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Chapter Seventeen

Introduction to Volume II: Not a Symphony, but Ètudes

Readers of Volume I, *Choice and Competitive Markets*, may expect that this second volume will be similar in form and content. If you have such expectations, set them aside: This volume is utterly different from Volume I, and my first task is to explain why and what you should expect instead.

Volume I concerned (1) the basic models of choice by individual economic agents (consumers and firms), (2) more specifically, the utility-maximizing and profit-maximizing choices of those agents in *competitive* market environments, environments in which they have no influence over prices, and (3) how those choices are reconciled in a *general equilibrium*.

Three characteristics of the models of Volume I are noteworthy:

- To the extent that more than one economic agent is explicitly involved, agents collectively affect the opportunities of other agents only through market prices, and all agents act as if prices are unresponsive to what they themselves do. Therefore, given prices, no agent is (directly) concerned with the actions of any other agent.¹ Economic opportunities for each agent are limited to price-mediated, competitive markets.
- No agent has information about states of nature that another agent lacks. Agents are well informed.
- Each agent is fully capable of making optimal choices, given her objectives and the opportunities that circumstances present to her. Agents are cognizant of all relevant uncertainty, even if they lack information that others possess, and they anticipate accurately what will transpire in every possible future contingency. In a word, agents are *hyper-rational*.

Roughly speaking, in this volume, subtitled *Imperfect Competition, Information, and Strategic Interaction*, we study economic choices and interactions where the first two of these characteristics fail to hold. But in the models discussed in this volume, the third characteristic is maintained.

Volume I concludes with General Equilibrium Theory, in which (virtually) everything that came before comes together in one grand framework. In a sense, Volume I is like a symphony in which early movements provide themes, all of

¹ There are a few minor exceptions, particularly in the discussion of externalities and Lindahl equilibria in Chapter 15.

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which are blended together in a grand final movement.²

No such grand synthesis is presented in this volume. Economic theorists have created more or less "general equilibrium models" in which many of the issues studied in this volume are unified. However, in my opinion, none of those unified theories captures everything of importance. Instead, I contend that economic models with imperfect competition, private information, and strategic interaction are best employed to model and analyze specific economic contexts and, in so doing, to gain insight into real-world contexts. The terms *partial equilibrium* or *small-world model* are appropriate: A particular relatively isolated piece of the economic environment is identified, modeled, and analyzed, so that (one hopes) insight is gained into that piece of the environment.

Franklin Fisher (1989), in his cri de cœur "Games Economists Play: A Noncooperative View," distinguishes between *generalizing theory* and *exemplifying theory*. Quoting him (p.117), "Generalizing theory proceeds from wide assumptions to inevitable consequences. It speaks in terms of what must happen, given the background circumstances." Fisher's first example of generalizing theory is General Equilibrium and the First and Second Theorems of Welfare Economics. In contrast (and again quoting from p.117), "Exemplifying theory does not tell us what *must* happen. Rather it tells us what *can* happen. In a good exemplifying-theory paper, the model is stripped bare, with specializing assumptions made so that one can concentrate on the phenomena at issue."

I prefer the term *exemplifying modeling* to Fisher's *exemplifying theory*. And I think that Fisher credits the generality of General Equilibrium too much: How "general," in the sense of being general conditions of real-life economic systems, are the assumptions that all markets are perfectly competitive, or all actors have access to the same information, or (in the sense of Chapter 16 in Volume I) all actors have perfect contingent foresight concerning future equilibrium prices? But setting those quibbles aside, I agree wholeheartedly with Fisher on this distinction. Theories in microeconomics that involve imperfect competition, private information, and strategic interaction are exemplifying: They employ models simple enough to provide insight into what *might* take place in a specific context.

This leads to Fisher's complaint about exemplifying theory: Such models settle nothing, because their conclusions derive from their assumptions and, just as much, from what the model builder leaves *out* of the model. Models can be shaped and tweaked to get virtually any conclusion the model builder desires; skeptics use the term *reverse engineering* to describe the practice of beginning with a desired conclusion and then creating a model from which that conclusion emerges.

So, how are the fruits of exemplifying modeling to be judged? Two types of tests can be employed. The first involves the intuitive appeal of the model: Do the assumptions on which the model was built make sense? Does the logic that leads from assumptions to conclusions seem sensible? What does the model ignore? And there is the possibility of empirical testing: Which predictions can be made, and are

² Experts in classical music will observe that I am stretching things in this analogy, for which I apologize.

What's in this volume? Tools of this trade

those predictions falsified when investigated in a sufficiently rich and varied set of circumstances?

What's in this volume? Tools of this trade

As a practicing economist and, in particular, as a practicing microeconomist, the odds are good that you will engage in exemplifying modeling. To help understand a particular economic phenomenon of interest, you may create and analyze a structured model of it. And even if you aren't directly in the model–creation business, you will need to understand such models. Because interesting economic phenomena often involve imperfect competition, private information, and (dynamic) strategic interactions, the models with which you must deal will probably possess some of these features. To define these terms:

- Agents do not necessarily take prices (when there are prices) as given. Agents may set prices, either unilaterally or as the result of a process of interaction with others. As far as price-and-market-mediated interactions go, this is *imperfect competition*.
- Agents may possess *information* that others lack. This can be information about the underlying state of nature, and it can be information about actions taken by themselves or others.
- When a specific agent's actions affect directly the choices and/or outcomes available to other agents—so that agents are concerned with what other specific agents do—we have a situation with *strategic interaction*. And when we add the modifier *dynamic*, we add the idea that agents may act and react to the actions taken by other agents. Indeed, in some cases, the economic essence is that agents interact repeatedly, with opportunities to react to the earlier actions of others.

Over the years, economists have developed paradigmatic models of these features, such as Akerlof's (1970) market for lemons, Spence's (1974) model of job-market signaling, and Green and Porter's (1984) model of collusion with imperfect price information. It is unlikely that one of these paradigmatic models will fit perfectly the context you are trying to understand, but these paradigms provide the techniques and basic ideas you will use in building your own model (or that are used to build a model that you wish to understand).

This describes the basic nature of Volume II: It is a book of *ètudes*, models on which you learn and practice the techniques that go into the construction of models fitted to the specific contexts and phenomena in which you will be interested.

The organization of these ètudes creates a dilemma. On one hand, the different models can be organized contextually: We might have, say, a chapter on oligopoly, which would include models from the classic work of Cournot and Bertrand, through to Green and Porter's model of collusion in repeated interactions with noisy prices. A separate chapter on auctions would deal with private-values and then common-value auctions.

Alternatively, we could organize the models based on the underlying mode

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of analysis. Start with models of static, one-shot interactions, with no private information, including the classic models of oligopoly. Move on to, say, models in which one party acts and a second (or several) others respond, such as von Stackelberg competition or the classic principal–agent model. At some point, models of dynamic interactions with an infinite horizon are considered, and simple models of oligopolistic collusion are provided. At another point, private information is explored, and (say) models of entry deterrence are discussed.

The problem with the first method is that virtually any contextual topic, covered completely, requires the full gamut of techniques, from basic static interactions to complex, multi-period interactions with private information that is strategically revealed and / or hidden. The problem with the second method is that the discussion will jump from contextual topic to contextual topic. Neither option is attractive.

In this volume, I present things in a hybrid fashion. The first five chapters gradually introduce the tools of modeling and analysis: Chapter 18 looks at situations that can be modeled with straightforward strategic-form games, in which the participants are assumed to act once, simultaneously and independently. Chapter 19 concerns situations modeled by simple action–reaction games: One party "sets the rules," and the other parties respond. Chapter 20 introduces incomplete information and beliefs-based equilibria. And Chapters 21 and 22 introduce the complexities of dynamics.

However, these chapters are written contextually. Chapter 18 concerns the classic models of oligopolistic competition—those of Cournot and Bertrand. Chapter 19 concerns moral hazard and the basic principal–agent model. Chapter 20 is about adverse selection, screening, and signaling. Chapter 21 introduces dynamics in the context of the Coase Conjecture; and Chapter 22 concerns repeated play, reciprocity, and reputation. The final four chapters are then contextual: Bilateral bargaining in Chapter 23, auctions in Chapter 24, matching markets in Chapter 25, and mechanism design in Chapter 26.

By organizing things in this fashion, I have tried to make this a book about economics, where game theory is the main tool of analysis, and more complex tools are introduced one by one. It is a text on economics using game theory, not game theory illustrated by economics.

"Foundations" has a double meaning

The title of these volumes begins with *Microeconomic Foundations*. One meaning of "foundations" is that the topics covered are the building blocks out of which economists study microeconomic phenomena (and also some macroeconomic phenomena, when the macroeconomics has "microfoundations"). But, there is a second meaning: In selecting models and contexts to discuss, I favor the "classics," papers and books such as Akerlof's (1970) "The Market for 'Lemons'," Spence's (1974) "Market Signaling," Green and Porter's (1984)"Noncooperative Collusion under Imperfect Price Information," and Rubinstein's (1982) "Perfect Equilibrium in a Bargaining Model." As warranted by expositional ease, I simplify in places, and I modify details. But I strongly believe that your education as an economist should include knowledge of the seminal work on each subject.

Noncooperative game theory

There has been and continues to be a deluge of extensions, amendments, qualifications, and improvements to the classics, and in places, I provide some "next steps." My selection is based on my perception of whether the methods employed serve a pedagogical function and on personal familiarity. Personal familiarity introduces a "home bias" in what is selected, for which I apologize.

However, this volume is not intended to be up to date or to cover all important work on any topic. Any specific topic covered in this volume can be—and often is—the basis of a full course that covers subsequent work. If you plan to work on any of these topics, you have a lot of reading to do to get up to date. What this volume tries to do—all I think a first textbook can do—is to provide you with a foundation (third meaning?) for your subsequent reading. So, in terms of up to date: Only a handful of papers that I cover are relatively recent, where my definition of "relatively recent" stretches to include any paper published in the current century.

This volume is limited in another way. Entire contextual topics are omitted; examples are networks, search, asset pricing with private infomation, and corporate finance. The ètudes presented in this volume are intended to strengthen your skills while covering some, but not all, important contextual areas. With your skills strengthened, you should (I hope) be able to absorb and then contribute to the literatures in contextual areas that are not covered here.

The bottom line is that this is a textbook of ètudes, not a reference book on the topics covered. It is, perhaps, a bit more than "Introductory (Finger) Exercises for the Economist," but it should be approached in the spirit of such books.

Assertions and proofs

In Volume I, I aimed to prove rigorously nearly every assertion. There were a few notable exceptions, and in places I only sketched the proof (often asking you to supply the missing steps as a problem, with the solution available online). That is no longer my objective in Volume II. Instead, my objective is to expose you to a variety of different models of economic phenomena and, to achieve the desired breadth, in places I tell you what is proved in the original source and send you to that source to see how the proof goes.

This approach comes with a warning: Journal articles are often not self-contained; they rely on previous work. Notation is not always consistent from article to article (or from this volume to the article I discuss). A skill you must develop is "reading backward"; I will cite a result from Article X and send you there to see the proof. Article X will use different notation from mine, and the proof there will rely on a result from Article Y, with still different notation. Volume I aimed to be self-contained, to spare you from having to make your way through this sort of maze. In this volume, to get the full picture, reading backward is sometimes required.

Noncooperative game theory

With few exceptions, the language of modeling and analysis in this volume is noncooperative game theory. This language isn't necessary, but it is reasonably well suited to formulating and then analyzing models of *some* economic phenomena

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that are of interest. And this way of doing business has become standard in the literature.

That said, this is *not* a textbook on noncooperative game theory, any more than Volume I was a textbook on real and convex analysis. To make your way through Volume I requires at least a good working knowledge of real and convex analysis; in precisely similar fashion, to make your way through this volume requires a good working knowledge of noncooperative game theory. In Volume I, the bare mathematical necessities were provided in a series of appendices; in similar fashion, appendices in this volume provide a review (blended with some strong opinions) of what you need to know about noncooperative game theory.

Game theory is *not* economics. It is a useful mathematical (abstract) language for building and studying models in economic contexts, as well as for building and studying models in at least some parts of political science, sociology, and social psychology. (I am told that it also can be fruitfully employed in various branches of the biological sciences and computer science, although I know little about this.) Game theory is useful because it has considerable virtues in deductive rigor, in understanding which assumptions lead to which conclusions, and in communicating ideas. But it has some very significant weaknesses. Perhaps its two greatest weaknesses are:

- 1. It relies on hyperrationality of economic agents. This is not new; in Chapter 16 (in Volume I), when we considered adaptations of general equilibrium to economies with time and uncertainty, the relevant equilibrium concept was an Equilibrium of Plans, Prices, and Price Expectations (EPPPE). In an EPPPE, consumers not only are assumed to know and react to prices of goods and securities being sold today; they are assumed to make their immediate consumption and security-purchase decisions based on accurate expectations about future equilibrium prices (contingent on states of nature). This, we observed, is asking a lot of the agents in the model. And, in some of the models discussed in this volume, we ask even more.
- 2. Game theory, as applied in the models encountered in this volume, begins with the specification of a game: a set of players; rules for how they can interact; and payoffs they receive, depending on how they interact. It is assumed that the game is *common knowledge* among the players: They know the rules; they believe that their rivals know the rules; they believe that their rivals know the rules; they believe that their rivals believe that they know the rules; and so forth. The introduction of so-called *games of incomplete information* loosens this modeling straitjacket to some extent. But, to keep the models tractable (amenable to analysis), this loosening barely begins to reflect the confusion and ambiguity of real-life interactions.

In 1990, when the methods of noncooperative game theory were at the height of economic fashion, I gave a series of lectures on what I saw as the strengths and weaknesses of this mode of modeling and analysis as a tool of economics (Kreps 1990b). I'd say things a bit differently today: Given what has happened in the intervening years, I'm more skeptical about how these methods have been used.

Concerning the appendices

One thing is worth saying right away: One cannot run an empirical test of "game theory." Game theory cannot be falsified empirically, any more than convex analysis can be. What can and should be tested to the extent possible—and what are certainly amenable to falsification—are the predictions that are derived from the contextual models discussed in this volume, models built with the language of noncooperative theory.

And, since empirical tests of applications of game theory are not always available or easy, practicitioners—that means you—must employ common sense. Go back to the first paragraph in this section, and the italicized *some* in the penultimate sentence. Not every economic phenomenon of interest is amenable to gametheoretic analysis, and not every game-theoretic model of some phenomenon passes the test of being sensible or capturing the most important aspects at work in the real world. As game theory is enlisted in this volume to model specific phenomena, it is essential that you ask and answer the subjective question: Does this model and analysis provide valuable insight into the phenomena? (In some cases, with models that are justifiably regarded as landmarks in the literature, I provide my own, negative opinion.) When and if you enlist these methods in your own research, answering this question—and being able to explain to others what those insights are—is even more important.

Concerning the appendices

In Volume I, the appendices succinctly outline the basic results in real and convex analysis that the text requires. A similar plan for this volume would mean appendices that outline basic concepts from and results in noncooperative game theory. Such appendices are provided, but they are longer and far more conversational than the appendices in Volume I. Controversies about the meaning of Berge's Theorem or the Separating Hyperplane Theorems may exist, but if they do, they surely aren't important to economists. But how one thinks about the application of game theory in economic modeling—when and why is it appropriate and/or useful in generating economic insight—is controversial; in the text but also in the appendices, I often wax philosophical on such issues. And, to be clear, the commentary that I provide is, in places, controversial among economists. Since I had personal involvement in the development of some of these concepts, I am certainly biased. You should seek out other perspectives to correct for my biases and to make up your own mind on these questions.

In particular, I present game theory as a tool for modeling and analyzing economic interactions. In so doing, I interpret game-theoretic concepts and constructs from what might be called an "intuitionist" perspective. Those parts of the gametheory literature that pursue foundational issues about game-theoretic concepts and constructs—in particular, what is known as *epistemic game theory*—might in contrast be said to take a "formalist" perspective. I do not mean to denigrate work that takes a more formalist perspective and, indeed, I suggest in the appendices sources that pursue these perspectives. But, for a textbook intended for first-year graduate students in economics, or even economics students who are taking a deeper look at the applications of game theory to economic issues, I believe the

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"intuitionist" perspective is appropriate. To put it plainly: Game theory, to be a fruitful tool of economic analysis, must support and not replace economic intuition. If you stipulate this view of the role game theory should play in economic analysis, I contend that the "intuitionist" perspective is the appropriate perspective to take.

Because the appendices are more than a collection of definitions and propositions in noncooperative game theory, readers who have not taken a course in game theory may conclude that the appendices can substitute for a full course on the subject. Instructors may conclude that they can use the appendices to "review" game theory as part of a course they teach, where "review" is very broadly interpreted. If one wants a nodding acquaintance with game-theoretic techniques, this may be so. However, the appendices are insufficient for anything approaching mastery of the material they cover. Game theory is a mathematical discipline, and to understand deeply any branch of mathematics, one needs to *do* the math, not just read about it. This requires problem sets, which the appendices do not contain. There are many excellent textbooks in game theory, and you will get more out of the economics in this volume if you consume one of them, preferably in a structured course or organized reading group on the subject, complete with working on the problems provided.

The craft of model building and analysis

A book of ètudes for, say, the piano, is intended primarily to promote the technique of performing or playing the piano, not to instruct the user in music composition. In this sense, the analogy between a book of piano ètudes and this volume breaks down. It is true (and I've emphasized here) that the point of this volume is for you to learn and practice the techniques of analysis that are nowadays applied in microeconomics. But as a practicing economist, you must both compose—build the model—and then perform, that is, provide a reasoned analysis of your model. I hope this volume helps you both to build and then analyze models. In this respect, what you read here provides examples of how this has been done by others. But reading about models and their analysis is insufficient; both are crafts that you learn best by doing. At the end of each chapter (after this one) are problems. Many have you complete proofs or arguments that are left undone in the text. Others—fewer perhaps—require you to construct variations on models in the text. In an ideal world, you would do them all. In the real world, you will get much more out of this volume if you do your fair share of these problems.

And, as you do the problems, please note: Solutions for all the problems in this volume are available in the *Online Supplement*, available online at the URL press.princeton.edu/online-supplement/microfoundations-II.

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