma is a simultaneous-move game, even though the extensive form of the game seems like sequential. By using the backward induction method we introduced in the previous chapter, you should be able to show that (*Confess*, *Confess*) is the equilibrium pair for this game.

FIGURE 3.1 Tree Diagram Illustration of the Prisoner's Dilemma Game



Notes

Since the punishment is coming from outside of the two players, this type of game is called a *variable-sum* game.[1] Because of this, we have great latitude to construct an equivalent game through varying the punishments. The only condition that must hold is that the *deny* strategy generates more severe punishment for a player, no matter what his opponent picks.

The classic assumption of behavior used in game theory unambiguously finds that "confess" is the dominant strategy for both players, and predicts that both players do exactly that. However, both players would be better off if they cooperated by denying than if they both confess. Why don't they do that? In actual experiments, they sometimes do. This can occur due to empathy for the other player, or collusion, or as irrational behavior. We discuss this further below.

The prisoner's dilemma game was developed in the 1950s by Merrill Flood and Melvin Dresher at RAND. Poundstone offers an interesting account of the context in which game theory arose and some of its first developers.

1. A constant-sum game always has the same sum of outcomes in the payoff matrix; a variable-sum game has different sums (assuming a finite-period game).

Modeling the Game with MATLAB

Below, we show how to model the prisoner's dilemma using the vector-processing software MATLAB. There are two different ways of modeling games in MATLAB. The first method is to enter the payoff data (and probabilities if any) first, and then run the model based on the definition of the game. The second method is to build the model and enter the data when the model asks the performer specific payoff and probability data. We use the second method because it is more straightforward to show the specifics of the game. See Figure 3.2 below for the MATLAB codes we developed for solving a game theory problem.

FIGURE 3.2 MATLAB Codes for Prisoner's Dilemma

```
% Prisoner's Dilemma with MATLAB
% IKG & MO, Generated on Mar 23, 2008
% Revised, Dec 13, 2008
%
% Below is the normal form of the Prisoner's
% Dilemma Game
%
%                        Prisoner 2
%                   Confess      Deny
% Prisoner1 Confess (X1, Y1)    (X3, Y3)
%           Deny    (X2, Y2)    (X4, Y4)
%
%
% Payoff Matrix of the Prisoner's Dilemma %Game:
%
%                        Prisoner 2
%                   Confess      Deny
% Prisoner1 Confess (-5, -5)    (-1, -10)
%           Deny    (-10, -1)   (-2, -2)
%
% ------------------------------
% Entering Prisoner 1's payoffs:


X1=input('Enter a value for X1:')
X2=input('Enter a value for X2:')
X3=input('Enter a value for X3:')
X4=input('Enter a value for X4:')


% Entering Prisoner 2's payoffs:


Y1=input('Enter a value for Y1:')
Y2=input('Enter a value for Y2:')
Y3=input('Enter a value for Y3:')
Y4=input('Enter a value for Y4:')


% Prisoner 1's payoff matrix:


Prisoner1=[X1 X3; X2 X4]


% Finding maximum payoff at each column for
```

```
% Prisoner 1:


A1=max(Prisoner1(:,1))
A2=max(Prisoner1(:,2))


% Dominant strategy analysis for Prisoner 1:

if A1==Prisoner1(1,1) & A2==Prisoner1(1,2)
    fprintf('Prisoner1s dominant strategy is confess')
else if A1==Prisoner1(2,1) & A2==Prisoner1(2,2)
        fprintf('Prisoner1s dominant strategy is deny')
    else fprintf ('No dominant strategy for Prisoner1')
    end
end


% Prisoner 2's payoff matrix:


Prisoner2=[Y1 Y3; Y2 Y4]


% Finding maximum payoff at each row for Prisoner
% 2:

B1=max(Prisoner2(1,:))
B2=max(Prisoner2(2,:))

% Dominant strategy analysis for Prisoner 2:

if B1==Prisoner2(1,1) & B2==Prisoner2(2,1)
    fprintf('Prisoner2s dominant strategy is confess')
else if B1==Prisoner2(1,2) & B2==Prisoner2(2,2)
        fprintf('Prisoner2s dominant strategy is deny')
    else fprintf ('No dominant strategy for Prisoner2')
    end
end

% Dominant strategy equilibrium analysis for
% the game:


if A1==Prisoner1(1,1) & A2==Prisoner1(1,2) & B1==Prisoner2(1,1) &
B2==Prisoner2(2,1)
    fprintf('(Confess, Confess) is a dominant strategy equilibrium')
else if A1==Prisoner1(2,1) & A2==Prisoner1(2,2) & B1==Prisoner2(1,2) &
B2==Prisoner2(2,2)
        fprintf('(Deny, Deny) is a dominant strategy equilibrium')
else if A1==Prisoner1(1,1) & A2==Prisoner1(1,2) & B1==Prisoner2(1,2) &
B2==Prisoner2(2,2)
        fprintf('(Confess, Deny) is a dominant strategy equilibrium')
else if A1==Prisoner1(2,1) & A2==Prisoner1(2,2) & B1==Prisoner2(1,1) &
B2==Prisoner2(2,1)
        fprintf('(Deny, Confess) is a dominant strategy equilibrium')
    else fprintf ('No dominant strategy equilibrium for this game')
    end
    end
    end
end
```

If you run the MATLAB program above, the model demonstrates the dominant strategies and equilibrium for the prisoner's dilemma game.

Tit for Tat and the Repeated Game

Above we went over the prisoner's dilemma and demonstrated the game with a payoff matrix, as well as how to recreate the game in MATLAB. The prisoner's dilemma is a one-shot game, with each player's action set being to cooperate and remain silent, or defect and confess.

Play may unfold differently with a repeated game; that is, where the players play the game more than once consecutively. This iterated prisoner's dilemma, while fundamentally similar to the original one-shot prisoner's dilemma, operates differently. The repeated game allows for players to issue threats and promises, and to develop reputations. The effect of these on the outcome led to the development in game theory of a formal "Tit for Tat" strategy.

Under Tit for Tat, players begin by cooperating. Specifically, the first player cooperates with the other and hopes the other player emulates this move. When a player does not cooperate and defects, the other player does the same. This is called *payment in kind* (or "Tit for Tat").

It is important to note that any kind of miscommunication of a play could lead to a chain reaction. If a player perceives cooperation to be defection and then responds with defection, the other player will then also respond with defection in an attempt to punish the other player. This will lead to a circular line of play (until perhaps one perceives cooperation, and thus the other mimics cooperation).

The Tit for Tat strategy is as common as strategy itself in everyday life, including everyday relations among neighbors, domestic politics, and foreign policy. For example, in 1988, Canada found the visiting Soviet diplomats were spying on them. As a result, Canada reduced the size of Canada's Soviet delegation, which led to the Soviet Union reducing the size of the Soviet Union's Canadian delegation. Indeed, the practice of declaring diplomats from foreign "persona non grata" when that country expels one of your diplomats is a formalization of a Tit for Tat strategy.

Famous Experiment

In 1980, political scientist Robert Axelrod conducted a computer-simulated iterated prisoner's dilemma round robin tournament. Players from around the world participated and submitted strategies for 200 games of the prisoner's dilemma that were to be played. The winner of the tournament, Anatol Rapoport, used the Tit for Tat strategy. Axelrod conducted the tournament a second time, and again Rapoport was the winner with the Tit for Tat strategy.

It should be noted that while the Tit for Tat strategy works quite well in the iterated prisoner's dilemma, it does not work at all in a one-shot prisoner's dilemma game.

Another Prisoner's Dilemma Experiment

In another experiment, Charles A. Holt, Merrill Bankard Professor of Economics at the University of Virginia, and Monica Capra, conducted the prisoner's dilemma in a classroom of 24 students. The results were published in the *Journal of Economic Education* in 2000.[2]

To conduct their classroom experiment, Holt and Capra used a single deck of playing cards. Each student was given a one-page sheet of instructions and two playing cards. At the bottom of the instruction sheet was a section to record their choices and payoffs. Each student was given two playing cards: one red (hearts or diamond) and one black (clubs or spades).

After distributing the necessary cards to each student, the instructions were read aloud. Students were paired with another person in the room only after they had decided which card to play. This pairing was done by the instructor, picking two at random; pairing students this way would also avoid students from colluding. Once two students were chosen, they would reveal their decisions. There would be no talking during the session while students chose their card. Both session 1 and session 2 games were one-shot games.

In session 1, playing a red card would give the student a payoff of $2, while a black card would not change their earnings but would increase their partners to $3. The card numbers are not relevant, only the color. See Table 3.2, "A Prisoner's Dilemma with Low Gains from Cooperation."

TABLE 3.2 A Prisoner's Dilemma with Low Gains from Cooperation

		Column Player	
		Black	*Red*
Row Player	*Black*	(3,3)	(0,5)
	Red	(5,0)	(2,2)

In session 2, payoffs changed slightly; while a red card would still earn $2 for the student, choosing a black card would now increase their partners' earnings to $8. See Table 3.3, "A Prisoner's Dilemma with High Gains from Cooperation."

TABLE 3.3 A Prisoner's Dilemma with High Gains from Cooperation

		Column Player	
		Black	*Red*
Row Player	*Black*	(8,8)	(0,10)
	Red	(10,0)	(2,2)

2. Holt, Charles A., and Monica Capra. "Classroom Games: A Prisoner's Dilemma." *The Journal of Economic Education*. Vol. 31, No. 3, 229-236, 2000.

Holt and Capra verified through their experiment that cooperation would increase when incentives to cooperate were greater. Cooperation increased greatly from period 1 to period 2. In period 1, cooperation in the class was 17 %; in period 2, it was 58 %.

Even More Experiments

The prisoner's dilemma game has been conducted many times by economists and behavioral scientists. In general, these experimental results confirm the implication of two experiments listed above: players do act mostly— but not always—in accordance with the standard predictions of rational behavior models. However, empathy, cooperation, and collusion also occur. Published results are listed below for curious readers who desire to see more results:

- Ahn, Toh-Kyeong, Elinor Ostrom, David Schmidt, Robert Shupp, and James Walker (1999) "Dilemma Games: Game Parameters and Matching Protocols," Indiana University, Discussion Paper.
- Bornstein, Gary, Ido Erev, and Harel Green (1995) "The Effect of Repeated Play in the PG and IPD Team Games," *Journal of Conflict Resolution*.
- Cain, Michael (1999) "An Experimental Test of Rational Cooperation in the Prisoner's Dilemma Game," University of Mississippi, Discussion Paper, presented at the Spring 1999 Public Choice Meetings.
- Cooper, Russell, Douglas V. DeJong, Robert Forsythe, and Thomas W. Ross (1996) "Cooperation without Reputation: Experimental Evidence from Prisoner's Dilemma Games," *Games and Economic Behavior*, 12:2 (February), 187-218.
- Green, Leonard, Paul C. Price, and Merle E. Hamburger (1995) "Prisoner's Dilemma and the Pigeon Control by Immediate Consequences," *Journal of the Experimental Analysis of Behavior*, 641-717.
- Holm, H. J. (1995) "The Prisoners' Dilemma or the Jury's Dilemma? A Popular Story with Dubious Name," *Journal of Institutional and Theoretical Economics*, 151:4 (December), 699-702.
- Kahn, Laurence M., and J. Keith Murnighan (1993) "Conjecture, Uncertainty, and Cooperation in Prisoner's Dilemma Games: Some Experimental Evidence," *Journal of Economic Behavior and Organization*, 22:1 (September), 91-117.
- Ortmann, Andreas, and Lisa K. Tichy (1999) "Gender Differences in the Laboratory: Evidence from Prisoner's Dilemma Games," *Journal of Economic Behavior and Organization*, 39:3, 227-339.
- Wu, J., and Robert Axelrod (1995) "How to Cope with Noise in Iterated Prisoner's Dilemma," *Journal of Conflict and Resolution*, 39:1 (March), 183-189.

Battle of the Sexes

Another famous game in the field of game theory is the Battle of the Sexes. Of course, some form of the battle of the sexes is as old as Adam and Eve. The formalization of this as a differing-preference game, however, is only a half-century old. This is a two-person, *non-zero-sum* game first described by R. Duncan Luce and Howard Raiffa in 1957.

In this game, two players, wife and husband, are deciding between attending two simultaneously occurring events: a football game and a musical.[3] Since the events take place at the same time, the couple may only attend one of these events. The players cannot communicate and must choose only based on their perception of the other player's future move. The payoffs are: the husband would get utility of 2 if both attended the football game and utility of 1 if both attended the musical. For his wife, the utility is reversed; that is, she would get utility of 1 if both attended the football game and utility of 2 if both attended the musical. Both players would get utility of zero if each attended an event alone. This normal form of the game is provided below (Table 3.4).

TABLE 3.4 Normal Form Illustration of Battle of the Sexes Game

		Wife	
		Football	*Musical*
Husband	*Football*	(2, 1)	(0, 0)
	Musical	(0, 0)	(1, 2)

Analysis

If the husband thinks his wife will choose the musical, then he would do better to choose the musical than to choose the football game. Similarly, if he thinks that she will choose the football game, then he would do better to choose the football game. The reasoning for the wife is identical.

The analysis above leads to an interesting conclusion: the game has multiple equilibria. Since both players would be better off together than apart, there are two *pure strategy* equilibria: (*Football*, *Football*) and (*Musical*, *Musical*). Since there is no dominant strategy in this game and neither player has an incentive to deviate from an equilibrium when they reach that, both of the equilibria are Nash equilibrium. While one player would benefit more than the other, both would get more utility than attending the event alone. Both of the pure strategy outcomes are Pareto optimal since one player cannot improve his situation without harming the other.

3. We use the stereotypical American preferences for illustration here; the same results would occur if we substituted non-stereotypical preferences.

The tree diagram of this game is illustrated below. See Figure 3.3 and Figure 3.4.

The battle of the sexes game we discuss above is a simultaneous-move game. If we design a sequential-move version of this game, the first mover has an advantage. If the husband moves first, the equilibrium of the game will be (*Football*, *Football*) with a payoff of (2, 1). If the wife moves first, the equilibrium of the game will be (*Musical*, *Musical*) with a payoff of (1, 2). As an exercise, see if you can show the equilibrium for each version of the sequential game by using backward induction.

FIGURE 3.3 Tree Diagram of Battle of the Sexes Game (Husband Moves First)

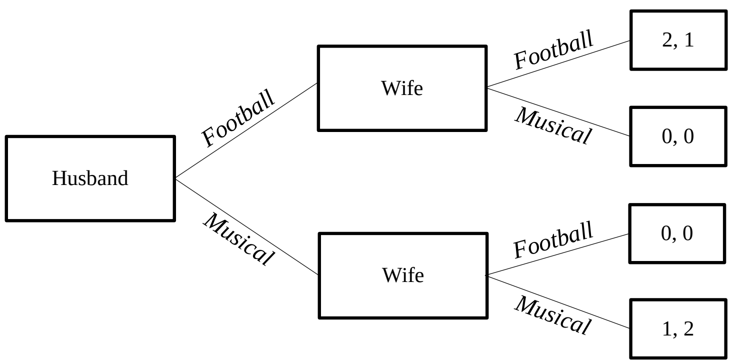
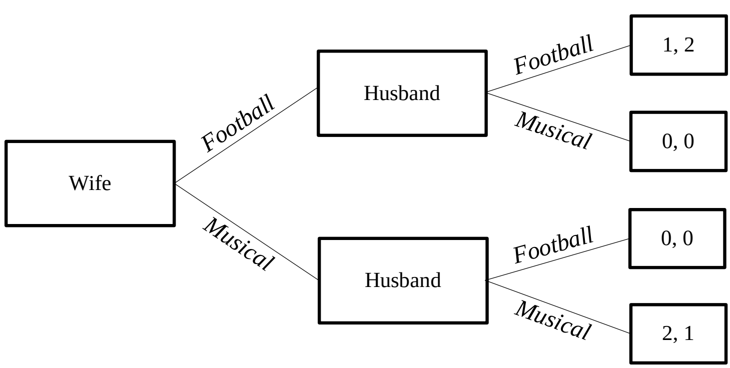


FIGURE 3.4 Tree Diagram of Battle of the Sexes Game (Wife Moves First)



Mixed Strategy

There is a third equilibrium in original simultaneous-move game of the battle of the sexes that involves a mixed strategy. In this strategy, both players would assign a probability weighting to each of their choices. They would base their probabilities on expected utility.

To find the probabilities in a particular formulation of this game, we can use two common methods. First, we can set up and solve a straightforward constrained optimization problem, using the Karush-Kuhn-Tucker conditions to assure that the probabilities of choosing each strategy are greater than zero. This method involves calculus and can be a bit tedious to solve by hand. We can solve this type of problem by MATLAB.

Second, we can use a technique where each player tries to select his probabilities so that the other player will be indifferent to his possible strategies. To accomplish this, the player selects his probabilities so that the expected utilities for his opponent are all the same regardless of his choice.

Modeling the Original Battle of the Sexes Game with MATLAB

As with other games, changing the payoffs for each player generates different versions of the game. However, we may generalize this game by maintaining the payoff inequalities in Table 3.5:

TABLE 3.5 Inequalities in the Battle of the Sexes Game

H(F, F) > H(M, M) > H(F, M)
H(F, F) > H(M, M) > H(M, F)
W(M, M) > W(F, F) > W(F, M)
W(M, M) > W(F, F) > W(M, F)
where, H: Husband, W: Wife, and F: Football; M: Musical

Below, we show how to model the battle of the sexes game. See Figure 3.5 below for the MATLAB codes.

FIGURE 3.5 MATLAB Codes for Battle of the Sexes Game

```
% Battle of the Sexes Game with MATLAB
% IKG & MO, Generated on Mar 27, 2008
% Revised, Dec 13, 2008
%
% Below is the normal form of the Battle of Sexes
% Game
%
%                               Wife
%                       Football    Musical
% Husband   Football    (X1, Y1)    (X3, Y3)
%           Musical     (X2, Y2)    (X4, Y4)
%
%
%
%
%
% Payoff Matrix of the Battle of Sexes Game:
```

```
%
%                              Wife
%                      Football    Musical
% Husband   Football     (2, 1)     (0, 0)
%           Musical      (0, 0)     (1, 2)
%
% ---------------------------
% Entering Husband's payoffs:


X1=input('Enter a value for X1:')
X2=input('Enter a value for X2:')
X3=input('Enter a value for X3:')
X4=input('Enter a value for X4:')

% Entering Wife's payoffs:

Y1=input('Enter a value for Y1:')
Y2=input('Enter a value for Y2:')
Y3=input('Enter a value for Y3:')
Y4=input('Enter a value for Y4:')

% Husband's payoff matrix:

H=[X1 X3;X2 X4]

% Finding maximum payoff at each column for
% Husband:

A1=max(H(:,1))
A2=max(H(:,2))

% Dominant strategy analysis for Husband:

if A1==H(1,1) & A2==H(1,2)
    fprintf('Husbands dominant strategy is Football')
else if A1==H(2,1) & A2==H(2,2)
        fprintf('Husbands dominant strategy is Musical')
    else fprintf ('No dominant strategy for Husband')
    end
end

% Wife's payoff matrix:

W=[Y1 Y3;Y2 Y4]

% Finding maximum payoff at each row for Wife:

B1=max(W(1,:))
B2=max(W(2,:))

% Dominant strategy analysis for Wife

if B1==W(1,1) & B2==W(2,1)
    fprintf('Wifes dominant strategy is Football')
else if B1==W(1,2) & B2==W(2,2)
        fprintf('Wifes dominant strategy is Musical')
    else fprintf ('No dominant strategy for Wife')
    end
end
% Dominant strategy equilibrium analysis for
% the game:
if A1==H(1,1) & A2==H(1,2) & B1==W(1,1) & B2==W(2,1)
    fprintf('(Football, Football) is a dominant strategy equilibrium')
else if A1==H(2,1) & A2==H(2,2) & B1==W(1,2) & B2==W(2,2)
        fprintf('(Musical, Musical) is a dominant strategy equilibrium')
else if A1==H(1,1) & A2==H(1,2) & B1==W(1,2) & B2==W(2,2)
        fprintf('(Football, Musical) is a dominant strategy equilibrium')
```

```
else if A1==H(2,1) & A2==H(2,2) & B1==W(1,1) & B2==W(2,1)
        fprintf('(Musical, Football) is a dominant strategy equilibrium')
    else fprintf ('No dominant strategy equilibrium for this game')
    end
    end
    end
end

% If the model does not generate any dominant
% strategy equilibrium,
% do the following analysis to find non-dominant
% equilibria, if any:

if A1==H(1,1) & B1==W(1,1)
    disp(' Football')
    fprintf (' and')
    disp(' Football')
    fprintf(' is an equilibrium condition.')
else if fprintf(' is not an equilibrium.')
    end
end

if A2==H(2,2) & B2==W(2,2)
    disp(' Musical')
    fprintf (' and')
    disp(' Musical')
    fprintf(' is an equilibrium condition.')
else if fprintf(' is not an equilibrium.')
    end
end


if A1==H(1,2) & B1==W(1,2)
    disp(' Football')
    fprintf (' and')
    disp(' Musical')
    fprintf(' is an equilibrium condition.')
    else if fprintf(' Not an equilibrium.')
        end
end


if A2==H(2,1) & B2==W(2,1)
    disp(' Musical')
    fprintf (' and')
    disp(' Football')
    fprintf(' is an equilibrium condition.')
    else if fprintf(' Not an equilibrium.')
        end
end
```

Running the MATLAB codes above generates two pure strategy equilibria for the battle of the sexes game: (*Football*, *Football*) and (*Musical*, *Musical*) with utility payoffs of (2, 1) and (1, 2), respectively.

A Battle of the Sexes Experiment

Russell Cooper, Douglas DeJong, Robert Forsythe, and Thomas Ross conducted the battle of the sexes (BOS) game with a group of students; the results were later published in the *RAND Journal of Economics* in 1989.

The experiment was with a group of students, consisting of upper-level undergraduates and MBA students from the University of Iowa. These students were placed at separate computer terminals with a copy of the instructions. The instructions were read aloud. No talking was allowed during the sessions.

Like the prisoner's dilemma experiment, there was a payoff matrix, based on the students' actions played; see Table 3.6, "Battle of the Sexes Payoff Matrix (University of Iowa Experiment)."

TABLE 3.6 Battle of the Sexes Payoff Matrix (University of Iowa Experiment)

		Column Player	
		C1	*C2*
Row Player	*R1*	(0,0)	(200,600)
	R2	(600,200)	(0,0)

This experiment was conducted three ways: no-communication, one-way communication, and two-way communication. In no-communication, players were not allowed to communicate with each other during the experiment other than through their actions. In one-way communication, the row player had the ability to send (or not send) the column player a message where the row player was allowed to indicate which action would be taken. After the message was received, both players simultaneously chose their actions. In two-way communication, both players had the ability to send messages simultaneously to each other, which were then followed by their actions.

Assumptions of the Researchers

The researchers had the following expectations about behavior by the players:

1. "If it is optimal for the row player to honor his announcement when the column player believes that the row player will honor it, then the announcement will be believed and honored.
2. If the announcements of both players constitute a pure-strategy equilibrium for the second stage game, each player will play his announced strategy.
3. If the announcements of both players do not constitute a pure-strategy equilibrium in the second stage game, each player will play his mixed-strategy Nash equilibrium strategy.
4. If, in the first round of communication, players' announcements constitute a pure-strategy equilibrium to the (final stage) BOS game, players will follow through on these first-round announcements, and the second round of communication (though perhaps still conducted) is irrelevant.
5. If, in the first round of communication, players' announcements do not constitute a pure-strategy equilibrium to the BOS game, players disregard these first-

round announcements. The second round of communication is governed by assumptions 2 and 3."[4]

They observed that with no communication, there were three equilibria and that the logical choice would be a mixed-strategy equilibrium where x=600 and y=200, and that the probability of strategy 1 (R1 or C1) was 0.25 and the probability of strategy 2 (R2 or C2) was 0.75.

There were 22 periods for each session of communication. Overall the proportion of "hits," i.e., the play of equilibrium strategies, was higher than anticipated. The play of strategy 2 was lower than anticipated. See Table 3.7, "Comparison of Results across Communications Treatments."

With one-way communication, they observed "hits" or equilibrium 95% of the time; this high success rate stemmed from the sender of the message announcing playing strategy 2, following through with this play, and the receiver choosing strategy 1, his best response. In this session, when a sender decided to remain silent, the outcome was often disequilibrium.

In two-way communication, they observed "hits" or equilibrium 55% of the time overall. When equilibrium play was communicated between the players, 80% of the time equilibrium play was achieved. This result was in line with their second assumption. The overall proportion of "hits" being 55% generally stemmed from all other occurrences, which often led to disequilibrium.

They concluded that the theory was fairly accurate in observed play; specifically, the actual "frequencies of play lie somewhere between those predicted by the theory and those consistent with players adopting cooperative mixed strategies."[5] Even though communication was between anonymous opponents and was non-binding in their experiments, they concluded that communication was beneficial, as it clearly encouraged choices that led to higher average payoffs.

TABLE 3.7 Comparison of Results across Communications Treatments

	Proportion of Hits	Proportion of Strategy 2 Plays
No Communication	.48	.63
One-way Communication	.95	.52
Two-way Communication	.55	.65

4. Cooper, DeJong, Forsythe, Ross, "Communication in the Battle of the Sexes: Some Experimental Results," *The RAND Journal of Economics*, Vol. 20, No. 4 Winter 1998, pp. 568-587.

5. "Communication in the Battle of the Sexes: Some Experimental Results," Cooper, DeJong, Forsythe, Ross, *The RAND Journal of Economics*, Vol. 20, No. 4 Winter 1998, pp. 568-587.

Additional Experiments

As the prisoner's dilemma game, battle of the sexes game has been conducted many times by economists and behavioral scientists. Some of them are listed below:

- Davis, Douglas D., and Charles A. Holt (1999) "Equilibrium Cooperation in Two-Stage Games: Experimental Evidence," *International Journal of Game Theory,* 28:1 (February), 89-109.
- Morgan, Dylan, Anne M. Bell, and William A. Sethares (1999) "An Experimental Study of the El Farol Problem," University of Wisconsin, Madison, Discussion Paper, presented at the Summer 1999 ESA Meeting.
- Sarin, Rajiv, and Farshid Vahid (1998) "Predicting Behavior in Experimental Games: A Procedurally Rational Model of Choice," Texas A&M University, Discussion Paper, presented at the Summer 1998 ESA Meeting.

A Sample Game of Dominated Strategies with MATLAB

Suppose that two players, Ahmet and Gozde are in a simple game. Player I (Ahmet) has three options in his action set, choosing *Up*, *Middle*, or *Bottom*; player II (Gozde) has two options in her action set, choosing *Left* and *Right*. We assume that our sample game here is a simultaneous-move game of perfect information.

If Ahmet picks *Up* and Gozde *Left*, Ahmet gets $50 million and Gozde gets $150 million. If Ahmet picks *Middle* and Gozde picks *Right*, Ahmet gets $150 million; Gozde gets $50 million. If Ahmet goes with *Bottom* and Gozde with *Left*, Ahmet gets $150 million, and Gozde gets $50 million. The complete set of the players' payoffs is provided in Table 3.8 below:

TABLE 3.8 Normal Form of the Sample Game with Dominated Strategies

		Gozde	
		Left	*Right*
Ahmet	*Up*	($50M, $150M)	($300M, $50M)
	Middle	($200M, $150M)	($150M, $50M)
	Bottom	($150M, $50M)	($50M, $300M)

If Ahmet chooses *Up*, Gozde gets $150 million by going *Left*, and $50 million by going *Right*. So *Left* is a better strategy for Gozde, if Ahmet chooses *Up*.

If Ahmet chooses *Middle*, Gozde gets $150 million by going *Left*, and $50 million by choosing *Right*. Again, choosing *Left* is a better strategy for Gozde.

If Ahmet goes with the strategy of *Bottom*, Gozde gets $50 million by going *Left*, and $300 million by choosing *Right*. In this case, choosing *Right* is a better strategy for Gozde.

In this game there is no dominant strategy for Gozde. Utilizing the same reasoning you find there is no dominant strategy for Ahmet either.

However, we know that Ahmet is better off by choosing *Middle*, when Gozde goes *Left*; and he is better off by choosing *Up*, when Gozde goes *Right*. Therefore, choosing *Bottom* is not a good strategy for Ahmet, regardless of what Gozde picks. *Bottom* is a dominated strategy for Ahmet. (Note that we introduced and briefly discussed dominated strategy concept in the previous chapter).

In this game, both Ahmet and Gozde know that, as a rational player, Ahmet will never choose a dominated strategy, the *Bottom* strategy. We can eliminate the *Bottom* from our game. We can illustrate the reduced form of the game between Ahmet and Gozde in Table 3.9 below:

TABLE 3.9 Reduced Form of the Sample Game with Dominated Strategies

		Gozde	
		Left	*Right*
Ahmet	*Up*	($50M, $150M)	($300M, $50M)
	Middle	($200M, $150M)	($150M, $50M)

Reduced form of the game shows that Gozde now has a dominated strategy, going *Right*. Gozde prefers getting $150 million by choosing *Left*, instead of $50 million by choosing *Right*. Therefore the strategy of picking *Right* is dominated by the strategy of picking *Left*. Please note that, obviously, *Left* is the dominant strategy for Gozde here.

After eliminating another dominated strategy here, we get the following reduced form of the game in Table 3.10 below:

TABLE 3.10 Reduced Form of the Game in Table 3.9

		Gozde
		Left
Ahmet	*Up*	($50M, $150M)
	Middle	($200M, $150M)

The only strategy available to Gozde is *Left*. Ahmet has two actions left: *Up* and *Middle*. Ahmet prefers getting $200 million by choosing *Middle*, instead of $50 million by choosing *Up*.

Our dominated strategy equilibrium is (*Middle*, *Left*) with the payoff ($200M, $150M).

Below, we show how to model the sample game with dominated strategies. See Figure 3.6 below for the MATLAB codes.

FIGURE 3.6 MATLAB Codes for Sample Game with Dominated Strategies

```
% Sample Game with Dominated Strategies w/MATLAB
% IKG & MO, Generated on Apr 3, 2008
% Revised, Dec 13, 2008
%
% Below is the normal form of the Sample Game
% between
% Ahmet (Player 1) and Gozde (Player 2)
%
%                          Gozde
%                     Left      Right
%           Up      (X1, Y1)    (X4, Y4)
% Ahmet     Middle  (X2, Y2)    (X5, Y5)
%           Bottom  (X3, Y3)    (X6, Y6)
%
% Payoff Matrix of the Sample Game
%
%                          Gozde
%                     Left        Right
%           Up      (50, 150)   (300, 50)
% Ahmet     Middle  (200, 150)  (150, 50)
%           Bottom  (150, 50)   (50, 300)
%
% -------------------------
% Entering Ahmet's payoffs:

X1=input('Enter a value for X1:')
X2=input('Enter a value for X2:')
X3=input('Enter a value for X3:')
X4=input('Enter a value for X4:')
X5=input('Enter a value for X5:')
X6=input('Enter a value for X6:')

% Entering Gozde's payoffs:

Y1=input ('Enter a value for Y1:')
Y2=input ('Enter a value for Y2:')
Y3=input ('Enter a value for Y3:')
Y4=input ('Enter a value for Y4:')
Y5=input ('Enter a value for Y5:')
Y6=input ('Enter a value for Y6:')

% Ahmet's payoff matrix:

Ahmet=[X1 X4; X2 X5; X3 X6]

% Finding maximum payoff at each column for Ahmet:

A1=max(Ahmet(:,1))
A2=max(Ahmet(:,2))

% Dominant strategy analysis for Ahmet:

if A1==Ahmet(1,1) & A2==Ahmet(1,2)
    fprintf(' Ahmets dominant strategy is Up.')
else if A1==Ahmet(2,1) & A2==Ahmet(2,2)
        fprintf(' Ahmets dominant strategy is Middle.')
    else if A1==Ahmet(3,1) & A2==Ahmet(3,2)
            fprintf('Ahmets dominant strategy is Bottom.')
 else fprintf (' No dominant strategy for Ahmet.')
    end
    end
```

```
end

% Gozde's payoff matrix:

Gozde=[Y1 Y2 Y3; Y4 Y5 Y6]'

% Finding maximum payoff at each row for Gozde:

B1=max(Gozde(1,:))
B2=max(Gozde(2,:))
B3=max(Gozde(3,:))

% Dominant strategy analysis for Gozde:

if B1==Gozde(1,1) & B2==Gozde(2,1) & B3==Gozde(3,1)
    fprintf(' Gozdes dominant strategy is Left.')
else if B1==Gozde(1,2) & B2==Gozde(2,2) & B3==Gozde(3,2)
        fprintf(' Gozdes dominant strategy is Right.')
    else fprintf (' No dominant strategy for Gozde.')
    end
end

% Dominant strategy equilibrium analysis for the
% game:

if A1==Ahmet(1,1) & A2==Ahmet(1,2) & B1==Gozde(1,1) & B2==Gozde(2,1) &
B3==Gozde(3,1)
    fprintf(' (Up, Left) is a dominant strategy equilibrium.')
else if A1==Ahmet(1,1) & A2==Ahmet(1,2) & B1==Gozde(1,2) & B2==Gozde(2,2) &
B3==Gozde(3,2)
        fprintf(' (Up, Right) is a dominant strategy equilibrium.')
else if A1==Ahmet(2,1) & A2==Ahmet(2,2) & B1==Gozde(1,1) & B2==Gozde(2,1) &
B3==Gozde(3,1)
        fprintf(' (Middle, Left) is a dominant strategy equilibrium.')
else if A1==Ahmet(2,1) & A2==Ahmet(2,2) & B1==Gozde(1,2) & B2==Gozde(2,2) &
B3==Gozde(3,2)
        fprintf(' (Middle, Right) is a dominant strategy equilibrium.')
else if A1==Ahmet(3,1) & A2==Ahmet(3,2) & B1==Gozde(1,1) & B2==Gozde(2,1) &
B3==Gozde(3,1)
        fprintf(' (Bottom, Left) is a dominant strategy equilibrium.')
else if A1==Ahmet(3,1) & A2==Ahmet(3,2) & B1==Gozde(1,2) & B2==Gozde(2,2) &
B3==Gozde(3,2)
        fprintf(' (Bottom, Right) is a dominant strategy equilibrium.')
    else fprintf (' No dominant strategy equilibrium for this game.')
    end
    end
    end
    end
    end
end

% ----------------------
% DOMINATED STRATEGIES

% Dominated strategy analysis for Ahmet:

if (A1==Ahmet(1,1) & A2==Ahmet(2,2)) | (A1==Ahmet(2,1) & A2==Ahmet(1,2))
    fprintf(' Ahmets dominated strategy is Bottom.')
else if (A1==Ahmet(1,1) & A2==Ahmet(3,2)) | (A1==Ahmet(3,1) & A2==Ahmet(1,2))
        fprintf(' Ahmets dominated strategy is Middle.')
    else if (A1==Ahmet(2,1) & A2==Ahmet(3,2)) | (A1==Ahmet(3,1) & A2==Ahmet(2,2))
            fprintf(' Ahmets dominated strategy is Up.')
 else fprintf (' No dominated strategy for Ahmet.')
    end
    end
end

% Dominated strategy analysis for Gozde:
```

```
if B1==Gozde(1,1) & B2==Gozde(2,1) & B3==Gozde(3,1)
    fprintf(' Gozdes dominated strategy is Right.')
else if B1==Gozde(1,2) & B2==Gozde(2,2) & B3==Gozde(3,2)
        fprintf(' Gozdes dominated strategy is Left.')
    else fprintf (' No dominated strategy for Gozde.')
    end
end

% Delete the row and/or column which includes
% dominated strategy.
% Our sample game had "Bottom" as a dominated
% strategy for Player I, Ahmet.
% The normal form of the reduced game is
% illustrated below:
%
%                          Gozde
%                     Left      Right
% Ahmet     Up      (X1, Y1)    (X4, Y4)
%           Middle  (X2, Y2)    (X5, Y5)
%
% Payoff Matrix of the Reduced Game:
%
%                          Gozde
%                    Left        Right
% Ahmet     Up      (50, 150)   (300, 50)
%           Middle  (200, 150)  (150, 50)
%
% Analyze the dominant and dominated strategies of
% the reduced form of the game
%
% Ahmet's new payoff matrix:

Ahmet=[X1 X4; X2 X5]

% Finding maximum payoff at each column for
% Ahmet's new payoff matrix:

A3=max(Ahmet(:,1))
A4=max(Ahmet(:,2))

% Dominant strategy analysis for Ahmet:

if A3==Ahmet(1,1) & A4==Ahmet(1,2)
    fprintf(' Ahmets dominant strategy is Up.')
else if A3==Ahmet(2,1) & A4==Ahmet(2,2)
        fprintf(' Ahmets dominant strategy is Middle.')
 else fprintf (' No dominant strategy for Ahmet.')
    end
end

% Gozde's new payoff matrix:

Gozde=[Y1 Y2; Y4 Y5]'

% Finding maximum payoff at each row for Gozde's new payoff matrix:

B3=max(Gozde(1,:))
B4=max(Gozde(2,:))

% Dominant strategy analysis for Gozde:

if B3==Gozde(1,1) & B4==Gozde(2,1)
    fprintf(' Gozdes dominant strategy is Left.')
else if B3==Gozde(1,2) & B4==Gozde(2,2)
        fprintf(' Gozdes dominant strategy is Right.')
    else fprintf (' No dominant strategy for Gozde.')
    end
end
```

```
% SECOND ITERATION OF DOMINATED STRATEGIES
% ANALYSIS

% Dominated strategy analysis for Ahmet:

if A3==Ahmet(1,1) & A4==Ahmet(1,2)
    fprintf(' Ahmets dominated strategy is Middle.')
else if A3==Ahmet(2,1) & A4==Ahmet(2,2)
        fprintf(' Ahmets dominated strategy is Up.')
 else fprintf (' No dominated strategy for Ahmet.')
    end
end

% Dominated strategy analysis for Gozde:

if B3==Gozde(1,1) & B4==Gozde(2,1)
    fprintf(' Gozdes dominated strategy is Right.')
else if B3==Gozde(1,2) & B4==Gozde(2,2)
        fprintf(' Gozdes dominated strategy is Left.')
    else fprintf (' No dominated strategy for Gozde.')
    end
end

% Delete the row and/or column which includes
% dominated strategy.
% At the second iteration, our sample game had
% "Right" as a dominated strategy for Player II,
% Gozde.
% The normal form of the reduced game is
% illustrated below:
%
%                      Gozde
%                      Left
% Ahmet     Up      (X1, Y1)
%           Middle  (X2, Y2)
%
% Payoff Matrix of the Reduced Game:
%
%                     Gozde
%                     Left
% Ahmet     Up      (50, 150)
%           Middle  (200, 150)
%
% Analyze the dominant and dominated strategies of
% the reduced form of the
% game.
%
% Ahmet's new payoff matrix:

Ahmet=[X1; X2]

% Finding maximum payoff at each column for
% Ahmet's new payoff matrix:

A5=max(Ahmet(:,1))

% Dominant strategy analysis for Ahmet:

if A5==Ahmet(1,1)
    fprintf(' Ahmets dominant strategy is Up.')
else if A5==Ahmet(2,1)
        fprintf(' Ahmets dominant strategy is Middle.')
 else fprintf (' No dominant strategy for Ahmet.')
    end
end

% Gozde's new payoff matrix:
```

```
Gozde=[Y1 Y2]';

% Finding maximum payoff at each row for Gozde's
% new payoff matrix:

% Note that Gozde is left by only one move at this
% level: Left

% Equilibrium analysis for the game:

if A5==Ahmet(1,1)
    fprintf(' (Up, Left) is a dominant strategy equilibrium.')
else if A5==Ahmet(2,1)
        fprintf(' (Middle, Left) is a dominant strategy equilibrium.')
    else fprintf (' No equilibrium for this game.')
    end
end
```

Chapter 4 A Theory of Strategic Value

Introduction: The Game of Business

For all the centuries in which businesses have fulfilled a central role in the economy of nations, we actually know relatively little about the fundamentals of business value. As we show below, the classical and neoclassical notions of the firm are too primitive to be of much usefulness in this regard, and modern constructs of mathematical finance are so abstract as to leave the firm far behind.

However, the notion of business as a game is not so outrageous, at least in the sense of a mathematical game. Businesses and business investors routinely take risks that are akin to games of chance, and the amounts at stake are often many times higher than the amount the same investor would ever stake on a true game of chance.[1]

In this chapter, we make rigorous notion of value for a business derived from the strategic position of the business. We show that business situations quite often have

1. One of the defenses of gambling is the assertion that the same thing done in a casino is what speculators do in the stock market. To be sure, this is a feeble defense when the investment is anything other than pure speculation. The existence of chance and risk does not convert activities to gambling.

the structure of a mathematical game. We introduce the concept of strategic value that derives from the game-like structure. We demonstrate that indeed, businesses have strategic value in the sense that game theory can be used profitably for both management and investment purposes.

Strategic Value for a Business

In this chapter, we take a rigorous—and highly useful—look at the *strategic value* for a business. Strategic value includes both the current earning potential of a business, and the potential for it to grow, to enter new markets, avoid obstacles, shed costs, influence governments, and overcome rivals.

To rigorously examine strategic value, we must abandon both primitive and abstract notions of business value, because they do not allow us to directly consider the effect of strategic decisions. However, there is a newly-developed theory of business value that directly fits our purposes. This theory provides a mathematical model for incorporating management flexibility that is the essence of strategy in business, as well as the traditional elements of financial models such as the earnings of current operations, discount rates, and operational elements.

One benefit of this approach is the direct incorporation of the "real options" inherent in most businesses. Another is the potential integration of the analytical model used by the financier with that of the business strategist.

Important Concepts

In order to model business decisions properly, we will need a number of concepts, including:

1. *A firm (or business)*

   Not all financial payments or receipts are due to the actions of a firm. There are differences between an employee and the firm that employs him or her; between a firm and a portfolio of investments; between a controlling interest in the firm and a large investment in the firm; and between equity ownership in a firm and the assets of the firm.

2. *An equity investment in a firm*

   An equity investment in a firm provides specific rights; we will distinguish these from other rights.

3. *A market*

   Without a market, it is difficult to discuss the actions of a firm, or the market value of equity investments.

4. *States of nature*

   The relevant information about a specific situation is often described as the "state of nature," or simply the "state." We formalize this for use in our study of strategic value.

5. *An event tree*

   We will tie together time, events, and states of nature in an event tree, which will allow us to visualize the effect of decisions and other events on the possible outcomes of a game.

6. *Dynamic outcomes of business strategic games*

   Instead of considering strategic games as having a set of possible static outcomes (such as "ten dollars" or "sentenced to ten years in prison"), we will consider those that are richer, and more relevant, to a business or an organization. Such outcomes will typically be specific business interests in specific states of nature. These have values that are not completely determined by the game, or by random events within the time period of the game.

7. *Business value*

   There are many competing notions of "value" used in discussions of business. We survey a number of these, most of which will prove inadequate. We then identify a specific subset of valuation theories that reflect the strategic nature of business ownership and management.

8. *Real options*

   Most professionals involved in business, economics or finance are familiar with financial options. An option, in general, gives a person the right but *not the obligation* to make a certain transaction. For example, a "call option" gives a person the right to buy a certain security for a certain price, during a certain time period. Obviously, a call option would be worth a lot more if the underlying security is more valuable than the *strike price* for the option. If it is not, then it may expire worthless.

   Real options are the options available to investors, managers, workers and consumers on real assets, rather than financial contracts. The ability to buy groceries next week at a local store, for known prices, is a real option. The ability to sell your collection of baseball cards at an online auction is another. Some businesses have enormous real options; others have relatively few. Any time a real option is present that could affect the future course of the firm, the firm has a strategic decision to make.

Advanced Topics

In addition to the core concepts listed above, we will also discuss others that are quite useful, but may involve technical points that are not essential on a first reading. These include:

1. *A stochastic process*

   We will discuss a class of stochastic processes, which can encode measurements of value, earnings, or other important factors over time. Many business and market variables are fundamentally stochastic processes that reflect both random events and the result of strategic decisions. In this discussion, we introduce some technical terms such as expected value and the Markov property.

2. *Valuation models*

   Although we will identify the key principles of a narrow set of valuation models, a proper treatment of their use is a topic that is too extensive to cover here. However, we will provide a summary of specific techniques that will allow the interested student of strategy—or of valuation involving businesses with strategic interests—with some basic tools and an introduction to the relevant sources available for further study.

Strategy and Value

The value of a business is based partially on its strategy. For many readers of this book, such a notion will seem obvious. However, traditional value models—from accounting, economics, and finance—largely ignore strategy. Let's consider some of these traditions briefly.

Accounting Net Worth

For example, the accounting framework used for the last several centuries, first codified in Italy in the sixteenth century, categorizes the assets of a firm largely using the principle of historical cost.[2]

Historical cost is not a value; it is not usefulness; it is not even a reliable indicator of replacement cost. Historical cost is just a useful fact. One might observe that the historical cost of a flyswatter is the same, whether there is a fly around or not. In the same way, the historical cost of the assets of a firm with many expansion options could be exactly the same as one with none. Obviously, we could not look at a company's balance sheet and ascertain its strategic options. Therefore, if strategic options have anything to do with the value of a business, accounting statements cannot be a reliable indicator of value.[3]

Current Income

In a similar manner, consider the income earned by a business in any one period. Generally, investors reward those firms that make money with a higher equity value. However, a firm that had consistently been making money could be worth a lot less than one that is barely breaking even, if the latter firm has tremendous potential for future profitability. An example of this is nearly every successful start-up firm; such firms

2. Luca Pacioli, a Franciscan monk and mathematician, is credited as the "father of accounting," because he described the accounting practices of Venetian trading houses in one chapter of his masterpiece *Summa de arithmetica, geometria, proportioni et proportionalita* (Venice, 1494).
3. Although this point may seem aggressive to some, the authorities on accounting in the U.S. long ago stated the purpose of accounting was not to establish the market value of a firm.

routinely lose money in their early years, and only later become routinely profitable. Of course, by that time many other unprofitable start-up firms would have gone out of business, so there is no denying the higher risk associated with start-up firms.

Even with this caveat, it is clear that the past earnings of a firm will fall short of determining its current value.

Portfolio Investment

There are also some wonderful innovations of *Modern Portfolio Theory* developed over the past half-century, which provide guidance for investors in stock markets. However useful such methods are for assembling an investment portfolio, they will fail miserably at establishing the value of a privately-held firm.[4]

Real Options

We defined real options above, and noted that their presence creates the opportunity for a strategic decision. Exercising (or not exercising, or purchasing, or writing) a real option is often a strategic decision for the business, because it reflects the management's expectation of the potential future states of the market, and the desire to place the firm in a specific position in one or more of those states. If such decisions affect the future earning power of the company—and many will—then we have established that strategy affects value.

Note that the current income, accounting net worth, and price (if traded) of a portfolio investment in the firm's equity may not be affected by the real option at all.[5] Thus, we must seek a theory of value that directly incorporates real options if we are to properly model strategic value.

States of Nature and Strategy

There are important mathematical preliminaries to using strategic value, real options, and the use of game theory in business decisions. One of these is the notion of the *state*, which we will formalize into a vector of state variables that change over time.

Much of the game theory literature presumes a one-dimensional uniform state of nature of the beginning of a game (think of many of the classic examples, including

4. Among the reasons for this failure: the illiquidity of the investments, the lack of traded price data, and the resultant inability to estimate covariance among the privately-held firm's equity prices and those of traded firms. This does not mean that such tools as the CAPM or the mean-variance framework are useless, just that they are tools for portfolio investment managment, not individual firm valuation.
5. Of course, one could postulate that the equity price had already been affected by investors' knowledge about the real option. Indeed, with publicly traded companies this is a regular occurrence. However, within this example, assuming that one already knows the true value makes the entire exercise a tautology, and therefore of little use.

those demonstrated in the beginning chapters of this book). However, the real world always involves more dimensions, and states of nature that affect different players in different ways. We formalize this in the state vector.

In the best tradition of the social sciences, we will provide an introduction to this important mathematical concept by telling a story that contains no equations at all, very few numbers, and a very important ending.

The State of Nature

A Short Revolutionary Example

The following very brief history lesson motivates quite well the idea of a *state*.

Philosophers of old grounded their theories about political organization in the predicament of a man in a world without any government. The seventeenth century philosopher Thomas Hobbes, in his masterpiece *Leviathan,* described the unhappy life of man in "the condition of mere nature" as follows:

> In such condition there is no place for industry, because the fruit thereof is uncertain: and consequently no culture of the earth; no navigation, nor use of the commodities that may be imported by sea; no commodious building; no instruments of moving and removing such things as require much force; no knowledge of the face of the earth; no account of time; no arts; no letters; no society; and which is worst of all, continual fear, and danger of violent death; and the life of man, solitary, poor, nasty, brutish, and short.[6]

Hobbes argued that avoiding this "solitary, poor, nasty, brutish, and short" life compelled man to organize a government, and to submit to its powers. Indeed, compared to anarchy and war, submitting to the power of a king may seem like an improvement.

Later philosophers also considered the "state of nature," and came to a different conclusion. John Locke argued that men in the state of nature were born with freedom, and that they should form civil governments that protected their liberty and property.[7] Locke's argument was thus a challenge to the traditional rights of monarchs, for whom Hobbes' philosophy provided a natural rationale. This was the stuff of revolution in the eighteenth century.

Indeed, revolutions did come. The American colonists that adopted the *Declaration of Independence* in 1776 asserted that men were "endowed by their Creator with

6. Thomas Hobbes, *Leviathan,* (originally published in England in 1651), Chapter XIII.
7. Locke's "Second Discourse," published in London in 1689, established a political philosophy grounded in the natural rights of man. The formal title of the pamphlet in which the "Second Discourse" was included was *Two Treatises of Government: In the Former, The False Principles and Foundation of Sir Robert Filmer, And His Followers, are Detected and Overthrown. The Latter is an Essay concerning The True Original, Extent, and End of Civil-Government,* which was first published anonymously by Locke himself.

certain unalienable rights." This was as direct a challenge to the right of the King of England to govern them as could have possible been issued. Thus set in motion one of the most momentous struggles in the last millennium.

Fortunately for citizens in free countries today, it was Locke's vision rather than Hobbes' that prevailed in that struggle, which became known as the American Revolution. Even today, the notion that the founding state of man is one of liberty, not subservience to a government, is a revolutionary idea in many parts of the world.

A Revolutionary Game: The State of Affairs in 1775

Abstracting away from the (much more important) ideas of liberty, think about the struggle between the colonists in America and the colonialists in England as a strategic game. Ignoring the differences in power, location, and tradition, would make such a game useless as a strategic tool. Therefore, we must begin a strategic study by thinking the situation of the America colonists at the beginning of 1776. Many of the colonists (though certainly not a large majority) did not like the state of affairs, notably the subservience to England. The grievances listed in the *Declaration of Independence* in 1776 were well known to the British, and indeed some of them had been debated in Parliament. However, the British government provided them significant benefits as well, and many colonists were unabashedly loyal to the crown.

We would define this situation as the *state*, which could be considered the "state of affairs" or the "current state of nature." To the extent we could quantify this relevant information, we could do so with a *state variable*, which might be a vector containing a number of different individual state variables. A prototype state vector is shown in Figure 4.1.

FIGURE 4.1 Prototype State Vector

$$S_1 = \begin{pmatrix} s_{11} \\ s_{21} \\ s_{31} \end{pmatrix};$$

$$[s_{it}] = \text{ state variable } i \text{ at time } t.$$

The notion of the state is very important in strategic valuation, and certain valuation methods require the explicit identification of state variables. Therefore, let us continue our historical example to further illustrate this notion.

State Variables in 1775 Colonial America

Let us consider the state of affairs at the end of 1775.[8] American colonists were displeased with British governance, which trampled on the sensibilities of themselves

8. Among numerous historical works about this epochal event, David McCullough's *1776* (Simon & Shuster, 2006) presents a fair-minded portrayal of that year, starting with the situation at the end of 1775.

as free men and women, and often as free *Englishmen* and women. The Quartering Act and Stamp Act passed by Parliament a decade before created widespread anger at the British, widespread refusal to comply with taxation demands, and occasional acts of rebellion. The Battle of Lexington and Concord in April 1775 demonstrated the willingness of local militias to challenge the British garrisons. However, the Continental Army had just been organized by the summer of 1775, and it was hardly an army. Although valiantly led by George Washington—formerly an officer in the *British* army—it could not count on the continued service of its soldiers for more than several months at a time, and had a tenuous supply line from a similarly-tenuous Continental Congress.

Meanwhile, England was the world's most powerful country, and one with well-demonstrated capabilities in establishing and running colonies. Moreover, most British subjects had expectations of certain rights and privileges, as well as standards of living, that were much higher than most other inhabitants of the world. Among the colonists, somewhere near a half were supportive of remaining loyal to the king. If war did break out, few doubted that the British would respond with overwhelming military power, especially where their navy could supply troops.

What could be the elements of a state vector for the American patriots and the British? Consider those in Figure 4.2.

FIGURE 4.2 Elements of the State Vector, 1775

$$S_{i,t} = \begin{bmatrix} \textit{extent and power of organized military} \\ \textit{organized central government} \\ \textit{size of national treasury} \\ \textit{theoretical justification for independence} \\ \textit{recognition by other governments} \\ \textit{support of populace} \\ \textit{knowledge of local terrain} \end{bmatrix};$$

$i =$ country or group;

$t =$ time period.

Examining the state vector for both parties allows one to quickly see the relevant factors that describe the current state of affairs. See Figure 4.3 for comparison of the 1775 state vectors for the British and the Americans. Indeed, reading this compilation of the state variable—done over two centuries later—demonstrates the long odds against succeeding in the effort to gain independence from Britain.

FIGURE 4.3 State Vectors for the British and Americans, 1775

$$S_{Americans,1775} = \begin{bmatrix} \textit{recently organized continental army; no navy} \\ \textit{no central government} \\ \textit{zero treasury} \\ \textit{novel, unproven, but powerful theory of liberty} \\ \textit{no recognition by other governments} \\ \textit{support of approximately half the populace} \\ \textit{excellent knowledge of local terrain} \end{bmatrix};$$

$$S_{British,1775} = \begin{bmatrix} \textit{world's best navy; one of world's best armies} \\ \textit{centuries old powerful central government} \\ \textit{very large treasury} \\ \textit{longstanding tradition of monarchies} \\ \textit{recognition by all relevant countries} \\ \textit{widespread support in England and much support in colonies} \\ \textit{very good knowledge of local terrain} \end{bmatrix}.$$

We know the outcome of the struggle that formally began in 1775. Given that knowledge, what do we observe just from the state vectors of the Americans and the British in 1775? We know that the traditional levers of power and resources overwhelmingly favored the British. The only advantages the Americans enjoyed were their novel theory of liberty and their knowledge of local terrain. Thus, simply examining the state vector should tell you a lot about the strategies these powers would employ in the forthcoming Revolutionary War.

State Variables for Business; Control Variables

How Many Ships in Your Navy?

Our example state vector above included the size of the armed forces. While very relevant to military and political strategy, the number of ships in your navy is not a relevant state variable for most businesses. Strategy is just as relevant, however, so we will consider identifying the elements of the state for a business to be just as important as identifying them for a nation.

What are the relevant factors that describe the state of affairs for a business? In listing these, we will broaden our inquiry one more dimension, by also asking what elements are under the control of the business manager.

A prototype state variable for an entrepreneur-managed business is presented in Figure 4.4. This figure includes an additional, important variable: an *action variable,* also known as a *control variable.*

The state variables are those that represent the state of affairs, regardless of how they became that way. The control variables, on the other hand, are those that are governed by the subject of the analysis. One element of the representative state vector for the entrepreneur-managed business is the amount of human capital the owner had committed over time. For many start-up firms, this is the single most costly and important variable. It is also a variable that reflects *past* decisions and events. The variable that is under control now is the amount of time the owner *currently* devotes to the business. This is also potentially very important to such a business.

Often, there are constraints on the control variables; for example, an enterpreneur cannot devote more than 24 hours a day to his or her businesss —though many have tried!

FIGURE 4.4 State Variable for Businesses

$$state = s = \begin{bmatrix} h_1 \text{ [human capital committed by owner]} \\ y_1 \text{ [general economic conditions]} \\ y_2 \text{ [industry or local market conditions]} \\ c_1 \text{ [competitive conditions]} \\ k_1 \text{ [cash or current assets]} \\ k_2 \text{ [net worth]} \\ k_3 \text{ [investments in plant and equipment]} \\ l_1 \text{ [current liabilities]} \\ n_1 \text{ [employees]} \\ t_1 \text{ [technology, patents, intellectual property]} \end{bmatrix}.$$

$$action = x = \begin{bmatrix} x_h \text{ [commit owner's time]} \\ x_l \text{ [borrow or repurchase of debt]} \\ x_a \text{ [advertise]} \\ x_p \text{ [change pricing]} \\ x_k \text{ [invest or expend on R\&D]} \\ x_n \text{ [hire employees]} \\ x_t \text{ [acquire technology or IP]} \end{bmatrix}.$$

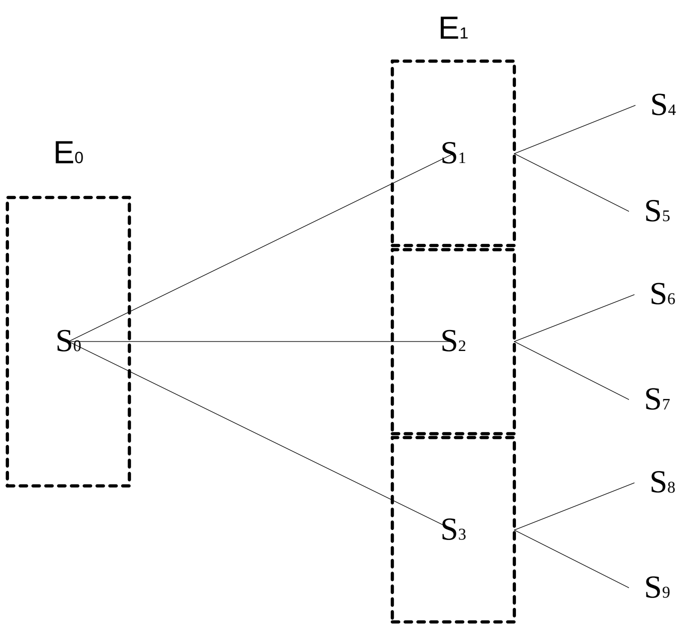
The Event Tree and Dynamic Payoffs

The Event Tree

We introduced an *event tree* and provided some examples in the previous chapter. Such a device combines the time dimension, possible states of nature, and the logical and sequential connections among those states. We explain here how this device, when used with a richer understanding of state and control variables, is particularly helpful in understanding strategy and strategic value.

The tree starts at a specific point in time, which conveniently can be drawn as a single point in a two-dimensional space. When illustrated on a two-dimensional space (such as a sheet of paper), the time index is illustrated by the distance away from the initial point. States of nature are normally visualized across the dimension perpendicular to the time dimension. In one classic way of drawing such a tree, time moves from left to right (as if you were “reading” the events as time passed) and the possible events are arrayed from top to bottom.

FIGURE 4.5 Prototype Event Tree



S_0,... S_9 = States of the world;
E_0, E_1 = Set of events possible at t=0, t=1.

In Figure 4.5, events occur at specific times, which result in certain states of nature being realized. These events could be random events, strategic decisions, or events determined exogenously from the persons under study.[9]

The Extensive Form and the Event Tree

Those readers familiar with other game theory texts will find a very close similarity between the event tree and the "extensive form" of a game. Indeed, event trees are often useful visualizations of games, and can incorporate the identical information as the extensive form of most games.

However, an event tree may not describe a game at all, and has a usefulness in financial economics that will be captured here for use by game theorists and other readers more interested in strategy than finance.

State and Control Variables in the Event Tree

We can now tie together the concept of the state variables, control variables, and the event tree neatly. In a model of strategic value, decisions (changes in the control variables) are one type of events. The decisions that the subject makes represent that subject's strategy. The outcome of these decisions moves the subject from one state of affairs to another. This can be summarized by a change in the state vector.

In Figure 4.5, the events E_0 and E_1 represent decisions (or random events) that caused the state variables to change; each state from S_1 to S_9 is different. Although this event tree doesn't specify how this occurs, the control variables pushed the state variables to change, and thus helped determine which state resulted.

Encoding History in the State

It is also important to note that there are more than just 6 possible states in Figure 4.5; there are nine plus the "root state" S_0. One of the state variables in each state could encode a portion of that history.

For example, the state of affairs for a sports team at the end of the season would include the results of the most recent game, as well as its win-loss record over the entire season. Much of the progress in the use of the dynamic programming technique we introduce later in this chapter involves more sophisticated ways of encoding such information in the state.[10]

The state of affairs in a repeated game would include an indication of the reputation of the player, and perhaps outstanding threats and promises. Recall that the famous

9. For a more rigorous discussion of event trees, see Yvan Lengwiler, *Microfoundations of Financial Economics,* Princeton, 2004, Chapter 2; or M. Magill & M. Quinzii, *Incomplete Markets,* MIT, 1996.

10. See Ljundqvist & Sargent (2004, preface) for a discussion of the improvements in the use of state variables in dynamic programming over the past two decades.

"tit for tat" strategy in repeated games requires remembering whether the opponent had been "good" or "bad" in the previous round; keeping track of this in a state variable is an example of encoding history in a useful way. In many mathematical applications, we require that all the useful information for the current decision be incorporated in a state variable of the current date; this is an informal description of a *Markov* process.[11]

Additional Examples

Later in this chapter, we will review additional examples of state and control variables. In Figure 4.6, we show how apparently random events (such as changes in the price of natural resources such as coal or oil) can change dramatically the earning potential of an investment. The state variables in that example include natural resource prices; the control variables include capital investments. In Figure 4.7, we examine how an interruption in a business (such as a natural disaster or failure of a supplier to fulfill a contract) can force a firm into a different state of affairs. The state variables in that example include the ability to operate retail stores; the action variables include hiring and advertising expenditures.

Payoffs and Business Value

Static "Payoffs" vs. Strategic Value

The classic games studied in game theory often have static payoffs. For example, the prisoner's dilemma is often posed in terms of outcomes that vary only in terms of the length of sentence. Gambling bets are similarly discussed in terms of static payoffs for each roll of the dice or hand of cards. As we emphasize throughout this book, properly identifying the payoff matrix is critical to real-world use of game theory models. For "business games," the most important payoffs are usually not one-time static amounts.

More commonly, the outcome of a series of business events will be a change in business prospects, which may involve a new contract, a merger or acquisition, a bankruptcy, a loss, the gain or loss of a key employee, and other similar changes in the future earnings or expenses of a business.

Value Changes

To study strategy in business and other matters, we will introduce outcomes that result in a *change in the value* of an investment. Often, though not always, this change in value does not represent a liquidated payoff (meaning that the resulting gains were turned into liquid assets such as cash).

11. See Appendix 4.A: "Stochastic Processes, Diffusions, and Expectations."

Dynamic Payoffs

If a person gains control over a business, a non-business enterprise (such as an association or political campaign), or a government, that person does not necessarily receive a liquidated payoff. Indeed, many times that control brings with it hardships as well as benefits.

When the payoff at some position in a game is one of control of an asset, and when control could result in additional gains or losses, we will call it a *dynamic payoff.* In general, control over a business is a dynamic payoff.

Dynamic payoffs are not the same as random payoffs. A random payoff on a game of chance may be much more predictable than a business investment in a casino. However, the payoff in the game of chance is static, while the business investment payoff is dynamic.

Some texts use the term “dynamic payoff” to refer to the payoff in a “dynamic game,” in which the payoff amount is uncertain. Certain lotteries, where the “jackpot” amount depends on partially random events, are examples of this.[12] However, a game in which the rules produce a certain type of payoff, which is certain as of the end of the game, is more of an uncertain static payoff than a true dynamic one.

Some investments in business enterprises (or payoffs in games involving non-business enterprises) do not provide dynamic payoffs, because the payoffs do not involve enough control to allow the person to exploit any dynamic nature of the investment. Relatively small investments in publicly traded companies in the U.S., for example, typically provide the owner with little or no control over the organization. Treasury bills, bets on a roulette wheel, and some financial options are other examples of static payoffs.

The Firm

People often speak loosely about a “business,” and this imprecision has seeped into academic and professional literature as well. In addition, the neoclassical economists that dominated the business and finance theory over the past century did not develop a complete theory of the firm. Thus, it is important to define exactly what we mean by a firm, by an equity investment in a firm, and by the markets in which a firm operates.

To use strategy in business, we will have to rigorously define a “firm.” Unfortunately, a loose definition of a firm would render meaningless much of our discussion of strategic value in business. Consider these definitions in common use:

12. Technically, the expected value of such a lottery is not known, because either the odds of winning, the amount of the award, or both are affected by the number of players.

- An organization with a profit motive.
  This certainly distinguishes a firm from a government entity, and from an association or other nonprofit organization as well. However, it does not distinguish a firm from a person that works as a contractor, and pays taxes as if his work was done by a separate business.
- An organization that pays taxes on its earnings.
  That certainly rules out nonprofits including non-profits that behave much like for-profit firms in terms of seeking market share. Many quasi-governmental agencies, and large healthcare organizations, are examples of non-profit entities that act very much like businesses when it comes to business strategy. It also potentially rules out organizations that function as pass-through entities for tax purposes (including most partnerships, "S" corporations, and LLCs).
- Title to future cash flows.
  This definition, commonly used in mathematical economics, does not distinguish an organization from a portfolio.

A better definition is found in Patrick Anderson's book, *Economics of Business Valuation*, which defines a *firm* as an organization (a human entity under management control) with the following three attributes:

1. A separate legal identity from its workers, managers, or owners.
2. A motivation to earn profit for the investors.
3. A set of replicable business processes.

We will use this definition in our discussion of strategy. The tenets of separate identity, management control, and replicable business practices make it possible to meaningfully discuss business strategy.

Equity in a Firm

Stocks are one form of equities in a firm, giving the owner title to any dividends issued to stockholders on a pro-rata basis, as well as voting rights in the election of the board of directors or other managing body of the firm.

In general, ownership of equity interests in a business enterprise does not, in general, give the owner an ability to immediately convert those interests into cash. In the case of publicly traded stocks, such a liquidation could normally occur quickly; such stockholders normally have a small fractional interest, and lack any control over the management.

However, stock is not the same as the businesses that issued the stock. For example, owning a fractional share of the equity in a firm does not allow a stockholder the right to demand the firm divide up its assets and present a share of them to the stockholder. Stockholders that, individually or jointly, have enough shares to effectively determine the election of directors or selection of managers are said to have a *controlling interest.* Because control is an essential factor in strategy, we will be careful to specify the terms of achieving control in examples involving stockholder.

Note on Limited-Liability Companies

Corporations, and other business forms in which the business is a separate legal "person," normally preserve the important concept of *limited liability* for their investors. Limited liability means that the total amount of investment at risk for an investor is the amount invested in the equity of the firm. Therefore, creditors of the firm cannot demand payment from the stockholders.

Limited liability is an important part of the underlying rules of business strategy; they insulate investors from having creditors to a company in which they invest come after them. This is one of the institutions that allows for a separation of ownership and control in modern large corporations.

Markets

We will routinely consider two markets in which businesses operate: the product market, in which the goods or services that the firm produces are exchanged, and the equity market, in which the equity interests for the firm are exchanged. Neither need be a physical space reserved for trading. What is important is whether the products or ownership interests are traded.

Of course, there are other markets that may be of interest. The market for borrowing is one. The market for hiring is another.

Real Options and Management Flexibility

The Ubiquity of Uncertainty

It is tempting for academic treatments of business strategy to view the business world as one of a handful of strategic decisions. However, the real business world is something quite different. The real business world is one of consumers and workers; and regulators and taxing authorities; customers that may not pay their bills and vendors that may not deliver; and the weather and changing prices and fickle consumer preferences.

In other words, *business always involves uncertainty.* It is this uncertainty that is the primary backdrop for the business world, not strategy. We will view strategy as a tool for dealing with uncertainty created both by seemingly random events, and by deliberate choices of others.

The Inherent Value of Management Flexibility

In an uncertain world, the ability to react to events is worthwhile, in and of itself. We will recognize this as the value of *management flexibility*. Note that valuing flexibility in management motivates managers to make decisions that could otherwise appear irrational.

For example, a manufacturing plant may expect to produce 1000 cars per day. However, the plant's manager may keep parts inventory on hand to build 1500—even if the extra inventory costs more, in both purchase price and storage costs. This means the plant manager does not maximize the profits of the plant.

However, neoclassical economics holds that producers act to maximize profits. Is the plant manager flunking economics? Or is neoclassical economics flunking strategic valuation?

This is a good introduction to various theories of valuation, some of which produce quite different answers to this question.[13]

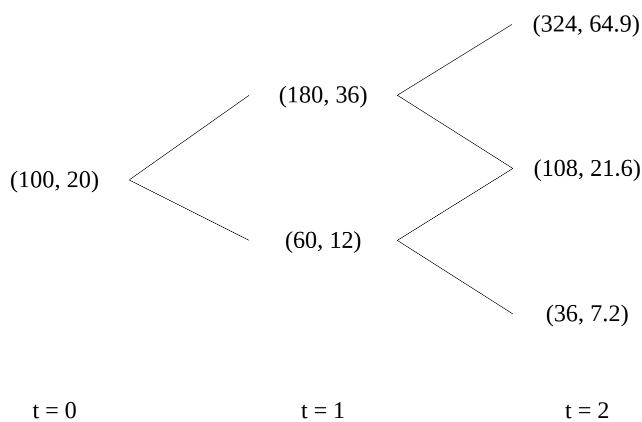
Consider a business that earns money from the extraction of material resources, such as oil, coal, and forested wood. One of the most important elements in its profitability is the availability and cost of these natural resources. The firm has the opportunity to invest in stocks of these natural resources, which costs the firm money up front but also secures for them the rights to extract and sell the resources in the future.

This is a classic case of "real options," and provides an excellent introduction to the pitfalls of naive valuation methods and the importance of considering real options.[14]

13. See the brief discussions in "Strategy and Value." and the detailed list in Table 4.1: "Available Principles of Valuation."

14. This example is drawn from Trigeorgis, "Real Options, An Overview," in Schwartz and Trigeorgis (2001).

FIGURE 4.6 Event Tree for Natural Resources Co.



Consider the event tree facing the company management at time *t=0,* displayed in Figure 4.6. Here the state vector of each node is $(V_{DCF,t}, S_t)$, where $V_{DCF,t}$ is the discounted cash flow ("DCF") expected value of a project at time *t*, and S_t the spot price of the natural resources commodity, at time *t.* By "DCF expected value," we mean the expected value (frequency-weighted average) of the future payoffs, discounted for time and risk.[15] The state vector of (100, 20) at *t=0* means that the discounted expected cash flow from an investment at that point is $100, and the price of the natural resource is $20 per unit.

The probability of an upward movement at each node is *q=0.5,* and the risk-free rate is *r=8%*. The expected discount rate of investments in the natural resource commodity itself is *d=20%*; this "twin security" is the natural basis for considering risk and return in equity investments of this type. Note that a higher equity discount rate is justified on the variability of price changes and other risks.

The Investment Decision

The event tree already includes the DCF expected value of each node. As shown, $V_{DCF,0}$ = $100.[16] If the project investment costs $104, should the company invest?

Standard DCF analysis says no because the project's expected net present value is *E(NPV)*=$100, while the investment cost $104.

Yet, if management has any flexibility in timing, this is probably the wrong answer. It is incorrect because it ignores the possibility of using management flexibility to

15. See the discussion of expected value in Appendix 4.A,"Stochastic Processes, Diffusions, and Expectations."

16. This can be calculated quickly by noting that the V_{DCF} of the next two nodes sum to 240, with 50% odds for each node. Half of 240 is 120, which discounted at 20% equals 100.

exploit the real option of waiting for more information. If we look at the next time period, we see that one "up" movement in the price results in an *E (NPV)=$180*—far above the initial price. Thus, assuming that the company could defer at least some of its investment until after the first event, or pay some fee to secure the option to invest at a later date, the investor is better off by staying in the game.

In general, many firms have real options that include deferring investment, abandoning investment, and expanding investment. A proper view of strategic value incorporates the value of these options.

What is "Value" for a Firm?

What is the value of a firm? This question has received surprisingly little direct examination for most of the history of economics. Indeed, the neoclassical microeconomics familiar to generations of college students largely ignores the concept of the firm as having value.

In this section, we briefly summarize the sources of value in a firm, and list a set of theories or principles of valuation that have been proposed in the past.

Earnings and Capital Gains

We can immediately identify two aspects of ownership of equities in a firm that are desirable enough to generate a desire by investors to purchase the equities. The willingness to pay for something is an indication of its value, so let us connect the dots: what two ways can stock ownership produce monetary benefits to the stockholder?

The answer is encapsulated in the measure of "total return" of a stock, which includes both the following:

1. The *income* on the stock, which is normally distributed through a dividend (or other distribution).
2. The *capital gains (or capital losses)* on the ultimate sale of the equities.

Just as wise investors consider both the income and the capital gain potential of an investment, students of strategy must recognize both as possible strategic objectives.

Strategy and the Pursuit of "Total Return"

We consider both income and capital gains to be valuable to investors in a firm. Therefore, in actual business settings, managers and investors make rational decisions that result in income in later periods. Sometimes these decisions result in lower profits in the current period. Therefore, the neoclassical economics notion of profit-maximizing firms will not be sufficient for strategic valuation. Similarly, other common valuation principles (such as current-period accounting income or net worth) are also deficient. We will need a more sophisticated valuation principle.

Available Principles of Valuation

We described a set of potential business valuation principles in the section titled "Strategy and Value." There, we concluded that at least three commonly used principles of valuation were not reliable for firms with strategic opportunities. We identify numerous principles that have been proposed as the basis for the value of a business; see Table 4.1.

These principles come from the fields of economics and mathematical finance as well as traditional methods.

TABLE 4.1 Available Principles of Business Valuation

Theory	Valuation principle; Original proponents	Validity as business value theory; Practical usefulness for business valuation
Economics:		
Classical	Labor theory of value: value is the sum of labor inputs. Smith, Ricardo (18th century); Marx, Sraffa.	Invalid as a theory of business valuation. Not useful in practice.
Neoclassical	Value theory in "marginalist" school; value is price times quantity of commodities; no theory of producer value. Walras, Debreu (19th century); Marshall, Dreze (20th century).	Invalid as theory of business valuation. Not useful in practice.
Modern	Recursive general equilibrium model; consumers choose savings (invest) to secure consumption in future periods. Bewley, Lucas, Sargent, Aiyagari (late 20th century).	Valid as a general theory of investment, but does not extend to value of individual firms. Not useful in practice.
Traditional Approaches:		
Asset Approach	Value of firm is value of assets less value of liabilities; an adaptation of accounting identity: Assets = Liabilities + Equity. First codified by Luca Pacioli (16th century).	Accounting identity is invalid as basis of business valuation. Accounting information is very useful for business management, and as information for investors. Can be useful in valuation when "firm" is essentially a collection of assets, for which market values are available.
Market Approach	Value of a firm is indicated by market value of similar firms.	Valid as a theory; ignores real options. Very useful in practice, when comparables are available.
Income Approach	Value of firm is expected net present value of future earnings; this leads to NPV rule of capital budgeting. Irving Fisher (early 20th century); Modigliani-Miller, Joel Dean (mid-20th century).	Partially valid as a theory. Workhorse practical method, but requires extensive subjective adjustments to overcome theoretical deficiencies when valuing actual firms.

(to be continued)

TABLE 4.1 Available Principles of Business Valuation (continued)

Theory	Valuation principle; Original proponents	Validity as business value theory; Practical usefulness for business valuation
Mathematical Finance:		
Modern Portfolio Theory	Value of a portfolio and selection of investments within a portfolio is set by trade-off between "risk" and "reward" of portfolio as a whole. Markowitz for mean-variance approach; Sharpe et al. for CAPM; numerous authors for factor models; Roll for his critique; Merton for intertemporal model (mid-20th century).	Invalid as a theory of business valuation; valid as a theory about portfolio investments in single period. Useful only for publicly traded firms and portfolio investments. Not useful for private firms or investments not for portfolio purposes.
Complete Markets ("No Arbitrage") Methods	In complete markets, no-arbitrage assumption provides unique price for all traded assets ("fundamental theorem of finance"). Arrow, Ross; Black, Scholes & Merton (mid- to late-20th century).	Valid as a theory for a very narrow class of assets; not applicable to non-complete markets. Not useful for most markets for private firms; very useful for certain financial contracts and commodities.
Option Value	Value of firm is the value of its real and financial options. Management flexibility has value. Dixit & Pindyck; McDonald-Siegel; Black, Scholes & Merton (late 20th century).	Partially valid as a theory of business valuation. Very useful for businesses with IP, natural resources, and similar assets; useful for some other firms.
Value Functional:		
Value Functional	Intrinsic value of firm is solution to entrepreneur's value functional equation, given market (state) conditions and ability to control (make policy decisions) in future. Anderson.	Valid as theory. Very useful in general sense; difficult to apply in practical cases.

Source: Adapted from: Patrick Anderson, Economics of Business Valuation (Stanford University Press, forthcoming 2010).

Practical Models

Because so many of the theoretical models are either invalid for use in actual business valuations, or difficult to apply, a small set of practical models have been developed that are used repeatedly in practice. These are summarized in Table 4.2.

TABLE 4.2 Valuation Models in Practical Use

Title	Principle	Notes
Expanded NPV	Value = E(NPV of earnings) + Real Options.	Partially valid as a theory. Very useful as conceptual basis of adjustments made in Income Method valuations. Often used in merger analyses.
Practical Income Method	Value = E[NPV (net cash flow)] with substantial adjustments to discount rate, earnings, and amount.	Adjustments are intended to bring model results closer to reality of market value. Key problem is the dominance of subjective adjustment factors.
Industry Rules-of-Thumb	Value = Multiple of base selected using "rule of thumb" for particular industry.	Very common in many industries as an initial estimate, or as a liquidated damages basis in a contract.
Practical Asset Method	Value is the value of individual assets, if the firm can be broken up into pieces.	Common for companies that can be neatly sliced into pieces. Poor choice for most operating firms.
Practical Market Method	Value is the value of similarly scaled companies with available market transactions, adjusted for differences in market conditions and for intrinsic differences.	Common when firms are publicly traded and have well-identified peers. Recurring problem is the unavailability of true substitutes.
Real Options	Value can be modeled by contingent claims, where markets exist for assets that have similar risk characteristics.	Very difficult to implement in practice, so infrequently used outside of natural resources.

Source: Patrick Anderson, Economics of Business Valuation (Stanford University Press, forthcoming 2010).

As can be seen from the "practical use" models, the commonly used models require extensive subjective adjustments in order to handle management flexibility, real options, and other factors. When such adjustments dominate the underlying method, it is time to ask whether the principle for the underlying method is correct. Clearly, the underlying principle is *not* correct for the majority of the theoretical valuation models. On the other hand, the "practical" models all seem to be rarely usable or to require extensive adjustments.

Example: Strategic Valuation for the Damaged Business

To illustrate the use of the value functional approach to valuation, consider the case of the damaged retailer. Assume this retailer has, at $t=0$, five stores open and a steady record of growth and profitability. At $t=1$, a natural disaster (or breach of contract) forces the closure of two of the five stores. This interruption will last for at least a half-year, far longer than most customers can postpone purchases.

The manager considers two courses of action:

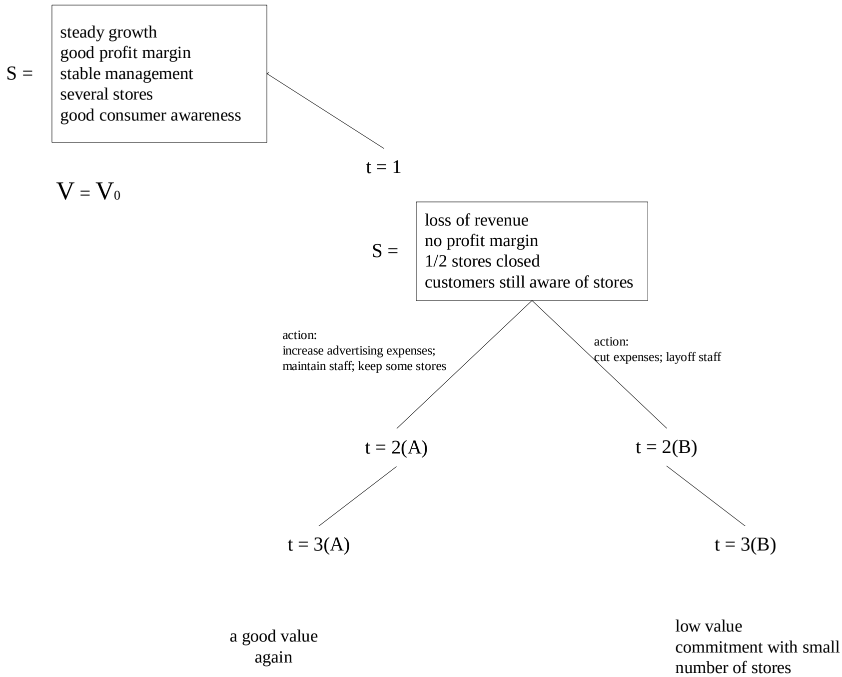
a. Mitigate by reducing costs. In this strategy, the store reduces staff, cuts advertising, and tries to regain profitability. When the stores are ready to open, the company hopes to have reduced its expenses enough to have a small profit available to fund the re-opening of one of the two closed stores.
b. Maintain presence by increasing advertising and staff. In this strategy, the company tries to maintain consumer awareness and enhances service at the other stores. Although this increases revenue at those stores, and ensures that the company can re-open two stores when possible without losing many customers, it dramatically increases costs in the short run as well.

There is no question that the “mitigate” strategy comes closer to the neoclassical economics model of the profit-maximizing firm. Most DCF models would, before adjustments, show a higher value for the firm if it mitigated its losses by laying off staff. However, the value functional approach would directly examine both strategies, and incorporate the potential gains in the future from maintaining consumer awareness, even though the costs were higher in the short run.

From the example, we don’t know what the “correct” strategy is. However, we do know that the wise manager would consider both strategies. Furthermore, he or she would do so in a way that is mimicked by the value functional approach, and would consider things that the standard DCF method does not. Previous work by the authors demonstrates how a business owner in similar situations could maximize value by not taking the path that appears to have the largest E(NPV). As such examples demonstrate even without the interaction implied by strategic games, a wise investor/manager/strategist thinks about future opportunities in a manner that extends beyond the simple discounted expected value.

The value functional approach typically presents difficult computational problems when the number of state and action variables are significant, or when the number of possible paths are large. One approach to solving the problem is very similar to the idea of “backward induction” widely used in game theory models. See the appendices to this chapter for more information.

FIGURE 4.7 Damages Example



Appendix 4.A Stochastic Processes, Diffusions, and Expectations

A. Introduction

Many aspects of life can be summarized by a series of numbers, which vary over time. This includes the fortunes of companies, countries, and families; the value of stocks, business investments, and currencies; and salaries, wages, and retirement benefits of individuals.

Note that such a series of numbers reflects random events (events that nobody appears to control); strategic decisions made by others (events outside the control of the individual, company, or country); and strategic events made by the subject.

For example, consider a series of numbers that are the annual wage and salary earnings of an individual. Random events that affect this would include the business cycle, market conditions in the area of the worker, and the luck involved in finding the right job or working with a company that has good fortune. Strategic decisions by others include where to locate a plant or office; tax and other government policies; and the terms of an employment offer. Strategic decisions made by the subject include whether to accept the employment offer; whether to remain at the company or leave to work elsewhere; and whether to work at all.

Use of Stochastic Processes in Study of Strategic Behavior

There are well-developed mathematical constructs that can be used to model these series of events. Perhaps the broadest definition of a series that records such events is that of a *stochastic process,* or a process with a random component that produces a series of numbers. Another definition, which is narrower, is that of a *diffusion* that incorporates random factors, with a defined structure.

Using the concept of a diffusion or other stochastic process, we can model many events that affect life, business, and the fortunes of people.

B. Brownian Motion and Random Events

Some elements of financial economics are based explicitly on the notion of a repeated series of random events. A series of coin tosses is a common basis for outlining a game of chance; there is a direct analogy of this that is a fundamental process used in financial economics.

Consider the price of a stock over time. Assume that the price could go up, or go down, each period, due to random and uncorrelated events. If we count each “up” movement as a one, and each “down” as a zero, the resulting sum of outcomes follows a *binomial distribution.*

Now add a little more structure to this process: a probability of going up *u*, and a fraction that describes the increase in price when an "up" event occurs. By the rules of probability, the probability of going down is *d=1-u.*

Such a process is so common that it enjoys a group of well-known names. Perhaps the most colorful is the term *random walk,* which accurately conveys a meandering stock price in which every movement is completely random. More precise terms are *Brownian motion,* after the botanist Robert Browning that first described such behavior involving plant species, or *Weiner process* after the economist and mathematician Norbert Weiner, who described some of its properties.

The Markov Property

In general, Brownian motion displays an important property of a large and important class of stochastic processes: the Markov property. A process with the Markov property contains all the information useful in predicting the next value in the previous realization of the same variable. For example, many people think that the rate of interest on short-term U.S. government bonds is close to a Markov process, meaning that there is no predictive benefit to knowing what the interest rates have been in the past once you know what they are today.

C. Geometric Brownian Motion and Stock Prices

A particularly useful diffusion process is known as *geometric Brownian motion,* or GBM. As the "geometric" adjective implies, a GBM process has a trend growth rate that is geometric, meaning growing at the same rate over time. In contrast, simple additive processes grow at a slower rate over time.

Geometric Brownian motion is the most common model used for stock prices and other phenomena, when the trend growth can be captured largely by a certain growth rate per period. A GBM process normally includes a random component as well.

For example, we might expect that income for a country, or stock prices, or output for a country would grow at an underlying trend rate of, say, 6%, with significant volatility around that trend. If we make the additional assumption that the variation around the trend is caused by numerous uncorrelated random events (a very convenient, and sometimes accurate, assumption) then we can invoke the Central Limit Theorem and assume that the variation has a normal distribution. In the classic GBM, the variation turns out to be *lognormal,* meaning that the natural log of the distribution is distributed normally.

GBM process can be characterized by only a few parameters including:

1. The trend growth rate per period.
2. The standard deviation of the variation per period.

In addition, the starting point, periodicity, and units are required to generate the output from such a model, as well as a set of random (or pseudo-random) numbers.

D. Expected Value

Random variables are described in terms of their *distributions.* For example, the nice "bell curve" distribution, neatly symmetrical and bulging in the middle, is the classic "normal" distribution. The normal distribution can be characterized by only two parameters: its mean and its variance. (The standard deviation is just the positive square root of the variance.)

Most distributions, however, are not so neatly symmetric. They may "lean" or *skew* to one side or another, for example; they may have long "tails" or truncated ones; they may degenerate at certain points.

However, a useful indicator of the distribution of a random variable is usually the mean, commonly called the average. The mean is also the *expected value* of a distribution. In most cases involving finite distributions, the expected value can be calculated as the frequency-weighted average of the elements of a distribution.

Expected Value of a Strategy

We can discuss, in some cases, the expected value of a strategy. In a game with finite payoffs, the expectation, taken across the distribution of all random events for which information is available at a specific time, of future events beginning from a certain state of nature, under a certain strategy, is called the (time-specific) expected value of the strategy.

Appendix 4.B Dynamic Programming

A. Optimization over Time

Dynamic programming is an optimization technique with wide applications in problems in which a person makes decisions at regular intervals, and where these decisions affect their situation in the future in a way that is somewhat predictable.

The essence of this approach is that an intertemporal (across time) optimization problem can be segmented into two parts: the current benefit (such as the return on an investment in the current period), and the change in the value at the end of this period (the change in the discounted future benefits). This string of small optimization decisions (one each period) can, under specific conditions, result in the person optimizing over the entire time path.

B. A Prototype "Bellman Equation" for a Private Firm

We call the fundamental equation in dynamic programming a *functional equation,* or the "Bellman equation." This equation establishes the value as a functional of the state variables, which could be the function of another variable, such as an action variable.

We can adapt this to a business using the following prototype value functional for the entrepreneur:

Bellman Equation for Private Firm (EQ 1)

$$V(s,t) = \max_{x} \{ f(s_t, x_t) + \beta E[V(s_{t+1}, t_{t+1})] \};$$

where:

$V(s,t) =$ value at time t given state s;

$f(s_t, x_t) =$ a reward function given state and action;

$t = 0,...,T$ is a time index;

$s_t = s_0,...,s_T$ are state variables;

$x_t = x_0,...,x_T$ are control variables; and

$0 < \beta < 1$ is a discount factor.

C. Recursive Decisions

Note the recursive nature of the decisions in this model:

1. The manager decides how to run the firm in the initial period, observing the situation (state) at the time. These decisions involve various control variables.

2. These decisions affect the reward earned in that period, and the state of affair in the next period. When that point in time is reached, the investor-manager again examines the state of the world, and makes a new set of decisions.
3. The manager always tries to maximize the sum of current benefit and the discounted value of the future benefits.

The structure matches the way actual managers and investors behave. It is particularly suited to evaluating a decision at one point in time, and then re-evaluating it after the next round of events.

D. Existence Theory

Does such a problem have a solution? For a wide class of problems, the answer is yes. We will not describe the mathematics underlying the existence theorems, in favor of the references discussed below.

However, we do provide a conceptual rationale for the existence of a solution: two key conditions must hold in order for a solution to be guaranteed to exist. First, consumers *discount* future returns. Second, the consumers have diminishing marginal returns (or a *convex reward function*). Although there are other technical conditions, they are often fulfilled in practical business valuation situations.[17]

We have seen the use of backward induction to solve a game theory model that can be expressed in an event-tree (extensive) form. Many of the solution algorithms for dynamic programming models are variations of this same approach.

17. Among these: the *transversality condition*, which requires that the discounted future value of profits converge to zero over time; finite action and state variables; and non-negativity constraints. The discounting requirement is typically fulfilled by any positive equity discount rate, and the convex reward function is fulfilled by production and managerial constraints. See Stokey and Lucas (1989) for the mathematical conditions for a solution, and Anderson (forthcoming 2010) for the interpretation of business constraints as meeting these conditions.

Chapter 5 A Dynamic Game of Asymmetric Information in the Beer Industry

A Game between a Global Brewer and a National Importer

Background[1]

Grupo Modelo ('Modelo') brews a number of brands of beer, the most popular of which is Corona. The beer was, prior to 2007, imported (in recent years through its closely related intermediary Extrade SA) into the United States by two importers: Barton Beers, Ltd. ('Barton') and The Gambrinus Company ('Gambrinus'). These two large organizations had each imported Modelo products into roughly half of the United States for nearly two decades, under agreements with Modelo (or its intermediaries) dated 1986, 1989, and 1994, as well as the disputed 1996 agreement.

These importer agreements were, except for the obvious differences between sales territories and the corresponding sales targets or quotas, equivalent in major provi-

1. All information used in this chapter is publicly available through various news reports, court of claims documents, and company filings.

sions. One such major provision is the section governing termination or renewal of the agreement. In the 1986, 1989, and 1994 agreements, this provision was identical between the Barton and Gambrinus agreements. As indicated by Gambrinus in their public release, it had been the practice and policy of Modelo to have equivalent agreements with each of its two importers.

However, when the final 1996 document was prepared, the parity between the key termination-and-renewal provisions between the Barton and Gambrinus agreements was changed. It was apparent from the statements of Gambrinus, and evidence available to the public, that Gambrinus executives were not told of this change, and were under the impression that this provision was again consistent across both importers.

According to statements of Gambrinus executives from the publicly available documents, the correct agreement was the one arising from a "meeting of the minds," and that the meeting of the minds was such that the provisions were identical. They further stated that their misinterpretation about the document was the result of a coordinated effort to deceive them, and offered substantial evidence to support this conclusion.

A proceeding of the International Court of Arbitration was initiated by The Gambrinus Company against Extrade SA, a business partner of Grupo Modelo and its consultant, Procermex.

We model this game between Modelo and Gambrinus to evaluate incentives of the parties in 1996, the options available to the parties in 1996, and the plausibility actions of the parties about their business intentions at that time, given the facts on their incentives and available options and strategies.

Motivation and Incentives of Companies: Maximizing Business Value

As we discussed in the previous chapter, it is commonplace to state that the objective of a business manager is to maximize profits. In economics, this simple formulation may be accurate if the "business" operates only during one period, and then stops. For example, a poker player typically wants to maximize the profits during an entire session of card-playing. The player carries forward losses and gains from one game to the next during the session, sometimes "dropping out" of a game when the chances seem slim of winning, and other times increasing the bet. When he or she *cashes out* at the end of the day, the total winnings (or losses) become apparent.

As in a poker game, for businesses that operate across multiple years, the correct interpretation of the incentives that operate on business owners and managers is to maximize *business value*. Business value is, in turn, defined as the sum of:

1. Current profits, and
2. The expected future profits, discounted for time, risk, and options available.

In particular, maximizing business value often requires the expenditure of money today (or foregoing of profits), in order to ensure that the business will be running tomorrow and generating larger cash flow in the future.

Examples

Almost every investment is an example of this principle, because it involves spending money today in order to earn greater money tomorrow. Other routine business expenditures, such as advertising and maintenance, similarly focus on increasing the profits that the business manager expects to earn in the future, knowing that the expenditures will reduce profits in the current period.

Contracts among business partners typically reflect the mutual goals of maximizing value. For example, in the beer businesses, supplier/importer and distributor agreements normally contain provisions that require advertising and other marketing expenses in every year, which are undertaken in an effort to increase future sales. Such contracts also typically contain provisions ensuring that the quality of the product is maintained (such as by refrigeration or freshness standards), which helps maintain or enhance the quality reputation of the product. Quality reputations, which require expenditures now in order to support future sales, are another indication of the principle of increasing business value.

Business Value Depends on a Strategic Course of Action

As stated in the previous chapter, in general, the value of any business is based on the likely discounted future benefits arising from that business. In order to identify these benefits, one needs to first identify what business arrangements and conditions are expected to produce these benefits. Most businesses have several potential courses of action, each of which would result in a different group of benefits and require different resources to produce. As investors will also consider how "likely" such benefits are, the risks and options available to the business are essential elements in estimating the business value.

Decisions concerning the best way to operate a business within the current industry, and with the current technology and market structure, are called "operating" decisions. Decisions about which markets to enter, which product categories to produce, and how to deal with competitors are called "strategic decisions."

Implications of Value, Risk, and Strategic Decisions to the Game

In 1996, Gambrinus had at least two courses of action, both of which would have produced some stream of future benefits and involved some set of risks. These benefits and risks extended far beyond the terms of the importer agreement with Grupo Modelo, in 1996. Similarly, Grupo Modelo had different potential courses of actions. Clearly, investors in Grupo Modelo believed that it would be in business beyond the current terms of its importer agreements (as a publicly traded firm, its stock price would drop dramatically if investors believed it would stop earning profits in the next several years). Grupo Modelo also had benefits and risks to consider.

Regulated Alcoholic Beverages Industry and Three-Tier System in the U.S.

The alcoholic beverage industry in the United States is uniquely subject to state regulation under the post-Prohibition XXI Amendment to the United States Constitution. This amendment allows states to regulate the distribution of alcoholic beverages within their borders.

Under this provision, almost all states impose some form of a "three-tier system." Under this "system," importers (or brewers) that supply the product must sell it to distributors. These distributors must then sell to retailers. Only retailers (including both package liquor stores and dining establishments) can sell directly to consumers. The original purposes of this segregation of the market were to encourage temperance (limit excess consumption of alcoholic beverages), increase the collection of tax revenue, and avoid the corruption and crime that plagued the (illegal) distribution business of alcoholic beverages during the period of Prohibition.

There are exceptions and differences in the treatment of different beverages among the states. However, all major players in the U.S. beer market must organize their business dealings to be consistent with the prohibitions on cross-ownership and vertical integration that are inherent in the three-tier system.[2]

In this case, the "supplier" (the first tier of the system) in the U.S., where Modelo products would be sold, would, in general, be the importer of the product into the United States. Thus, Gambrinus and Barton are required to set up networks of distributors, to whom they sell the product. These distributors, in turn, sell to retailers. Neither Gambrinus or Barton, nor Modelo or major brewers such as Anheuser-Busch, are allowed to set up vertically integrated distribution networks in which they brew (or import), distribute and sell beer.

2. There are a small number of good summaries of the beer market and the three-tier system, including Anderson, Patrick L., Ilhan K. Geckil, "Countries, Tastes, and the Value of Beer Franchises in the United States" AEG Working Paper 2004-1; and Greer, Douglas, "Beer" in *Industry Studies, 2nd edition,* Larry Duetsch, editor, ME Sharpe, 1998.

Sales Performance of Gambrinus; General Import Market

The Gambrinus Company, by any reasonable measure, has been very successful in its core business of importing and distributing beer products. In 1994, Gambrinus imported products that represented 0.3% of the American beer market. By 2003, their market share had increased to 2.4%. Gambrinus increased its market share more than any other importer in the U.S. during that 10-year-period.

The following tables in Appendix 5.A of this chapter detail these data:

- Table 5.6, "Selected Major Brewers and Importers, Total U.S. Shipments, 1994-2003."
- Table 5.7, "Selected Major Brewers and Importers, U.S. Market Share, 1994-2003."

Even after the renewal of the import agreement in 1996, The Gambrinus Company kept performing well (note that this increase in sales occurred when Gambrinus would have been operating under the false impression that it had uniform terms). In 1997, one year after the renewal of the import agreement in 1996, Modelo products represented 69% of the Gambrinus Company's volume. By 2003, that share increased to 90%. This shift implies that Gambrinus continued to focus its management and resources on growing the Modelo brands during this period. See the following table in the Appendix.

- Table 5.8, "Beer Shipments by Brand: Gambrinus v. Barton, U.S., 1997-2004."

Incentives at the Time of the 1996 Decision

In 1996, Grupo Modelo initiated negotiations on new importer agreements with Gambrinus and the other major importer of their products, Barton. These agreements, in the past, had been nearly identical except for the sales territories and quotas. At that time, the existing agreement (from 1994) had another two years until expiration.

In late 1996, a proposed agreement was presented to Gambrinus, which would have extended the term to 2006, with a mid-term meeting at which either party could serve notice that it was terminating the agreement at the end of 2001. Gambrinus was given the impression that the terms of the proposed agreements for Barton and Gambrinus were identical, as they had been in the past. This was, according to the Gambrinus executives stated in the proceeding of the International Court of Arbitration, a deliberate misimpression that resulted in their signing an agreement that they would not have signed, had they known of the difference in terms.

Incentives for Grupo Modelo

The key incentives that affected Grupo Modelo in 1996 were the following:

1. Maintaining the current profits from brewing and exporting of beer to the current importers, in current market conditions, under current pricing.
2. Increasing the value of Modelo brands in the United States, by increasing the sales of the Modelo brands, and therefore the potential future profits of brewing and exporting those brands.
3. Increasing the margins on their current business by reducing their costs (greater efficiency in their own operation), or increasing the wholesale price.
4. Avoiding the anticipated desire by Anheuser-Busch, the dominant U.S. brewer, to purchase a larger share of Modelo, and pressure Modelo to allow it to control the importing of its products to the United States.
5. Avoiding the emergence of strong competitors in the imported beer market in the United States.
6. Maintaining a consistent approach to marketing, operations, and logistics across the United States by its two importers.

All these are valid business objectives, and would have been known and understood by all parties.

Objectives of Gambrinus

The objectives of Gambrinus can be similarly summarized:

1. Maintaining the current profits from importing of Modelo beer, in their current territory, in current market conditions, under current pricing.
2. Increasing the value of the Modelo brands in the United States by increasing the sales and therefore the potential future profits of importing those brands. This incentive of Gambrinus, however, only extends to the anticipated term or terms of their importing agreements with Modelo.
3. Increasing the margins on their current business, by reducing their costs (greater efficiency in their own operation), or increasing their wholesale (to distributors) price.
4. Over time, diversifying their sources of product to avoid being seriously damaged by either market downturns for individual products or adverse business decisions by their primary supplier, Grupo Modelo.
5. Maintaining a consistent approach to marketing, operations, and logistics across the United States by Modelo's two importers.

Matching and Conflicting Objectives

In business relationships involving a franchise, the core business objectives of each party are shared. By "shared," we mean both parties wish to increase the value of the franchise, and therefore work to improve the sales and brand image. Their objectives match, and therefore they share the burden of reaching them.

There are other objectives that are not shared. Of course, in any buyer-seller relationship, the price of the product is a variable that must be negotiated, as increasing or decreasing it (within the range of plausible prices that allow each party to remain in business) transfers benefits from one party to another. In addition, in some business relationships there is a subset of non-price objectives that conflict. This should be a concern to both parties, and typically requires the most attention in contracts between them.

We sort through the objectives of the parties below as of 1996, identifying the matching and conflicting objectives.

Matching Objectives

1. Maintaining the current profits from the brewing and exporting of beer, to the current importers, in current market conditions, under current pricing.
2. Increasing the sales and therefore value of the Modelo brands in the United States, through the anticipated term or terms of the importing agreements between Modelo and Gambrinus.
3. Avoiding the emergence of strong competitors offering direct substitutes to Modelo products in the imported beer market, through the existing and anticipated terms of the importer agreements with Gambrinus.
4. Increasing the margins on their current business, by reducing their costs (greater efficiency in their own operation).
5. Maintaining a consistent approach to marketing, operations, and logistics across the United States by both importers of Modelo products.

Conflicting Objectives

1. The wholesale (to the importer) price of Modelo products, after adjusting for non-price financial burdens such as advertising and marketing, and any reimbursements from the brewer.

   This is the key price variable, which is a directly conflicting one in almost every business transaction.
2. Increasing the value of Modelo brands in the United States *beyond* the term or terms of the importer agreements with Gambrinus.

   This key objective of Modelo was not shared with Gambrinus.

3. Avoiding the anticipated desire by Anheuser-Busch, the dominant U.S. brewer, to purchase a larger share of Modelo, and pressure Modelo to allow it to control the importing of its products to the United States.

   This key objective of Modelo was not shared with Gambrinus, beyond Gambrinus' desire to continue to import Modelo products in its territory. However, the ownership of Modelo stock by A-B would have been known to Gambrinus, and the interests of A-B were well known in the industry.

4. Avoiding the emergence of strong competitors offering direct substitutes to Modelo products in the imported beer market, past the term of the existing and anticipated importer agreements with Gambrinus.

   This objective of Modelo was not shared with Gambrinus. To the extent Gambrinus could supply or distribute such products in the event that Modelo terminated its importer agreements, this objective directly conflicted with that of Gambrinus.

Concluding Remarks on Incentives

Categorization of incentives neatly identifies the conflicting objectives that existed in 1996. This identification does not prove that one party acted in bad faith, misrepresented any terms of its agreements, or broke any agreements. However, it does highlight the incentives that party would have operated under. All these factors created an incentive for Grupo Modelo to deceive Gambrinus about the differential terms in 1996.

Strategic Options Available in 1996 and the Game

In the previous sections, we dealt with the fundamental principle of value maximization, and the specific incentives for both Gambrinus and Modelo in 1996. In this section, we explicitly describe the options available to the parties at that time.

Introduction of Strategic Options

In 1996, both parties had "strategic options"; that is, courses of actions would affect their business value over time. First, for the incentives listed above, Modelo wished to change the terms for Gambrinus, but not for Barton. They had at least two options in 1996: to disclose the differential terms to Gambrinus or to conceal them.

We next consider the strategic options available to Gambrinus. At the time, they considered signing a new importer agreement with Modelo through its exporter, Extrade. The simplest discussion of this event was that it offered Gambrinus two strategic options: to sign the agreement or to walk away.

Strategic Options at Two Stages

We consider now the options available to Gambrinus and Modelo in 1996, using only the information available to each party at that time, in two stages. These stages and options in each stage will be discussed in detail under the upcoming section "Game-Theoretic Model." Briefly, these options in each stage are listed below.

1. First stage: 1996
   a. Modelo's available actions: disclose or conceal the different terms of the proposed agreement.
   b. Gambrinus' available actions: sign or not sign the agreement, given the knowledge (or lack of knowledge) of the different terms.

   First stage: 1996-2001
   a. Gambrinus' available actions: renegotiate or arbitrate agreement, seeking same terms as Barton (automatic renewals every five years).
   b. Modelo's available actions: renegotiate agreement to have an extended term beyond 2006 with request of financial concessions as part of bargain on revisions to terms.
   c. Gambrinus' and Modelo's available actions: allow agreement to end December 31, 2001, i.e., walk away and/or termination.
   d. Gambrinus' and Modelo's available actions: allow agreement to end December 31, 2006, i.e., walk away and/or termination.
2. Second stage: subgame
   a. Gambrinus' and Modelo's available actions: renegotiate agreement or redeployment by developing network of distributors and alternate suppliers that could compete with Modelo products, after the end of their terms (either December 2001 or December 2006).

These options are illustrated in Figure 5.1, "Strategic Options of Modelo and Gambrinus in 1996; Extensive Form of the Game." and Figure 5.2, "Stage III: Subgame; Renegotiation or Redeployment."

Potential Outcomes

The potential outcomes of the available actions of the two parties include at least the following:

1. Renegotiate to Equivalent Terms

Gambrinus and Modelo renegotiate their contract, to have terms equivalent to those of Barton. This may involve a payment or financial concession from one party to another as part of a settlement.

2. Sudden Termination in 2001

Gambrinus allows the agreement to expire December 31, 2001. Modelo endures an enormous disruption of their distribution network in one-half of the United States. Both parties suffer significant losses, but stay in business.

3. Maximize Short-Term Profits Until 1998; Set up Competing Import Products

Gambrinus walks away in 1996, and maximizes short-term profits from the Modelo brands while it sets up a competing network of distributors, and competing import products. Modelo is forced to appoint a new importer. Both parties lose profits, but stay in business.

4. Maximize Short-Term Profits Until 2006; Set up Competitors

Gambrinus allows the agreement to expire December 31, 2006. Between 2001 (when it discovers the differential terms and Modelo's efforts to conceal them) and 2006, it sets up a competing network of suppliers, and maximizes its current profits on Modelo products. Modelo sets up a new importer in 2007, which operates with less sales momentum and more competition. Both parties lose profits, but stay in business.

Game-Theoretic Model

Description

To understand the incentives and actual plays and reactions of Grupo Modelo and Gambrinus, we built a game-theoretic model with different strategies and actions. By building an extensive form representation of the game, the strategic behavior of players in this game can be analyzed (see Figure 5.1). The extensive form of the game specifies:

i. The players in the game: Grupo Modelo and the Gambrinus Company;

ii. When each player has a move; what a player can do at each opportunity to move (set of actions); what a player knows at each opportunity to move (information set); and

iii. The payoffs received by each player for each combination of moves that could be chosen by the players.

Information

The game between Gambrinus and Modelo is a game of incomplete and asymmetric information. Recall that in a game of incomplete information, there are some uncertainties about the moves or actions of players or time sequence of the game. Also, recall that in a game of asymmetric information, players have different information regarding each other's moves. In this game, Grupo Modelo knew the complete set of Gambrinus' actions, as of 1996. However, Gambrinus did not know the complete set of Modelo's actions regarding the renewal of the importer agreement.

FIGURE 5.1 Strategic Options of Modelo and Gambrinus in 1996; Extensive Form of the Game

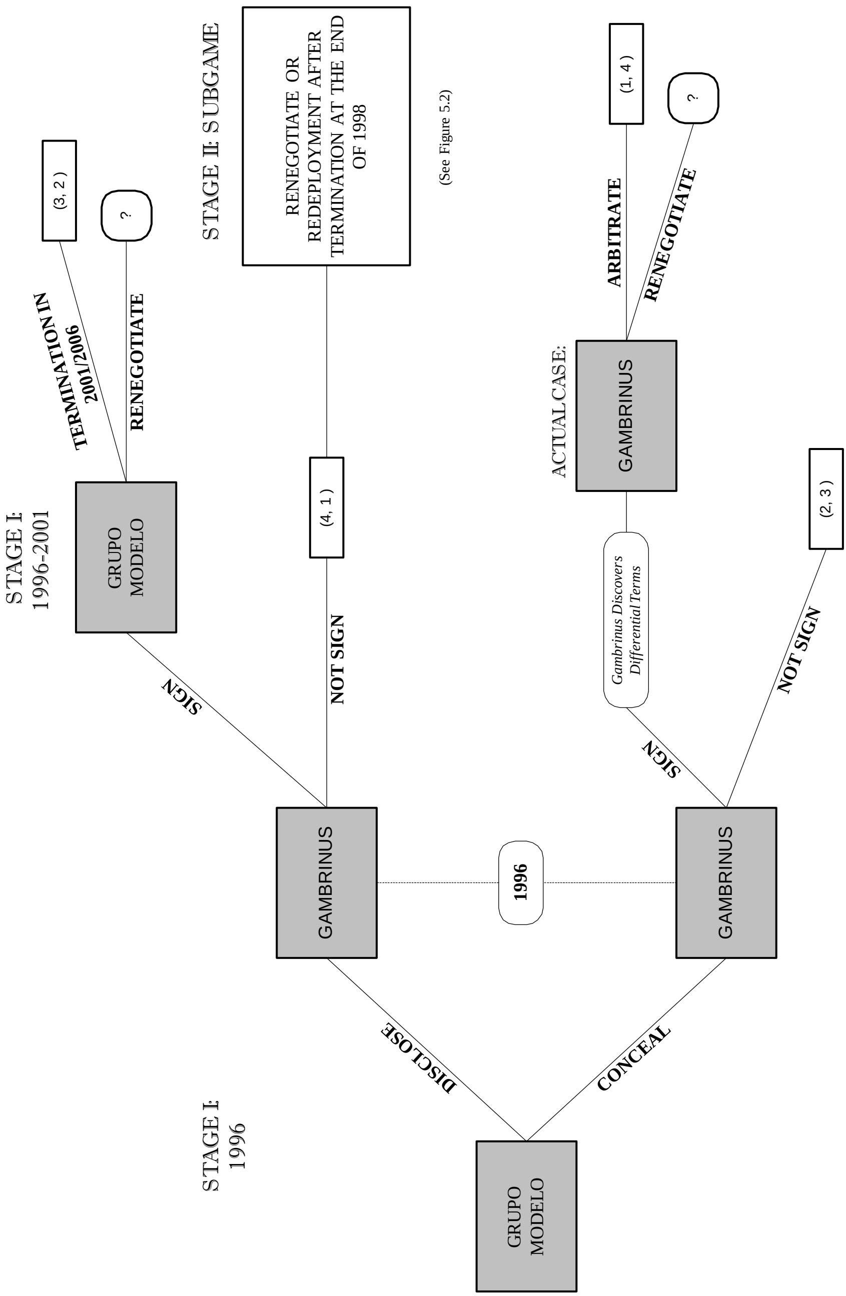
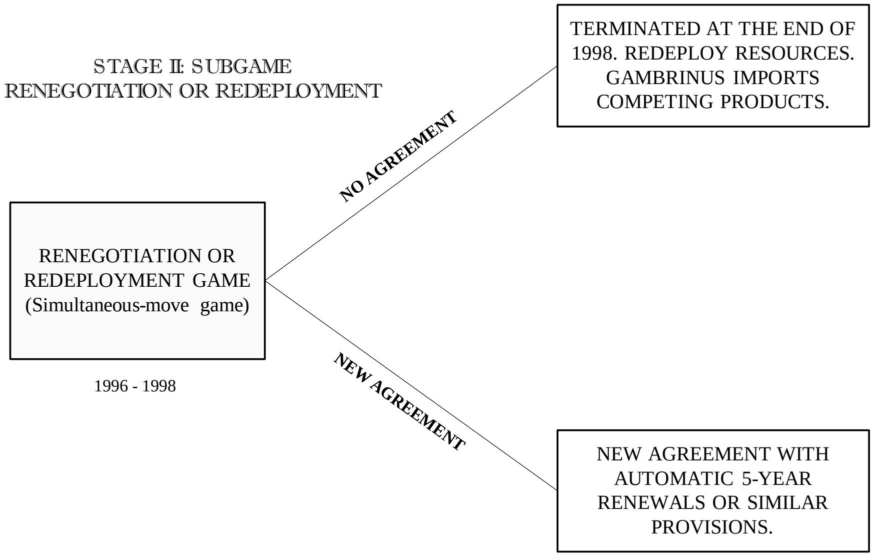


FIGURE 5.2 Stage III: Subgame; Renegotiation or Redeployment



Analysis of the Game

Stage I (1996)

In the first stage, as of 1996, the brewer Grupo Modelo chooses an action *a1* from the feasible set *A1={Disclose, Conceal}*, where *Disclose* is disclosing the difference between the importer agreement with Barton and the importer agreement with Gambrinus, and *Conceal* is hiding it. The game in Stage I is a sequential game of incomplete and a symmetric information.

The brewer wants its importer to sign the agreement. After the brewer's action, there are two possible outcomes: a signed importer agreement or a non-signed importer agreement. Probabilities of sign and not sign primarily depend on what information the importer has, i.e., information set. The potential outcomes and probabilities are shown in Table 5.1.

TABLE 5.1 Actions and Probabilities of Stage I

		Brewer	
		Conceal *	*Disclose*
Importer	p(sign) *	1	p_{11}
	p(not sign)	0	p_{22}

* Actual Case

<u>*Assumptions:*</u>
i) $p_{11} + p_{22} = 1$
ii) $p_{22} > p_{11}$

p(sign): probability of the importer's signing agreement after the brewer's action.

p(not sign): probability of the importer's not signing the agreement after the brewer's action.

If the brewer hides the fact that it asks its two importers in the U.S. to sign a different agreement, then the importer (Gambrinus) signs the agreement. This is actually what happened between the parties.

If the brewer discloses the fact about the existence of two different agreements, then the importer would have two options: sign the agreement or not sign. If the importer knows that difference, we believe the probability of not signing the agreement is substantially higher than signing it.

The payoff matrix of the game in Stage I is provided below:

TABLE 5.2 Payoff Matrix of Stage I

		Brewer	
		Conceal *	*Disclose*
Importer	*Sign* *	(j_{11}, q_{11})	(j_{21}, q_{21})
	Not sign / Renegotiate	(j_{12}, q_{12})	(j_{22}, q_{22})

* Actual Case

<u>*Assumptions:*</u>
i) $q_{11} > q_{12}$; $q_{11} \geq q_{21}$; $q_{12} \geq q_{22}$; $q_{21} \geq q_{22}$
ii) $j_{11} < j_{21}$; $j_{12} < j_{22}$; $j_{11} < j_{12}$; $j_{21} < j_{22}$

Based on the payoff matrix and assumptions provided in the table above, we can assign numbers to the utility levels of the Importer and Brewer. Assigning numbers makes our game less abstract, and easier to read.

TABLE 5.3 Payoff Matrix with Assigned Numbers

		Grupo Modelo	
		Conceal	*Disclose*
Gambrinus	*Sign*	(1, 4)	(3, 2)
	Not sign / Renegotiate	(2, 3)	(4, 1)

If the importer does not find signing the agreement to be a sound business decision, he is left with two options: walk away by redeploying or renegotiate for a new agreement based on the cooperation level of the brewer. This is a "simultaneous move game" between the brewer and importer, which is going to be analyzed in Stage II. See Figure 5.1, "Strategic Options of Modelo and Gambrinus in 1996; Extensive Form of the Game." for the extensive form of the game.

Stage I (1996-2001)

At the first stage we have two cases after the initial phase of the game: (1) the actual case, and (2) the importer making a decision about its business relationship and the import agreement with the brewer based on its strategic and investment plans, and the cooperation level of the brewer.

We know what happened when the "*actual case*" occurred. The outcome of this case is (j_{11}, q_{11}), where q_{11} is an outcome for the brewer and j_{11} is an outcome for the importer.

If the brewer disclosed the fact that it offered the other importer a different agreement, then the importer would have re-evaluated its business relationship and agreement with the brewer. At this phase the importer would have chosen an action *b1* from the action set *B1={Sign, Not sign}*. If Gambrinus signs the agreement even though it knows the different terms, the brewer chooses an action a2 from the action set *A={Termination, Renegotiation}*. Most likely, the importer would not sign the importer agreement with the knowledge of differential terms.

If the importer chooses not to sign the agreement with differential terms, the importer gets better off. As Table 5.2 and Table 5.3 show, *Not sign* is the dominant strategy for Gambrinus at the first stage of the game. *Conceal* is the dominant strategy for the other player, Grupo Modelo. By using its "first-mover" advantage, as described in Chapter 2 while we discuss sequential games, Modelo would conceal the differential terms. Our equilibrium for this game is {*Conceal*, *Not sign*}.

However, we know that Gambrinus signed the differential agreement in 1996. What would be the reason of Gambrinus' action? Because of the incomplete and asymmetric nature of the information set, Gambrinus misinterpreted the situation, and signed the agreement. If Grupo Modelo did not hide the information about the differential terms in importer agreement, Gambrinus would have played the game more smartly and would be able to carry the game to the second stage. If Modelo disclosed the information, Gambrinus would not sign the agreement as the payoff matrix of the first stage shows [4>3]. See Table 5.3. Then, Gambrinus and Grupo Modelo would have left with a cooperative game of perfect information of Stage II.

Stage II

The game in the second stage is a simultaneous-move game. The importer Gambrinus chooses an action *q1* from the action set *Q={Renegotiate for a new agreement, Redeployment}*; and the brewer Grupo Modelo chooses between *Cooperate* and *Not cooperate.*

The potential outcomes and probabilities are shown in Table 5.4, "Actions and Probabilities of Stage II," and Table 5.5, "Outcomes of Stage II."

TABLE 5.4 Actions and Probabilities of Stage II

		Brewer	
		Cooperate	*Not cooperate*
Importer	*p(Redeployment - no agreement)*	r_{11}	r_{12}
	p(new agreement)	r_{21}	r_{22}

Assumptions:
i. $r_{11} + r_{21} = 1$; $r_{12} + r_{22} = 1$
ii. $r_{11} < r_{21}$; $r_{22} < r_{12}$

p(*Redeployment*): probability of the importer's walking away based on the cooperation level of the brewer.

p(*sign a new agreement*): probability of the importer's signing a new agreement based on the cooperation level of the brewer.

Based on the importer agreements signed previously, there are two possible outcome sets at the end of the simultaneous move game between the brewer and the importer:

- Redeployment and walk away with 3 years of extended agreement: (imp_1, br_1), where imp_1 is an outcome for the importer and br_1 is an outcome for the brewer.

- re-negotiate and sign a new agreement with open-ended lifetime period for the import agreement or long-term agreement, such as 10 years: (imp_2, br_2), where imp_2 is an outcome for the importer, and br_2 is an outcome for the brewer.

TABLE 5.5 Outcomes of Stage II

		Brewer	
		Cooperate	*Not cooperate*
Importer	walk away with 3 years of extended agreement		(imp_1, br_1)
	re-negotiate and sign a new agreement - 10 years	(imp_2, br_2)	

Assumptions:

i. $imp_2 > imp_1$
ii. $br_2 > br_1$

{Re-negotiate and sign a new agreement, Cooperate} is the equilibrium outcome for this game, based on the assumptions in Table 5.4 and Table 5.5.

Outcomes of the Game and Conclusion

The brewer maximizes its benefit by choosing to *Conceal* the difference between import agreements. By using backward induction, we see why the brewer hid the fact.

If the brewer did not hide the facts regarding the different versions of the import agreement, the game would reach Stage II. At this stage, the brewer is better off by choosing *Cooperate* to get a signed agreement.

The best outcome for the importer is to choose Re-negotiate and sign a new agreement at the second stage. The only way to get this outcome, however, is sincerity and cooperation to exist on behalf of the brewer. Due to incomplete information and the conditional nature of the best outcome, the importer was unable to act in its best interest.

As a result of the brewer's strategies and moves to get the best outcome in this case, the importer ended up being worse-off.

Appendix 5.A

TABLE 5.6 Selected Major Brewers and Importers, Total U.S. Shipments, 1994-2003

Brewers and Importers	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	CAGR* (1994-2004)
Bbls (000)												
Anheuser-Busch	88,529	87,539	91,000	91,300	94,200	96,800	99,200	100,425	102,525	103,350	103,750	1.6%
Miller	45,243	45,006	43,799	43,675	42,674	44,175	42,532	40,563	39,850	38,300	38,900	-1.5%
Coors	20,200	20,000	20,100	20,630	21,240	22,000	22,780	22,760	22,780	22,450	22,350	1.0%
HeinekenUSA	2,775	2,900	3,190	3,350	3,600	3,975	4,560	4,800	5,280	5,295	5,525	7.1%
Gambrinus	685	975	1,300	1,975	2,870	3,385	3,793	4,447	4,910	4,944	5,181	22.4%
Barton	1,070	1,340	1,680	2,070	2,683	3,080	3,505	3,945	4,272	4,600	4,575	15.6%
Labatt USA	2,215	2,240	2,500	2,780	3,200	3,537	3,929	4,113	4,374	4,513	5,125	8.8%
Beck's	590	640	605	670	750	780	740	740	718	658	694	1.6%
Sub-Total	**161,307**	**160,640**	**164,174**	**166,450**	**171,217**	**177,732**	**181,039**	**181,793**	**184,709**	**184,110**	**186,100**	**1.4%**
Others	38,260	38,089	36,090	33,543	29,872	26,424	24,362	25,159	24,453	24,078	23,822	-4.6%
Total	**199,567**	**198,729**	**200,264**	**199,993**	**201,089**	**204,156**	**205,401**	**206,952**	**209,162**	**208,188**	**209,922**	**0.5%**
Memo:												
Total Imports	*10,602*	*11,394*	*12,557*	*14,324*	*16,446*	*17,897*	*20,116*	*21,891*	*23,212*	*23,663*	*23,997*	*8.5%*

* Compounded annual growth rate.

Data Source: Adam 's Beer Handbook, 2003, 2004, and 2005.

TABLE 5.7 Selected Major Brewers and Importers, U.S. Market Share, 1994-2003

Brewers and Importers	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Anheuser-Busch	44.4%	44.0%	45.4%	45.7%	46.8%	47.4%	48.3%	48.5%	49.0%	49.6%	49.4%
Miller	22.7%	22.6%	21.9%	21.8%	21.2%	21.6%	20.7%	19.6%	19.1%	18.4%	18.5%
Coors	10.1%	10.1%	10.0%	10.3%	10.6%	10.8%	11.1%	11.0%	10.9%	10.8%	10.6%
HeinekenUSA	1.4%	1.5%	1.6%	1.7%	1.8%	1.9%	2.2%	2.3%	2.5%	2.5%	2.6%
Gambrinus	0.3%	0.5%	0.6%	1.0%	1.4%	1.7%	1.8%	2.1%	2.3%	2.4%	2.5%
Barton	0.5%	0.7%	0.8%	1.0%	1.3%	1.5%	1.7%	1.9%	2.0%	2.2%	2.2%
Labatt USA	1.1%	1.1%	1.2%	1.4%	1.6%	1.7%	1.9%	2.0%	2.1%	2.2%	2.4%
Beck's	0.3%	0.3%	0.3%	0.3%	0.4%	0.4%	0.4%	0.4%	0.3%	0.3%	0.3%
Sub-Total	**80.8%**	**80.8%**	**82.0%**	**83.2%**	**85.1%**	**87.1%**	**88.1%**	**87.8%**	**88.3%**	**88.4%**	**88.7%**
Others	19.2%	19.2%	18.0%	16.8%	14.9%	12.9%	11.9%	12.2%	11.7%	11.6%	11.3%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Memo:											
Total Imports	*5.3%*	*5.7%*	*6.3%*	*7.2%*	*8.2%*	*8.8%*	*9.8%*	*10.6%*	*11.1%*	*11.4%*	*11.4%*

Note: Boxes highlight the change in market share of the major beer importers in the U.S. market from 1994 to 2004.

Data Source: Adam's Beer Handbook, 2003, 2004, and 2005.

TABLE 5.8 Beer Shipments by Brand: Gambrinus v. Barton, U.S., 1997-2004

	1997	1998	1999	2000	2001	2002	2003	2004	CAGR* (1997-2004)
				(000 2.25-Gallon Cases)					
Gambrinus									
Corona Extra	19,180	27,896	34,871	39,395	46,354	50,229	52,528	54,248	16.0%
Corona Light	1,180	1,744	2,335	2,774	3,609	4,159	5,137	5,464	24.5%
Shiner Bock	2,600	3,013	3,129	3,221	3,355	3,195	3,166	3,234	3.2%
Modelo Especial	1,047	674	953	1,195	1,681	2,140	2,775	3,754	20.0%
Moosehead	1,600	1,535	1,637	1,787	1,924	1,730	1,628	1,575	-0.2%
Negra Modelo	324	418	442	548	718	792	869	978	17.1%
Pete's Wicked Ale	1,430	987	775	666	584	430	330	275	-21.0%
Pete's Wicked Summer Brew	1,210	919	639	454	451	345	190	-	-100.0%
Pete's Strawberry Blonde	500	406	341	333	348	320	281	239	-10.0%
BridgePort India Pale Ale	115	157	203	259	322	307	363	371	18.2%
Others	2,354	2,042	1,246	1,352	1,237	1,082	1,020	1,000	-11.5%
Total Gambrinus	31,540	39,791	46,571	51,984	60,583	64,729	68,287	71,138	12.3%
Total Modelo Products, Shipments by Gambrinus	21,731	30,732	38,601	43,912	52,362	57,320	61,309	64,444	**16.8%**
Percentage of Total Modelo Products Shipments by Gambrinus to Total Gambrinus Shipments	*69%*	*77%*	*83%*	*84%*	*86%*	*89%*	*90%*	*91%*	
Total Non-Modelo Products, Shipments by Gambrinus	9,809	9,059	7,970	8,072	8,221	7,409	6,978	6,694	**-5.3%**
Percentage of Total Non-Modelo Products Shipments by Gambrinus to Total Gambrinus Shipments	*31%*	*23%*	*17%*	*16%*	*14%*	*11%*	*10%*	*9%*	
Barton									
Corona Extra	20,220	26,000	30,629	34,510	38,765	41,044	43,577	43,682	11.6%
Modelo Especial	2,620	2,700	3,347	4,053	4,977	5,619	6,493	7,197	15.5%
Pacifico	1,174	1,300	1,700	2,684	3,168	3,215	3,583	3,809	18.3%
Corona Light	920	1,200	1,365	1,852	2,216	2,517	3,005	3,241	19.7%
St. Pauli Girl	1,850	1,800	1,750	1,988	2,105	2,268	2,329	2,467	4.2%
Negra Modelo	606	720	883	919	1,084	1,172	1,256	1,409	12.8%
Tsingtao	805	825	805	832	837	827	817	843	0.7%
Peroni	190	225	275	311	354	404	446	428	12.3%
St. Pauli Girl NA	165	174	200	251	289	325	360	389	13.0%
St. Pauli Girl Dark	215	200	200	215	216	211	206	202	-0.9%
Tetley's English Ale	-	-	50	106	112	117	101	-	-
Double Diamond	200	200	125	93	56	31	27	-	-100.0%
Total Barton	28,965	35,344	41,329	47,814	54,179	57,750	62,200	63,667	11.9%
Total Modelo Products, Shipments by Barton	25,540	31,920	37,924	44,018	50,210	53,567	57,914	59,338	**12.8%**
Percentage of Total Modelo Products Shipments by Barton to Total Barton Shipments	*88%*	*90%*	*92%*	*92%*	*93%*	*93%*	*93%*	*93%*	
Total Non-Modelo Products, Shipments by Barton	3,425	3,424	3,405	3,796	3,969	4,183	4,286	4,329	**3.4%**
Percentage of Total Non-Modelo Products Shipments by Barton to Total Barton Shipments	*12%*	*10%*	*8%*	*8%*	*7%*	*7%*	*7%*	*7%*	

* Compounded annual growth rate.

Data Source: Adam's Beer Handbook, 2003, 2004, and 2005.

Chapter 6 Consolidation in the Wine and Spirits Industry

Introduction

In this chapter, we illustrate the use of game theory insights in actual business situations, using the wine and spirits industry as the backdrop. We describe in some detail the actual market condition, laws, and major players in the industry. Using this information, we show how game theory models can be used profitably to help guide strategy.

Like the beer industry, the wine and spirits industry is heavily regulated. The wine and spirits industry has a three-tier system structure as well. The industry, from producers to consumers, has four levels of actors:

- Suppliers and importers of wine and spirits
- Wholesalers
- Retailers, bars and restaurants
- Consumers

We analyzed a game for the beer industry in the previous chapter, involving the top level of the three-tier system, Tier 1. In this chapter, we develop a case for Tier 2, the wholesalers segment of the industry.

Economic Structure of the Industry

In the U.S., each state regulates its own wine and spirits industry within the boundaries of the three-tier system. We discussed the three-tier system in the alcoholic beverages industry under the section "Regulated Alcoholic Beverages Industry and Three-Tier System in the U.S." in Chapter 5.

Although the three-tier structure has been adopted almost uniformly across the United States, there is much variation in its implementation among the various types of alcoholic beverages. Beer has the most consistent regulatory structure across the states. Typically, states have a large number of beer distributors, each with a local responsibility to distribute specific brands.

Wine and spirits, on the other hand, are often distributed by a much smaller number of distributors, or distribution agents for states. Wine distribution laws vary widely across the states. In some states, "direct shipping" of wines to adult consumers is allowed; in others, it is prohibited.

There are also differences among the states in the degree of regulatory control. Some states are considered "control" states, because they have a monopoly on the wholesaling or retailing of certain alcoholic beverages. In these states, the government itself is part of the distribution system, and heavily controls the industry, including pricing. Approximately one-fourth of the U.S. population lives in a control state. Approximately 18 states, and two Maryland counties, are considered control jurisdictions.[1] Other states, while regulating alcoholic beverage businesses extensively, do not actually control the business themselves. We call these states non-control states.

Distribution Arrangements in the Industry

Given the three-tier system, the distribution arrangements in the industry require contractual agreements among suppliers, wholesalers, and retailers. These have many common elements, although there is some variation by state.

The dominant form of business organization in this industry is that of local franchised wholesalers operating under agreement with a much smaller number of suppliers. The supplier produces different kinds of products which they brand

1. The National Alcoholic Beverage Control Association (NABCA) maintains a list of control jurisdictions. The enumeration of the control jurisdictions is current as of March 2008. The NABCA web site is: http://www.nabca.org.

differently and often advertise nationally or regionally. The individual wholesalers are given the rights to distribute these branded products in specific geographic areas. That specific market area might be a county or an entire state. The distribution agreements may provide exclusive representation in the area.

There are a number of reasons for this form of organization:

- The forcible separation of the supplier, wholesaler, and retailer in the industry;
- The importance of image and brand in consumer purchase decisions about alcoholic beverage;
- The relatively high cost of distributing beverages across large geographic areas, providing an incentive for a small number of wholesalers to service a large number of brands in each geographic area.
- The capital-intensive nature of manufacturing the products, which encourages large facilities run by manufacturers that ship the product to wholesalers across the country.

The Wine and Spirits Industry and Consolidation

The wine and spirits manufacturers and importers are dominated by a few major players, and have undergone sizable consolidation in the last decade. Although not as significant as the consolidation in the beer market, in 2004 approximately 60% of the volume for the wine industry came from four suppliers. Constellation Brands had 18.6% of the supplier sales, Gallo had 21.9%, The Wine Group had 12.8% and Foster's Wine Estates had 6.8%.[2] See Table 6.7, "Top Ten Suppliers of Wine by Sales, U.S., 2003 and 2004," in Appendix 6.A.

Constellation is one of the significant players in the consolidation of the wine industry with its acquisition of Fortune Brands' wine portfolio in 2007, Robert Mondavi and many other small acquisitions since the late 1990s. The large players not only have cost advantages and the ability to sustain an economic downturn, they also have favorable, and at times exclusionary, relationships with distributors.

Similar consolidation has occurred in the spirits industry, including Diageo's acquisitions, and the purchase of a significant portion of Seagram's spirit portfolio.[3] Five suppliers had approximately 60% of the U.S. spirits sales in 2005. Diageo was the largest supplier with 22.9% of the spirits consumption in 2005, Beam Global Wine and Spirits had 10.5%, Constellation Brands had 9.9%, Bacardi USA had 9.4%, and

2. Adam's Beverage Group, *Wine Handbook 2005*.

3. In 2001, Diageo and Pernod Ricard were given approval from the FTC to jointly purchase Seagram's brands. The brands assigned to Diageo included Crown Royal, Seagrams V.O., 7 Crown, Captain Morgan and Myers's Rum. We discuss the use of game theory in anti-trust in Chapter 9.

Pernod Ricard USA had 7.8%.[4] These large companies, particularly Diageo and Constellation, have divested other businesses to concentrate on the lucrative, high-margin spirits industry. See Table 6.8, "Top Ten Suppliers of Spirits by Volume, U.S., 2005," in Appendix 6.A.

In the global market, U.S. distillers and vintners have benefited from exporting wines and spirits to other countries. These international wine markets are opening up, and U.S. wine and spirits exports have been growing at about 10% per year, due to increased marketing, changing consumer preferences, and the weak dollar.[5] The market price for wine and spirits in the U.S. is likely to be more affected in the future by this foreign demand for U.S. products.

Consolidation at Wholesaler Level

Industry consolidation has not been limited to the manufacturers and importers. It has also occurred at the wholesaler level. There are fewer distributors in the wine and spirits industry than beer industry in most of the states. Industry conditions, such as tougher competition and smaller profit margins, push wholesalers to consolidate in their segment further. As John Goff indicated in his article in CFO Magazine, "...a wave of consolidation has dramatically pared the number of U.S. wholesalers. Big market states such as Illinois and Florida now have 2 major distributors where before there were a dozen.[6]" The top 10 wine and spirits wholesalers in the U.S. have a 60% market share of the wine and spirits distribution.[7] Among wine distributors, the number of distributors has dropped dramatically in the past decade and a half, primarily due to consolidations, and now falls between 700 and 800. By contrast, there are approximately 5,000 domestic producers, most of whom are small.[8]

The industry has fewer and fewer wine and spirits wholesalers in major markets, such as New York City, and Chicago. Suppliers have been pushing wholesalers for consolidation, because of the law of economics of scale and efficiency of more consolidated market.

In this chapter, we will build a model analyzing consolidation in the suppliers segment and wholesalers segment. We will show that consolidation among wine and spirits suppliers in Tier 1 affects wholesalers in Tier 2, and trigger further consolidation in local markets.

4. Adam's Beverage Group, *Liquor Handbook 2006*.
5. Hong, Judy E., et al., "Industry Primer 2007, United States: Beverages," Goldman Sachs Group, Inc., April 17, 2007.
6. Goff, John, "Days of Wine and Mergers," *CFO Magazine*, December 1, 2005.
7. Goff, John, "Days of Wine and Mergers," *CFO Magazine*, December 1, 2005.
8. Barbara Insel, "The US Wine Industry," *Business Economics*, vol. 43 no. 1, January 2008.

Recent M&As and Business Ventures in Major Markets at Wholesaler Level

There have been many mergers and acquisitions (M&As), and joint ventures realized among wine and spirits wholesalers in the recent decade. Most recently, 2008 was a very dynamic and active year of transactions among wholesalers. Some of those transactions are small-sized ones. We list some of the key transactions among the large wholesalers in the major markets or in the U.S. below to show the consolidation trend in the wine and spirits industry at wholesaler level:

- In 2004, Eber Bros., Paramount Brands and National Distributing Company formed a joint venture for distributing of wine and spirits in metropolitan New York.[9]
- Southern Wine & Spirits (SWS) purchased the assets (100%) of Premier Wine & Spirits of New York as well as their western New York distribution company, Letchworth Wine & Spirits in 2004. A year after, SWS bought New Jersey based premium wine importer/distributor, Lauber Imports, operating in New York, New Jersey and Pennsylvania.[10]
- In August 2006, Glazer's Distributors announced that the company has exercised its right to purchase 100% of the assets of Chicago-based Union Beverage Company from NWS-Illinois, LLC. Union Beverage Company was owned by NWS-Illinois and was operated and managed by Glazer's Distributors of Illinois, Inc. when the transaction occurred.[11]
- In 2006, The Charmer Sunbelt Group and Peerless Importers combined their Metro New York operations and created subsidiary/new company called Empire Merchants, LLC, which would be owned equally by the parties.[12]
- Republic Beverage Company (RBC) and National Distributing Company (NDC) combined their businesses to form a new entity, RNDC. This transaction created the second largest distributor of premium wine and spirits in the U.S. The parties made the announcement of the merger on May 1, 2007.[13]
- In July 2008, Judge & Dolph and Union Beverage entered into a joint venture that will result in the two companies controlling over 90% of Illinois's wine and spirits wholesaling.[14]
- Southern Wine & Spirits of America and Glazer's Distributors have formed a strategic joint venture for wine and spirits in 2008. The combined company covers the 38 states. These states are representing slightly more than 80% of the total wine and spirits volume in the entire United States.[15]

9. "Jocks & Jills Sports Bar Looking to Franchise," *Atlanta Business Chronicle*, September 24, 2004.
10. "Southern Wine & Spirits of America Inc. Enters New York Marketplace," PR Newswire Association, October 11, 2004. Southern Wine Buys Lauber Imports," *South Florida Business Journal*, February 2, 2005.
11. "Glazer's Exercises Right to Purchase Union Beverage Company," WineBusiness.com, August 7, 2006.
12. "Major Wine Distributors Charmer, Peerless Team Up in New York." WineBusiness.com, July 7, 2006.
13. RNDC's Corporate Web Site.
14. "Wirtz Family's Judge & Dolph Teams with Union Beverage," *Chicago Tribune*, March 29, 2008.
15. "Southern and Glazer's Merge," *Wine & Spirits Daily*, August 12, 2008.

- On December 18, 2008, Wirtz Beverage Group and Young's Market Co. announced that two companies have entered into a joint venture. The business venture will make them the fourth largest distributor, to be completed in the first quarter as of 2009. Young's largest market is the state of California, but also operates in nine other Western states.[16]

A Hypothetical Consolidation

Using the industry condition, businesses, and laws described above, we now describe a game theory model that illustrates certain strategic decisions the industry participants face. In the example below, the "rules" of the game include the continuation of the three-tier system, and the continuation of the existing state laws regarding the distribution of wine and spirits. The state of nature includes the industry participants, trends in both distribution agents and consumer preferences, and prices in the industry relative to consumer income.

Suppose we have a market with three wine and spirits suppliers, four wholesalers, and six brands (A-F). Products suppliers provide and wholesalers distribute are listed below:

TABLE 6.1 Sample Market of Wine and Spirits, before Consolidation

	Wholesaler i	**Wholesaler ii**	**Wholesaler iii**	**Wholesaler iv**
Supplier I	A, B			F
Supplier II		C		
Supplier III			D	E

Supplier I provides products A, B and F, Supplier II provides product C, and Supplier III supplies products D and E.

Wholesaler i distributes products A and B, Wholesaler ii distributes C, Wholesaler iii distributes D and the last wholesaler distributes E and F products.

Let us assume that Supplier I acquires Supplier II. This transaction triggers a consolidation in our sample market. After the acquisition, Supplier I terminates distribution rights of Wholesaler ii, and assigns distribution rights of product C to Wholesaler i (or pushes Wholesaler ii to sell its distribution rights to Wholesaler i). We assume Wholesaler ii does not have enough leverage against consolidation pressures due to the special structure of the industry, and lets its distribution rights go to Wholesaler i, with or without compensation.

16. "Wirtz Beverage Group, Young's Market Co. Agree to Joint Venture," *Chicago Tribune*, December 18, 2008.

After Supplier I's acquisition of Supplier II, our sample market has two suppliers and three wholesalers. The new market schematic is provided below:

TABLE 6.2 Sample Market of Wine and Spirits, after Supplier I's Acquisition of Supplier II

	Wholesaler i	Wholesaler iii	Wholesaler iv
Supplier I	A, B, C		F
Supplier III		D	E

After the consolidation, Wholesaler i and Supplier I's products gain market dominance. Supplier II's acquisition by Supplier I and Wholesaler ii's market exit may bring further consolidation at wholesaler level.

At this juncture, the market dominance (power) of Supplier I and Wholesaler i forces a strategic decision. Supplier III has its products split among wholesalers, while its competitors have more focus from their wholesalers. It is likely that Supplier III would ask two wholesalers (iii and iv) distributing its products in the sample market to consolidate their operations. That might be a merger, acquisition, or some kind of business venture. With such a transaction, Supplier III would have a more efficient distribution network, and the new wholesaler (a business venture between Wholesalers iii and iv) would have more market power and create some level of economies of scale for its operations.

Assuming such transactions did occur, the sample market would have two suppliers and two wholesalers after the consolidation occurred in the market, triggered by Supplier I's acquisition of Supplier II. Table 6.3 shows the new market distribution schematic.

TABLE 6.3 Final Version of the Sample Market after the Sequence of Consolidations

	Wholesaler i	Joint Venture between Wholesalers iii and iv
Supplier I	A, B, C	F
Supplier III		D, E

How would these transactions, which involve multiple businessess and business owners, actually occur, and why? We can use a game theory model to figure out the likelihood of such events transpiring. To reach the market structure illustrated in Table 6.3, after the initial transactions, Supplier III, and Wholesalers iii and iv play a game described in the next section.

Description of the Consolidation Game

We described a hypothetical consolidation scenario above. Originally, our sample market had three wine and spirits suppliers, four wholesalers, and six brands. After Supplier I's acquisition of Supplier II, and termination of distribution rights of Wholesaler ii, our sample market transformed into a new market with two suppliers and three wholesalers. See Table 6.2, "Sample Market of Wine and Spirits, after Supplier I's Acquisition of Supplier II," After these transactions, our sample market became more consolidated, and Supplier I and Wholesaler i gained more market power and dominance. In response to these changes, Supplier III and Wholesalers iii and iv should restructure their business arrangement in that specific market.

We develop a cooperative game of perfect information between Supplier III, Wholesaler iii, and Wholesaler iv to respond to transactions occurred in the market area. To reach the market structure illustrated in Table 6.3, "Final Version of the Sample Market after the Sequence of Consolidations," to be competitive in the new market structure, Supplier III and Wholesalers iii and iv have to act strategically. Specifically, they play the following games:

- A sequential-move game of perfect information between Supplier III and two wholesalers, and
- A non-cooperative simultaneous-move game of imperfect information between Wholesalers iii and iv.

Market Share and Power

Suppose that we have the following market share allocation for consumption of wine and spirits brands in the sample market:

TABLE 6.4 Consumption Market Share of Brands in the Sample Market

A	B	C	D	E	F
26%	10%	18%	22%	18%	6%

Based on this allocation, the market share of suppliers and wholesalers, before and after Supplier I's acquisition of Supplier II and termination of the distribution rights of Wholesaler ii, are illustrated in Table 6.5.

TABLE 6.5 Market Shares after Initial Transaction

Market Share of Suppliers (%)

	Before	After
I	**42**	**60**
II	18	-
III	40	40

Market Share of Wholesalers (%)

	Before	After
i	**36**	**54**
ii	18	-
iii	22	22
iv	24	24

After the transactions led by Supplier I, its market share in the specific market increased from 42% to 60%. Wholesaler i's market share increased substantially as well, from 36% to 54%. This situation triggers further consolidations in the market; because, as a response to the higher market power of Supplier I and Wholesaler i, other players in the market need to improve their competitiveness.

The New Market and Strategic Issues

Given the structure imposed by the three-tier system, the appointment of wholesalers is a critical decision for suppliers. As they cannot sell directly to the ultimate consumers, the wholesaler and the retailer are the "face" and delivery agent for the consumer. As the supplier does not interact directly with the retailer, the quality of the wholesaler network is an overriding concern. Suppliers therefore have an enormous interest in maintaining a well-running distribution network that is both efficient and effective.

Supplier III, like other suppliers, capitalizes on its brands in its distribution strategy. As the wine and spirits business is a competitive one among suppliers, suppliers encourage their wholesalers to earn as much "shelf space" in retailers as possible. Wholesalers with larger volumes find it easier to gain "shelf space" from retailers. Given this industry characteristic, Supplier III has a strong incentive to combine the distribution of its brands (products D and E in this case).

Reducing the relative percentage of Supplier III products (relative to Supplier I's share) shipped to various wholesalers in the market would seriously reduce the ability of the supplier to gain the critical attention of its wholesalers. Reduced attention, in this competitive sales-oriented business would seriously hamper the sales of its products. Even if Supplier III's wholesalers wanted to encourage sales of Supplier III products, the wholesaler would have less leverage on its retailers without the strength of the consolidated portfolio of brands.

Therefore, ensuring that wholesalers have adequate resources and enough volume to have leverage with retailers is a strategic, well-established concern of Supplier III. Note that the primary goal of Supplier III here is an efficient distribution network, competing against the distributing network of Supplier I effectively given the new market and business conditions.

Before the transactions of Supplier I (acquisition of Supplier II and termination of Wholesaler ii), Wholesaler i was the market leader with 36% of the market share, followed by wholesalers iv and iii, with 24% and 22% of the market share, respectively. After the transactions, Wholesaler i's market share increased to 54%. As the largest company in the specific market, Wholesaler i will benefit disproportionately from economies of scale. For instance, the operating profit of Wholesaler i could be more than twice that of Wholesalers iii and iv. Wholesaler i could also realize sizable cost savings on the marketing and administrative level. Wholesaler i's advertisement cost per unit sale could be much smaller than those of the two smaller companies.

The dominant wholesaler in our sample market is now Wholesaler i, and its plausible aggressive approach in the market affect the other wholesalers. Wholesaler i's product strategy, distribution strategy, and investments in the market will affect the players of our game.

The other wholesalers should try to follow similar aggressive strategies, but the economics of the wine and spirits distribution business, and the fact that none are as large as Wholesaler i, will not allow them to influence the retailers as effectively.

Indeed, some industry specialists have stated that, in order to remain viable and competitive, a wholesaler has to capture at least a 25% market share, in a given territory.[17] As a result of these factors, most geographic markets of significant population density have two or three wholesalers. Hence, microbrewers, imports and smaller brands face difficulties in getting the attention of the wholesalers to effectively pursue their marketing strategies. As the competition for retail self space has intensified, achieving "critical mass" for a wholesaler's brands has become more important.

The separation imposed by the three-tier system strongly affects the reliance by the suppliers on sales efforts by the middle tier. Suppliers can establish brand image through advertising and other marketing to consumers, but cannot effectively sell their products to retailers that sell to those same consumers. They rely on wholesalers in the middle tier to perform this vital task. Given the importance of ensuring a consistent representation of the brand throughout the region, suppliers almost

17. "Lite Hand," *Beverage World*, February 2000, pages 32, 33, 34-36.

always reserve the right to approve the transfer of distribution rights to another wholesaler. This is the case with Supplier III and its wholesalers, as it is with other suppliers and their wholesalers.

In many states, contractual right of the supplier to select qualified wholesalers or transfer distribution rights is implicitly or explicitly recognized by statutes, although limited to the use of reasonable factors with a genuine commercial basis.

Players' Strategies and Information

In this game, Supplier III wants to achieve a more efficient and effective distribution network after the initial transactions by Supplier I. To achieve its primary goal, Supplier I will push some sort of consolidation of its distribution network. That might be a merger or acquisition, or a business venture between Wholesalers iii and iv. If wholesalers are not willing to cooperate, Supplier III will terminate one of its wholesalers (possibly compensating them for loss of distribution rights). Supplier III might terminate one of its wholesalers, without trying to push a transaction between wholesalers.

Therefore, Supplier III's set of strategies is the following:

$S = \{P, T_{iii}, T_{iv}\}$, where P is asking wholesalers to have some sort of business venture willingly, T_{iii} is terminating distribution rights of Wholesaler iii, and T_{iv} is terminating distribution rights of Wholesaler iv.

We assume our game for this case is a game of perfect, complete information for Supplier III's actions and moves.

Wholesalers iii and iv's best interest is also to have more efficient distribution network to compete with Wholesaler i effectively. To do that, they need to have economies of scale and more efficiency. We assume that they know the strategies of the supplier and his moving sequence. They know that if they cooperate and found some sort of business venture, Supplier III will honor the new entity or venture with renewed distribution rights. If they do not cooperate, Supplier III will terminate one of the wholesalers.

Wholesalers iii and iv will have a non-cooperative simultaneous-move game of imperfect information with the same set of strategies:

$W_n = \{C, NC\}$, where n = 1, 2, C is cooperating with each other, NC is not cooperating.

Note that Wholesaler iii and Wholesaler iv are almost identical. Their market share is very close to each other, 22% and 24%, respectively (See Table 6.5). The major difference between them is that, unlike Wholesaler iii, Wholesaler iv is a distributor of both Supplier I and Supplier III (See Table 6.1). The extensive form of the game between the supplier and wholesalers is illustrated in Figure 6.1.

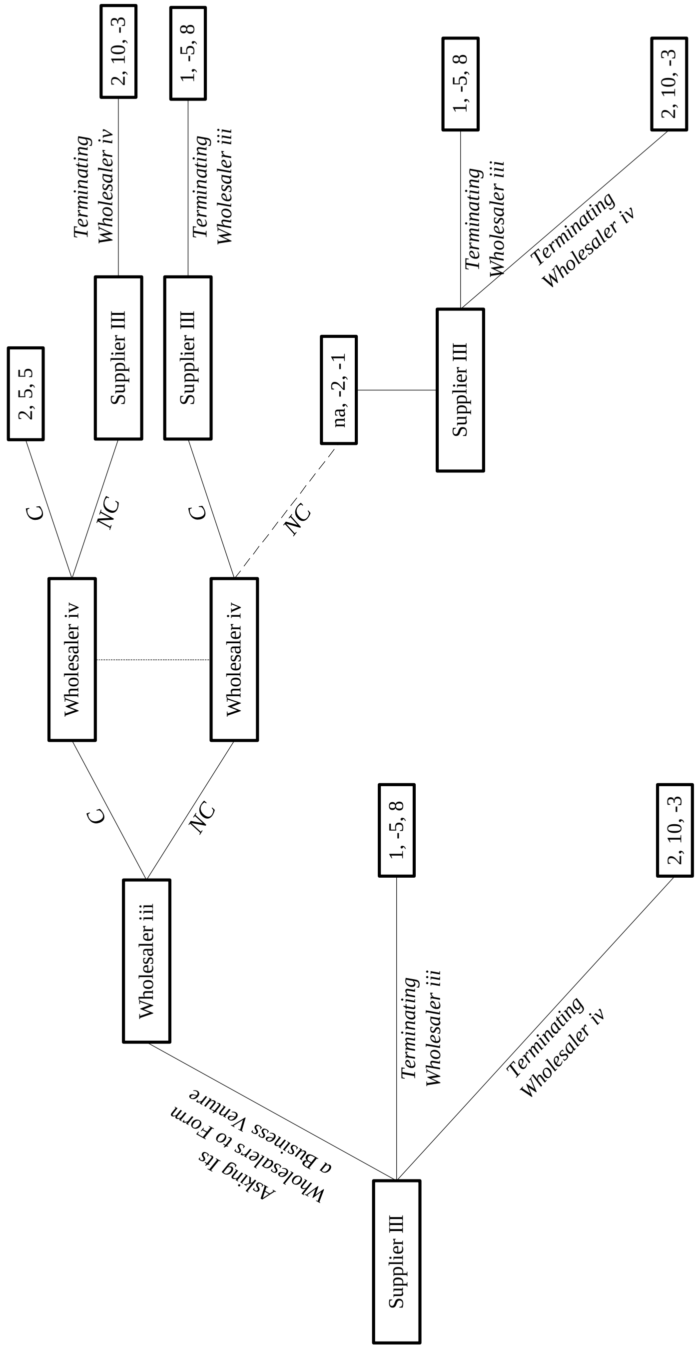
Analysis of the Game

At the beginning of the game, Supplier III has three possible actions: asking wholesalers to form a business venture, including a merger and acquisition; terminating Wholesaler iii's distribution rights; or terminating Wholesaler iv's distribution rights.

If the supplier terminates distribution rights of one of the wholesalers, the game ends there. Otherwise, the game reaches the upper branch of the tree diagram. Then, wholesalers play a simultaneous-move game of imperfect information.

We use backward induction here to solve our game between Supplier III and wholesalers. Thus, we need to analyze the simultaneous-move game between Wholesalers iii and iv first, before we solve the game illustrated in Figure 6.1, "Extensive Form of the Game between Supplier III and Wholesalers iii and iv."

FIGURE 6.1 Extensive Form of the Game between Supplier III and Wholesalers iii and iv



Simultaneous-Move Game between Wholesalers iii and iv

After Supplier III's move, Wholesalers iii and iv are left with a simultaneous-move game with a strategy set of {*Cooperate (C)*, *Non-cooperate (NC)*}. The payoff matrix of this game is provided in Table 6.6 below.

TABLE 6.6 Normal Form of the Game between Wholesalers iii and iv

		Wholesaler iv	
		C	*NC*
Wholesaler iii	*C*	(5, 5)	(10, −3)
	NC	(−5, 8)	(−2, −1)

Wholesalers know that if they do not cooperate, Supplier III terminates one of the wholesalers. However, they do not know which one is terminated.

If one picks cooperation, and the other non-cooperation, Supplier III will observe this and punish the one who picks non-cooperation.

However, Wholesaler iv is in a better situation. Unlike the other wholesaler, it distributes another supplier's products (Supplier I's F products).

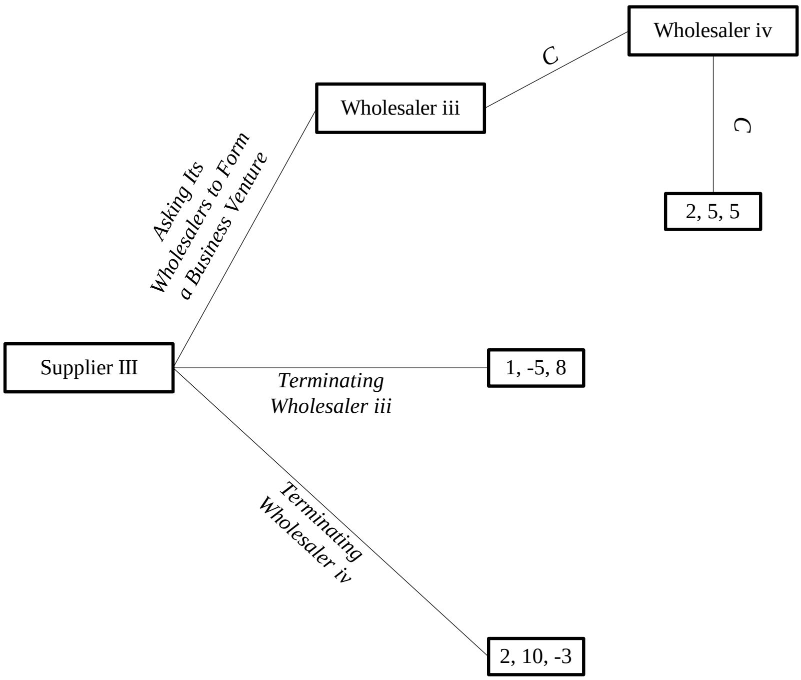
The payoff matrix shows that cooperation is a dominant strategy for both Wholesaler iii and Wholesaler iv. Since Supplier III's threat is credible, both wholesalers most likely pick the cooperation strategy.

The simultaneous-move game between wholesalers has a dominant strategy equilibrium: (*Cooperate*, *Cooperate*).

Sequential Move Game between Supplier III and Wholesalers iii and iv

Let us go back to our extensive form game between Supplier III and wholesalers illustrated in Figure 6.1. The upper branch of the game results with a cooperation between wholesalers. Supplier iii is informed that wholesalers have some sort of business venture, and agree that they form a new business entity, which creates a more efficient and effective distribution network. The new version of the extensive form game, based on the equilibrium outcome of the simultaneous-move game between wholesalers, is illustrated below:

FIGURE 6.2 Extensive Form of the Game after the Simultaneous-Move Game between Wholesalers



By using backward induction, Supplier III figures out that it has the following outcomes based on the strategies he picks:

- ***2***, by assigning distribution rights of its products D and E to the new entity formed by wholesalers iii and iv
- ***1***, by terminating distribution rights of Wholesaler iii, and assigning distribution rights of products D to Wholesaler iv.
- ***2***, by terminating distribution rights of Wholesaler iv, and assigning distribution rights of product E to Wholesaler iii.

Since assigning distribution rights of its products to the new entity generates the same outcome with terminating distribution rights of Wholesaler iv, we have two equilibria in this game.

Why would Supplier III terminate Wholesaler iv? The answer is very straightforward: Supplier III's main objective here is to have a more efficient distribution network, as a strategic response to the initial consolidations by Supplier I. Having only one but a stronger wholesaler in the market is another way of creating an effective distribution network for Supplier III. Supplier III does not really care what entity distributes its products in the market area as long as its objective of more efficient distribution network is achieved.

Why does Supplier III pick Wholesaler iv for termination, but not Wholesaler iii? Wholesaler iv distributes products of both suppliers I and III. Strategically, it makes more sense for Supplier III to get rid of a wholesaler distributing also its competitor's products. As we discussed above, in the alcoholic beverages industry, it is common for suppliers to expect their wholesalers to concentrate more on their own products, and put more of their efforts for marketing and fighting for "shelf space" in retail stores. After terminating distribution rights of Wholesaler iv, Supplier III will have only one wholesaler in the market; and its only distributor, Wholesaler iii, will have a strong position in the market, with a market share of 40%.

Conclusion

We established and analyzed a cooperative game in the wine and spirits industry. Properly defining the game required outlining important industry structure, legal, and business factors. Our analysis showed the rationale and strategic reasoning of the industry fact that a consolidation at supplier level often triggers further consolidations in local markets among wholesalers.

Since the industry is very competitive, and the distribution network is crucial for a success or failure of a supplier, the main objective of suppliers is to have an efficient and effective distribution network in state and local markets. To achieve this objective, suppliers need to act strategically to respond to industry events and their competitors' moves. Sometimes their strategic moves force their wholesalers to establish business ventures, mergers or acquisitions in state and local markets.

Appendix 6.A

TABLE 6.7 Top Ten Suppliers of Wine by Sales, U.S., 2003 and 2004

Total Wine Volume and Sales, U.S., 2003

(000 9 Liter Cases)

		Volume		Supplier Sales Dollars	
		Cases	Share	$ Millions	Share
1	E & J Gallo Winery	58,805	22.8%	$ 1,176	15.7%
2	Constellation Brands	39,683	15.4%	$ 980	13.1%
3	The Wine Group	31,685	12.3%	$ 805	10.7%
4	Beringer Blass Wine Estates	12,474	4.8%	$ 593	7.9%
5	Robert Mondavi Winery	9,049	3.5%	$ 441	5.9%
6	Kendall-Jackson Wine Estates	4,650	1.8%	$ 346	4.6%
7	Brown-Forman Beverages	5,602	2.2%	$ 316	4.2%
8	Trinchero Family Estates	8,004	3.1%	$ 244	3.3%
9	Southcorp Wines USA	4,679	1.8%	$ 240	3.2%
10	Allied Domecq Wines USA	2,594	1.0%	$ 202	2.7%
	TOP 10 TOTAL	**177,225**	**66.1%**	**$ 5,343**	**67.6%**
	TOTAL WINE	***258,250***	***100.0%***	***$ 7,500***	***100.0%***

Total Wine Volume and Sales, U.S., 2004

(000 9 Liter Cases)

		Volume		Supplier Sales Dollars	
		Cases	Share	$ Millions	Share
1	Constellation Brands	49,850	18.6%	$ 1,460	18.5%
2	E & J Gallo Winery	58,670	21.9%	$ 1,180	14.9%
3	Foster's Wine Estates Americas	18,360	6.8%	$ 895	11.3%
4	The Wine Group	34,415	12.8%	$ 880	11.1%
5	Kendall-Jackson Wine Estates	4,758	1.8%	$ 355	4.5%
6	Brown-Forman Beverages	5,328	2.0%	$ 310	3.9%
7	W.J. Deutsch & Sons	8,016	3.0%	$ 257	3.3%
8	Trinchero Family Estates	8,272	3.1%	$ 252	3.2%
9	Allied Domecq Wines USA	2,823	1.1%	$ 220	2.8%
10	Banfi Vintners	6,570	2.5%	$ 197	2.5%
	TOP 10 TOTAL	**197,062**	**73.5%**	**$ 6,006**	**76.0%**
	TOTAL WINE	***268,062***	***100.0%***	***$ 7,900***	***100.0%***

Data Source: Adams Beverage Group, *Wine Handbook*, 2004 and 2005.

TABLE 6.8 Top Ten Suppliers of Spirits by Volume, U.S., 2005

Total Spirits Volume and Sales, U.S., 2002

(000 9 Liter Cases)

	Volume		Supplier Sales Dollars	
	Cases	Share	$ Millions	Share
1 Diageo	30,739	20.0%	$ 2,873	21.2%
2 Allied Domecq Spirits USA	12,041	7.9%	$ 1,237	9.1%
3 Bacardi USA	11,940	7.8%	$ 1,076	7.9%
4 Schieffelin & Somerset	5,841	3.8%	$ 1,035	7.6%
5 Brown-Forman Beverages	10,801	7.0%	$ 1,025	7.6%
6 Jim Beam Brands/Future Brands	14,598	9.5%	$ 906	6.7%
7 Constellation Brands	14,856	9.7%	$ 701	5.2%
8 Absolut Spirits Co./Future Brands	4,503	2.9%	$ 594	4.4%
9 Pernod Ricard USA	5,230	3.4%	$ 586	4.3%
10 Heaven Hill Distilleries	7,408	4.8%	$ 441	3.3%
TOP 10 TOTAL	**117,957**	**76.9%**	**$ 10,474**	**77.4%**
TOTAL SPIRITS	***153,317***	***100.0%***	***$ 13,540***	***100.0%***

Total Spirits Volume and Sales, U.S., 2005

(000 9 Liter Cases)

	Volume		Supplier Sales Dollars	
	Cases	Share	$ Millions	Share
1 Diageo	38,958	22.9%	$ 4,177	23.7%
2 Bacardi USA	15,930	9.4%	$ 1,704	9.7%
3 Pernod Ricard USA	13,289	7.8%	$ 1,465	8.3%
4 Beam Global Wine and Spirits	17,808	10.5%	$ 1,457	8.3%
5 Brown-Forman Beverages	11,215	6.6%	$ 1,171	6.6%
6 Constellation Brands	16,094	9.5%	$ 835	4.7%
7 Absolut Spirits Co.	4,767	2.8%	$ 712	4.0%
8 Moet Hennessy USA	3,100	1.8%	$ 681	3.9%
9 Heaven Hill Distilleries	8,130	4.8%	$ 538	3.1%
10 Skyy Spirits USA	3,562	2.1%	$ 401	2.3%
TOP 10 TOTAL	**132,853**	**78.0%**	**$ 13,141**	**74.6%**
TOTAL SPIRITS	***170,296***	***100.0%***	***$ 17,620***	***100.0%***

Data Source: Adams Beverage Group, *Liquor Handbook*, 2003 and 2006.

Chapter 7 A Regulatory Game: CAFE Standards and Competing Automakers

Introduction[1]

In many classic strategy games, the government is a neutral party that sets the rules and then enforces them. Of course, part of the *rationale* for a government is the need for someone to set rules and enforce them. As nearly all taxpayers in a democracy eventually learn, governments have a hard time remaining neutral when political power, interest groups, money, and influence are at stake.

In many business settings, government laws or regulations help one set of employers at the expense of others. Entire categories of examples exist just in the United States: federal highway appropriations are not uniformly distributed among states, nor distributed on the basis of either miles traveled or weather-induced costs of maintenance; the location of military bases reflect political power as much as current geopolitical realities; subsidies for farms, crops, and groups are approved by vote-seeking legislators that receive campaign contributions from the same individ-

1. This chapter is a based on the paper of Ilhan K. Geçkil, “Competitive Response to CAFE Standards,” published in *Business Economics*, in 2003. It has been extensively revised.

uals that benefit from the subsidies; often-arcane tax law provisions can mean large differences in tax bills for similar companies.

Lobbying and Game Theory

Such differential effects will not surprise many readers. Achieving advantages through laws and regulations is often an explicit *goal* of lobbying efforts by trade unions, businesses, or activist groups.

Lobbying has been around a long time. Shakespeare's plays (such as *Julius Caesar*) describe those near to power and hoping to gain influence; biblical accounts of ancient courts note the accompanying magicians, advisors, courtesans, and petitioners. Other masterpieces of ancient literature, such as the Indian *Arthashastra* written by the Indian sage Kautilya around the second century BC, also testify to the ubiquity of influence peddling.

The verb "lobby" comes from the practice of influencing peddlers standing around in the lobby of a hotel or government building, in the hopes of engaging an official in a little discussion on a matter of interest.[2]

Lobbying as Part of the Game

Because so many classic game theory models involve a neutral or uninvolved government, it may surprise some game theorists to see lobbying described as part of the game itself. However, if game theory is to serve strategists, it must expand to include all stratagems. Thus, it is essential to consider the potential of persons involved in a strategic battle to affect the actions of one or more governments.

In this chapter, we discuss a longstanding, very important U.S. government program: corporate fuel economy standards. Many people would view these regulations as neutral among manufacturers, and indeed the specific goal was to improve fuel economy among all manufacturers. However, we will show that the *effect* of the regulations has been quite different among the various automakers. The corporate average fuel economy (CAFE) story is an instructive example of the potential for government agencies, by commission or omissions, to dramatically affect the marketplace even as it pursues an ostensibly neutral goal.

2. Various accounts place the original "lobby" as the Willard hotel near the White House, in the time of President Abraham Lincoln or President Ulysses S. Grant; or the Parliament in Great Britain.

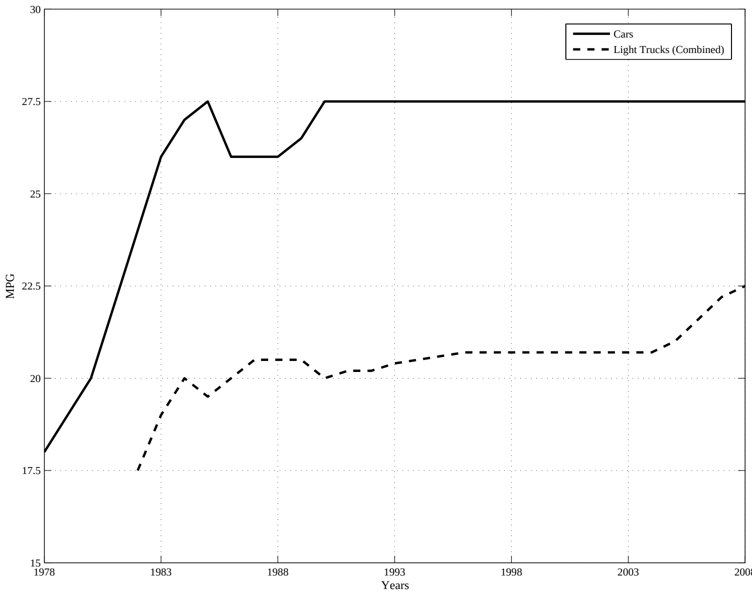
History of Corporate Average Fuel Economy (CAFE)

Corporate Average Fuel Economy (CAFE) standards set the average miles per gallon (mpg) that the fleet of light vehicles sold by a manufacturer in the United States must attain. CAFE was established by the Energy Policy and Conservation Act (EPCA) in 1975 to reduce U.S. dependence on foreign oil.[3] The oil shocks of the early 1970s, along with the Nixon-era price controls, caused small-scale supply disturbances to result in a large-scale oil shortages and a large price shock in October 1973. Under these special circumstances, lawmakers agreed upon the policy goals of restraining consumption and imports, and protecting consumers from gas price volatilities.[4] After a series of debates regarding market solutions versus mandate solutions, President Ford signed the EPCA, which enacted CAFE in December 1975.

Implementation of CAFE standards began in 1978 with the passenger car level at 18.0 mpg. The standards for light trucks were implemented in 1979 with 2WD light trucks at 17.2 mpg and 4WD light trucks at 15.8 mpg. The standards for both cars and light trucks increased nearly every year. By 1990, the CAFE standard for passenger cars was 27.5 mpg, where it remains today. In 1992, there no longer were 2WD and 4WD levels, but simply a combined light truck standard. From 1996 to 2004, the combined light truck standard was 20.7 mpg. As of the beginning of 2008, the standard for light trucks was 22.5 mpg.[5] (For the historical trend of CAFE standards, see Figure 7.1).

3. Walton, Tom, "CAFE: A Solution in Search of a Problem: History, Economics and Politics," Tenth Annual Automotive Outlook Symposium, Federal Reserve Bank of Chicago, May 29, 2003.
4. Walton, Tom, "CAFE: A Solution in Search of a Problem: History, Economics and Politics," Tenth Annual Automotive Outlook Symposium, Federal Reserve Bank of Chicago, May 29, 2003.
5. *Summary of Fuel Economy Performance*, U.S. Department of Transportation, NHTSA, November 2008.

FIGURE 7.1 Historical CAFE Standards for Cars and Light Trucks (Combined), Model Years 1978 through 2008

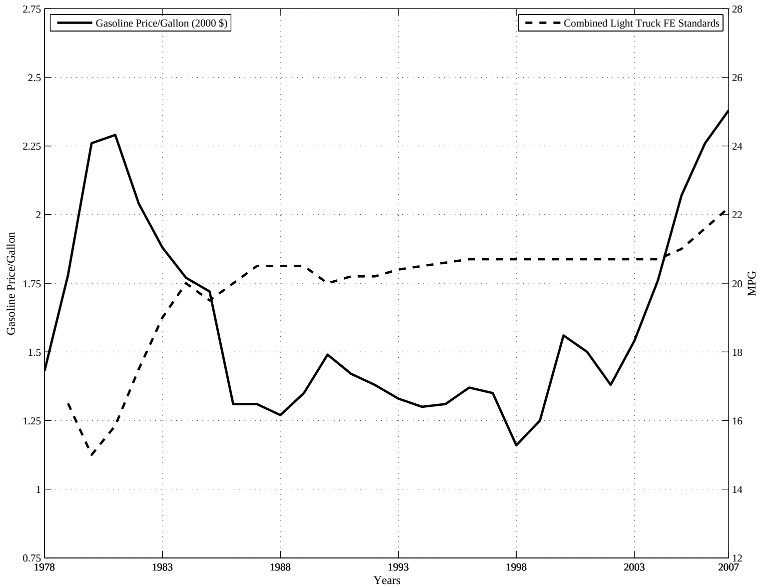


Data Source: National Highway Traffic Safety Administration

Although it was not well known by consumers, a number of auto manufacturers chose not to meet the standards, but instead paid fines to the U.S. government. These were lower-volume luxury carmakers that implicitly passed along the cost of the fines to consumers.

In 1981, when President Reagan eliminated oil price controls, gas prices were quick to decrease to the levels seen when CAFE regulation was enacted (see Figure 7.2).

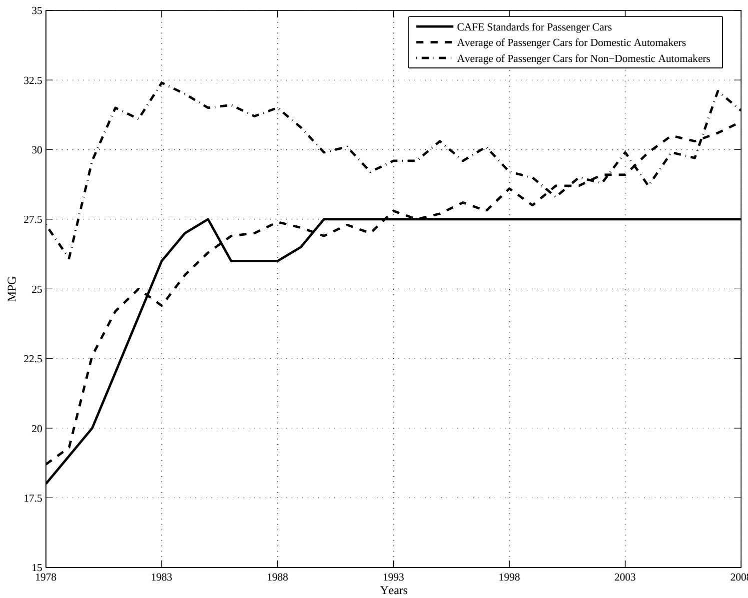
FIGURE 7.2 Real Gas Prices v. Combined Light Trucks CAFE Standards



Data Source: Energy Information Administration (EIA), Department of Energy; National Highway Traffic Safety Administration

Since the early 1980s, non-domestic automakers have had a fuel economy advantage over domestic automakers. This advantage stemmed from non-domestic automakers concentrating on smaller cars and trucks. However, that advantage eroded significantly in the 2000s, because domestic vehicles became more fuel efficient, and because Japanese and other non-domestic automakers began shifting to large vehicles (see Figure 7.3).

FIGURE 7.3 Domestic v. Non-Domestic Passenger Car Fuel Economy Averages



Data Source: National Highway Traffic Safety Administration

National security concerns, increasing oil prices in 2007 and 2008, energy dependence on OPEC countries, as well as global climate change triggered recent discussions about CAFE. Recent debates and CAFE proposals focused on increasing the standards, especially those for light trucks. Light trucks have been the focus due to the loophole in the 1975 law and the fact that the CAFE standard for passenger cars is generally considered acceptable. Auto manufacturers had been growing significantly in the light-truck segment until 2007.[6] As of 2007, light trucks accounted for about 58.3% of GM sales, 66.9% of Ford sales, and 68.3% of Chrysler sales. Light trucks' share as of total light vehicle sales for Toyota, Honda, and Nissan are relatively lower at 42.2%, 43.1%, and 40.5%, respectively.

The standard for light trucks was held to 20.7 mpg from 1996 to 2004. On March 31, 2003, The National Highway Traffic Safety Administration (NHTSA) issued new light truck standards: 21.0 mpg for model year (MY) 2005, 21.6 mpg for MY 2006, and 22.2 mpg for MY 2007. In 2006, NHTSA issued light truck standards for

6. According to the *Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards, 2002* report of the Committee on the Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards et al.: "In 1984 minivans were introduced and by 1990 were selling nearly a million units annually. Then came four-door SUVs and pickup trucks with passenger-friendly features such as extra rows of seats. SUV sales increased from fewer than 1 million units in 1990 to 3 million in 2000; large SUVs were the fastest-growing segment and by 2000, accounted for nearly one-third of all SUVs sold. Sales of large pickup trucks nearly doubled in the 1990s" (p. 23).

2008 through 2010: 22.5 mpg for MY 2008, 23.1 mpg for MY 2009, and 23.5 mpg for MY 2010.

Non-domestic automakers with core products being passenger cars, environmentalist groups, and non-governmental organizations, as well as some political figures, support “higher-CAFE-standards” proposals. Generally, domestic automakers, non-domestic automakers with a profitable and/or growing light truck fleet, as well as auto dealerships, labor unions, and some politicians are against increasing the CAFE standards. Although these opposing parties changed their view on the issue slightly due to the signing of the Energy Independence and Security Act of 2007 (EISA) and the high gas prices of 2008, they are still against higher CAFE standards.

In respect to the CAFE game, it is important to note the position of non-domestic automakers with concentration on passenger cars, such as Honda, that have certain indirect advantages with increases in the CAFE standards. From a strategic business and economic point-of-view, higher CAFE standards cause their competitors’ total cost to increase, thereby giving them a competitive advantage in pricing. Salop and Scheffman showed that firms could profitably gain market power by working to raise their competitors’ costs (Salop and Scheffman, 1983). The next section further discusses strategic and game theoretical points on this subject.

Non-domestic automakers with concentration on passenger cars, environmental groups, as well as certain politicians, and others concerned with energy independence are the most active proponents of higher CAFE standards. The most active opponents of higher-CAFE-standard groups are domestic automakers (the Big Three), Toyota, and labor unions. In politics, there is not an accepted partisan line in current CAFE debates. Some Democrats and Republicans support higher CAFE standards, whereas some do not. Due to concerns of national security, high oil prices, United States’ dependence on foreign oil, and global climate change, there is an agreement for higher CAFE standards; however, there is no consensus on the magnitude of the change.

While the debate about CAFE policy is important, this chapter focuses on strategic behaviors of the key players, and on the game-theoretic modeling of CAFE, which analyzes the actions and strategies of the key players in that game.

Future Standards: Energy Independence and Security Act of 2007, 2011-2015 Targets

On December 19, 2007, President George W. Bush signed EISA. One of the provisions of the bill signed into law was to increase CAFE standards. Specifically, the new CAFE standards require that the combined car and light truck fleet performance reach at least 35 mpg by 2020. EISA also limited any future Department of Transportation (DOT) rule(s) to be set for no more than five model years (e.g., 2011-2015).

On April 22, 2008, the U.S. Transportation Secretary announced the first set of preliminary CAFE rules from the DOT regarding passenger vehicles and light trucks pertaining to MY 2011-2015. For passenger vehicles, the standard would increase from 27.5 mpg to 35.7 mpg by 2015. For light trucks, it would increase from 23.5 mpg to 28.6 mpg. The combined standards annually increase 4.5% when averaged. The CAFE standards increase would be implemented differently for each vehicle manufacturer depending on the vehicle's footprint (track width × wheelbase), as well as the distribution of each manufacturer's vehicles. Thus the exact standards depend on the actual vehicle mix sold by a manufacturer in a given year. For National Highway Traffic Safety Administration (NHTSA) projections for the industry-wide fuel economy targets, see Table 7.1, "DOT Average Fuel Economy Targets, Model Year 2011-2015."

Prior to legislative enactment, the Bush Administration estimated that the proposed 35 mpg standards would cost the Big Three and, ultimately, their consumers, about $85 billion. This included $20 billion for Ford, $25 billion for Chrysler, and $40 billion for General Motors.[7] Although very promising new technology is being introduced, and consumers have shifted somewhat to more fuel-efficient vehicles, the gap between the statutory demand and the consumer willingness to pay is unlikely to be closed in the near future without dramatic technological or lifestyle changes, implicit government financing, or other measures. This regulatory risk is particularly severe for full-line manufacturers such as GM, Ford, and Chrysler.

The new size-based standards will mitigate some of the disadvantages to the domestic/full-line producers since each manufacturer has to improve within each size class, making the standard into something approaching an equal-percentage improvement standard.

TABLE 7.1 DOT Average Fuel Economy Targets, Model Year 2011-2015

Model Year	Car - mpg	Light Truck - mpg	Combined - mpg
2010 (base)	27.5	23.5	25.3
2011	31.2	25.0	27.8
2012	32.8	26.4	29.2
2013	34.0	27.8	30.5
2014	34.8	28.2	31.0
2015	35.7	28.6	31.6

Source: "Corporate Average Fuel Economy Rulemaking," NHTSA, June 24-27, 2008

Energy Independence and Security Act of 2007 includes three new provisions for the use of tax credits:

7. "Fuel Plan Would Cost Big Three," *The Detroit News,* March 1, 2007.

1. Automakers can now hold credits forward for up to five years instead of three years.
2. Automakers can also sell credits to other companies; there is no limit to how much any company can buy.
3. Automakers can transfer credits between their car and truck fleets; however, they can only transfer credits earned in 2011 or later years. Transfers are capped at 1 mpg for 2011-2013, 1.4 mpg 2014-2017, and 2.0 mpg for 2018 and beyond.

As before, automakers will earn credits when they exceed CAFE standards and can either bank those credits for a time or sell them right away, presumably at a cost below the fine for not meeting the standard.

The Bush Administration had stated that it would issue the final rules for the 2011-2015 targets before the end of 2008.[8] Later, the Bush Administration decided to leave the standard setting to the Obama Administration.[9]

Current Debates

The debate on CAFE standards has lessened compared to previous years largely due to the Bush Administration signing into law the EISA of 2007 last December, followed by the preliminary CAFE standards for MY 2011-2015 announced in April 2008, as well as the record high gas prices consumers faced in the summer of 2008.

In the spring of 2007, when the discussion of raising the CAFE standards became a strong possibility, The Alliance for Automobile Manufacturers (comprised of the Big Three, Nissan, Toyota, BMW, Volkswagen, Volvo, and Mazda) launched a campaign calling the fuel economy legislation unrealistic. However, major automakers began backing the proposal shortly after the bill was signed into law in December. GM's chief executive, Richard Wagoner, stated that the new standards would be a challenge for GM, but that they would be prepared.[10] Toyota stated they would continue to move forward and strive to be the most fuel efficient full-line auto manufacturer.[11]

Following the signing of EISA, was the first set of preliminary CAFE rules announced in April of 2008, from the DOT for MY 2011-2015, which technically goes into effect October 1, 2010.[12] The rules have not been finalized. The Bush Administration stated once that it would issue the final rules for the 2011-2015 tar-

8. "Tougher CAFE Standards Loom," *Automotive News*, November 3, 2008
9. "Bush Leaves CAFE Decision for Obama," *Automotive News*, January 7, 2009.
10. "If Ya Can't Beat' Em: Automakers Support 35 MPG Rule," Edmunds.com, December 3, 2007.
11. "If Ya Can't Beat' Em: Automakers Support 35 MPG Rule," Edmunds.com, December 3, 2007.
12. "Fuel Efficiency is Coming - It just Takes Time," *Automotive News*, November 3, 2008.

gets before the end of 2008. It is uncertain how the new president will affect current and future standards.

For a while, the debate on CAFE standards further lessened and was overwhelmed by the focus on higher gasoline prices; demanding lower gas prices and more fuel-efficient vehicles in response. In June 2008, the national average price for a gallon of regular unleaded gasoline was approximately $4.[13] While auto manufacturers have been working on more fuel-efficient vehicles for years, new CAFE standards soon to go into effect, as well as the market demanding more fuel efficient cars, and the current short contraction of the economy with automotive sales suffering, have led manufacturers to move even faster to deliver high-mileage vehicles. For example, GM's Chevrolet Volt, arriving at the end of 2010, will run on electricity for the first 40 miles, then will switch over to its engine, getting as much as an estimated 50 mpg on average according to GM.[14]

The debate on CAFE standards has subsided due to the signing of EISA, the preliminary rules from DOT for MY 2011-2015, and the current market conditions. For the most part, it seems discussion has moved from the CAFE standards being seen as unrealistic to car companies showing off their new fuel-efficient vehicles. GM's Chevrolet Volt does raise the issue of how such cars will be measured in respect to miles per gallon, but the Environmental Protection Agency (EPA) must determine this first; the NHTSA will most likely decide then how this may change future CAFE standards. For now, it is not known where the CAFE debate will lead as the new president has yet to take actions regarding CAFE policies, consumers and policy makers worry about the possibility of facing higher gas prices in the future, and the U.S. auto industry attempts to survive a tumultuous time.

We would like to acknowledge here the fight between auto companies and some states, e.g., California, over whether those states should be allowed to set a separate and much higher standards. The companies have been fighting this very hard, but appear to be losing this fight given that Obama endorsed it before he became president.

Strategic and Game Theoretical Motivation behind CAFE

Important players of this game are: (1) the federal government (regulator), (2) domestic automakers and non-domestic automakers with concentration on light trucks (Big Three and Toyota), and non-domestic automakers with concentration on passenger cars (e.g., Honda).

13. "Gas Prices Record Reaches $4 a Gallon," CNNMoney.com, June 8, 2008.

14. "Fuel-Economy Ratings for GM's Volt," CNNMoney.com, September 15, 2008.

Performance of passenger car fuel economy between domestic and non-domestic automakers is very competitive. For several years, the Big Three achieved the CAFE levels that many higher-CAFE-standards proposals/bills seek for passenger cars. In fact, the 2000, 2002, 2004, 2005, and 2006 models of domestic auto manufacturers obtained higher average fuel economy levels than non-domestic auto manufacturers on average (see Figure 7.3 and Table 7.6 in Appendix 7.A). However, the light truck fuel economy levels of the Big Three are very low compared to the levels that most of the proposals/bills set forth. In order for the Big Three as well as non-domestic automakers with concentration on light trucks to achieve the DOT's Average Fuel Economy Targets for model years 2011 through 2015, they will need to spend billions of dollars. According to *The Detroit News*:

> U.S. Rep. Fred Upton, R-Mich., said implementing the Bush administration's plans would cost the auto industry $100 billion. Nicole Nason, chief of NHTSA, initially said that figure was too high. But The Detroit News obtained a December 13 Bush administration summary of fuel economy proposals that confirmed Upton's estimate and Nason later on Wednesday acknowledged the document's accuracy.
>
> The summary shows the Bush plan would cost Detroit's Big Three about $85 billion and foreign automakers $29 billion between 2010 and 2017. That includes about $40 billion for General Motors Corp., $25 billion for DaimlerChrysler AG's Chrysler Group, $20 billion for Ford Motor Co., $8.4 billion for Toyota Motor Corp., and $4 billion for Honda Motor Co.[15]

This spending would cause price increases in their light trucks on average. As a result, the automakers would lose their competitive power in the very profitable light truck market. Additionally, there is further competition from some non-domestic automakers, such as Toyota, who have fairly recently entered the light truck market due to appealing profit margins.[16]

As mentioned earlier, there is not a strict partisan line in respect to the debate for higher CAFE standards. For example, in the State of Michigan, most of the Democrat and Republican lawmakers, including both Democrat senators, are against any significant increase in CAFE standards. As a strategy, non-domestic automakers that favor higher-CAFE-standards will remain silent as they do not want to stir American public opinion, in essence allowing the domestic automakers to play the "buy American" card.[17]

The federal government regulators have power in the decision-making process. Consumers and workers have important effects on the decision of the government as well; however, the opinions of citizens can easily be manipulated when they do not have common interests and goals. As a result, politicians and public opinion can be

15. "Fuel Plan Would Cost Big Three," *The Detroit News*, March 1, 2007.
16. Ilhan K. Geckil, "Competitive Response to CAFE Standards," *Business Economics*, Volume 38, Number 2, April 2003.
17. Ilhan K. Geckil, "Competitive Response to CAFE Standards," *Business Economics*, Volume 38, Number 2, April 2003.

directed by big players and lobbying groups when there is a lack of interest among consumers and workers.[18]

Two primary actors in the CAFE game are: (1) domestic automakers and non-domestic automakers with concentration on light trucks, and (2) non-domestic automakers with concentration on passenger cars.

Building the Game and Players, Strategies, Payoffs, and Solution

By building an extensive form representation of the game, the strategies of key players in our CAFE game can be analyzed. The extensive form of the game specifies:[19]

a. The players in the game: domestic automakers and non-domestic automakers with concentration on light trucks, non-domestic automakers with concentration on passenger cars, and government (as regulator);
b. When each player has a move, what a player can do at each opportunity to move, what a player knows at each opportunity to move; and
c. The payoffs received by each player for each combination of moves that could be chosen by the players.[19]

Game Stage 1

Representative domestic automaker and non-domestic automaker with concentration on light trucks (Automaker T) chooses an action *a1* from the feasible set A1={*H*, *M*, *L*}, where *H* is high, *M* is medium, and *L* is a low expenditure on lobbying against higher-level CAFE standards.

At this initial stage, the representative non-domestic automaker with concentration on passenger cars (Automaker C) chooses to be perceived as an environmentalist and indifferent to CAFE debates, even though it has a competitive advantage in fuel efficiency and would have certain advantages if the ‘higher-CAFE-standards’ were legislated. It does not choose an action because it does not want to provoke nationalist feelings and give a “buy American” marketing tool to the domestic automakers.

18. There are some other important factors in government’s decision-making process: the statutory criteria, the impact of CAFE standards on safety, on the U.S. auto industry and on employment in the auto sector, and the effect on consumers. Even though these factors are quite important in understanding government decision-making process about CAFE, this chapter concentrates solely on the strategic behaviors of the key players, including government.

19. Ilhan K. Geçkil, “Competitive Response to CAFE Standards,” *Business Economics*, Volume 38, Number 2, April 2003.

After Automaker T's action, there are two possible outcomes it can get: success or failure. It is assumed that probabilities of success and failure primarily depend on the level of lobbying expenditures. See Table 7.2 below.

TABLE 7.2 Automaker T's Level of Expenditure on Lobbying and Probabilities of Success and Failure

	High	**Medium**	**Low**
p(Success)	x_{11}	x_{21}	x_{31}
p(Failure)	x_{12}	x_{22}	x_{32}

Assumptions:

(a) $0 \leq x_{tk} \leq 1$, where t={1,2,3} and k={1,2}
(b) $x_{t1} + x_{t2} = 1$, where t={1,2,3}
(c) $x_{11} > x_{12}$; $x_{21} > x_{22}$; $x_{31} < x_{32}$
(d) $x_{11}/x_{12} > x_{21}/x_{22} > x_{32}/x_{31}$

Game Stage 2

Automaker T's action (level of expenditure on lobbying) would have a certain amount of influence on the public, media, and government. Because of this, the second player—government—observes *a1* and then chooses the action *a2*. The action is selected from the set A2={*H*, *M*, *N*}, where *H* represents a steep increase in CAFE standards, M represents a moderate level increase in CAFE standards, and *N* represents no major changes in CAFE standards, i.e., the CAFE standards remain unchanged or realize miniscule change. See Table 7.3, "Probabilities of Higher-CAFE-Standards Legislation Based upon Outcomes of the Lobbying Efforts of Automaker T."

TABLE 7.3 Probabilities of Higher-CAFE-Standards Legislation Based upon Outcomes of the Lobbying Efforts of Automaker T

		Automaker T	
		Success	**Failure**
Regulator (Federal Government)	**p(H)**	y_{11}	y_{21}
	p(M)	y_{12}	y_{22}
	p(N)	y_{13}	y_{23}

Assumptions:

(a) $0 \leq y_{tk} \leq 1$, where t={1,2} and k={1,2,3}
(b) $y_{t1} + y_{t2} + y_{t3} = 1$, where t={1,2}
(c) $y_{11} < y_{12} < y_{13}$
(d) $y_{21} > y_{22} > y_{23}$

Outcomes of Game Stages 1 and 2

Before concentrating on the final stage of the game, it is important to understand the outcomes of the first two stages of the game. Prior to the government's decision, both Automaker T and Automaker C have the following information:

(i) Automaker T's expenditure on lobbying at the first stage (*H*, *M*, or *L*).

(ii) Probabilities of success and failure of Automaker T after it takes action at the first game stage. See Table 7.2, "Automaker T's Level of Expenditure on Lobbying and Probabilities of Success and Failure."

(iii) Whether lobbying efforts of Automaker T are a success or failure.

(iv) Probabilities of legislation of CAFE (p(*H*), p(*M*) and p(*N*)), depending on the success or failure of Automaker T's lobbying efforts taken at the first stage, regardless of the level of expenditure. See Table 7.3 above.

(v) The government's decision.

The government's decision process could possibly take years. Until the government reaches a final outcome, the first four information items summarized above help both Automaker T and Automaker C construct and/or revise corporate strategies for their future financial and operational plans based upon the action taken by Automaker T during the first stage. By using (1) probabilities of success and failure for Automaker T depending on the expenditure level (expenditure-success matrix), and

(2) probabilities of the legislation of higher level CAFE standards by the government depending on the success or failure of Automaker T's lobbying efforts (success-legislation matrix); the model can determine the probabilities of higher-level-CAFE standards being legislated (expenditure-legislation matrix). See Table 7.4, "Lobbying Expenditure — Legislation Matrix."

TABLE 7.4 Lobbying Expenditure — Legislation Matrix

	p(H)	**p(M)**	**p(N)**
High Expenditure	$x_{11}y_{11} + x_{12}y_{21}$	$x_{11}y_{12} + x_{12}y_{22}$	$x_{11}y_{13} + x_{12}y_{23}$
Medium Expenditure	$x_{21}y_{11} + x_{22}y_{21}$	$x_{21}y_{12} + x_{22}y_{22}$	$x_{21}y_{13} + x_{22}y_{23}$
Low Expenditure	$x_{31}y_{11} + x_{32}y_{21}$	$x_{31}y_{12} + x_{32}y_{22}$	$x_{31}y_{13} + x_{32}y_{23}$

Notes:

p(H): probability of steep increase in CAFE standards by lawmakers;
p(M): probability of moderate increase in CAFE standards by lawmakers; and
p(N): probability of no or miniscule increase in CAFE standards by lawmakers,
based on lobbying expenditure levels of automakers in favor of low CAFE standards.

From information included in Table 7.4, both Automaker T and Automaker C can make informed-decisions about their strategies and planning even though the government has not reached a final decision. Looking at Table 7.4, row one (High Expenditure), if Automaker T's expenditure is high at the first stage, Automaker T will have x_{11} probability of success and x_{12} probability of failure. Government's decision depends on whether Automaker T's campaign, regardless of the expenditure level, is successful. If Automaker T chooses high expenditure at the first stage, the chance of CAFE standards being non-changed is: $[x_{11}y_{13} + x_{12}y_{23}]$. Calculating an expenditure-legislation probability matrix will help players, in the next section, solve the game and find the equilibrium by employing backward induction.

Game Stage 3

At the third and the last stage of the game, Automaker T and Automaker C are left with legislated 'steeply increased CAFE standards,' 'moderately increased CAFE standards,' or 'the unchanged CAFE standards.' Based upon the government's decision (with perfect and complete information), Automaker T and Automaker C face one of the three simultaneous-move sub-games:

Subgame-1: After 'steeply increased CAFE standards' game,

Subgame-2: After 'moderately increased CAFE standards' game, or

Subgame-3: ‘Maintenance of CAFE standards’ game.

Subgame-3 is not simply maintenance of the status quo, because pressure from the public, media, and some politicians will continue. Automaker T understands that the government may still decide to raise CAFE standards in the future, even if the current “higher-CAFE-standards” proposals are not legislated.

The concern of Automaker T is not improving their average fuel efficiency, but having enough time to do so at the lowest possible cost in a very competitive industry landscape. So not-accepted ‘higher-CAFE-standards’ in the short run will allow Automaker T to spend less money on research and development while increasing fuel efficiency, and concentrating on other issues such as credits and financial problems.

Meanwhile, for Automaker C, the game is “raising rivals’ costs.” Salop and Scheffman showed that firms could gain market power by conduct that raises their rivals’ costs. In addition, according to Krattenmaker and Salop, “Raising rivals’ costs is a more credible route to market power than is predatory pricing because it is not necessary to cause the rivals to exit, no ‘deep pocket’ is required, and the additional profits are gained immediately” (Krattenmaker and Salop, 1985b, p.109).

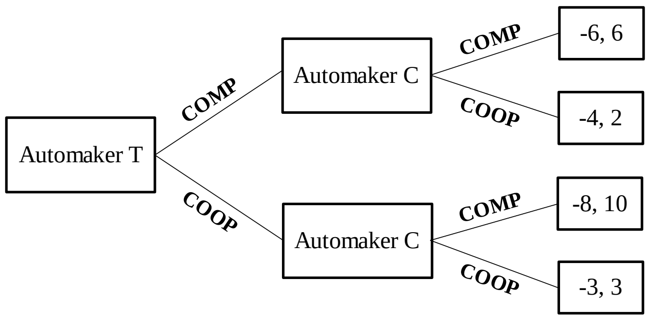
If cost to Automaker T increases, it has two options: (1) increase average prices of vehicles, or (2) accept decreasing profit. Automaker T and Automaker C play a non-cooperative simultaneous-move game at the last stage. A tree diagram representation of the game, based upon the utility payoffs of Automaker T and Automaker C related to their actions in the last stage, is given below (see Figure 7.4).

Solving the Problem and Nash Equilibrium

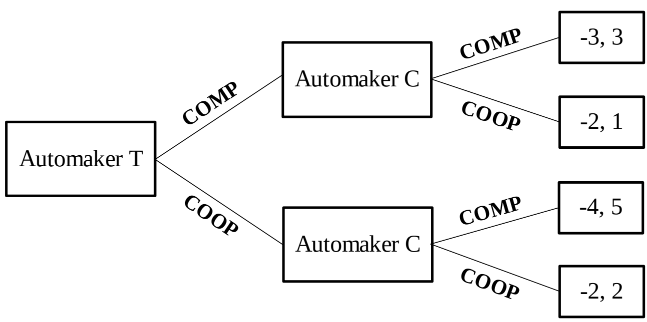
Both Automaker T and Automaker C choose an action from the feasible set A3={*Comp*, *Coop*} simultaneously. Let us assume that each knows the other’s utility levels for all 12 pairs of utility payoffs given in Figure 7.4. Regardless of whether ‘higher-CAFE-standards’ are legislated, “competitive” is a strictly dominant strategy of the game in the last stage for both domestic and non-domestic automakers. By employing backward induction and calculating expected utilities for Automaker T (See Table 7.5), we figure out optimal strategies for Automaker T and C. (High, Comp) is optimal strategy for Automakers T (high expenditure on lobbying at the first stage of the game and being competitive at the last stage of the game), and (*Comp*) is optimal and dominant strategy for Automaker C (being competitive at the last stage of the game). This results in three sub-game Nash equilibria for the game, illustrated in Figure 7.4.

FIGURE 7.4 Tree Diagram of the Game at the Last Stage between Automakers T and C and Their Utility Payoffs

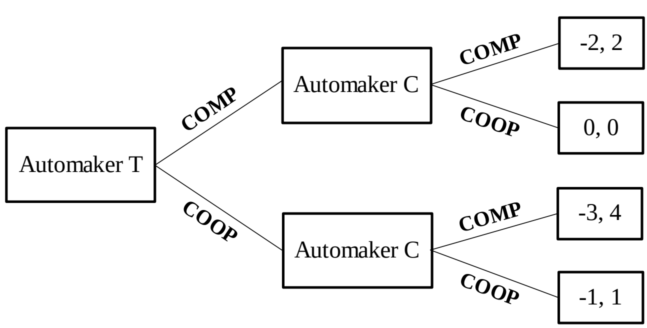
Subgame I: Steep Increase in CAFE Standards



Subgame II: Moderate Increase in CAFE Standards



Subgame III: No Change in CAFE Standards



I. (*High*, *H*, (*Comp*,*Comp*)): high expenditure on lobbying by Automaker T at the first game stage, legislated 'steeply increased CAFE standards' by the government at the second game stage, and competitive strategies by Automaker T and Automaker C at the last stage.

II. (*High*, *M*, (*Comp*,*Comp*)): high expenditure on lobbying by Automaker T at the first game stage, legislated 'moderately increased CAFE standards' by the government at the second game stage, and competitive strategies by Automaker T and Automaker C at the last stage.

III. (*High*, *N*, (*Comp*,*Comp*)): high expenditure on lobbying by Automaker T at the first game stage, non-legislated 'higher-CAFE-standards' by the government at the second game stage, and competitive strategies by Automaker T and Automaker C at the last stage.

TABLE 7.5 Expected Utility Payoffs for Automaker T for Its Different Level of Expenditures at the First Stage

Expenditure on Lobbying	Expected Utility Payoffs
High: EU(H) =	$[(x_{11}y_{11} + x_{12}y_{21})*(-6)] + [(x_{11}y_{12} + x_{12}y_{22})*(-3)] + [(x_{11}y_{13} + x_{12}y_{23})*(-2)]$
Medium: EU(M) =	$[(x_{21}y_{11} + x_{22}y_{21})*(-6)] + [(x_{21}y_{12} + x_{22}y_{22})*(-3)] + [(x_{21}y_{13} + x_{22}y_{23})*(-2)]$
Low: EU(L) =	$[(x_{31}y_{11} + x_{32}y_{21})*(-6)] + [(x_{31}y_{12} + x_{32}y_{22})*(-3)] + [(x_{31}y_{13} + x_{32}y_{23})*(-2)]$

Conclusion

Based upon the game-theoretic model, developed for the specific CAFE case, the dominant strategy for the domestic automaker and non-domestic automaker with concentration on light trucks (Automaker T) is to activate its resources, and to increase lobbying efforts against "higher-CAFE-standards" proposals, at the first game stage. Non-domestic automakers with concentration on passenger cars (Automaker C) are preferred to be perceived indifferent regarding CAFE proposals at the first stage since they do not want to give their rivals a "buy American" card for their lobbying and marketing efforts. However, they increase their competitive advantages if 'higher-CAFE-standards' are legislated by the government. Based upon their past and current strategic behaviors, it is assumed that they would like to be perceived indifferent to the CAFE debates and they continue their silent position at the initial stages of the CAFE game. However at the last stage, they start being strategically active and play "Raising Rivals' Costs" move to gain market power. The dominant strategy for non-domestic automakers with concentration on cars (Automaker C) at the last stage of the game is being "competitive." At the last stage of the game, being "competitive" is the dominant strategy for both Automakers T and C.

Appendix 7.A

TABLE 7.6 Fuel Economy Averages (mpg) by Automaker for 2000, 2004, and 2008

Domestic Passenger Cars

Manufacturer	2000	2004	2008
Chrysler*	27.9	29.6	29.5
Ford	28.3	26.7	29.8
GM	27.9	29.3	29.6
Honda	31.4	33.1	35.3
Nissan	28.1	27.9	33.7
Toyota	33.3	33.2	33.9
CAFE Standards	*27.5*	*27.5*	*27.5*

Imported Passenger Cars

Manufacturer	2000	2004	2008
BMW	24.8	26.4	27.4
Chrysler*	25.1	26.9	27.4
Daimler	-	-	26.4
Ford	27.4	27.7	30.6
GM	25.4	30.3	31.4
Honda	29.3	32.7	33.2
Hyundai	30.4	29.6	33.8
Kia	30	29.1	33.4
Nissan	28.3	28.9	29.4
Toyota	28.9	32.4	38.5
Volkswagen	28.8	29	28.8
CAFE Standards	*27.5*	*27.5*	*27.5*

Light Trucks

Manufacturer	2000	2004	2008
BMW	17.5	21.5	22.9
Chrysler*	21.4	20.5	23.6
Daimler	-	-	20.6
Ford	21	21	23.6
GM	21	21.4	22.8
Honda	25.4	24.6	25.5
Hyundai	-	24.2	25.5
Kia	23.5	20.5	24.2
Nissan	20.8	21.2	24
Toyota	21.8	22.7	23.7
Volkswagen	18.9	19.2	20.1
CAFE Standards	*20.7*	*20.7*	*22.5*

*Was DaimlerChrysler in 2000 and 2004

Data Source: NHTSA Summary of Fuel Economy Performance November 2008.

Chapter 8 Business Strategy and Crisis: The U.S. Auto Industry

Introduction and Cause of the 2008 Auto Industry Crisis

The crisis of the auto industry in 2008 provided an opportunity to use strategic thinking and game theory insights in the real world. In this chapter, we evaluate the strategic thinking of key players. As this book goes to press, these events are only now playing out.

While domestic automakers have been struggling and losing market share for several years, the economic crisis in 2008 sent light vehicle sales plummeting. Based on the first three quarters of 2008 sales, annual sales dropped to less than 13.5 million units, down from 16 million units in 2007 and from a post-2001 trend of 16-17 million vehicles per year. Per capita sales were at their lowest levels since World War II. However, the trigger for the crisis was the prohibitively damaging rate of sales that has persisted since September 2008: approximately 10.5 million units per year. That was roughly a 40% reduction in sales—a reduction that could not be accommodated alongside the survival of all Original Equipment Manufacturers (OEM) of the automotive industry in operation.

The magnitude of the crisis was publicized by two events:

- On November 7, 2008 GM announced that its cash reserves could fall below the minimum required to satisfy covenants with key lenders, and that the “minimum” cash position could be breached early in 2009. Subsequently, the company confirmed that the GM board had discussed bankruptcy, although it had rejected it.
- The Detroit Three CEOs, along with the United Auto Workers (UAW) president, went to Capitol Hill to lobby Congress for federal assistance in the week of November 20. The harsh reception they received—including repeated tongue-lashings about such topics as the use of private planes, their failure to improve fuel economy fast enough, the apparently poor service received on a Congressional spouse’s car, and other matters both trivial and momentous— was a stunning rejection of that plea, and an awakening to the lack of political capital the industry had in Washington. By the close of that disastrous week, the Detroit Three were given, in effect, an ultimatum: “submit” restructuring plans that satisfied the House and Senate leaders, or forget about any aid.

These events had a devastating effect on consumer confidence. In a research survey commissioned by GM, and reported in their December 2 submission to Congress, fully 30% of consumers that “very recently” decided against buying a GM vehicle in favor of another, cited the possibility of a GM bankruptcy as the top reason.

Worsening economic conditions, a tighter credit market, along with plummeting consumer confidence created tougher conditions for the Detroit Three. Detroit-based automakers had short-term and long-term problems. Seriousness of the short-term problems were driven by liquidity specific matters. Especially GM and Chrysler needed financial support to finance their operations. According to Ford executives, the company did not have financial problems as serious as GM and Chrysler had. Because of the tighter credit market of late 2008, both GM and Chrysler looked for some kind of financial aid from the federal government. The Detroit Three acted strategically to get financial support from the federal government to overcome their liquidity problems.

In this chapter, we analyze the possible scenarios, and strategies of the Detroit Three and lawmakers regarding the industry crisis in 2008. We develop a game-theoretic model to illustrate the auto industry crisis of 2008, and strategies for a potential merger between GM and Chrysler.

Likely Scenarios for the Automotive Industry

There were essentially five likely scenarios for the auto industry under the circumstances caused by the financial meltdown of 2008:

1. GM and Chrysler merger with federal financial aid (such as a bridge loan).
2. Federal financial aid and radical restructuring outside of bankruptcy.

3. Federal financial aid and radical restructuring outside of bankruptcy for GM and Ford; Chrysler's assets purchased by competitors.
4. Chrysler files for Chapter 11 bankruptcy; GM and Ford restructure outside bankruptcy.
5. Both GM and Chrysler file for Chapter 11 bankruptcy; Ford restructures outside bankruptcy.

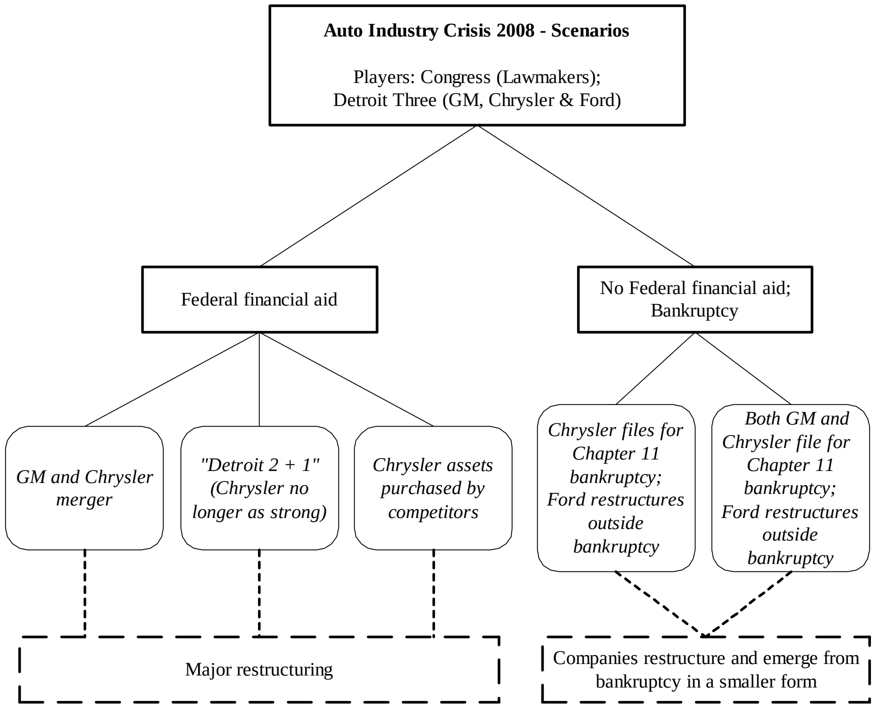
Although it is difficult to predict how Congress acts, it is clear that the key dividing line among the various scenarios is a commitment to some type of federal financing assistance. Based on the auto sales trends as of December 2008 and the financial (particularly cash) resources of the Detroit Three, the domestic auto companies wanted both lawmakers and public to take their situation seriously, and believe that such a commitment was a must before the end of January 2009 to prevent any OEM bankruptcy and massive loss of jobs.

It is possible that a "commitment" could be signaled by something other than a statute enacted before January ends, if such a commitment was welcomed by other lenders as firm enough to extend their own resources for a temporary period.

What form could this "assistance" take? A bridge loan is the most direct, and economically effective, method. However, any such assistance will be approved based on political considerations (the strategic dangers for the Detroit Three which are discussed below), and therefore a large variety of potential structures (and labels) could be used. The fundamental needs of the automakers are to restore consumer confidence in their operations long enough to restructure their operations in the manner we describe here. That requires cash; it does not require specific payment terms.

Figure 8.1 demonstrates likely scenarios.

FIGURE 8.1 Flowchart of the Likely Scenarios



Economic and Industry Conditions

Domestic automakers have been losing sales and market share for several years. Car sales in the United States fell by slightly over 6% when comparing the first three quarters of 2007 and 2008. In late 2008, what some consider to be the worst financial crisis in nearly 80 years sent the economy reeling into recession. The economic downturn, credit crisis, and industry-specific concerns caused vehicle sales to plummet.

Our annual auto sales estimate for 2008 was less than 13.5 million units, down from 16 million units in 2007, and even further down from the post-2001 trend of 16-17 million vehicles per year. Per capita sales were at their lowest levels since World War II. Worse, the year that began with automakers selling vehicles at a rate slightly below the recent trend ended with a quarter in which vehicle sales dropped to the lowest rate in recent memory. See Table 8.1 below.

TABLE 8.1 Light Vehicle Sales in the U.S., 2003-2008 (in millions of units)

2003	2004	2005	2006	2007	2008
16.7	16.9	17.0	16.6	16.2	13.5
Data Sources: Automotive News; Anderson Economic Group.					

Sales Trends by Automaker

While the Detroit-based manufacturers have struggled since 2003, the industry was able to sell between 16 and 17 million light vehicles until 2008. Total sales of light vehicles held steady between 2003 and 2007.

Car Sales

After 2007, the automotive industry experienced a rapid decline in car sales. The downward industry trend in the U.S. market hit all automakers, but hit the Detroit Three particularly hard. In particular:

- The Detroit Three all had serious reductions in sales. GM, Chrysler, and Ford lost market share in the car segment as well as sales. Chrysler experienced the most significant reduction in car sales, falling by slightly over 23%.
- Toyota, which nearly matches the Detroit Three in model lineup, and whose vehicles are often more expensive than their domestic competitors, also suffered a decline.
- Honda and Nissan were the least affected. Honda and Nissan were the only two brands to increase market share in the car segment. Reflecting its concentration in smaller and more fuel-efficient vehicles, Honda was also the only manufacturer to increase sales, with an increase of nearly 8%.

See Table 8.2 below.

TABLE 8.2 Car Sales in the U.S. for the Major Manufacturers, First Three Quarters, 2007-2008

	3 Quarters-2008	Market Share, 2008	3 Quarters-2007	Market Share, 2007	% Change in Sales 2007-08
GM	1,118,208	19.3%	1,236,144	20.4%	-9.5%
Chrysler	381,355	6.6%	497,359	8.2%	-23.3%
Ford	602,509	10.4%	658,287	10.9%	-8.5%
Toyota	1,108,123	19.2%	1,168,505	19.3%	-5.2%
Honda	730,160	12.6%	677,779	11.2%	7.7%
Nissan	486,650	8.4%	488,659	8.1%	-0.4%
Subtotal	**4,427,005**	**76.5%**	**4,726,733**	**78.1%**	**-6.3%**
Data Source: Automotive News.					

Truck Sales

Record-breaking fuel prices caused high-margin truck sales to fall 21% in the first three quarters of 2008 compared to the similar period for 2007. GM lost one percentage point market share in the truck segment, Chrysler lost slightly more than one percentage point, and Ford lost slightly less than half a percentage point. Toyota gained slightly over half a percentage point market share in the truck segment, while both Honda and Nissan gained nearly a percentage point each. See Table 8.3.

The decline in this segment—which was dominated by the Detroit Three and carries higher profit margins than on most of the car segments—compounded the financial effects of the overall market decline.

TABLE 8.3 Truck Sales in the U.S. for the Major Manufacturers, First Three Quarters, 2007-2008

	3 Quarters-2008	Market Share, 2008	3 Quarters-2007	Market Share, 2007	% Change in Sales 2007-08
GM	1,294,458	26.0%	1,697,949	27.0%	-23.8%
Chrysler	802,164	16.1%	1,081,464	17.2%	-25.8%
Ford	976,890	19.6%	1,253,859	19.9%	-22.1%
Toyota	685,179	13.8%	833,140	13.2%	-17.8%
Honda	450,423	9.0%	515,741	8.2%	-12.7%
Nissan	299,049	6.0%	324,393	5.2%	-7.8%
Subtotal	**4,508,163**	**90.5%**	**5,706,546**	**90.6%**	**-21.0%**

Data Source: Automotive News.

Long-Term Sales Trends

It is unclear how long the economic downturn would last and how severe it would be. Declining consumer confidence, falling consumer spending, and rising unemployment were a reflection of the impact of the financial meltdown on the real economy, and especially on auto sales.

Consumer credit tightened, particularly for the higher risk borrowers. Even when not constrained by credit availability, American consumers spent less and postponed spending on major durable goods, such as cars and trucks.

After the end of the recession, it is likely auto sales will return to a historic trend of 15 million light vehicles per year. Note that lifestyle changes and living patterns, as well as the durability of vehicles and fuel prices, are unlikely to radically change in the next few years in a manner that precludes consumer demand for vehicles from returning.

Investor Confidence in Domestic Automakers and Suppliers

All companies in the automobile industry had difficulty with financing given the environment. However, this difficulty varied considerably:

- Automotive manufacturers were effectively shut out of the credit market. The continuing sales decline, and the threat of bankruptcy, caused disastrous consequences for their equity values. Their bond ratings were similarly very poor.
- Some suppliers, particularly those with high leverage or over concentration with one manufacturer, also saw investor confidence diminish.

GM's stock price declined from $24 in January 2008 to $3 in November 2008, and still lower as of this writing. Daimler marked down the value of its stake in Chrysler to late in November 2008. See Table 8.4 below.

TABLE 8.4 2008 Economic Crisis and Impact on Auto Companies' Value (Stock Prices in USD, Daily Close)

	November 20, 2007	January 2, 2008	November 20, 2008
General Market:			
Dow	13,010.14	13,043.96	7,552.29
Nasdaq	2,596.81	2,609.63	1,316.12
S&P 500	1,439.70	1,447.16	752.44
Major Automotive Companies:			
Ford	7.24	6.60	1.39
GM	26.29	24.41	2.88
Johnson Controls Inc.	36.54	34.59	14.14
Lear Corp.	28.68	26.61	1.00
Visteon Corp.	3.98	4.05	0.28

Data Source: Yahoo! Finance.

Key Events to Date (December 2, 2008)

In this section we summarize key events that occurred in the fourth quarter of 2008 to demonstrate the conditions of the automotive industry, and hint incentives of the Detroit Three automakers. Understanding the nature of events will help us to analyze a potential merger between GM and Chrysler. Note that the events and dates summarized below are from various news sources; and they vary somewhat from the actual occurrences.

On October 10, 2008, it was first reported that preliminary talks concerning a possible merger between GM and Chrysler, LLC had been underway for nearly a month.[1] Cerberus reportedly had proposed trading Chrysler's automotive operations in exchange for GM's 49% stake in GMAC. The remaining 51% of GMAC is owned by Cerberus.[2] GM reportedly approached Ford Motor Co. about a possible merger in July; however, Ford ended any discussion about the possibility in September.[3]

On October 13, 2008, it was reported that GM's board met the previous week concerning the possible acquisition of Chrysler, LLC and that they were hesitant on the deal.[4]

On October 20, 2008, GM reportedly had trouble moving forward with a possible merger with Chrysler due to GM not being able to secure the financing needed for a deal.[5] Cerberus reportedly discussed a potential Chrysler deal with Nissan Renault; however, a sale to GM was preferred to reduce Cerberus' exposure to the global auto industry's volatility.[6]

On October 23, 2008, based on earnings figures reported by Daimler AG, Chrysler, LLC had a $660 million operating loss in the second quarter of 2008. Chrysler announced it would be cutting a shift at its Toledo, Ohio plant and closing its Newark, Delaware, assembly plant as of December 31, reducing workforce by 1,825 employees.[7] Members of the Michigan Congressional Delegation sent a letter to Treasury Secretary Henry Paulson and Federal Reserve Board Chairman Ben Bernanke. The letter asked the two agencies to take the necessary steps to encourage liquidity in the U.S. auto industry.[8]

On October 24, 2008, Chrysler, LLC announced it would reduce its salaried workforce by 25%, eliminating approximately 5,000 salaried workers and contract employees. The workforce reduction would begin in November.[9]

On October 27, 2008, GM reportedly asked the U.S. government for approximately $10 billion, which would include approximately $3 billion in exchange for preferred stock, to help with the merger of Chrysler, LLC.[10] The Energy Department reportedly was working on releasing $5 billion to GM through the Energy Department's

1. "GM and Chrysler Explore Merger," *The New York Times*, October 10, 2008.
2. "GM Discussing Merger," MSNBC, October 13, 2008.
3. "GM Said to Seek Merger With Ford Before Chrysler," *The New York Times*, October 11, 2008.
4. "GM Board Was Cool to Chrysler Link," *The Wall Street Journal*, October 13, 2008.
5. "GM Lacks Investors to Fund Deal With Chrysler," *The Wall Street Journal*, October 20, 2008.
6. "Chrysler Weighs Renault-Nissan Alliance," *The Wall Street Journal*, October 21, 2008.
7. "Chrysler Retrenches Amid Losses," *The Wall Street Journal*, October 23, 2008.
8. "Dingell on Michigan Delegation Calls on Paulson, Bernanke to Help Restore Liquidity to Auto Industry," The House of Representatives, October 23, 2008.
9. "Chrysler to Cut 25% of Salaried and Contract Jobs," *The New York Times*, October 24, 2008.
10. "GM seeks $10 billion in aid for Merger," *Reuters*, October 28, 2008.

$25 billion low interest loans program approved in September for the auto-industry.[11] Moody's Investor Service lowered GM's credit rating to Caa2, which is eight grades below investment quality.[12]

On October 28, 2008, GMAC reportedly was looking into becoming a bank holding company. As a bank holding company, GMAC would be eligible to receive aid from the government's $700 billion financial bailout plan.[13]

GM and Cerberus Capital Management reportedly resolved specific issues regarding a possible merger; however, the shape of the deal would rely on the available financial and government support. Both companies have agreed that GM CEO Rick Wagoner would lead the new merged GM-Chrysler automaker.[14] GM announced that its global vehicle sales decreased by approximately 14% in the third quarter due to low demand in North America and Europe. GM sales specifically in North America, its largest market, fell by nearly 19%.[15]

On November 7, 2008, GM CEO Rick Wagoner stated that GM was no longer exploring any kind of acquisition and that GM would be "better off to put 100% of our efforts on the liquidity side. We've set aside such acquisition actions as a near term priority."[16]

On November 10, 2008, it was reported that Hyundai Motor Co. had talks with Cerberus Capital Management LP concerning potentially acquiring their Jeep brand and possibly other assets; however, on November 12, Hyundai clearly stated they had "no interest in acquiring any company. That includes Chrysler."[17]

On November 17, 2008, GM sold its 3% stake in Suzuki Motor Corp for nearly $230 million to help with their liquidity problem. GM stated they will continue their existing projects with Suzuki as well as their joint operations.[18] GM's vice-president of North American sales Mark LeNeve announced that GM will delay incentive payments to dealers beginning November 28 through December 11 to help the company preserve cash.[19]

On November 18, 2008, hearings on "Examining the state of the Domestic Automobile Industry," by the Senate Banking, Housing and Urban Affairs Committee began. CEOs Alan Mulally of Ford, Rick Wagoner of GM, and Robert Nardelli of

11. "GM Said to Seek Treasury Aid in Chrysler Merger Talks," Bloomberg, October 27, 2008.
12. "GM Said to Seek Treasury Aid in Chrysler Merger Talks," Bloomberg, October 27, 2008.
13. "GMAC Seeks Bank Status for Rescue Finding," *Automotive News*, October 29, 2008.
14. "Major Issues Resolved in GM-Chrysler Talks," *Automotive News*, October 29, 2008.
15. "GM's Q3 Global Vehicle Sales Fall 11.4%," *Automotive News*, October 29, 2008.
16. "GM says Chrysler Acquisition talks are off," *Automotive News*, November 7, 2008.
17. "Hyundai: 'We have no interest' in Chrysler," *Automotive News*, November 12, 2008.
18. "GM dumps Suzuki stake for much-needed Cash," *Automotive News*, November 17, 2008.
19. "GM will delay dealer incentive payments," *Automotive News*, November 17, 2008.

Chrysler testified, telling the committee they required aid to survive the current economic situation.[20]

On November 20, 2008, legislation to provide $25 billion in emergency federal loans to the Detroit Three was blocked. It was decided that the Detroit Three would have to submit plans on how they would use the aid. House and Senate hearings on these plans were scheduled for the first week of December. If the plans pass, Congress would be called back into session to consider the legislation the following week.[21]

On November 26, 2008, it was reported that Cerberus' ongoing discussions with Daimler to acquire the remaining 19.9% of Chrysler owned by Daimler had stalled. Daimler issued a statement that morning that their negotiations with Cerberus "have been made considerably more difficult during the last weeks due to exaggerated demands by Cerberus...The claims made now go beyond the framework of the contractually agreed possible obligations under representations and warranties... Daimler rejects these absurd allegations and the claims derived there from as being completely without substance."[22]

On December 2, 2008, all of the Detroit Three submitted plans to Congress describing their promised restructuring plans. November sales figures for GM and Ford were also released, indicating drops in sales of 30% to 40% for these automakers, compared to the previous year.

Discussion of Potential Scenarios

In this section, we discuss each of the potential scenarios, the most likely scenario in some detail; the others briefly.

Note that these are discussions of possible scenarios; such discussion requires some speculation about the surrounding market and political conditions, and the actions of various competitors and constituencies. For this reason, we caution readers that these "scenarios" should be considered within the proper context.

We anticipate Chrysler going out of business as an independent entity in every scenario. Given the serious decline in sales, some manufacturers cannot be sustained. Chrysler does not have the overseas presence of GM or Ford. Neither does it have as full a lineup of vehicles across as many market niches as do its two Detroit-based competitors. However, its short-term cash position may be better than GM's without

20. "Big Three Tell Senate They Need U.S. Aid to Survive on Tuesday afternoon," *The New York Times*, November 18, 2008.
21. "Bailout Compromise Blocked, but Hope Remains," *Automotive News*, November 20, 2008.
22. "Cerberus-Daimler Talks on Chrysler Stake Stall," *Detroit Free Press*, November 26, 2008.

federal financing. We note that Daimler marked the value of its holdings of Chrysler assets down to zero in late November 2008. Squabbling between Cerberus and Daimler, however, could complicate any negotiations to sell all or portions of Chrysler's assets to a competitor.

The Most-Likely Scenario

Scenario 1: A GM-Chrysler Merger with Federal Financial Aid

Based on the conditions of the American automotive industry, as of December 2008, the scenario involving a federal aid, such as a federal bridge loan, and a GM-Chrysler merger, is the most likely of the scenarios identified at the beginning of this chapter. It is also the least costly in terms of employment and output reductions in the U.S. Although the "most likely" scenario in such a complicated situation means a less than 50% chance of occurring, it is still a useful baseline to use when discussing other potential scenarios.

As stated earlier in the chapter, on October 10, 2008, it was first reported that preliminary talks concerning a possible merger between GM and Chrysler, LLC had been underway for nearly a month. After a very dynamic month, on November 7, 2008, GM's CEO Rick Wagoner stated that General Motors suspended its efforts to acquire Chrysler. GM stated "it is more important at the present time to focus on our immediate liquidity challenges" than to continue pursuing the merger with Chrysler. However, we believe that was a strategic move by GM for two reasons: (1) showing Congress that GM's concentration is on the current crisis and the liquidity problem of the company; (2) pushing the value of the target company down, or getting a better position in negotiations with Cerberus over Chrysler. Note that GM officials knew their financial situation before November 2008—and they were still pursuing a merger with Chrysler. GM officials later said talks with Cerberus would hinder its efforts to win additional federal financial support.

Assuming GM can get past the current liquidity crisis with commitment to federal assistance by January 2009, we believe a GM-Chrysler merger remains the most likely scenario.

Under this scenario, it is highly likely GM and Chrysler will go through heavy restructuring, and increase the competitiveness of the new company as a result of the merger. It is likely that the new company keeps Chrysler's Jeep models—an iconic brand with loyal clientele—as well as its minivan segment and some of Chrysler brand entry level and small fuel efficient vehicles. They might also eliminate the Dodge brand.

GM likely would sell the Saturn brand, eliminate the Pontiac brand (except for "specialty" vehicles) and sell its Hummer and Saab brands.

Other Likely Scenarios

Scenario 2: Federal Financial Aid and Radical Restructuring outside of Bankruptcy

The second scenario is a radical restructuring which occurs outside of bankruptcy with no immediate ownership changes. This scenario assumes that the Detroit Three structure transforms into the "Detroit Two" with a significantly smaller-sized Chrysler.

Many or all of the same brands would be eliminated as in the first scenario. Even in this case, we do not believe all three would survive as fully independent entities.

Scenario 3: Federal Financial Aid and Radical Restructuring outside of Bankruptcy; Chrysler Assets Purchased by Competitors

Under the third scenario, Nissan-Renault, Volkswagen, or some other foreign-owned auto producer would purchase some assets of Chrysler, such as Chrysler and Jeep brands, or minivan line of the company. Ford and GM undertake the same sort of radical restructuring, outside of bankruptcy, as under the second scenario. They may also purchase some of Chrysler's assets, such as the Dodge truck, Jeep, or minivan business.

The exact outcome would depend on the nature of the foreign purchaser. Nissan-Renault, for example, might follow a strategy similar to that outlined for GM, except that it would probably eliminate most if not all of Chrysler's small car lines. The foreign automaker might be interested in a strong position in the North American market and keep Chrysler models aggressively. Vehicle manufacturers from China or India might also enter the market through this avenue. However, this is less likely than the first two scenarios, because congressional representatives would be less likely to provide financial support for an entity involving foreign ownership.

Scenario 4: Chrysler Files for Chapter 11 Bankruptcy; GM and Ford Restructure outside Bankruptcy

In the fourth scenario, Chrysler would file for Chapter 11 bankruptcy while GM and Ford restructure outside bankruptcy. Chrysler would sell off many of its brands to other companies in order to get the cash necessary to emerge from Chapter 11. For example, it might sell Jeep and keep minivans and some of its entry-level smaller cars.

Under this scenario, both GM and Ford would realize some difficulties financing their operations. We expect to see major plant closures, layoffs, and the cutting of some brands and models under this scenario.

Scenario 5: Both GM and Chrysler File for Chapter 11 Bankruptcy

In the fifth scenario, GM would also file for Chapter 11 bankruptcy along with Chrysler. Under this scenario, we expect that Ford would get a sizeable fraction of the GM as well as Chrysler customer base.

This will amount to major restructuring and downsizing, which will affect the dealerships and suppliers in respect to job cuts and other reductions. We believe a portion of GM would emerge from bankruptcy under this scenario, although it would be smaller than if it did not go through bankruptcy.

Strategic Approach to a Potential Merger: Strategies of Key Players

There are no easy solutions to the serious problems the auto industry faced in 2008. The Detroit Three would cut production, labor and the number of dealerships, and realize some major restructuring. Regardless of what scenario occurred as identified in Figure 8.1, "Flowchart of the Likely Scenarios," American automakers and federal lawmakers need to make serious decisions and act strategically to leave this tough period behind them in the least costly way.

As noted above, the scenario involving federal financial aid and a GM-Chrysler merger is the most likely of the scenarios identified at the beginning of this chapter. In order to return these two automakers to profitability, the resulting entity must dramatically reduce its costs in both the manufacturing and distribution segments of the industry. This will mean reductions in productive capacity that include closure of some plants, reductions in auto workers, design and technical staffs, and sharp reductions in the number of dealerships.

Other scenarios, including those involving bankruptcies, would involve larger costs in terms of layoffs, permanent reductions in output in the U.S., and other costs. That is why the authors of this book believe automakers and lawmakers prefer the most likely scenario realized. However, all members of the Detroit Three club and lawmakers in Congress have different, and sometimes conflicting incentives, as well as common incentives.

Let us develop a game-theoretic model, by identifying players and strategies available to them, and constructing various decision tree diagrams to illustrate the interaction between the players; and analyze incentives and strategies for such a merger between GM and Chrysler.

Players and Incentives

Two main actors of our "merger game" are General Motors and Chrysler. Under the economic and industry conditions of 2008, one of the preconditions of such a merger is financial support from the federal government, such as a federal bridge loan. Therefore, another player of the game is Congress, i.e., federal lawmakers. We assume that a GM-Chrysler merger is not plausible without federal financial aid as of December 2008. Liquidity and other financial problems do not only affect GM and Chrysler, but Ford as well. Any federal financial package, provided assistance to GM and Chrysler, would open a door to Ford for a similar assistance. Even though Ford is not a party in the merger, the major prerequisite of the merger, federal aid, brings Ford to our game.

Thus, the players of our merger game are:

- General Motors,
- Chrysler,
- Congress, and
- Ford.

Incentives of the Players

Players have different incentives, as well as common ones. We discuss these incentives here.

GM, Chrysler, and Ford have two major common incentives: (1) getting federal financial aid to overcome short-term liquidity and financial problems in the dismal environment of the 2008 financial meltdown; and (2) increasing shareholder value.

In addition, GM and Chrysler have a strong incentive of merging two companies. As we discussed above, the number of light-vehicle sales in 2008 does not support three automakers in the U.S. A merger (or acquisition) would create economies of scale and synergies to transform the industry into the "Detroit Two." The new structure of the industry would be more efficient for GM and Chrysler, and provide them with market power to compete more effectively against Ford and foreign automakers, such as Toyota and Honda. GM and Chrysler lost market share to the Japanese Big Three (Toyota, Honda, and Nissan) in the past decade. The new automaker after such a merger would gain the lost market share back.

Ford has two conflicting incentives regarding a merger between GM and Chrysler. Ford would benefit from the new automotive industry structure with only two American automakers. The merger would eliminate one of Ford's competitors. Instead of competing against two domestic automakers, Ford would compete against only one domestic company. Furthermore, healthy industry conditions help all members of the Detroit Three club. For instance, equity prices of Ford would be positively affected from the new efficient and orderly market. On the other hand, a stronger competitor, a merged GM-Chrysler, would be something Ford does not want to deal with. Because of these conflicting incentives, we believe Ford would not take a position for or against the potential merger between GM and Chrysler.

Lawmakers know that a merger between GM and Chrysler is possible only if they provide financial aid to these companies to overcome their short-term liquidity and other financial problems. Their concern of course, is not the merger, but helping automotive industry to strengthen the national economy against a likely depression triggered by the financial meltdown in 2008. Lawmakers have two major incentives: (1) using taxpayers' money responsibly and effectively, since they are responsible to their constituents; (2) helping automakers to save American jobs, income, and output. Note that these incentives are not necessarily conflicting, as they seem like. Some of the other incentives of lawmakers are listed below:

- Increase the Corporate Average Fuel Economy (CAFE) standards as discussed in the previous chapter,
- Act consistently with their party's position for providing financial aid to the private sector by using taxpayers' money, and
- Represent their constituents effectively.

Strategies

Lawmakers have two main strategies: providing federal financial aid to automakers, or not providing financial support. If they pick the "providing financial support" strategy, they would develop different strategies, such as providing them a conditional loan requiring automakers to commit certain CAFE standards during a certain time period.

Ford's main strategy is not to be for or against a merger between GM and Chrysler. Additionally, Ford wants to show consumers that the company is stronger against the 2008 economy and industry crisis than GM and Chrysler, to appeal to customers. As we discussed at the beginning of the chapter, consumers are hesitant to buy cars and trucks from troubled companies associated with the possibility of a bankruptcy. Ford's strategies do not play a major role in this game.

GM and Chrysler have some shared strategies such as lobbying for federal financial aid, threatening lawmakers with likely bankruptcies resulting in massive layoffs and reduction in output, cutting production for a certain time period to show the seriousness of the situation, and filing Chapter 11 bankruptcy to get protection against their creditors and reorganize their companies as they wish.

However, GM and Chrysler have some different strategies regarding the merger, such as negotiating for a lower or higher value for the target company based on their role in such a merger.

Based upon the conditions of the auto industry and companies, it seems the merger would not be a "merger of equals." Instead, it is highly likely GM to acquire Chrysler. GM's main objective is then to decrease the value of Chrysler as much as possible during negotiations. On the other hand, Cerberus, owner of Chrysler, would like to get the highest price possible.

Sample Tree Diagrams Illustrating Players' Moves and Their Strategies

Based on the incentives and strategies we discussed above, we can develop different merger games. Decision-tree diagrams of some of these games are depicted below. See Figure 8.2, Figure 8.3, and Figure 8.4.

FIGURE 8.2 Decision-Tree Diagram of a Sample "Merger Game" - I

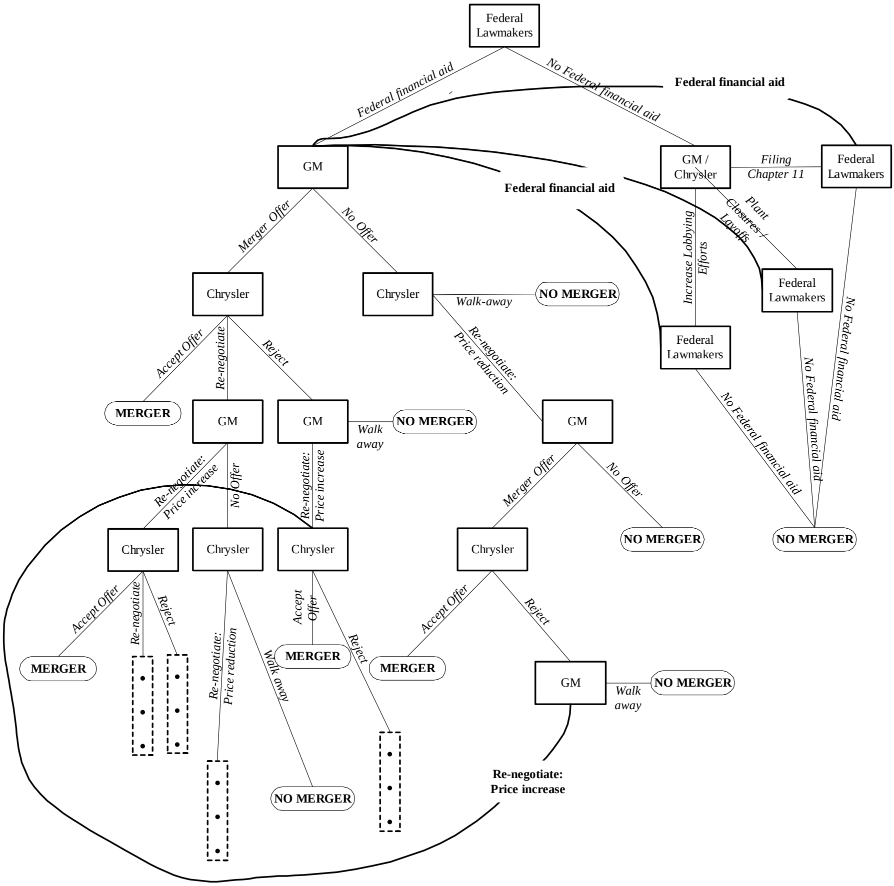


FIGURE 8.3 Decision-Tree Diagram of a Sample "Merger Game" - II

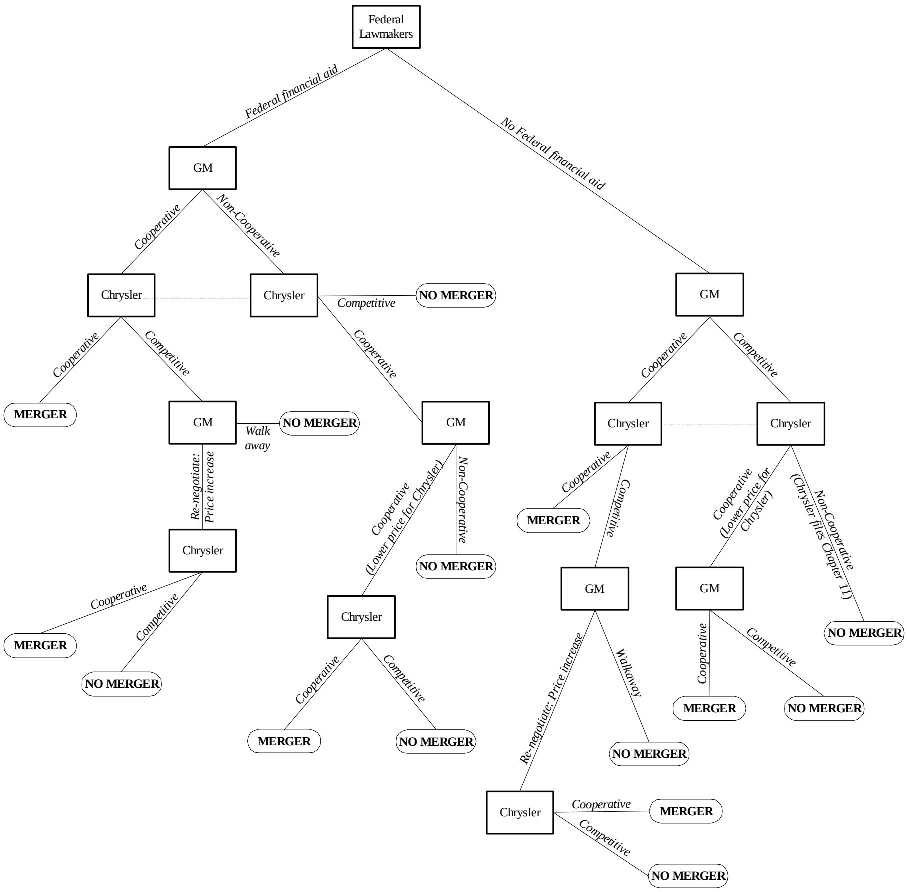
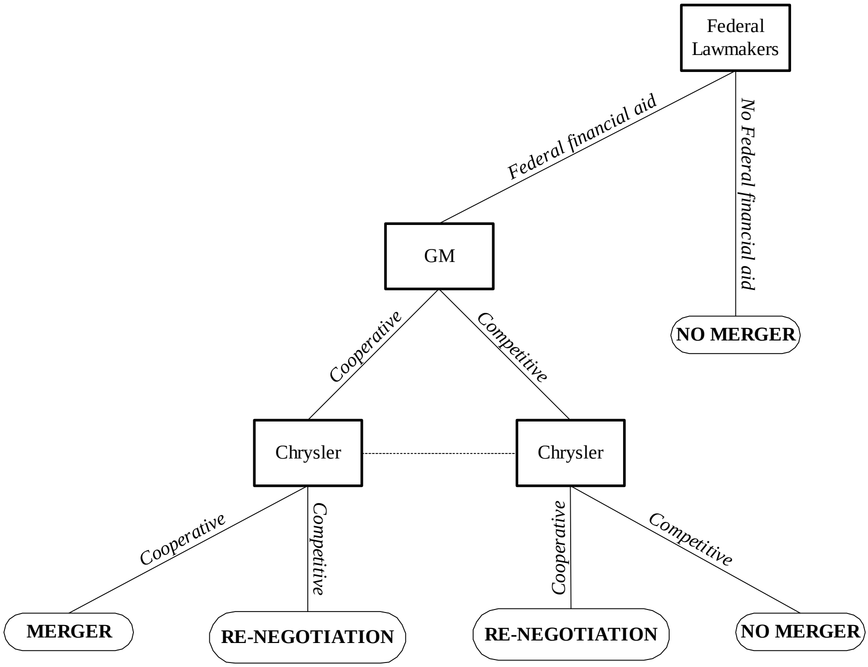


FIGURE 8.4 Decision-Tree Diagram of a Sample "Merger Game" - III



Strategic Analysis and Conclusion

We illustrated three different games with similar strategies above. Every tree diagram illustrated above has an important key element; that is, federal lawmakers (Congress) making a decision about providing financial assistance to American carmakers in trouble. Both GM and Chrysler signaled that they are seriously interested in a merger in the fourth quarter of 2008. [We showed that under the section, "Key Events to Date (December 2, 2008)"].

Because of the tough economic environment and industry conditions, both GM and Chrysler decided to concentrate on their most serious problems: short-term liquidity and other credit-related financial problems. As indicated by GM in their public announcement, they stopped talking to Chrysler regarding a potential merger, because of the company's current liquidity and other financial problems. A logical interpretation of this announcement is that if GM was not having these problems, the company would have continued discussing a merger opportunity with Chrysler further.

If both companies resolve their current problems after receiving federal financial assistance, they are highly likely to go back to merger discussions.

Our decision-tree diagrams illustrated above show that without federal financial assistance, a merger between GM and Chrysler is unlikely. If they get financial aid from the federal government, a GM-Chrysler merger depends on parties' strategies. If both automakers act cooperatively, our strategic models predict such a merger is highly likely. If one party pushes for a better deal, the likeliness of a merger depends on the other party's response and willingness of how much to increase or decrease the price of the deal.

Based on signals sent by the management of the automakers, we believe the automakers act cooperatively, and successfully merge in the near future.

We identified and analyzed incentives and strategies of the parties in early sections. By using backward induction, lawmakers could conclude that a merger between GM and Chrysler is highly likely. After concluding that, they need to review different scenarios and alternatives to make an informed decision.

One of the most important incentives of the lawmakers is to protect American jobs and prevent reductions in American output. Lawmakers need to assess the economic and fiscal cost of a merger between GM and Chrysler; and then compare their assessment results to the other alternatives, such as a Chapter 11 bankruptcy, or even a Chapter 7 bankruptcy, liquidation.

Authors of this book believe that federal financial aid (such as a bridge loan) and a merger of two automakers is the least costly scenario under the current circumstances. Based on our industry expertise and assessment, we believe all of the three games illustrated above have similar results: lawmakers provide federal financial assistance, and GM and Chrysler act cooperatively and merge their companies.

Chapter 9 Game Theory and the Law

Introduction

Game theory offers valuable tools to anyone faced with critical decisions in interactive decision-making environments. The legal system is replete with such occasions. Lawmakers consider the magnitude of penalties when they adopt criminal statutes; potential lawbreakers consider the chances of being caught and the likely penalty if caught; parties to a lawsuit consider the costs of litigation along with the chances of prevailing in court; and litigation attorneys think of their own interests as well as their opponents' interests, and are forced to respond to their opponents' actions.

Robert Cooter and Thomas Ulen state the benefits of using game theory in law in their book *Law and Economics*: "The law frequently confronts situations in which there are few decision-makers and in which the optimal action for one person to take depends on what another actor chooses. These situations are like games in that people must decide upon a strategy... Game theory will, consequently, enhance our understanding of some legal rules and institutions."[1]

1. Cooter, Robert, and Thomas Ulen, *Law and Economics*, Pearson Addison Wesley, 2004, p. 38.

Lawmakers, citizens, attorneys, and economic experts can use game theory in a wide range of areas involving the law, including:

- The setting of penalties in statutes, sometimes called the study of "optimal sanctions."
- The consideration of pursuing a lawsuit rather than settling a claim, given the costs and risks involved with both courses of action.
- Decisions about compliance with demands by other contracting parties and government agencies, including those that extend beyond *bona fide* legal obligations under contract or law.
- The estimation of compensatory damages to parties involved in breaches of contract or other causes of commercial damages, where one or more of the parties have multiple options.
- Strategies that plaintiffs and defendants could follow during the course of litigation, including those actions taken before, during, and after trial.
- Analysis of oligopoly behavior and antitrust claims.

In this chapter, we show how to use game theory to analyze and understand incentives of parties in a legal case. We provide a couple of game-theoretic models as examples. Then we analyze a famous antitrust case by using game-theoretic concepts.

Classic Game Theory Applications in Litigation

Incentives to Settle

The litigation process can be very costly. Although dramatic presentations of the legal system, such as those in popular movies, often focus on courtroom intrigue, the reality of most litigation is that courtroom activity is a very small fraction of the time and effort involved by the parties.

A typical legal dispute moves through several stages, with each additional stage creating more expense—and often an escalation of risk—for one or both parties. The costs and risks of litigation create substantial incentives to settle, and a classic use of game theory in law is the modeling of those incentives.

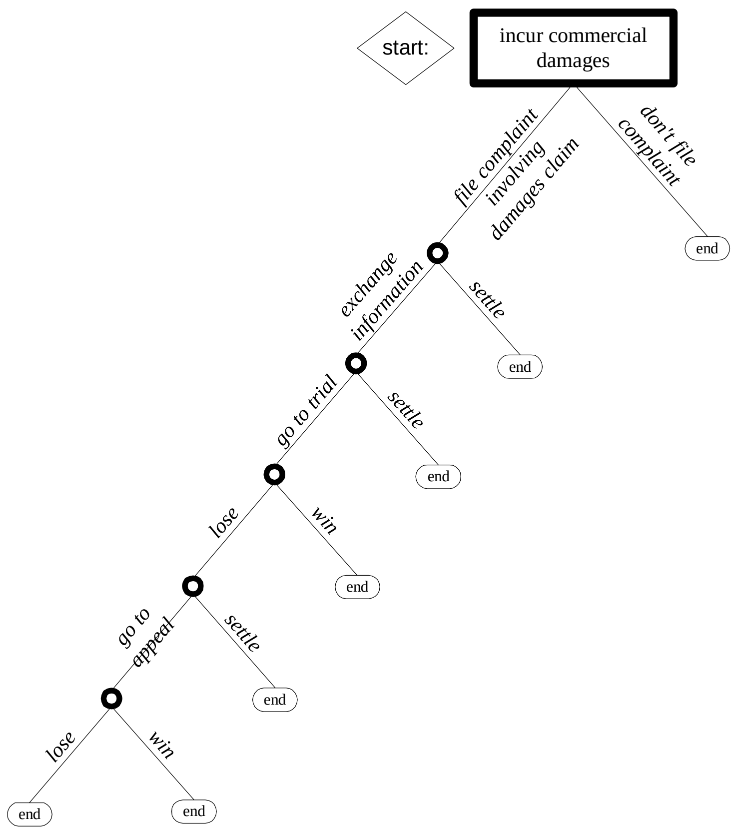
Example: Litigation or Settlement in a Commercial Damages Case

We present a tree diagram of an example commercial damages case in Figure 9.1 The events in the diagram begin with the plaintiff filing the complaint, and end either by a settlement among the parties, or by a decision of the court. Along the way, the parties are required to provide information (through "discovery"), engage in various pre-trial activities through their attorneys, have an opportunity to settle, and may move forward to a trial. If a trial court renders a decision, one or more parties have the opportunity to appeal. Each of these steps is costly and involves risk.

There is a natural balancing point for parties to such a case. For the defendant in a civil case, at some point the costs of continuing the litigation might be higher than the compensation the plaintiff is willing to accept in a settlement. By "costs" here, we mean the entire cost to the party, which would include the settlement payment to the other party; the costs of retaining lawyers, experts, and paying court fees; and the cost of their time. In cases involving criminal charges, and in many civil cases, the costs also include damage to their reputation.

By analyzing such a decision tree, legal professionals can develop strategies that better reflect the interests of their clients. Such a tool can also provide the basis for communication with clients about potential risks, costs and rewards of a case.

FIGURE 9.1 Events in a Commercial Damages Case



Optimal Sanctions

A second classic application of game theory in law is the search for the right severity of punishment for a crime, given the risks of being caught, the difficulty of proving guilt in a court, and the damage caused by the crime. This topic is often called "optimal sanctions" or "rational damages" and extends to both civil and criminal violations of law.[2]

We can introduce the topic of optimal sanctions by recalling a classic game presented earlier in this book: the Prisoner's Dilemma. In that discussion, we focused on the incentives facing the accused prisoners, assuming that the crime had already been committed and the penalties already set. In the field of optimal sanctions, we ask the converse question: how would the behavior of potential violators and the costs to society change when we vary the penalty?

Game theory provides powerful insights into this question, and tools to solve specific questions. Many of the examples we present in this book can be adapted to questions of optimal sanctions. These include questions related to commercial damages, which are discussed below.

Example: "Punitive" Damages

Government sanctions for crimes are often designed explicitly to punish the offender, whereas sanctions for the destruction or loss of property due to negligence often involve compensation. We discuss compensatory damages below; in this section we discuss punitive damages.

In criminal matters, lawmakers often try to make the "punishment fit the crime," or at least match the crime in severity. This pattern has existed for well over 3,000 years of human history.[3] Punitive damages in civil cases are sometimes called *exemplary* damages, because they "make an example" from the plight of the convicted lawbreaker. Although punitive damages are largely the province of criminal law, they do exist in many civil sanctions. Perhaps the best known of these in business law involves U.S. federal antitrust law, which establishes treble damages for many violations. One frequently articulated reason for this high sanction is the great difficulty of catching, prosecuting, and convicting a guilty party.

2. For sanctions involving business law violations, see Frank Easterbrook & Daniel Fischel, "Optimal Damages," in *The Economic Structure of Corporate Law*, Harvard, 1991; an overview is found in Patrick Anderson, *Business Economics & Finance*, chapter 11; CRC Press, 2004.

3. A review of the penalties applied to crimes in the Old Testament of the Bible vividly supports this observation. It also applies outside the Judeo-Christian tradition, as evidenced by the *Code of Hammurabi* (Babylon, circa 1780 BC) and the schedule of punishments in Kautilya's *Arthashastra* (India, circa 250 BC).

Properly Constructing the Payoff Matrix

Many games illustrated in game theory articles and books are created using very simple payoff matrices. In many of those examples, the magnitude of the payoffs is directly taken from one salient indicator present in the game. For example, most presentations of the Prisoner's Dilemma use the number of years of jail time the prisoner might be sentenced as the elements of the payoff matrix.

Throughout this book, we argue that practical use of game theory requires a careful analysis of the game, and the proper construction of it. Although it should be obvious, some experience in examining supposedly real-world-driven "game theory" models suggests to us the following rule: *always think carefully about your payoff matrix, and include everything in it that the subject thinks is important.*

Note the key identification of the *subject's* views: it is the subject that receives the payoffs (or negative payoffs, such as punishments); game theory models should consider the motivations of the subjects involved, not the social scientists studying them. If a social scientist constructs a nice, neat model with round numbers for the parameters, which roughly capture the most important factor in the minds of the subject, she is only part-way to the goal. Indeed, "solutions" to game theory models that are built with improper payoff matrices are no solution at all.

Examples: The Actual Payoff Elements

For example, let us consider a small handful of situations we discuss in this book, including the Prisoner's Dilemma, the incentives to settle, and the regulatory game. For each of these, there are obvious elements of the payoff matrix of the players involved. For teaching purposes, these elements are often quite sufficient to demonstrate game theory concepts, and even to derive the correct incentives for the parties involved.

However, for each there are at least a small group of other elements of their payoff matrices. These include, for example, the cost of executive time; the loss of reputation; and any "code" of behavior of the relevant group. Ignoring these can produce nicely modeled games that, even when "correctly" solved, leave the incorrect answer. See Table 9.1.

Remember, if the subject thinks it is important, *it is important*, and probably belongs in the payoff matrix. Properly constructing that payoff matrix is an essential step toward the practical use of game theory, and failing to accomplish it will often lead to gross errors.

TABLE 9.1 Elements of a Payoff Matrix

Game	Obvious Element	Other Elements
Prisoner's Dilemma	Sentencing time	Reputation; fear of reprisal; commitment to clan, gang, or ethnic group; "code" of behavior; risks or benefits of life in prison; potential to escape prison; potential to be injured or killed in prison.
Litigation: Incentives to Settle	Possible penalty, attorney fees	Cost of executive time; loss of reputation; "principle," informal commitments or code of behavior among business groups; risks of other discoveries or embarrassments; financial risk.
Regulatory Game	Effect on subject company	Effect on competitors; market entry; credibility with key customer groups.

Commercial Damages

Overview of Commercial Damages

Commercial damages are damages suffered by a business due to causes such as breaches of contract, natural disaster, labor unrest, thefts of property, interruption of supply, and expropriation by governments. Because these actions typically cause the business to lose the benefit in commerce of the use of the property (or reliance on the contract), we call these commercial damages.

Such damages to the business are typically larger than simply the cost of the lost property or similar measure. For example, even a relatively small labor disruption (in terms of wages) can cause dramatic losses in production—a key factor in management-labor union relations. Similarly, a breach of a contract requiring a supplier to provide parts for a manufactured good can result in the loss of business worth many times more than the cost of the missing parts.

In this section, we consider *compensatory* damages, meaning damages that compensate for the loss caused by the breach of contract or other cause. We do not consider here *punitive* or *exemplary* damages, which are designed to punish or make an example of the party committing the breach. (We discuss punitive damages under "Optimal Sanctions," above.)

Events in a Typical Commercial Damages Case

In a typical commercial damages case, there are at least two parties: the plaintiff(s) and the defendant(s). In the U.S. legal system, the matter often begins when the plaintiffs' attorneys file a complaint against the defendants, asserting that their clients' business was damaged due to certain actions of the defendants, and asserting that the defendants should not have committed the actions. Plaintiff-side attorneys typically assert the existence of damages (and later commission an expert to estimate them), and then ask the court to order the defendant to pay compensation for damages occurred. (We present key events in a commercial damages case in a tree diagram in Figure 9.1)

The compensation might be claimed for losses defined as "lost profits," the "diminished value" of the plaintiffs' business, or another measure of damages. These concepts have particular meaning within forensic economics.

Evaluating Commercial Damages Using Game Theory

In many cases, well-established techniques of business valuation can be used to estimate the damages caused to a business by a breach of contract or other event. This is especially the case if the event caused a reduction in the earnings of a firm, and where all the following qualifications were fulfilled:

- The company was consistently profitable before the event.
- The company had stable management.
- The company was not involved in any change in its business model or significant expansion.
- The company had excellent accounting and business records available.
- The company was not involved in an industry during a time of significant change.
- The breach caused an immediate, but limited-duration, loss of income.
- The breach did not affect the company's competitors.
- The breach did not affect the future demand of customers for the company's products.

While this list presents no barrier to the creators of examples, it provides high barriers to those required to actually estimate damages due to an actual breach of contract for an actual firm. In the practical experience of the authors, *most* firms incurring commercial damages do not meet one or more of these qualifications, and a good subset does not meet half.

The use of game theory in commercial damages arises from the difficulty in using the traditional methods when one or more of the qualifications list above is lacking, and where the business interests of the subject companies are affected by the actions of each other or other players. In some of these cases, a game theoretic model can be developed that characterizes the important events and decisions which affect the value of the subject firm, or its earning potential. Such a model could include:

- The options available to business operators that have been damaged by a breach of contract, infringement of a property right, or property loss.
- Any potential actions that fulfill the doctrine of "mitigation of damages" in the U.S. system of laws.
- A proper use of techniques available for the estimation of the value of investments under uncertainty.

We have discussed the use of the extensive form of a game earlier in this book. This form, or a similar event-tree or decision-tree, can often be used to model the options available to a damaged business. Often, the same model can incorporate mitigation opportunities and the consequences of them.

We discussed in the "Strategic Value" chapter the importance of considering strategic position when evaluating the value of a firm. Below, we extend this topic to include "real options." Valuation and damages estimates that fit the actual conditions and constraints of businesses often cannot be produced by traditional methods, such as discounted cash flow models arising from an established base. When the firm faces strategic and competitive factors that can be modeled using game theory concepts, the tools we suggest here should be considered, along with the traditional tools such as discounted cash flow analysis, to see which perform more reliably or take into account more information.

The Value of Investments under Uncertainty

Many applications in corporate finance, rely upon the following behavioral rule: if the expected net present value (NPV) from an investment exceeds its cost, make the investment. Indeed, the NPV rule is the basis for many "cash flow" models of valuation, and is a mainstay of numerous books in business valuation. Much of the capital budgeting literature, and modern finance courses based upon it, follow this rule.

Unfortunately, the NPV rule is often wrong. In particular, the static NPV method of valuing investments systematically ignores powerful factors that actual investors nearly always consider: the option to wait, the option to abandon, and the option to invest again. These are not the same as financial options; these are "real options" that investors typically hold.

The study of real options examines the value of investments when uncertainty exists about the future, and when an investor has the option to wait, or to abandon, an investment. One powerful insight from this field is the importance of identifying explicitly whether an investment should be considered irreversible, or open to various timing and change options. Most traditional examinations of investment behavior have focused on single irreversible investment decisions, often driven by the NPV rule. Some investments, of course, fit this definition quite closely. However, most practical strategic investments do not.[4]

Game Theory and Real Options

There is a distinction between the use of classic real options valuation techniques, and those we describe below for game theory. The distinction arises from the source of the uncertainty. The classic treatment of real options involves a “twin security” that drives market prices. Such a security is commonly illustrated by a natural resource price (such as oil, gold or steel), or a price of a product that is sold by a firm (such as corn, wheat, or forest products). If the price dynamics of such an asset is encapsulated in a traded security, the value of a separate asset tied to that security can usually be modeled closely. Real options techniques can provide very useful valuation insights, though often difficult to apply. Even a non-precise real options valuation, when compared directly with a traditional static NPV valuation estimate, provides a basis for valuing managerial flexibility.

Game theory models, by definition, focus on the effects of one party’s decision on another’s interests. Such decisions are not random ones.[5] Thus, game theory models are a natural way to examine the value of investments or operating assets that are strongly affected by another’s actions.

Extensive Form Modeling of an Investment Outcome

The basic tool we borrow from game theory for this purpose is the use of the “extensive form,” or decision tree, to model the potential paths and outcomes for the subject business. This is similar to “decision tree analysis,” in its conceptualization. However, the “decisions” in a decision tree can be based on almost any factor, or no factor other than random events. In a game theory model, the important decisions are made on the basis of what a player believes another’s interests and actions might be.

This can be of great use to economic experts in complex cases. In particular, it allows explicit modeling of business interruptions and other forms of injuries to businesses that restrict managerial freedom, whether they caused immediate cash losses or not. These models can also be extended to include other fundamental factors that affect the value of a business, such as the industry conditions, business

4. A simple thought experiment shows how this is true. A true strategic investment decision is not one taken in the normal course of business, or with a nonmaterial likely effect on the company’s welfare. Such a decision must weight mightily on the future value of the firm. Now, consider how many times such decisions are made in a manner that “bets the company.” Such irreversible decisions are taken by firms, but very rarely, and for good reason.

5. We assert this is true even when an opponent follows a “mixed” strategy that involves the use of random actions, because the choice to use randomization as a basis for an action is a specific decision itself, not a random event.

cycle, and other economic factors. These economic factors are often given scant notice in valuation analyses based largely on past accounting records. However, analyses of these factors are not only necessary to forecast future earnings, they are also often required by case law, statute, or regulation.[6]

A Simulation Model for Real Options and Game Theory Valuation

We present below an illustration of a simulation model developed by the authors for the purpose of examining the value of a business that operates under uncertainty, has significant real options, and which has suffered some type of business interruption or costly breach of contract. We note that nearly *all* businesses fit the first two of the three characteristics of this example firm, and in some years will fill all three of three.

The model simulates the earnings of the subject company under three different scenarios:

1. The "no breach" scenario, in which no business interruption or breach of contract occurs, and during which the firm is largely undamaged by the category of outside events under study.
2. The "breach" scenario, in which the firm suffers the effects of the event or breach, and slowly recovers from it using its standard operating practices.
3. The "mitigation" scenario, in which the firm takes aggressive steps to mitigate the immediate damages due to the breach or event, even though the time and expense of such actions may result in less effort being expended toward exploring and business development.

The model is illustrated in Figure 9.2 This model was created using SIMULINK and MATLAB software, which provide vector-processing and simulation capability. The model "blocks" here include random events, discounting over time, and aggregating the results over time, for all three scenarios. There are three scenarios, each of which is illustrated by one linear set of blocks, connected by a "wire" or "pipe." In this model, the flow of information and time moves from right to left. As you can see from the illustration, random events on the right side produce varying amounts of income, which affect the value of the firm by affecting the income the firm can realize over time (represented by the blocks at the left side of the diagram). Using the model requires two parts: the simulation model itself, and a program file to initialize the model (establish variables, initial values, the number of time periods, etc.) and run it.[7] The latter steps, repeated numerous times, give a *Monte Carlo* result that can indicate the pattern of outcomes that are likely to occur in numerous events of this

6. The most commonly cited basis for "fair market value" is IRS Revenue Ruling 59-60, which includes economic factors as essential factors.

7. Excerpts from this initialization script file are included in Figure 9.5, in the appendix to this chapter.

type. Note that to simulate the model illustrated in Figure 9.2, “Business Interruption with Mitigation Opportunities,” you need to run MATLAB codes provided in Appendix 9.A. See Figure 9.5

Using this kind of approach can provide powerful benefits that are not available with standard discounted cash flow analysis, notably the ability to explicitly incorporate the dynamics of individual decisions affecting the outcome of a chain of events, and to simulate the outcome of experiments hundreds of times.

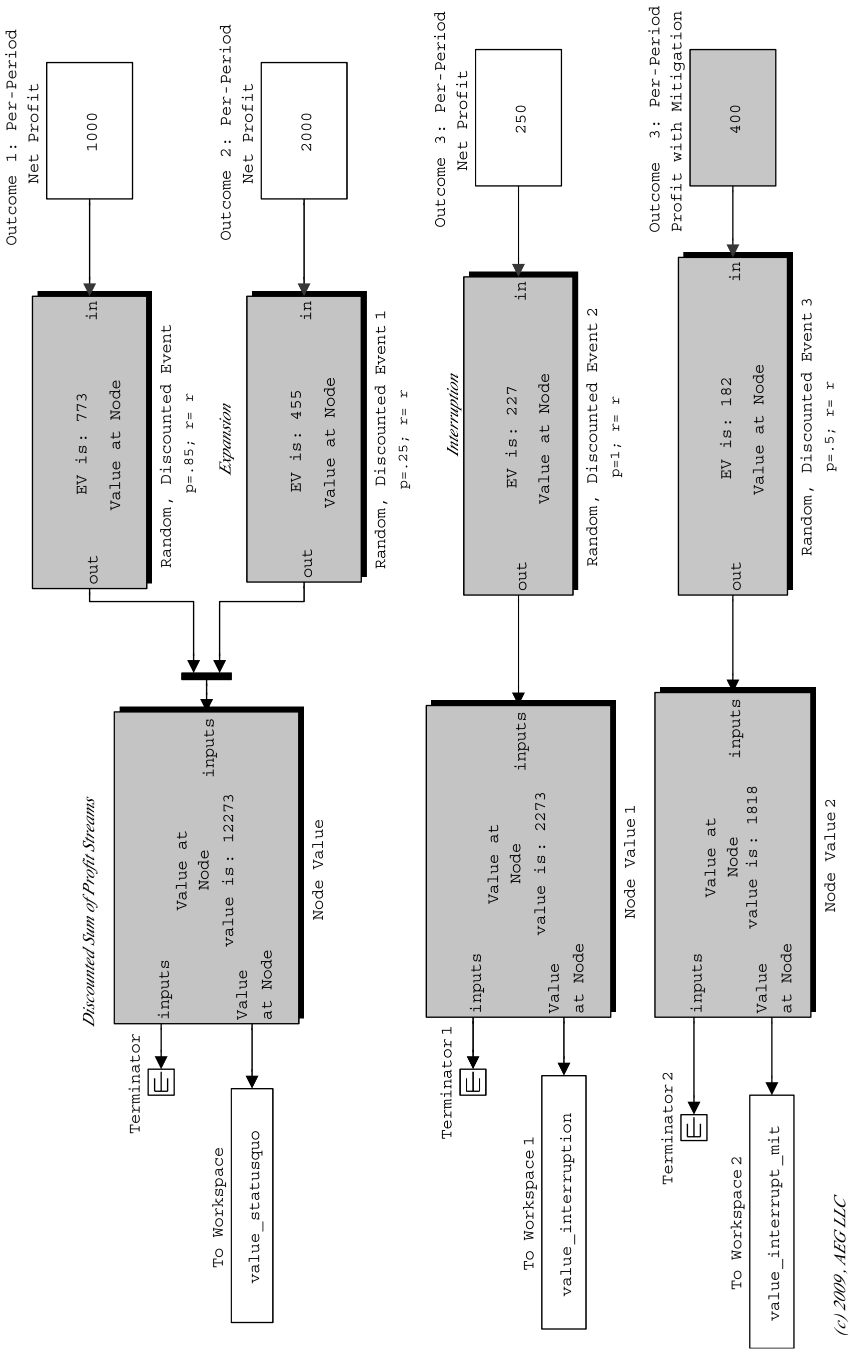
Results of Experiment Using Simulation Model

The model, as described above, simulates the results of many decisions and events. It can be used to estimate directly the commercial damages that resulted from a (hypothetical) business interruption of a successful retailer.

In this example, we assume the retailer is also underway with expansion plans. The breach, however, forces the retailer to temporarily abandon the expansion effort. What are the damages? How do we treat the partially completed efforts at expansion? How do we treat the lost profits due solely to the destruction of the retailer’s option to re-invest in a different market, for say two years?

Keeping in mind that this is a hypothetical example, and assuming we have properly characterized the payoff matrix, we can directly estimate damages using the Monte Carlo results. Indeed, it appears that the average earnings of the hypothetical company are slightly larger with the “expansion” strategy, than with the “return to status quo.” However, the initial losses are higher under the “expansion” strategy. The results in the example are not important, but the potential to use this tool in much more complex cases is important.

FIGURE 9.2 Business Interruption with Mitigation Opportunities



Game Theory and Antitrust Law

Market Entry and Collusion

Every firm has an interest in avoiding competition, keeping the market from becoming saturated as well as maintaining or growing its market share and profit margin(s). When a firm plans to enter into a new market, it anticipates facing resistance from the companies already in the market. A new firm in a market may mean a smaller market share for some of the companies already in the market, and lower profit margins because of higher level of competition.

Firms develop strategies to deter potential market entrants not to enter into their markets. Some of those strategies are acceptable, some of them are banned by federal and state laws. Collusion is one of the banned strategies by legal authorities in the U.S., like in other free-market economies. Collusion is defined as "secret agreement or cooperation especially for an illegal or deceitful purpose" by *Merriam-Webster's Dictionary.* In economics, collusion occurs when competing firms cooperate for their mutual benefit. Collusion happens within the oligopolistic market structure, where the collusion of a few firms can significantly impact the market.

In our market entry discussion here, collusion is a strategy involving market entrant and incumbent firm(s). That collusion might be on pricing, wages, or market share issues to prevent lost profits. To develop market entry related strategies, firms need to assess each other and their market power well. If an incumbent firm believes that the firm with potential entry does not have enough resources to support such an entry, it would fight against the entrant firm to deter the market entry. Likewise, if the entrant firm believes the incumbent firm(s) do(es) not have enough market power to prevent its entry, the entrant would enter the market without any type of negotiation.

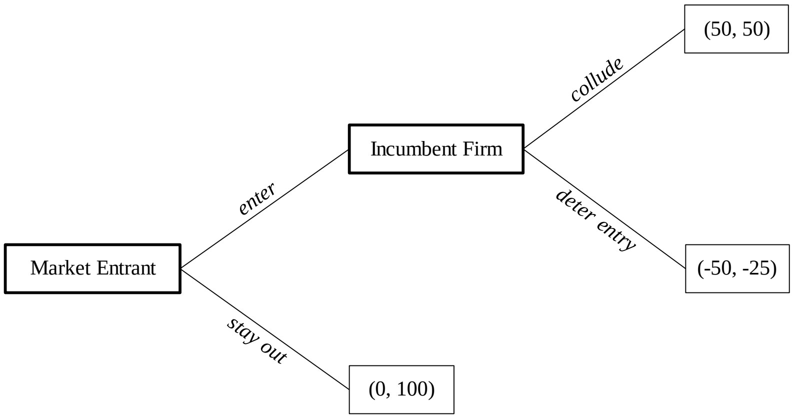
Since collusion is banned by state and federal laws, lawyers deal with collusion-related illegal business activities quite often. Antitrust attorneys need to understand incentives and strategies of parties to develop their cases and defend their clients' interests. Game theory is very helpful to antitrust attorneys in this regard.

Example

Let us develop a sample game-theoretic model involving two players: market entrant and incumbent firm. Let us assume our game is a non-cooperative game of imperfect information. Strategies of the entrant firm are {*Enter, Stay out*}. The incumbent firm has two strategies: {Collude, Deter entry}.

The extensive form of the game is illustrated in Figure 9.3

FIGURE 9.3 A Tree Diagram of Market Entry and Collusion Example



In this sample game, if the market entrant decides not to enter into the market, its payoff would be zero; and incumbent firm's payoff would be 100 units. If the entrant firm enters into the market, its payoff would be 50 units, if the incumbent firm colludes. If the incumbent firm sets prices low enough to deter market entry, the market entrant's payoff would be negative 50 units. The incumbent party gets 50 units of payoff if it colludes, otherwise it would get negative 25 units as a payoff.

The antitrust attorneys representing parties in this case would see collusion as a strong incentive for players, if the entrant firm decides to enter into the market.

If our game-theoretic model is a single period game, collusion is an equilibrium strategy for both players. If our game is a repeated game, incumbent firm might be willing to lose money in some time period not to lose market share and its market power. Recall that in dynamic, repeated games, market power is a very important concept to analyze the incentives and strategies of the players, and the game overall.

Antitrust Case Study: United States of America, et al., v. Microsoft Corporation

Microsoft Corporation is a well-known computer software and consumer electronics manufacturer. Microsoft Corp. was founded in Albuquerque, New Mexico in 1975 by Bill Gates and Paul Allen. Its headquarters are located in Redmond, Washington. Microsoft is a publicly traded company, best known by its co-founder and chairman Bill Gates and by the Windows operating systems, its flagship product. Microsoft also produces application software such as its very successful Office Suite comprised of widely used programs like Word, Excel, and PowerPoint. Nearly all Microsoft software products complement a Windows operating system.

On May 18, 1998, The United States Department of Justice along with 20 states and the District of Columbia, filed a consolidated civil antitrust lawsuit against Microsoft. The primary allegations were:

- Microsoft monopolized the operating systems market, an act deemed illegal under the Section 2 of the Sherman Antitrust Act.
- Microsoft had anti-competitive contractual agreements with PC manufacturers, Internet Service Providers (ISPs), along with others, and also took illegal exclusionary actions to preserve its monopoly of the operating system market; agreements and actions deemed illegal under Section 2 of the Sherman Antitrust Act.
- Microsoft attempted to illegally monopolize the market for Internet browser software by bundling its Internet browsing software, Internet Explorer with its operating system, Windows; an act deemed illegal under Section 2 of the Sherman Antitrust Act.
- Microsoft's tying of its Internet browser software Internet Explorer (IE) with its separate Windows operating system was anti-competitive and illegal under Section 1 of the Sherman Antitrust Act.

History of Investigations Leading up to the Antitrust Suit

The Federal Trade Commission and the Department of Justice had investigated Microsoft concerning several antitrust allegations with these investigations before the 1998 lawsuit.

On July 15, 1994, The Department of Justice sued Microsoft in violation of the Sherman Antitrust Act under Section 2, alleging that Microsoft had entered into licensing and contractual agreements with PC original equipment manufacturers (OEMs), which prevented other operating system competitors to compete in the operating system market as many PCs would come with the Windows operating system. The suit was settled through a consent decree in 1995, with the primary stipulation being that Microsoft would not bundle Microsoft products with its Windows operating system; however, Microsoft was not prohibited from developing and tying integrated applications and features into its operating system.

On October 20, 1997, The Department of Justice alleged that Microsoft had violated the consent decree and petitioned the District Court to find Microsoft in civil contempt. The allegations stemmed from Microsoft bundling IE with its Windows operating system and requiring PC manufacturers to distribute PCs with Windows (and thus with IE). Microsoft claimed that there was no violation as they considered Internet Explorer a feature of the operating system and not a separate product.

On December 11, 1997, Judge Thomas Jackson issued a preliminary injunction barring the bundling of Internet Explorer with Windows; however, on June 23, 1998, the Court of Appeals ruled that Microsoft was not in violation of the 1995 consent decree. On May 18, 1998, the Department of Justice, along with 20 states, and the

District of Columbia filed a a consolidated civil antitrust lawsuit.[8] They alleged violations under Section 1 and Section 2 of the Sherman Antitrust Act that Microsoft had primarily monopolized the market for PC operating systems, as well as attempted to monopolize the Internet browsing software market by bundling Internet Explorer with its Windows operating system, and had engaged in illegal exclusionary agreements and actions when doing so.

Market Power: Windows and Internet Explorer

From 1990 to 1999, Microsoft's share of the PC market for Intel-compatible operating systems had been over 90% with projections that Microsoft's market share would increase even further. Even if Apple's Mac OS operating system were to be included in this market, Microsoft's market share was estimated to still be over 80%.

The Internet browser market was much more competitive in the 1990s; the competition, primarily between Netscape Navigator and Internet Explorer was commonly known as the "Browser Wars." Netscape Navigator was an Internet browser like Internet Explorer created by Netscape Communications Corporation, which dominated the market in the early 1990s in respect to usage.[9] However, Netscape market share gradually decreased. In 1996, Netscape market share was estimated to be approximately 80%, with Internet Explorer's being a mere 5%. In 1997, Netscape market share was approximately 55%, while 35% of the market was using Internet Explorer. By the middle of 1998, Netscape was estimated to have 50-55% of the market and Internet Explorer was estimated to have 45-50%.[10] Internet Explorer was first integrated or bundled into the Windows Operating System in 1995, later becoming a key factor of the antirust lawsuit, as Microsoft's share of the PC market for Intel-compatible operating system was over 90%. In 1999, Internet Explorer 5.0 was released; it continued to be bundled with Windows 98. Along with this bundling, IE 5.0 was generally viewed by PC analysts and consumers as the superior browser to Netscape's.

Major Competitors

Microsoft's primary competitors in the 1990s were Netscape Communications Corp, Sun Microsystems, IBM, and Apple Inc.[11] While Microsoft's competitors were not

8. The 20 states that filed the lawsuit with the Department of Justice and the District of Columbia were: California, Connecticut, Florida, Illinois, Iowa, Kansas, Kentucky, Louisiana, Maryland, Massachusetts, Michigan, Minnesota, New Mexico, New York, North Carolina, Ohio, South Carolina, Utah, West Virginia, and Wisconsin.

9. Netscape was headquartered in Dulles, Virginia. From 1995-2003, it was a publicly traded company. In 1998, Netscape was acquired by AOL, LLC. On July 15, 2003, Time Warner disbanded Netscape.

10. "Findings of Fact," US District Judge Thomas Jackson, November 5, 1999.

11. During 1997, Senator Orin Hatch of Utah (R) lead congressional hearings on Microsoft. During this time Sun Microsystems, Oracle, IBM, Netscape, and Novell lobbied for antitrust action against Microsoft.

in direct competition with Microsoft and the Windows operating system, these companies were viewed to be competitors in various ways as their applications were complements for the Windows operating system, and could potentially weaken the applications barrier to entry and perhaps lower the entry barriers in the operating system market as well.

The primary applications competitor was Netscape Communications Corp. (Netscape) and its Netscape Navigator Internet browsing software discussed above. Navigator was very successful when it debuted. Microsoft was concerned that Navigator could become an alternative platform for applications development. However, Netscape's market power diminished with Navigator losing to Internet Explorer.

Sun Microsystems is an information technology and software services company, founded in 1982. Sun is widely known for its Java platform and software. In May 1995, Sun announced it had completed development of its Java programming language, which would have numerous uses such as enhancing Internet browsing through more dynamic graphics and visuals. Sun Microsystem's strategy to distribute Java concerned Microsoft, particularly when Sun's Java runtime environment software was bundled with Netscape Navigator, becoming Sun's primary means of distribution at the time for its runtime software. The tying of Netscape and Java was seen to further reduce the application's barrier to entry.

A smaller competitor was IBM and its e-mail software, Lotus Notes, which also used Sun's Java runtime environment software, as well as having a uniformed look and Interface across all operating systems it was applicable for, from Apple's MAC OS to Microsoft's Windows.

Apple Inc., while having its own operating system, the MAC OS, as well as having its own line of computer hardware and PCs, was not seen as a true competitor at the time. This was mainly because Apple did not license the MAC OS separately from its PC hardware products. Microsoft in comparison did not have hardware, only software with agreements with Intel-compatible PCs to include Windows. Also, the majority of software applications available on Intel compatible PCs were not available on the MAC OS.[12]

A Game-Theoretic Model of the Microsoft Antitrust Case

To understand the "antitrust game" between Microsoft and federal and state governments, we need to develop a complex cooperative n-player game of perfect information. The game is cooperative, because the federal and state antirust acts and laws are binding. Microsoft needs to meet the antitrust criteria as not to violate certain laws subject to the lawsuits filed against the company.

12. The Court stated in its Findings of Fact that, "Section III of these findings demonstrates, including the Mac OS in the relevant market would not alter the court's conclusion as to the level of Microsoft's market power."

Even though the major players of the game are Microsoft, the federal government, and specific state governments, Microsoft's key competitors are players as well because of the antitrust nature of the game. Microsoft's primary competitors in the 1990s were Netscape Communications Corp., Sun Microsystems, IBM, Novell, and Apple Inc.

During 1997, Sun Microsystems, Oracle, IBM, Netscape, and Novell lobbied for antitrust action against Microsoft. While Microsoft's competitors were not in direct competition with Microsoft and its flagship product, the Windows operating system, these companies were viewed to be competitors in various ways as their applications were complements for the Windows operating system.

Key Incentives

Microsoft's key incentive is to settle the case as cost-efficiently as possible, and be able to use one of its proven successful business models: offering bundled products to customers.

Microsoft's key competitors' shared incentive is to diminish the market power of Microsoft, and lobby against Microsoft's business model; that is, the tying of various products including Internet Explorer with Windows.

Federal and state governments involved in the case share a common incentive of protecting consumer rights, and making sure that consumers have choices among different products, and are not forced to use certain products because of the fact that one company tied its products.

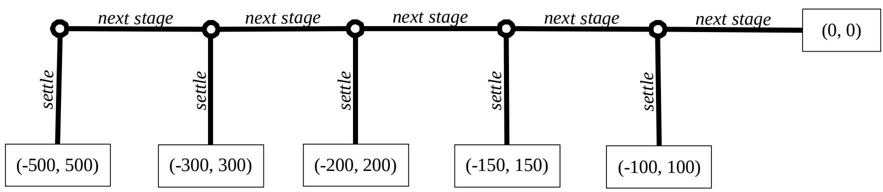
Analysis of Microsoft's Decision Tree

Microsoft had various strategies during this major antitrust lawsuit. Two of them were: settling the case and fighting against all antitrust claims. The major objective of Microsoft was to be able to continue its successful business model of tying of various products including Windows with Internet Explorer, at the end of the lawsuit.

If Microsoft was able to achieve its major objective by settling the case, it would have settled. Otherwise, the company would fight against the claims of violation of the antitrust acts and laws. Indeed, that was what happened. As we see at the end of the chapter, one of the settlement points was "Microsoft would have no restrictions on bundling its products."

We can illustrate Microsoft's play, borrowing the extensive-form of the *centipede game.*[13] See Figure 9.4 below.

FIGURE 9.4 Extensive Form of the Antitrust Game: Microsoft Move



The first number in each payoff pair belongs to Microsoft, the second one belongs to a competitor of Microsoft subject to the antitrust case (such as Netscape). The extensive form of the game illustrated above shows Microsoft carries the case as far as possible, until it gets a favorable settlement or ruling. Because of its market power and rich resources, the company was able to follow such a strategy. At the end of such a game, Microsoft would be able to get a favorable ruling. In our case, that was the court's allowance for Microsoft continuing its successful business model.

Below, we provide more information about the trial, the conclusion of law, and the settlement.

The Trial and Conclusions of Law

The trial began on October 19, 1998 and ended on June 24, 1999.[14] Twelve witnesses from each side testified. Chairman and then CEO Bill Gates did not testify; however, the video of his deposition was used in the trial. Judge Jackson announced early that he would announce his "Findings of Fact" before his "Conclusions of Law." This was generally seen as implying that Judge Jackson was wanting the two sides to reach a compromise and resolve the case, possibly through a consent decree like in 1995.

On November 5, 1999, Judge Jackson issued his "Findings of Fact," siding strongly with the plaintiffs that Microsoft's dominance of the PC market for Intel-compatible operating systems constituted a monopoly and that Microsoft took actions against its competitors to preserve it.

13. Centipede game was first introduced by Robert Rosenthal in his paper: "Games of Perfect information, Predatory Pricing and the Chain Store Paradox," published in *Journal of Economic Theory* in 1981.

14. On October 20, 1997, The Department of Justice alleged that Microsoft had violated the 1995 consent decree and petitioned the District Court to find Microsoft in civil contempt. On December 11, 1997, Judge Thomas Jackson issued a preliminary injunction barring the bundling of Internet Explorer with Windows; however, on June 23, 1998, the Court of Appeals ruled that Microsoft was not in violation of the 1995 consent decree.

In December 1999, Judge Richard Posner, Chief Judge of the Seventh Circuit Court of Appeals, agreed to serve as mediator for the settlement discussions; however, on April 1, 2000, these discussions fell through. And on April 3, 2000, Judge Jackson issued his "Conclusions of Law," finding for the plaintiffs on most allegations: that Microsoft had attempted monopolization with its Internet Browser, and had committed monopolization with its operating system, and that these acts were done in violation of Section 1 and Section 2 of the Sherman Antitrust Act. On June 7, 2000, Judge Jackson issued his remedy decision that Microsoft would be split into two companies: one company that specifically handled the Windows operating system and one that took care of all other software and products.

The Appeal

Microsoft appealed the ruling, which was later granted by the District Court. The District Court later petitioned the Supreme Court to hear the court immediately, which is highly irregular, but on September 26, 2000, the Supreme Court stated it would not hear the case before the Court of Appeals.

On February 27, 2001, The Washington DC Court of Appeals heard Microsoft's appeal of Judge Jackson's ruling. The court's ruling significantly changed the course of events for Microsoft and the case. The general points by the court were:

- Microsoft's split up ruling was rescinded.
- Microsoft was found liable under Section 2 of the Sherman Act to have attempted to maintain its monopoly of the operating systems market.
- Microsoft was not liable for bundling Internet Explorer with Windows nor was Microsoft liable for attempting to monopolize the Internet browser market.
- The court found Judge Thomas Jackson had violated judicial rules by speaking with reporters. The Appeals Court disqualified the judge retroactively and ruled that a different judge would be remanded to the case (Judge Colleen Kollar-Kotelly was later chosen by lottery to preside over the case).

The Settlement

On November 2, 2001, The United States and Microsoft discussed and proposed a settlement concerning the antitrust case. Judge Kollar-Kotelly gave the plaintiff states until November 6 to decide to agree (or not) to the settlement. On November 6, 2001, nine states, Illinois, Kentucky, Louisiana, Maryland, Michigan, New York, North Carolina, Ohio, and Wisconsin, agreed to settle. The District of Columbia and the remaining plaintiff states, California, Connecticut, Florida, Kansas, Iowa, Massachusetts, Minnesota, Utah, and West Virginia, stated the settlement was not adequate and that they would pursue the suit further. It should be noted that there were originally 20 states that filed the suit along with the District of Columbia and the Department of Justice. New Mexico settled the suit in July of 2001 with Microsoft paying the state's legal costs; the state would still share any future result of the case.

South Carolina withdrew months after the original filing.[15] On June 30, 2004, the U.S. Court of Appeals unanimously approved the settlement with the Department of Justice. The primary points of the settlement were:

- Microsoft would not be split up.
- Microsoft would have no restrictions on bundling its products.
- Microsoft would be allowed to increase the functionality of its Windows operating system.
- Microsoft would not be allowed to make agreements, which would give exclusive support and development to Microsoft software.
- Microsoft would be required to disclose some of its server protocols.
- Microsoft would be required to disclose some of its middleware interfaces for use with Windows.
- Microsoft would allow PC manufacturers the autonomy to install middleware software.

15. "One of the original states participating in the suit was South Carolina, whose attorney general, Charles Condon, was facing re-election in 1998. Shortly before the election, Microsoft contributed $25,000 to the South Carolina Republican Party. According to the Chairman of the South Carolina Republican Party this was the largest unsolicited donation ever received. Three weeks after he won, Attorney General Condon withdrew from the antitrust case," Declaration of Edward Roeder, Department of Justice, 2002.

Appendix 9.A

FIGURE 9.5 MATLAB Codes for the SIMULINK Diagram

```
% Initialize GT Retailer3--from Initialize_GT retailer3
% PLA (c) 2009, AEG LLC.

%-------------------------------------------------

% I. Configuration

Tstart = 0;
Tstop = 10;
Tstep = 1;

modelname = 'GT_retailer3';
line = '-----------------------------';

% II.  Variables

% discount rate
r = .10;

% mean, var, and seed for (normal) random number generator
% seed = 0;

seed = 100000*rem(now, 1);  %changes seed for random number generator with time.
%note that you may have to wait 2 seconds for seed value to change enough
%to change the random numbers.

% seed = clock

mean = 1;
variance = 1;
novariance = 0;

% III. Simulate Base Case--No Variance

var = novariance;

sset = simset('SrcWorkspace','current');
% sim(modelname, [Tstart:Tstep:Tstop], sset, []);
sim(modelname, [Tstart Tstop], sset, []);

display('Model Simulated--Base Case.')
whos

display(line);
display('Results: Output structure; signal values')

output_value

output_value.signals.values

disp('Individual outcomes per period');
NVinput.signals.values

disp(line);

% III. Update Mask to Display Expected Value

% variable list

varlist = {EV_0, EV_1, NVoutput, NVoutput1, NVoutput2};


updateMask1(modelname, varlist, 'EV is: ');
updateMask3(modelname, varlist, 'EV is: ');
disp('Updating Mask');
```

```
% IV. Simulate Using Random Events
var = variance;

sset = simset('SrcWorkspace','current');
% sim(modelname, [Tstart:Tstep:Tstop], sset, []);
sim(modelname, [Tstart Tstop], sset, []);

display('Model Simulated--with Randomness.')
whos
disp(line);

% Re-Edit Mask (Note this is not "expected value"

updateMask1(modelname, varlist, 'Actual Value is: ');
disp('Updating Mask');

% could have call back use variable here to say "expected value" or
% "actual value"


% Diagnostics

display(line);
display('Results: Output structure; signal values')

x=output_value.signals.values;
y1 = sum(x, 1);
disp(' (row totals)');
y2 = sum(x,2)

disp('Individual outcomes per period');
xx=NVinput.signals.values
disp(' (column totals:)');
yy1 = sum(xx, 1)
disp(' (row totals:)');
yy2 = sum(xx,2)

disp('Output; Individual Outcomes');
[y2 yy2]

disp(line);disp(line);
```

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