Microeconomic Analysis

Third Edition

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To my parents

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THIRD EDITION

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PREFACE

The first edition of *Microeconomic Analysis* was published in 1977. After 15 years, I thought it was time for a major revision. There are two types of changes I have made for this third edition, structural changes and substantive changes.

The structural changes involve a significant rearrangement of the material into "modular" chapters. These chapters have, for the most part, the same titles as the corresponding chapters in my undergraduate text, *Intermediate Microeconomics.* This makes it easy for the student to go back to the undergraduate book to review material when appropriate. It also works the other way around: if an intermediate student wants to pursue more advanced work on a topic, it is easy to turn to the appropriate chapter in *Microeconomic Analysis.* I have found that this modular structure also has two further advantages: it is easy to traverse the book in various orders, and it makes it more convenient to use the book for reference.

In addition to this reorganization, there are several substantive changes. First, I have rewritten substantial sections of the book. The material is now less terse, and, I hope, more accessible. Second, I have brought a lot of material up to date. In particular, the material on monopoly and oligopoly has been completely updated, following the major advances in the theory of industrial organization during the eighties.

Third, I have added lots of new material. There are now chapters on game theory, asset markets, and information. These chapters can serve as an appropriate introduction to this material for first-year economics students. I haven't tried to provide in-depth treatments of these topics since I've found that is better pursued in the second or third year of graduate

studies, after facility with the standard tools of economic analysis have been mastered.

Fourth, I've added a number of new exercises, along with complete answers to all odd-numbered problems. I must say that I am ambivalent about putting the answers in the book—but I hope that most graduate students will have sufficient willpower to avoid looking at the answer until they have put some effort into solving the problems for themselves.

Organization of the book

As I mentioned above, the book is organized into a number of short chapters. I suspect that nearly everyone will want to study the material in the first half of the book systematically since it describes the fundamental tools of microeconomics that will be useful to all economists. The material in the second half of the book consists of introductions to a number of topics in microeconomics. Most people will want to pick and choose among these topics. Some professors will want to emphasize game theory; others will want to emphasize general equilibrium. Some courses will devote a lot of time to dynamic models; others will spend several weeks on welfare economics.

It would be impossible to provide in-depth treatment of all of these topics, so I have decided to provide introductions to the subjects. I've tried to use the notation and methods described in the first part of the book so that these chapters can pave the way to a more thorough treatment in books or journal articles. Luckily, there are now several book-length treatments of asset markets, game theory, information economics, and general equilibrium theory. The serious student will have no shortage of materials in which he or she can pursue the study of these topics.

Production of the book

In the process of rewriting the book, I have moved everything over to Donald Knuth's TEX system. I think that the book now looks a lot better; furthermore, cross-referencing, equation numbering, indexing, and so on are now a lot easier for both the author and the readers. Since the cost to the author of revising the book is now much less, the reader can expect to see more frequent revisions. (Perhaps that last sentence can be turned into an exercise for the next edition...)

Part of the book was composed on MS-DOS equipment, but the majority of it was composed and typeset on a NeXT computer. I used Emacs as the primary editor, operating in Kresten Thorup's `auc-tex` mode. I use `ispell` for spell-checking, and the standard `makeindex` and `bibtex` tools for indexing and bibliographic management. Tom Rokicki's TEXview was

the tool of choice for previewing and printing. Preliminary versions of the diagrams were produced using Designer and Top Draw. An artist rendered final versions using FreeHand and sent me the Encapsulated Postscript files which were then incorporated into the TEX code using Trevor Darrell's `psfig` macros. I owe a special debt of gratitude to the authors of these software tools, many of which have been provided to users free of charge.

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Several people have contributed suggestions on the new third edition, including Eduardo Ley, Pat Reagan, John Weymark, and Jay Wilson. Eduardo Ley also provided some of the exercises and several of the answers.

Finally, I want to end with a comment to the student. As you read this work, it is important to keep in mind the immortal words of Sir Richard Steele (1672–1729): "It is to be noted that when any part of this paper appears dull there is a design in it."

Ann Arbor
November 1991

CONTENTS

3 Profit Function

4 Cost Minimization

5 Cost Function

6 Duality

7 Utility Maximization

8 Choice

9 Demand

10 Consumers' Surplus

11 Uncertainty

12 Econometrics

13 Competitive Markets

14 Monopoly

15 Game Theory

16 Oligopoly

17 Exchange

18 Production

19 Time

20 Asset Markets

21 Equilibrium Analysis

22 Welfare

23 Public goods

24 Externalities

25 Information

26 Mathematics

27 Optimization

CHAPTER 1

TECHNOLOGY

The simplest and most common way to describe the technology of a firm is the **production function**, which is generally studied in intermediate courses. However, there are other ways to describe firm technologies that are both more general and more useful in certain settings. We will discuss several of these ways to represent firm production possibilities in this chapter, along with ways to describe economically relevant aspects of a firm's technology.

1.1 Measurement of inputs and outputs

A firm produces outputs from various combinations of inputs. In order to study firm choices we need a convenient way to summarize the production possibilities of the firm, i.e., which combinations of inputs and outputs are **technologically feasible**.

It is usually most satisfactory to think of the inputs and outputs as being measured in terms of *flows:* a certain amount of inputs per time period are used to produce a certain amount of outputs per unit time period. It is a good idea to explicitly include a time dimension in a specification of inputs

and outputs. If you do this you will be less likely to use incommensurate units, confuse stocks and flows, or make other elementary errors. For example, if we measure labor time in hours per week, we would want to be sure to measure capital services in hours per week, and the production of output in units per week. However, when discussing technological choices in the abstract, as we do in this chapter, it is common to omit the time dimension.

We may also want to distinguish inputs and outputs by the calendar time in which they are available, the location in which they are available, and even the circumstances under which they become available. By defining the inputs and outputs with regard to when and where they are available, we can capture some aspects of the temporal or spatial nature of production. For example, concrete available in a given year can be used to construct a building that will be completed the following year. Similarly, concrete purchased in one location can be used in production in some other location.

An input of "concrete" should be thought of as a concrete of a particular grade, available in a particular place at a particular time. In some cases we might even add to this list qualifications such as "if the weather is dry"; that is, we might consider the circumstances, or state of nature, in which the concrete is available. The level of detail that we will use in specifying inputs and outputs will depend on the problem at hand, but we should remain aware of the fact that a particular input or output good can be specified in arbitrarily fine detail.

1.2 Specification of technology

Suppose the firm has n possible goods to serve as inputs and/or outputs. If a firm uses y_j^i units of a good j as an input and produces y_j^o of the good as an output, then the **net output** of good j is given by $y_j = y_j^o - y_j^i$. If the net output of a good j is positive, then the firm is producing more of good j than it uses as an input; if the net output is negative, then the firm is using more of good j than it produces.

A **production plan** is simply a list of net outputs of various goods. We can represent a production plan by a vector $\mathbf{y}$ in R^n where y_j is negative if the j^{th} good serves as a net input and positive if the j^{th} good serves as a net output. The set of all technologically feasible production plans is called the firm's **production possibilities set** and will be denoted by Y, a subset of R^n. The set Y is supposed to describe all patterns of inputs and outputs that are technologically feasible. It gives us a complete description of the technological possibilities facing the firm.

When we study the behavior of a firm in certain economic environments, we may want to distinguish between production plans that are "immediately feasible" and those that are "eventually" feasible. For example, in the short run, some inputs of the firm are fixed so that only production

plans compatible with these fixed factors are possible. In the long run, such factors may be variable, so that the firm's technological possibilities may well change.

We will generally assume that such restrictions can be described by some vector $\mathbf{z}$ in R^n. For example, $\mathbf{z}$ could be a list of the maximum amount of the various inputs and outputs that can be produced in the time period under consideration. The **restricted** or **short-run production possibilities set** will be denoted by $Y(\mathbf{z})$; this consists of all feasible net output bundles consistent with the constraint level $\mathbf{z}$. Suppose, for example, that factor n is fixed at $\overline{y}_n$ in the short run. Then $Y(\overline{y}_n) = \{\mathbf{y} \text{ in } Y : y_n = \overline{y}_n\}$. Note that $Y(\mathbf{z})$ is a subset of Y, since it consists of all production plans that are feasible—which means that they are in Y—and that also satisfy some additional conditions.

EXAMPLE: Input requirement set

Suppose we are considering a firm that produces only one output. In this case we write the net output bundle as $(y, -\mathbf{x})$ where $\mathbf{x}$ is a vector of inputs that can produce y units of output. We can then define a special case of a restricted production possibilities set, the **input requirement set**:

$$V(y) = \{\mathbf{x} \text{ in } R^n_+ : (y, -\mathbf{x}) \text{ is in } Y\}$$

The input requirement set is the set of all input bundles that produce *at least* y units of output.

Note that the input requirement set, as defined here, measures inputs as positive numbers rather than negative numbers as used in the production possibilities set.

EXAMPLE: Isoquant

In the case above we can also define an **isoquant**:

$$Q(y) = \{\mathbf{x} \text{ in } R^n_+ : \mathbf{x} \text{ is in } V(y) \text{ and } \mathbf{x} \text{ is not in } V(y') \text{ for } y' > y\}.$$

The isoquant gives all input bundles that produce exactly y units of output.

EXAMPLE: Short-run production possibilities set

Suppose a firm produces some output from labor and some kind of machine which we will refer to as "capital." Production plans then look like $(y, -l, -k)$ where y is the level of output, l the amount of labor input, and k the amount of capital input. We imagine that labor can be varied immediately but that capital is fixed at the level $\overline{k}$ in the short run. Then

$$Y(\overline{k}) = \{(y, -l, -k) \text{ in } Y : k = \overline{k}\}$$

is an example of a **short-run production possibilities set**.