

HAL R. VARIAN

INTERMEDIATE

MICROECONOMICS

WITH CALCULUS

Intermediate Microeconomics

With Calculus

First Edition

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With Calculus

First Edition

Hal R. Varian

Google and University of California at Berkeley



W. W. Norton & Company • New York • London

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Printed in the United States of America

FIRST EDITION

Editor: Jack Repcheck
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ISBN 978-0-393-12398-2

W. W. Norton & Company, Inc., 500 Fifth Avenue, New York, N.Y. 10110
W. W. Norton & Company, Ltd., Castle House, 75/76 Wells Street, London W1T 3QT
www.wwnorton.com

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To Carol

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PREFACE

This book is my classic *Intermediate Microeconomics* text with the mathematical treatment that was previously in the chapter appendices incorporated into the body of the chapters. This makes the analysis flow somewhat better for those students who are comfortable with elementary calculus.

My aim in writing the original text was to present a treatment of the methods of microeconomics that would allow students to apply these tools on their own and not just passively absorb the predigested cases described in the text. I have found that the best way to do this is to emphasize the fundamental conceptual foundations of microeconomics and to provide concrete examples of their application rather than to attempt to provide an encyclopedia of terminology and anecdote.

The calculus treatment will, I hope, be helpful to students who have appropriate backgrounds. However, it should be remembered that one can go a long way with a few simple facts about linear demand functions and supply functions and some elementary algebra. It is perfectly possible to be analytical without being excessively mathematical.

The distinction is worth emphasizing. An analytical approach to economics is one that uses rigorous, logical reasoning. This does not necessarily require the use of advanced mathematical methods. The language of mathematics certainly helps to ensure a rigorous analysis and using it is undoubtedly the best way to proceed when possible, but it may not be appropriate for all students. This is why there are two versions of the text.

Calculus offers deeper ways to examine the same issues that one can also explore verbally and graphically. Many arguments are much simpler with a little mathematics, and all economics students should learn that. In many

cases I've found that with a little motivation, and a few nice economic examples, students become quite enthusiastic about looking at things from an analytic perspective.

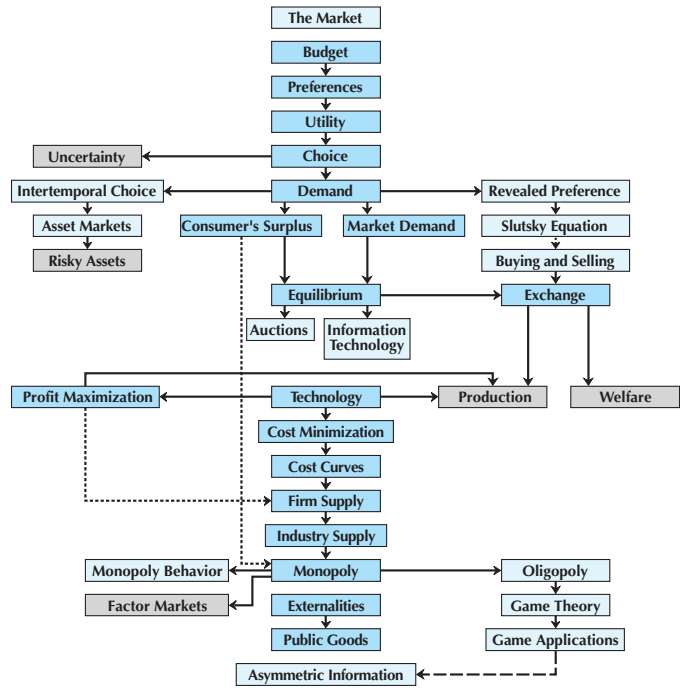
There are several other innovations in this text. First, the chapters are generally very short. I've tried to make most of them roughly "lecture size," so that they can be read in one sitting. I have followed the standard order of discussing first consumer theory and then producer theory, but I've spent a bit more time on consumer theory than is normally the case. This is not because I think that consumer theory is necessarily the most important part of microeconomics; rather, I have found that this is the material that students find the most mysterious, so I wanted to provide a more detailed treatment of it.

Second, I've tried to put in a lot of examples of how to use the theories described here. In most books, students look at a lot of diagrams of shifting curves, but they don't see much algebra, or much calculation of any sort for that matter. But it is the algebra that is used to solve problems in practice. Graphs can provide insight, but the real power of economic analysis comes in calculating quantitative answers to economic problems. Every economics student should be able to translate an economic story into an equation or a numerical example, but all too often the development of this skill is neglected. For this reason I have also provided a workbook that I feel is an integral accompaniment to this book. The workbook was written with my colleague Theodore Bergstrom, and we have put a lot of effort into generating interesting and instructive problems. We think that it provides an important aid to the student of microeconomics.

Third, I believe that the treatment of the topics in this book is more accurate than is usually the case in intermediate micro texts. It is true that I've sometimes chosen special cases to analyze when the general case is too difficult, but I've tried to be honest about that when I did it. In general, I've tried to spell out every step of each argument in detail. I believe that the discussion I've provided is not only more complete and more accurate than usual, but this attention to detail also makes the arguments easier to understand than the loose discussion presented in many other books.

There Are Many Paths to Economic Enlightenment

There is more material in this book than can comfortably be taught in one semester, so it is worthwhile picking and choosing carefully the material that you want to study. If you start on page 1 and proceed through the chapters in order, you will run out of time long before you reach the end of the book. The modular structure of the book allows the instructor a great deal of freedom in choosing how to present the material, and I hope that more people will take advantage of this freedom. The following chart illustrates the chapter dependencies.



The darker colored chapters are “core” chapters—they should probably be covered in every intermediate microeconomics course. The lighter-colored chapters are “optional” chapters: I cover some but not all of these every semester. The gray chapters are chapters I usually don’t cover in my course, but they could easily be covered in other courses. A solid line going from Chapter *A* to Chapter *B* means that Chapter *A* should be read before chapter *B*. A broken line means that Chapter *B* requires knowing some material in Chapter *A*, but doesn’t depend on it in a significant way.

I generally cover consumer theory and markets and then proceed directly to producer theory. Another popular path is to do exchange right after consumer theory; many instructors prefer this route and I have gone to some trouble to make sure that this path is possible.

Some people like to do producer theory before consumer theory. This is possible with this text, but if you choose this path, you will need to supplement the textbook treatment. The material on isoquants, for example, assumes that the students have already seen indifference curves.

Much of the material on public goods, externalities, law, and information can be introduced earlier in the course. I’ve arranged the material so that it is quite easy to put it pretty much wherever you desire.

Similarly, the material on public goods can be introduced as an illustration of Edgeworth box analysis. Externalities can be introduced right

after the discussion of cost curves, and topics from the information chapter can be introduced almost anywhere after students are familiar with the approach of economic analysis.

Changes for this Edition

The text of the book is closely aligned with *Intermediate Microeconomics*. I have added a new chapter on measurement which describes some of the issues involved in estimating economic relationships. The idea is to introduce the student to some basic concepts from econometrics and try to bridge the theoretical treatment in the book with the practical problems encountered in practice.

I have offered some new examples drawn from Silicon Valley firms such as Apple, eBay, Google, Yahoo and others. I discuss topics such as the complementarity between the iPod and iTunes, the positive feedback associated with companies such as Facebook, and the ad auction models used by Google, Microsoft, and Yahoo. I believe that these are fresh and interesting examples of economics in action.

I've also added an extended discussion of mechanism design issues, including two-sided matching markets and the Vickrey-Clarke-Groves mechanisms. This field, which was once primarily theoretical in nature, has now taken on considerable practical importance.

The Test Bank and Workbook

The workbook, *Workouts in Intermediate Microeconomics*, is an integral part of the course. It contains hundreds of fill-in-the-blank exercises that lead the students through the steps of actually applying the tools they have learned in the textbook. In addition to the exercises, *Workouts* contains a collection of short multiple-choice quizzes based on the workbook problems in each chapter. Answers to the quizzes are also included in *Workouts*. These quizzes give a quick way for the student to review the material he or she has learned by working the problems in the workbook.

But there is more . . . instructors who have adopted *Workouts* for their course can make use of the *Test Bank* offered with the textbook. The *Test Bank* contains several alternative versions of each *Workouts* quiz. The questions in these quizzes use different numerical values but the same internal logic. They can be used to provide additional problems for students to practice, or quizzes to be taken in class. Grading is quick and reliable because the quizzes are multiple choice and can be graded electronically.

In our course, we tell the students to work through all the quiz questions for each chapter, either by themselves or with a study group. Then during the term we have a short in-class quiz every other week or so, using the alternative versions from the *Test Bank*. These are essentially the *Work-*

outs quizzes with different numbers. Hence, students who have done their homework find it easy to do well on the quizzes.

We firmly believe that you can't learn economics without working some problems. The quizzes provided in *Workouts* and in the *Test Bank* make the learning process much easier for both the student and the teacher.

A hard copy of the *Test Bank* is available from the publisher, as is the textbook's *Instructor's Manual*, which includes my teaching suggestions and lecture notes for each chapter of the textbook, and solutions to the exercises in *Workouts*.

A number of other useful ancillaries are also available with this textbook. These include a comprehensive set of PowerPoint slides, as well as the Norton Economic News Service, which alerts students to economic news related to specific material in the textbook. For information on these and other ancillaries, please visit the homepage for the book at <http://www.wwnorton.com/varian>.

The Production of the Book

The entire book was typeset by the author using T_EX, the wonderful typesetting system designed by Donald Knuth. I worked on a Linux system and using GNU *emacs* for editing, *rCS* for version control and the T_EX Live system for processing. I used *makeindex* for the index, and Trevor Darrell's *psfig* software for inserting the diagrams.

The book design was by Nancy Dale Muldoon, with some modifications by Roy Tedoff and the author. Jack Repchek coordinated the whole effort in his capacity as editor.

Acknowledgments

Several people contributed to this project. First, I must thank my editorial assistants for the first edition, John Miller and Debra Holt. John provided many comments, suggestions, and exercises based on early drafts of this text and made a significant contribution to the coherence of the final product. Debra did a careful proofreading and consistency check during the final stages and helped in preparing the index.

The following individuals provided me with many useful suggestions and comments during the preparation of the first edition: Ken Binmore (University of Michigan), Mark Bagnoli (Indiana University), Larry Chenault (Miami University), Jonathan Hoag (Bowling Green State University), Allen Jacobs (M.I.T.), John McMillan (University of California at San Diego), Hal White (University of California at San Diego), and Gary Yohe (Wesleyan University). In particular, I would like to thank Dr. Reiner Buchegger, who prepared the German translation, for his close reading of the first edition and for providing me with a detailed list of corrections. Other individuals to whom I owe thanks for suggestions prior to the first edition

are Theodore Bergstrom, Jan Gerson, Oliver Landmann, Alasdair Smith, Barry Smith, and David Winch.

My editorial assistants for the second edition were Sharon Parrott and Angela Bills. They provided much useful assistance with the writing and editing. Robert M. Costrell (University of Massachusetts at Amherst), Ashley Lyman (University of Idaho), Daniel Schwallie (Case-Western Reserve), A. D. Slivinskie (Western Ontario), and Charles Plourde (York University) provided me with detailed comments and suggestions about how to improve the second edition.

In preparing the third edition I received useful comments from the following individuals: Doris Cheng (San Jose), Imre Csekó (Budapest), Gregory Hildebrandt (UCLA), Jamie Brown Kruse (Colorado), Richard Manning (Brigham Young), Janet Mitchell (Cornell), Charles Plourde (York University), Yeung-Nan Shieh (San Jose), and John Winder (Toronto). I especially want to thank Roger F. Miller (University of Wisconsin), and David Wildasin (Indiana) for their detailed comments, suggestions, and corrections.

The fifth edition benefited from comments by Kealoah Widdows (Wabash College), William Sims (Concordia University), Jennifer R. Reinganum (Vanderbilt University), and Paul D. Thistle (Western Michigan University).

I received comments that helped in preparation of the sixth edition from James S. Jordon (Pennsylvania State University), Brad Kamp (University of South Florida), Sten Nyberg (Stockholm University), Matthew R. Roelofs (Western Washington University), Maarten-Pieter Schinkel (University of Maastricht), and Arthur Walker (University of Northumbria).

The seventh edition received reviews by Irina Khindanova (Colorado School of Mines), Istvan Konya (Boston College), Shomu Banerjee (Georgia Tech), Andrew Helms (University of Georgia), Marc Melitz (Harvard University), Andrew Chatterjea (Cornell University), and Cheng-Zhong Qin (UC Santa Barbara).

Finally, I received helpful comments on the eighth edition from Kevin Balsam (Hunter College), Clive Belfield (Queens College, CUNY), Reiner Buchegger (Johannes Kepler University), Lars Metzger (Technische Universitaet Dortmund), Jeffrey Miron (Harvard University), Babu Nahata (University of Louisville), and Scott J. Savage (University of Colorado). I am particularly grateful to Carola Conces who provided research assistance in merging the calculus appendices with the chapter bodies.

Berkeley, California
January 2014

CHAPTER 1

THE MARKET

The conventional first chapter of a microeconomics book is a discussion of the “scope and methods” of economics. Although this material can be very interesting, it hardly seems appropriate to *begin* your study of economics with such material. It is hard to appreciate such a discussion until you have seen some examples of economic analysis in action.

So instead, we will begin this book with an *example* of economic analysis. In this chapter we will examine a model of a particular market, the market for apartments. Along the way we will introduce several new ideas and tools of economics. Don't worry if it all goes by rather quickly. This chapter is meant only to provide a quick overview of how these ideas can be used. Later on we will study them in substantially more detail.

1.1 Constructing a Model

Economics proceeds by developing **models** of social phenomena. By a model we mean a simplified representation of reality. The emphasis here is on the word “simple.” Think about how useless a map on a one-to-one

scale would be. The same is true of an economic model that attempts to describe every aspect of reality. A model's power stems from the elimination of irrelevant detail, which allows the economist to focus on the essential features of the economic reality he or she is attempting to understand.

Here we are interested in what determines the price of apartments, so we want to have a simplified description of the apartment market. There is a certain art to choosing the right simplifications in building a model. In general we want to adopt the simplest model that is capable of describing the economic situation we are examining. We can then add complications one at a time, allowing the model to become more complex and, we hope, more realistic.

The particular example we want to consider is the market for apartments in a medium-size midwestern college town. In this town there are two sorts of apartments. There are some that are adjacent to the university, and others that are farther away. The adjacent apartments are generally considered to be more desirable by students, since they allow easier access to the university. The apartments that are farther away necessitate taking a bus, or a long, cold bicycle ride, so most students would prefer a nearby apartment . . . if they can afford one.

We will think of the apartments as being located in two large rings surrounding the university. The adjacent apartments are in the inner ring, while the rest are located in the outer ring. We will focus exclusively on the market for apartments in the inner ring. The outer ring should be interpreted as where people can go who don't find one of the closer apartments. We'll suppose that there are many apartments available in the outer ring, and their price is fixed at some known level. We'll be concerned solely with the determination of the price of the inner-ring apartments and who gets to live there.

An economist would describe the distinction between the prices of the two kinds of apartments in this model by saying that the price of the outer-ring apartments is an **exogenous variable**, while the price of the inner-ring apartments is an **endogenous variable**. This means that the price of the outer-ring apartments is taken as determined by factors not discussed in this particular model, while the price of the inner-ring apartments is determined by forces described in the model.

The first simplification that we'll make in our model is that all apartments are identical in every respect except for location. Thus it will make sense to speak of "the price" of apartments, without worrying about whether the apartments have one bedroom, or two bedrooms, or whatever.

But what determines this price? What determines who will live in the inner-ring apartments and who will live farther out? What can be said about the desirability of different economic mechanisms for allocating apartments? What concepts can we use to judge the merit of different assignments of apartments to individuals? These are all questions that we want our model to address.

1.2 Optimization and Equilibrium

Whenever we try to explain the behavior of human beings we need to have a framework on which our analysis can be based. In much of economics we use a framework built on the following two simple principles.

The optimization principle: People try to choose the best patterns of consumption that they can afford.

The equilibrium principle: Prices adjust until the amount that people demand of something is equal to the amount that is supplied.

Let us consider these two principles. The first is *almost* tautological. If people are free to choose their actions, it is reasonable to assume that they try to choose things they want rather than things they don't want. Of course there are exceptions to this general principle, but they typically lie outside the domain of economic behavior.

The second notion is a bit more problematic. It is at least conceivable that at any given time peoples' demands and supplies are not compatible, and hence something must be changing. These changes may take a long time to work themselves out, and, even worse, they may induce other changes that might "destabilize" the whole system.

This kind of thing can happen ... but it usually doesn't. In the case of apartments, we typically see a fairly stable rental price from month to month. It is this *equilibrium* price that we are interested in, not in how the market gets to this equilibrium or how it might change over long periods of time.

It is worth observing that the definition used for equilibrium may be different in different models. In the case of the simple market we will examine in this chapter, the demand and supply equilibrium idea will be adequate for our needs. But in more general models we will need more general definitions of equilibrium. Typically, equilibrium will require that the economic agents' actions must be consistent with each other.

How do we use these two principles to determine the answers to the questions we raised above? It is time to introduce some economic concepts.

1.3 The Demand Curve

Suppose that we consider all of the possible renters of the apartments and ask each of them the maximum amount that he or she would be willing to pay to rent one of the apartments.

Let's start at the top. There must be someone who is willing to pay the highest price. Perhaps this person has a lot of money, perhaps he is

very lazy and doesn't want to walk far ... or whatever. Suppose that this person is willing to pay \$500 a month for an apartment.

If there is only one person who is willing to pay \$500 a month to rent an apartment, then if the price for apartments were \$500 a month, exactly one apartment would be rented—to the one person who was willing to pay that price.

Suppose that the next highest price that anyone is willing to pay is \$490. Then if the market price were \$499, there would still be only one apartment rented: the person who was *willing* to pay \$500 would rent an apartment, but the person who was willing to pay \$490 wouldn't. And so it goes. Only one apartment would be rented if the price were \$498, \$497, \$496, and so on ... until we reach a price of \$490. At that price, exactly two apartments would be rented: one to the \$500 person and one to the \$490 person.

Similarly, two apartments would be rented until we reach the maximum price that the person with the *third* highest price would be willing to pay, and so on.

Economists call a person's maximum willingness to pay for something that person's **reservation price**. The reservation price is the highest price that a given person will accept and still purchase the good. In other words, a person's reservation price is the price at which he or she is just indifferent between purchasing or not purchasing the good. In our example, if a person has a reservation price p it means that he or she would be just indifferent between living in the inner ring and paying a price p and living in the outer ring.

Thus the number of apartments that will be rented at a given price p^* will just be the number of people who have a reservation price greater than or equal to p^* . For if the market price is p^* , then everyone who is willing to pay at least p^* for an apartment will want an apartment in the inner ring, and everyone who is not willing to pay p^* will choose to live in the outer ring.

We can plot these reservation prices in a diagram as in Figure 1.1. Here the price is depicted on the vertical axis and the number of people who are willing to pay that price or more is depicted on the horizontal axis.

Another way to view Figure 1.1 is to think of it as measuring how many people would want to rent apartments at any particular price. Such a curve is an example of a **demand curve**—a curve that relates the quantity demanded to price. When the market price is above \$500, zero apartments will be rented. When the price is between \$500 and \$490, one apartment will be rented. When it is between \$490 and the third highest reservation price, two apartments will be rented, and so on. The demand curve describes the quantity demanded at each of the possible prices.

The demand curve for apartments slopes down: as the price of apartments decreases more people will be willing to rent apartments. If there are many people and their reservation prices differ only slightly from person to

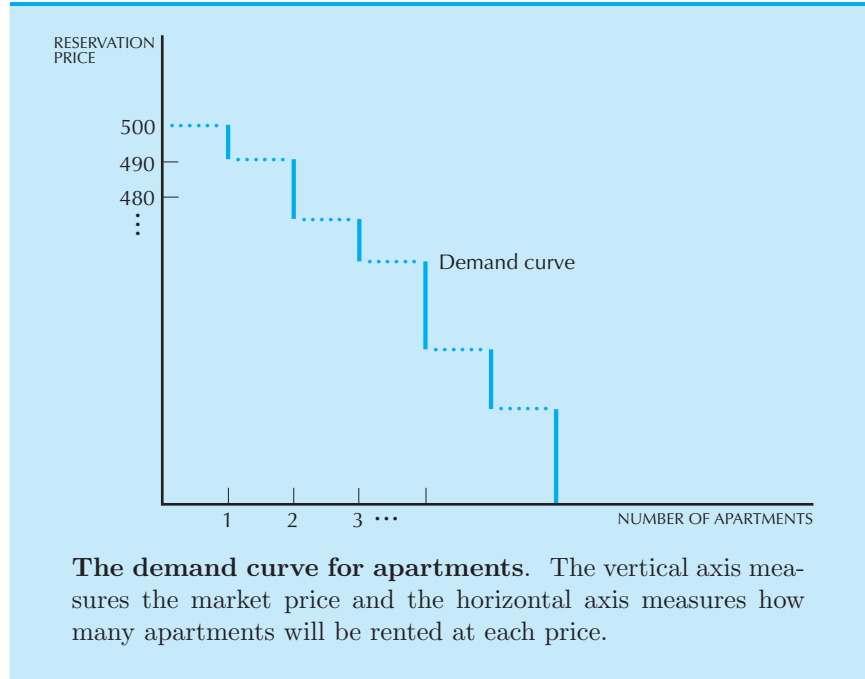


Figure 1.1

person, it is reasonable to think of the demand curve as sloping smoothly downward, as in Figure 1.2. The curve in Figure 1.2 is what the demand curve in Figure 1.1 would look like if there were many people who want to rent the apartments. The “jumps” shown in Figure 1.1 are now so small relative to the size of the market that we can safely ignore them in drawing the market demand curve.

1.4 The Supply Curve

We now have a nice graphical representation of demand behavior, so let us turn to supply behavior. Here we have to think about the nature of the market we are examining. The situation we will consider is where there are many independent landlords who are each out to rent their apartments for the highest price the market will bear. We will refer to this as the case of a **competitive market**. Other sorts of market arrangements are certainly possible, and we will examine a few later.

For now, let’s consider the case where there are many landlords who all operate independently. It is clear that if all landlords are trying to do the best they can and if the renters are fully informed about the prices the landlords charge, then the equilibrium price of all apartments in the inner ring must be the same. The argument is not difficult. Suppose instead that there is some high price, p_h , and some low price, p_l , being charged

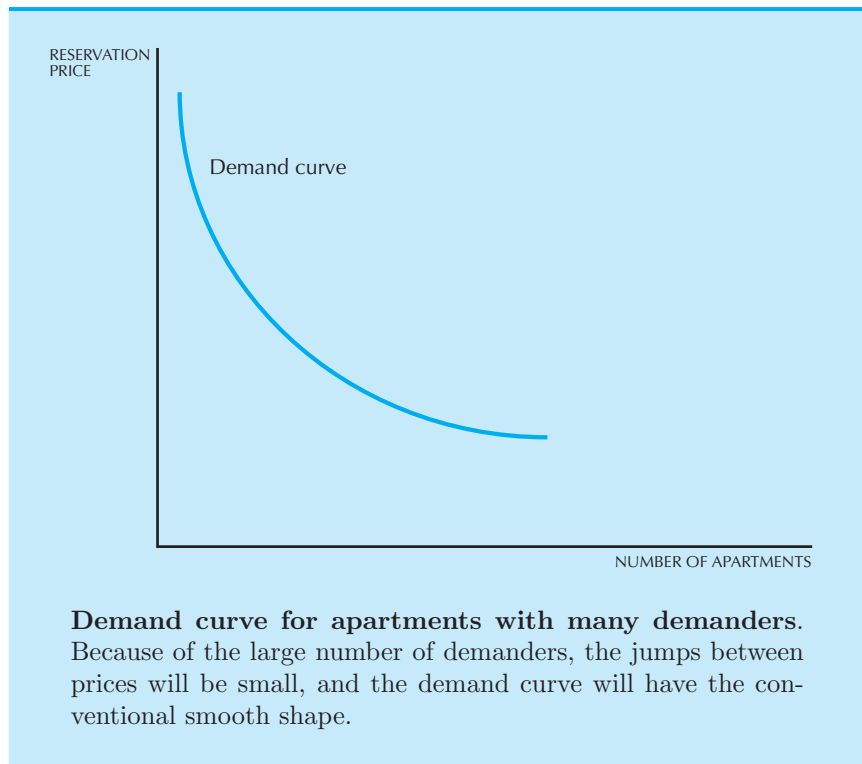


Figure 1.2

for apartments. The people who are renting their apartments for a high price could go to a landlord renting for a low price and offer to pay a rent somewhere between p_h and p_l . A transaction at such a price would make both the renter and the landlord better off. To the extent that all parties are seeking to further their own interests and are aware of the alternative prices being charged, a situation with different prices being charged for the same good cannot persist in equilibrium.

But what will this single equilibrium price be? Let us try the method that we used in our construction of the demand curve: we will pick a price and ask how many apartments will be supplied at that price.

The answer depends to some degree on the time frame in which we are examining the market. If we are considering a time frame of several years, so that new construction can take place, the number of apartments will certainly respond to the price that is charged. But in the “short run”—within a given year, say—the number of apartments is more or less fixed. If we consider only this short-run case, the supply of apartments will be constant at some predetermined level.

The **supply curve** in this market is depicted in Figure 1.3 as a vertical line. Whatever price is being charged, the same number of apartments will be rented, namely, all the apartments that are available at that time.

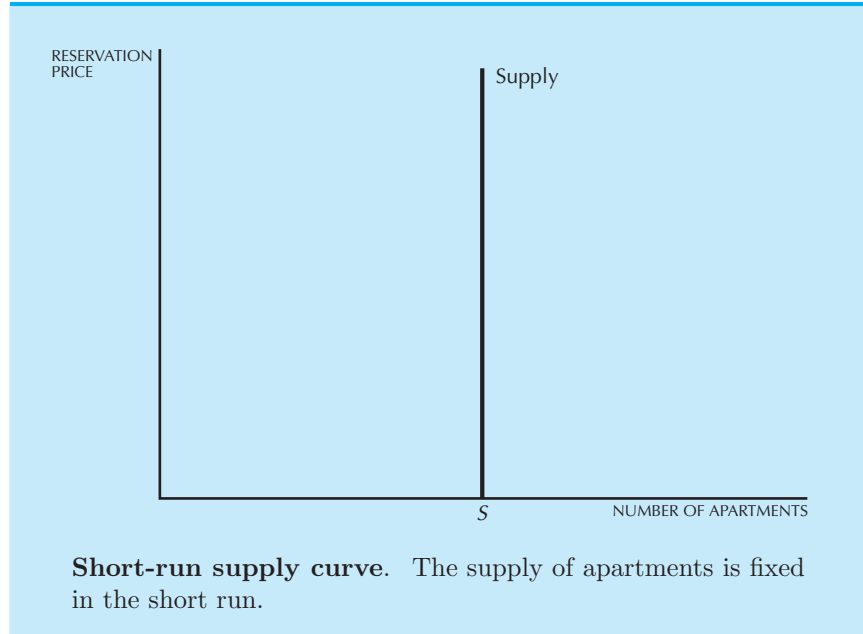


Figure 1.3

1.5 Market Equilibrium

We now have a way of representing the demand and the supply side of the apartment market. Let us put them together and ask what the equilibrium behavior of the market is. We do this by drawing both the demand and the supply curve on the same graph in Figure 1.4.

In this graph we have used p^* to denote the price where the quantity of apartments demanded equals the quantity supplied. This is the **equilibrium price** of apartments. At this price, each consumer who is willing to pay at least p^* is able to find an apartment to rent, and each landlord will be able to rent apartments at the going market price. Neither the consumers nor the landlords have any reason to change their behavior. This is why we refer to this as an *equilibrium*: no change in behavior will be observed.

To better understand this point, let us consider what would happen at a price other than p^* . For example, consider some price $p < p^*$ where demand is greater than supply. Can this price persist? At this price at least some of the landlords will have more renters than they can handle. There will be lines of people hoping to get an apartment at that price; there are more people who are willing to pay the price p than there are apartments. Certainly some of the landlords would find it in their interest to raise the price of the apartments they are offering.

Similarly, suppose that the price of apartments is some p greater than p^* .

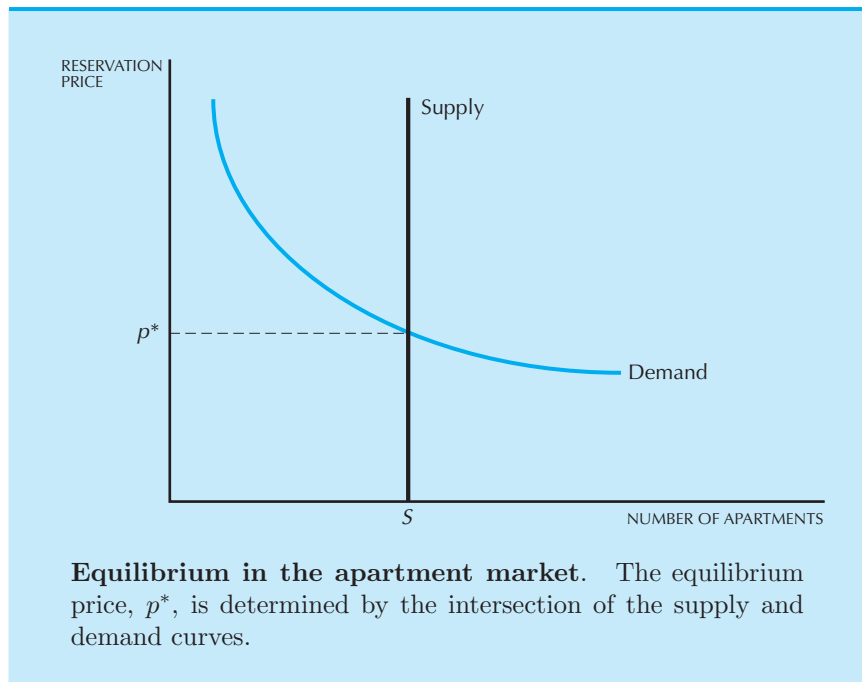


Figure 1.4

Then some of the apartments will be vacant: there are fewer people who are willing to pay p than there are apartments. Some of the landlords are now in danger of getting no rent at all for their apartments. Thus they will have an incentive to lower their price in order to attract more renters.

If the price is above p^* there are too few renters; if it is below p^* there are too many renters. Only at the price of p^* is the number of people who are willing to rent at that price equal to the number of apartments available for rent. Only at that price does demand equal supply.

At the price p^* the landlords' and the renters' behaviors are compatible in the sense that the number of apartments demanded by the renters at p^* is equal to the number of apartments supplied by the landlords. This is the equilibrium price in the market for apartments.

Once we've determined the market price for the inner-ring apartments, we can ask who ends up getting these apartments and who is exiled to the farther-away apartments. In our model there is a very simple answer to this question: in the market equilibrium everyone who is willing to pay p^* or more gets an apartment in the inner ring, and everyone who is willing to pay less than p^* gets one in the outer ring. The person who has a reservation price of p^* is just indifferent between taking an apartment in the inner ring and taking one in the outer ring. The other people in the inner ring are getting their apartments at less than the maximum they would be willing to pay for them. Thus the assignment of apartments to renters is determined by how much they are willing to pay.

1.6 Comparative Statics

Now that we have an economic model of the apartment market, we can begin to use it to analyze the behavior of the equilibrium price. For example, we can ask how the price of apartments changes when various aspects of the market change. This kind of an exercise is known as **comparative statics**, because it involves comparing two “static” equilibria without worrying about how the market moves from one equilibrium to another.

The movement from one equilibrium to another can take a substantial amount of time, and questions about how such movement takes place can be very interesting and important. But we must walk before we can run, so we will ignore such dynamic questions for now. Comparative statics analysis is only concerned with comparing equilibria, and there will be enough questions to answer in this framework for the present.

Let’s start with a simple case. Suppose that the supply of apartments is increased, as in Figure 1.5.

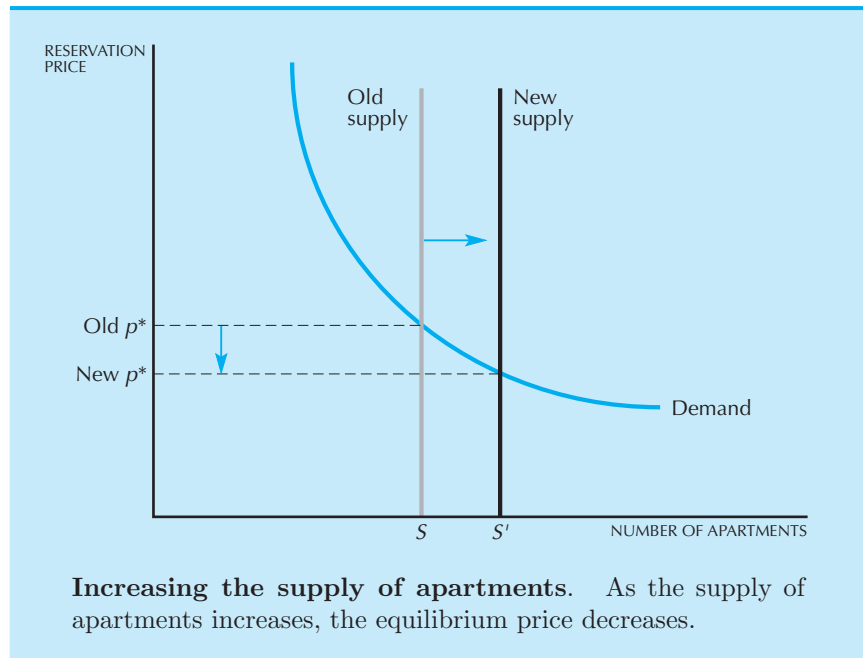


Figure 1.5

It is easy to see in this diagram that the equilibrium price of apartments will fall. Similarly, if the supply of apartments were reduced the equilibrium price would rise.