

Chapter One Overview

Strategy is the essence of politics; a nonstrategic politician cannot achieve his or her aims. The political scientist who has neither the time, the training, nor the inclination for strategic thought will be poorly equipped to understand the strategic twists and turns of politics. Candidates compete to win office in elections. After electoral campaigns in multiparty democracies, political parties strive to form governments. Legislators contend to advance their own legislation and block bills they oppose. Legislatures oversee executive agencies to verify that the bureaucrats carry out the intent of the laws they pass. National leaders vie to prevail in international crises, while also trying to avoid war. Nations raise and lower barriers to trade in order to influence other nations to lower their own trade barriers. All of these situations, and many others in politics, are strategic. Actions are taken to influence other actors' choices; no one actor alone can determine the outcome of the situation. All actors must think about what the other actors will do when choosing their own actions.

What Is Game Theory?

Strategic situations are a subgroup of social situations. Social situations involve the interaction of individuals; to study and understand social situations, we need a theory that explains how individuals' decisions are interrelated and how those decisions result in outcomes. Game theory is one such theory. It is a theory of interdependent decisions—when the decisions of two or more individuals jointly determine the outcome of a situation. The “individuals” can be persons or collective entities that make consistent choices.

Individuals' choices are also shaped by their social settings, which social scientists often call “structure.” “Structure” ranges from the factors that produce the consequences of decisions, such as military capabilities in international politics, to whether people even believe that they have choices. Game theory provides a way to formalize social structures and examine the effects of structure on individual decisions. To specify the structure of a game, we must specify what choices the players face, how those choices lead to outcomes, and how the actors evaluate those outcomes. Those choices of game structure capture different social theories. If one of the themes of this book is that individual choices depend upon the choices of others, how the choice of game structure captures competing social theories is the second theme. Game theory cannot tell us whether certain theories are accurate descriptions of the world, but it can tell us what behavior we should expect as a consequence of those theories.

Game theory can model economic, political, or more general social situations. Economic situations include markets where the choices of many affect prices for all, oligopolistic competition where the marketing decisions of a few firms affect prices, and bargaining between two or more buyers and sellers. Political situations could be electoral competition among candidates, legislative voting in committees, and international bargaining in world politics. Social situations cover the range of group interactions in different settings. This book focuses on political settings as illustrations because it is written for political scientists. However, the techniques described are relevant for a broad range of social interactions.

What Can You Do with Game Theory?

Game theory began in the 1920s with the Minmax Theorem, the first statement of the basic solution of a situation of pure conflict, a two-person, zero-sum game. The early developments were collected into a coherent body of mathematical theory and published in 1943 by Von Neumann and Morgenstern in *Theory of Games and Economic Behavior*. That book became an instant classic and triggered an explosion of interest in game theory among mathematicians and economists. Von Neumann and Morgenstern produced the basics of classical game theory—how to solve two-person, zero-sum games and the classical approach to n-person games (i.e., games with more than two players).

With the explosion of government funding for the social sciences after World War II in the United States, game theory flowered as a field. In the decade between 1945 and 1955, game theory matured both in its basic mathematics and in its application to social and military situations. Many of the basic mathematical tools of game theory were developed during this period, and the applications of game theory to social situations helped to feed these developments. In a sense, this period was a golden age of game theory; after the mid-1950s, the field divided into mathematicians and social scientists as the mathematics became more technical and the applications less cutting-edge.

After the division of the field, the application of game theory to social situations became common. In economics, much of the basic theory has been recast in game-theoretic terms. For example, general equilibrium theory, which examines the properties of whole economies in equilibrium, relies on n-person game theory. This spread of application occurred during the 1960s and 1970s. At the same time, the performance of game theory lagged behind its promise. Many became convinced the theory could not produce what it had promised in its early days and that game theory was inadequate to answer most central questions in the social sciences. Outside of economics, game theory became more of a curio than a central methodology in the social sciences.

Game theory has changed fundamentally to address some of its weaknesses. It now has answers to many questions of interest to all social scientists. Formal developments in the concept of equilibrium have pushed game theory in ways not anticipated during its first flowering. These developments, known as noncooperative game theory, have been driven by substantive problems in the social sciences. The purpose of this book is to introduce the political scientist both to the traditional basis of game theory and to recent developments in noncooperative game theory with an eye to acquiring a competency to work with both.

Now more than ever, the tools exist to address formally many questions that are central to political science. Noncooperative game theory has been applied to both two-party and multiparty elections, legislative decisions, bureaucratic politics, international crises, and international organizations. General questions of how political institutions work and why they exist and change have been addressed with game-theoretic models. Communication in a variety of settings has been examined in these models.

This book also attempts to introduce the reader to many of the basic models in political science. Many journal articles are difficult to read without the proper training and an extensive background in the field. Nevertheless, the ideas in those articles can often be expressed in simpler models that are accessible to a wider audience. Several of the basic models used in political science are interwoven throughout this book. The reader can see how those models develop as different techniques are applied to them.

Four Problems in Political Science

This book pays special attention to four problems in political science: the role of legislative rules, deterrence in international crises, voting in mass elections, and bargaining. What is the strategic logic of each of these situations? There is no single correct model of any of these problems; instead, theory advances through sequences of models. Some models strive to answer questions presented by earlier models; other subsequent models address different aspects of problems. This book presents several models of each of these problems in separate chapters. You, the reader, can see how work on these four problems has developed. I discuss these four problems in general terms here to lay the groundwork for the models that follow. The book also presents models from areas other than these four, but these four recur in the book.

Legislatures adopt rules to regulate how bills are proposed and considered. In the U.S. Congress, the committee system regulates how bills are proposed, revised, and finally voted on. The common empirical observation is that committees and the chairs of committees have disproportionate influence on the

shaping and adoption of legislation. Particular voting rules help protect the influence of committees. Why would a legislature adopt rules that appear to give some members disproportionate influence in an area of policy?

I present three different models of congressional rules that capture different arguments about why rules are adopted and what the consequences of those rules are. The first argument claims that the committee system is a way to enforce deals that support pork-barrel legislation across members of Congress. Members seek positions on committees that address issues of particular interest to their constituencies. On the floor, they defer to committees to support implicit bargains that protect legislation that addresses their particular interests. Legislative rules are adopted to help protect bills proposed by committees from amendments. The sections on structure-induced equilibria in Chapter Five develop this argument.

I also discuss a second approach to legislative rules in Chapter Five. Pork-barrel projects have distributive consequences. The benefits are concentrated in some districts, while the costs are spread across all districts. Members of Congress have an incentive to exclude some members from pork-barrel deals to increase the net benefits to their own constituents. But the excluded members can try to split the coalition behind any deal by offering a better deal to some members of the coalition. The result can be an endless chain of bargaining among legislators. In this view, legislative rules provide a way to discipline such deals. The voting rules have consequences for what deals are possible and how easily such deals can be upset by excluded legislators.

Chapter Eight presents a third view of legislative rules. Members of Congress cannot be certain about the consequences of legislation. They share an interest in having some members develop expertise in different policy areas. Specialized members serve on committees that propose legislation in their area of expertise. Rules protect legislation proposed by committees to motivate members to specialize.

Each of these three views leads to different models of congressional rules and committees. They all capture some part of the logic of legislative rules. The models help us understand the consequences of these different views.

Deterrence in international crises is the second problem. When two nations are embroiled in a crisis, each makes threats against the other to try to influence the other's actions. What makes such threats successful? Carrying out threats is costly to the threatener as well as the threatened. Nations receiving threats may not believe that the threat will be carried out if they do not comply. The credibility of a threat depends on both the magnitude of the costs to be imposed and the willingness of the threatener to carry it out.

Chapter Two presents the logic of deterrence from the perspective of decision theory. What probability of carrying out a threat is sufficient to deter a nation? The credibility of threats, as captured in the probability that the threat will be carried out, is given in this model. But deterrence is not the decision

of an isolated nation; each nation must consider the other's reaction when it chooses to make a threat. Chapter Three uses deterrence to introduce the basic elements of a game. The resulting game is solved in Chapter Seven. This model considers how threats can be used to signal intentions in a crisis. If there is a cost to making a threat and then backing down from it, actors who are willing to carry out threats are more likely to make them than actors unwilling to carry them out. The probability of a threat's being carried out is determined within the model, rather than being fixed outside the model as in the decision-theoretic model.

Chapters Six and Eight present other models of deterrence. Nuclear deterrence is a special case of deterrence. If nuclear war is worse than any peaceful outcome, how can actors make nuclear threats credible? The model in Chapter Six considers one possible answer, the reciprocal fear of surprise attack. If there is an advantage to striking first, each actor may consider attacking if it fears that the other is planning to attack first. The model in Chapter Eight considers what inferences can be drawn from events that did not occur. Does the failure to make a costly threat signal weakness or strength? This model begins to consider some critical problems about how a reputation for resolve can be created.

The third problem is voting in mass elections. How do voters choose between candidates, and how can candidates influence voters' choices? Chapter Two includes the classic decision-theoretic model of why people vote (or more correctly, why they should not vote). Candidate strategy in a two-candidate race is addressed in Chapter Four. That section presents the Median Voter Theorem in a two-person, zero-sum game. But each of these models separates the voters' decisions from the candidates' strategies. Chapter Seven presents a simplified version of a model that combines the two problems. This model considers the decision to vote as a strategic problem among voters. If everyone else votes, then I do not want to bear the costs of voting. If no one else votes, I want to vote so that I can determine the outcome. Chapter Nine includes a model of retrospective voting. The other models of voting are prospective: voters choose candidates based on what the latter do once in office. In a retrospective voting model, voters use the record of the incumbent to judge what his or her future performance is likely to be.

Bargaining, the fourth problem, is common to many political settings. Bargaining occurs when two or more actors are willing to reach any one of several agreements, but they disagree about which agreement is best. They resolve their differences by bargaining. Chapter Four describes the Nash bargaining solution, the basic concept in two-person, cooperative game theory. This solution postulates four conditions that bargains should satisfy and then characterizes what bargain should occur. Chapter Five presents a different approach to bargaining, the Rubenstein bargaining model. That model treats offers within a bargaining session as strategic moves and solves for what offers are made

and which accepted. This approach is extended in Chapter Eight by a model of bargaining where the sides do not know what bargains the other side will accept. These three examples provide an introduction to game-theoretic work on bargaining.

Why Model?

All four of the problems discussed above have been addressed by formal models. Formal modeling is a research strategy that is unfamiliar to many political scientists. The social and political world is immensely complex; how can the brute simplifications of formal models provide any insight into that world?

The primary advantage of formal modeling is the rigor and precision of argument that it requires. Writing down an argument formally forces the modeler to decide precisely what the assumptions of the argument are. Many verbal arguments in political science can be formalized in a number of different ways. Those verbal arguments fail to specify their assumptions and assertions completely. When we formalize those arguments, we may expose unstated assumptions. The conclusions of those arguments may not hold for all cases because they depend upon those unstated assumptions. Without the rigor of a formal model, we would fail to see the lack of generalizability of an informal argument.

Similarly, formal models allow us to see exactly why the conclusions of a model follow from its assumptions. Other supporting arguments that do not follow from the assumptions are ruled out. Some verbal arguments pile up supporting arguments that conflict with one another in an attempt to overawe the reader with argumentative bulk. Derivations of conclusions from assumptions can also suggest new avenues of argument that may lead to additional conclusions. Such avenues can lead to conclusions beyond the initial intuition underlying the model.

Formal modeling also creates a logical structure for the accumulation of a series of models about increasingly general questions. Many formal models produce some conclusions at variance with observations. The logical structure of a model allows modelers to add to it in order to derive new conclusions that may explain those observations at odds with existing models. Successful formal models generate streams of research that lead to areas never anticipated by the original work. Any particular model should be seen as one link in a chain of research. Still, each link must carry its own weight. Individual models within a chain of research must each lead to new insights or the clarification of problems in existing models.

Conceptual clarity and rigorous argument are obviously desirable, but do we sacrifice too much "realism" when we model? Models are by their very nature abstractions. Modeling aspires to lay bare social interactions in simplest terms.

Simplification is a virtue. Modeling tries to capture the essence of a social situation. Any argument, even the thickest of descriptions, is a simplification of an immensely complex world. More historical evidence has been lost by the failure of the participants to collect it at the time than has ever been published.

The proper criterion to judge the "realism" of an argument is the accuracy of its conclusions. Formal models help us determine the observable consequences of our arguments. We can then test those hypotheses against the real world. It is often difficult to determine what conclusions actually follow from informal arguments that invoke a more complex world. The purported conclusions usually follow from such arguments for most but not all cases. Testing such arguments is difficult at best; what counts as disconfirming evidence? In contrast, formal models often show that commonly used tests of theories are not appropriate. There are well-known formal models in which almost any behavior can result. Such models and the arguments they reflect cannot be tested by examining specific behavior; any evidence is consistent with the argument.

Fruitful models carefully combine intuition about political problems, skill in modeling, and common sense. Formal models have contributed to my understanding of politics by disciplining my intuition. Working with models forces you to refine your initial understandings of an argument. Solving the mathematics of a model leads you to see why some arguments are logically sound and others are not. Over time, your intuition changes to reflect the discipline of a model. The model has added rigor to the initial intuition, and now the refined intuition may lead to new models and additional insights.

The Rational Choice Approach to Social Modeling

There are models in political science that do not invoke the concept of rationality. Game theory, however, requires the assumption of rationality, an assumption quite familiar to economists, somewhat familiar to political scientists and psychologists, and probably alien to most sociologists and others. We assume that people have goals and that they attempt to realize those goals through their actions. The focus here is on how individuals' attempts to achieve their goals are constrained (or assisted) by one another's actions and the structure of the game.

The distinctive elements of the rational choice approach are as follows. First, rational choice theorists assume people have goals which they attempt to achieve; the moral value of actors' goals is not judged. Of course, those goals may be difficult to achieve, or the consequences of actions undertaken to achieve them may be unclear. Second, rational choice theorists assume that people have some freedom of choice. Although structure, as represented in a game tree, does constrain choices, actors believe they have some choices. The choices may be unpleasant for an actor, and how actors evaluate their choices

may be colored by their beliefs, but some choice exists. Third, rational choice theorists assume that individuals choose actions that they believe will achieve their goals. The concept of goals seems worthless if we do not assume that actors strive to achieve their goals. Fourth, rational choice theorists deliberately simplify and abstract reality in their models. Game models do not even attempt to address all the complexity of the social world. Instead, they focus on certain elements of social situations to lay bare how motivations and actions are interrelated. At times, then, game-theoretic analyses seem simplistic, but such simplifications can help clarify complex interactions.

The idea of equilibrium accompanies a rational choice approach to understanding social phenomena. In equilibrium, no actor wishes to change its behavior on its own. Behavior at an equilibrium is stable in the sense that no actor, given its current position and knowledge, can improve its own position on its own. Equilibria are not assumed to be fair or balanced to the actors or desirable according to any ethical criteria. Often the equilibria of a model are grossly unfair to one actor or reflect a socially suboptimal outcome. Nor do we assume that an equilibrium must persist for eternity in society; very few models claim to address global change over long periods of time. Instead, a designation of equilibrium is just the statement that no actor, within the confines of the current model, wishes to change its choices.

This book strives to explain what the idea of equilibrium means in all its complexity. The idea that predictions of a model should require that no actor wishes to change its behavior is more subtle than its simple appearance. Equilibria serve as the predictions of a model. As the conditions we wish to model grow more complex, so must the concept of equilibrium. Although the general idea of equilibrium is straightforward, the conditions that equilibria must satisfy are not. This book begins with the cleanest definition of equilibrium and advances to the more elaborate definitions. But the idea of equilibrium underlying all those definitions is the same. They differ in how we understand that idea.

How to Use This Book

This book strives to achieve three ends. First, it introduces the reader to game theory at a level accessible to a general audience in political science. Second, it tries to teach the reader not only the concepts of game theory, but also how to solve simple models. Third, it introduces the reader to basic versions of the models commonly used in political science. I am convinced that political scientists need not only the ability to read, understand, and critique formal literature in the field, but also the ability to set up and solve their own models. Modeling imposes discipline upon one's arguments; one must model to gain the benefits of this discipline. Many arguments in political science would profit

from even the great simplification of basic models. Great technical proficiency is not needed to solve such models.

However, some mathematics is necessary to solve game theory models. The first appendix provides a review of the basic mathematics that the book uses. It begins with algebra, progresses through set theory and probability theory, and on to both differential and integral calculus. It ends with a brief discussion of the idea of a mathematical proof. I recommend that you review this appendix unless you are very comfortable with all these topics. Most of the book requires only algebra and probability theory. For the sections that require more than just algebra, I note what mathematics is required for them at their beginning.

In choosing between accessibility and precision, I hope I have reached a happy medium. I have striven to be both careful and clear in my exposition. Where I have been forced to choose between the two, I have chosen to use minimal technical notation. Because of this choice, there are areas where I fail to reach the technical standards demanded of much formal work. This book is an introduction to the field and is not meant to be a definitive source.

As an aid to the reader, I have included a glossary of terms in game theory at the end of the book. The glossary gives informal statements of important terms that recur throughout the book. The reader should refer to the text for formal definitions of these terms.

As a guide to further reading, I provide annotated references at the end of each chapter. These "Further Reading" sections also include bibliographic essays on different substantive areas of political science. These essays survey work that uses game-theoretic models in a given area. They do not attempt to provide a complete survey of game theory models in these areas. Instead, they provide an entry into these literatures through work I have found useful and interesting. I have tried to draw on books and surveys of the literature in these essays because I feel those works are more helpful for the reader entering the formal literature. The table of contents lists these bibliographic essays to help readers find their area of particular interest. I encourage readers interested in a deeper treatment of these topics to seek out these additional sources. The bibliography provides ratings of the mathematical complexity of each cited work. Works with no asterisks are relatively simple and demand at most algebra to be understood. Those followed by one asterisk require either higher mathematics or else greater attention to the formal argument. Those followed by two asterisks are highly formal and require careful reading.

Because I want the reader to gain the ability to solve simple models, I have embedded problems in the text. The reader should solve these problems when he or she reaches them. Most of the embedded problems are not difficult, and they generally follow directly from the material in the text. Answers for many of the problems are provided in an appendix. I remind the reader that problems