8th edition

URBAN ECONOMICS

Arthur O'Sullivan

Urban Economics

EIGHTH EDITION

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Arthur O'Sullivan
Department of Economics
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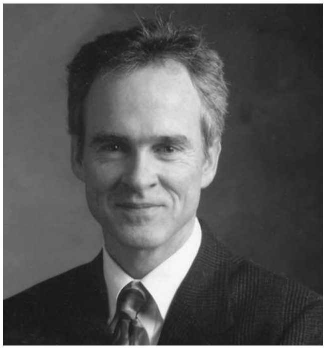
To Professor Ed Whitelaw, the most talented teacher I've ever known.
It has been almost 30 years since I've been in Ed's class, but whenever
I start thinking about how to teach some new material,
my first thought is "How would Ed present this material?"

About the Author



ARTHUR O'SULLIVAN is a professor of economics at Lewis and Clark College in Portland, Oregon. After receiving his B.S. degree in economics at the University of Oregon, he spent two years in the Peace Corps, working with city planners in the Philippines. He received his Ph.D. degree in economics from Princeton University in 1981 and taught at the University of California, Davis and Oregon State University, winning teaching awards at both schools. He is the Robert B. Pamplin Junior Professor of Economics at Lewis and Clark College in Portland, Oregon, where he teaches microeconomics and urban economics. He is the coauthor of the introductory textbook, *Economics: Principles and Tools*, currently in its seventh edition.

Professor O'Sullivan's research explores economic issues concerning urban land use, environmental protection, and public policy. His articles appear in many economics journals, including *Journal of Urban Economics, Regional Science and Urban Economics, Journal of Environmental Economics and Management, National Tax Journal, Journal of Public Economics*, and *Journal of Law and Economics*.

Preface

This book is on urban economics, the discipline that lies at the intersection of geography and economics. Urban economics explores the location decisions of utility-maximizing households and profit-maximizing firms, and it shows how these decisions cause the formation of cities of different size and shape. Part I of the book explains why cities exist and what causes them to grow or shrink. Part II examines the market forces that shape cities and the role of government in determining land-use patterns. Part III looks at the urban transportation system, exploring the pricing and design of public transit systems and the externalities associated with automobile use (congestion, environmental damage, collisions). Part IV explores the economics of urban education and crime, two factors that play key roles in household location decisions. Part V explains the unique features of the housing market and examines the effects of government housing policies. The final part of the book explains the rationale for our fragmented system of local government and explores the responses of local governments to intergovernmental grants and the responses of taxpayers to local taxes.

The text is designed for use in undergraduate courses in urban economics and urban affairs. It could also be used for graduate courses in urban planning, public policy, and public administration. All of the economic concepts used in the book are covered in the typical intermediate microeconomics course, so students who have completed such a course will be able to move through the book at a rapid pace. For students whose exposure to microeconomics is limited to an introductory course— or who could benefit from a review of the concepts covered in an intermediate microeconomics course—I have provided an appendix ("Tools of Microeconomics") that covers the key concepts.

CHANGES FOR THE EIGHTH EDITION

The eighth edition improves on the previous edition in two ways. First, I've rewritten Chapter 11 (Urban Transit) to incorporate the most recent developments in economic theory, empirical results, and practical experience with transit systems. Included in the revised chapter is a thorough analysis of the rationale for transit subsidies and a discussion of the size of the socially efficient subsidy. In addition, the chapter has a full accounting of the relative costs of light rail versus buses.

The second improvement is a new chapter on education (Chapter 12). This chapter uses the education production function as a framework to explore the economics of K–12 education. The chapter identifies the key inputs to the production process—teachers, the home environment, and classroom peers. One of the insights from the production function is that teacher productivity varies significantly across teachers. For example, if we replace an average teacher with an above-average teacher for one year, the benefit is roughly $210,000. At the other end of the productivity scale, if we were to replace the bottom 8 percent of teachers with average teachers, aggregate earnings in the national economy would increase by roughly $112 trillion. The education chapter also looks at spending inequalities across schools and evaluates the effects of intergovernmental grants on spending and achievement inequalities.

WEB SITE

The Web site for the book (www.mhhe.com/osullivan8e) has the following resources.

- Color versions of the maps in the book
- Maps for other cities
- For each chapter
  - PowerPoint presentations, which include all the figures and tables from the text
  - Lecture notes
- A chapter, "The Core-Periphery Model of Regional Development," that presents some key ideas from economic geography
- A list of corrections. The author has a typo-bounty program that pays $5 to the first person to identify a particular error.

The instructors' version of the Web site also has model answers to the exercises in the book.

Acknowledgments

I am indebted to many people who read the book and suggested ways to improve the coverage and the exposition. In particular I would like to thank those instructors who participated in surveys and reviews that were indispensable in the development of the Eighth Edition of *Urban Economics*. The appearance of their names does not necessarily constitute their endorsement of the text or its methodology.

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CHAPTER 1

Introduction and Axioms of Urban Economics

Cities have always been the fireplaces of civilization, whence light and heat radiated out into the dark.

—THEODORE PARKER

I'd rather wake up in the middle of nowhere than in any city on earth.

—STEVE MCQUEEN

This book explores the economics of cities and urban problems. The quotes from Parker and McQueen reflect our mixed feelings about cities. On the positive side, cities facilitate innovation, production, and trade, so they increase our standard of living. On the negative side, cities are noisy, dirty, and crowded. As we'll see in the first part of the book, firms and people locate in cities because the obvious costs of being in a city are more than offset by subtle benefits of producing in close proximity to other firms and people. As we'll see later in the book, policies that combat urban problems such as congestion, pollution, and crime are likely to increase the vitality of cities, causing them to grow.

WHAT IS URBAN ECONOMICS?

The discipline of urban economics is defined by the intersection of geography and economics. Economics explores the choices people make when resources are limited. Households make choices to maximize their utility, while firms maximize their profit. Geographers study how things are arranged across space, answering the question, Where does human activity occur? Urban economics puts economics and geography together, exploring the geographical or location choices of utility-maximizing households and profit-maximizing firms. Urban economics also identifies inefficiencies in location choices and examines alternative public policies to promote efficient choices.

Urban economics can be divided into six related areas that correspond to the six parts of this book.

1. **Market forces in the development of cities.** The interurban location decisions of firms and households generate cities of different size and economic structure. We explore the issues of why cities exist and why there are big cities and small ones.
2. **Land use within cities.** The intraurban location decisions of firms and households generate urban land-use patterns. In modern cities, employment is spread throughout the metropolitan area, in sharp contrast to the highly centralized cities of just 100 years ago. We explore the economic forces behind the change from centralized to decentralized cities. We also use a model of neighborhood choice to explore the issue of segregation with respect to race, income, and educational level.
3. **Urban transportation.** We explore some possible solutions to the urban congestion problem and look at the role of mass transit in the urban transportation system. One issue is whether a bus system is more efficient than a light-rail system or a heavy-rail system like BART (San Francisco) or Metro (Washington).
4. **Crime and public policy.** We look at the problem of urban crime and show the links between crime and two other urban problems, poverty and low educational achievement.
5. **Housing and public policy.** Housing choices are linked to location choices because housing is immobile. We'll discuss why housing is different from other products and how housing policies work.
6. **Local government expenditures and taxes.** Under our fragmented system of local government, most large metropolitan areas have dozens of local governments, including municipalities, school districts, and special districts. In making location choices, households consider the mix of taxes and local public goods.

WHAT IS A CITY?

An urban economist defines an urban area as a geographical area that contains a large number of people in a relatively small area. In other words, an urban area has a population density that is high relative to the density of the surrounding area. This definition accommodates urban areas of vastly different sizes, from a small town to a large metropolitan area. The definition is based on population density because an essential feature of an urban economy is frequent contact between different economic activities, which is feasible only if firms and households are concentrated in a relatively small area.

The U.S. Census Bureau has developed a variety of geographical definitions relevant to urban economics. Since much of the empirical work in urban economics is based on census data, a clear understanding of these definitions is important.

The appendix to this chapter provides the details of the census definitions. The key census definitions, some of which are new for the 2000 Census, are as follows.

1. **Urban area:** A densely settled geographical area with a minimum population of 2,500 people and a minimum density of 500 people per square mile. In 2000, there were 3,756 urban areas in the United States.
2. **Urban population:** People living in urban areas. In 2000, the urban population was 79 percent of the total population.
3. **Metropolitan area:** A core area with a substantial population nucleus, together with adjacent communities that are integrated, in an economic sense, with the core area. To qualify as a metropolitan area, the minimum population is 50,000 people. In 2000, there were 361 metropolitan statistical areas in the United States.
4. **Micropolitan area:** A smaller version of a metropolitan area with a concentration of 10,000 to 50,000 people. In 2000, there were 559 micropolitan statistical areas in the United States.
5. **Principal city:** The largest municipality in each metropolitan or micropolitan statistical area. A municipality is defined as an area over which a municipal corporation exercises political authority and provides local government services such as sewage service, crime protection, and fire protection.

This book uses three terms to refer to spatial concentrations of economic activity: *urban area, metropolitan area,* and *city*. These three terms, which will be used interchangeably, refer to the economic city (an area with a relatively high population density that contains a set of closely related activities), not the political city. When referring to a political city, we will use the term *central city* or *municipality*.

WHY DO CITIES EXIST?

This is the fundamental question of urban economics. People need land to produce food and other resources, and living in dense cities separates us from the land where food is produced. As Bartlett (1998) points out, no other creatures in the animal world form anything like cities. Herbivores such as wildebeests and bison form larger herds but constantly migrate to fresh land to ensure a steady supply of food. Coral is concentrated in stationary reefs, but ocean currents provide a steady supply of food to the stationary coral. Perhaps the closest thing to a city in the natural world is a bee hive or an anthill. Eusocial insects such as bees and ants form colonies with thousands of inhabitants, with highly specialized castes—soldier ants, drones, breeders, nurses, and cleanup crews. In contrast with human cities, these insect agglomerations are closed to non-natives and not based on voluntary exchange.

Cities exist because human technology has created systems of production and exchange that seem to defy the natural order. Three conditions must be satisfied for a city to develop.

1. **Agricultural surplus.** People outside cities must produce enough food to feed themselves and city dwellers.

2. **Urban production.** City dwellers must produce something—goods or services—to exchange for food grown by rural workers.
3. **Transportation for exchange.** There must be an efficient transportation system to facilitate the exchange of food and urban products.

Figure 1–1 shows the share of people living in cities in the United States from 1800 to 2010. Over this period, the urban share increased from 6 percent to 82 percent, a remarkable transformation that also occurred in other parts of the world. As we'll see in the next three chapters of the book, the transformation of a rural society into an urban one occurred because technological advances increased the agricultural surplus (condition 1), increased the productivity of urban workers (condition 2), and increased the efficiency of transportation and exchange (condition 3).

Figure 1–2 shows urbanization rates for different regions around the world, with projections for the year 2030. In 1950, urbanization rates were relatively low in Africa and Asia, and highest in Oceania and North America. Between now and the year 2030, urbanization rates are expected to increase everywhere, with the largest increases in Africa and Asia. For the world as a whole, the urbanization rate was 30 percent in 1950 and is expected to double by the year 2030.

Table 1–1 (page 6) shows the population figures for the nation's 30 largest metropolitan areas. The New York area tops the list, followed by Los Angeles, Chicago, Dallas, and Philadelphia. The third column shows the percentage growth of each

FIGURE 1–1 Percent of U.S. Population in Urban Areas, 1800–2010

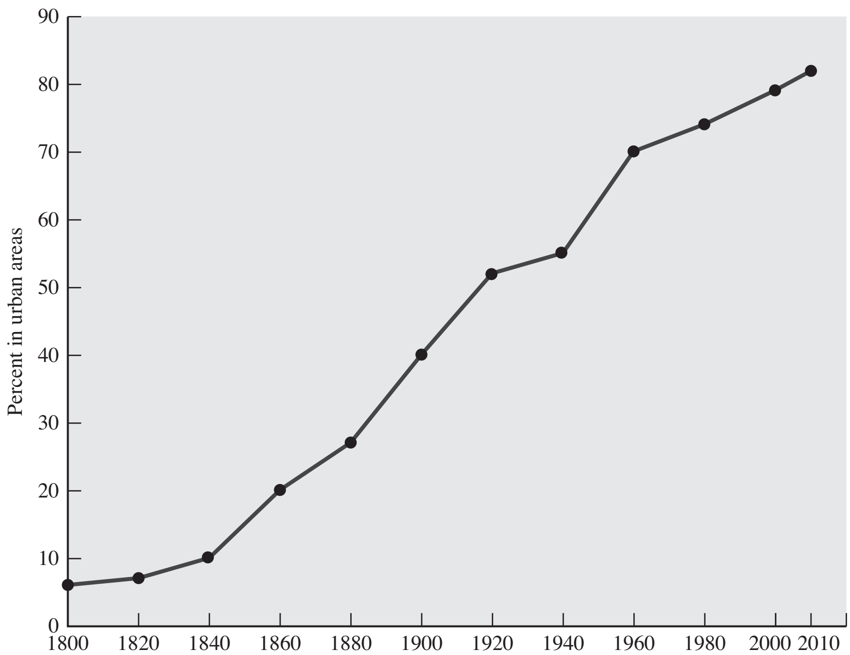
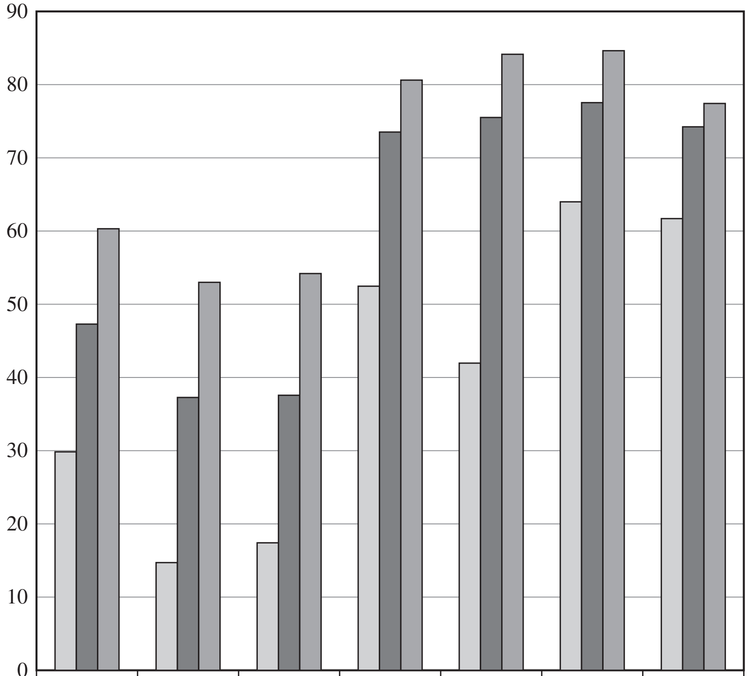


FIGURE 1–2 Urbanization Rates, by World Region, 1950–2030



	World	Africa	Asia	Europe	Latin America and the Caribbean	North America	Oceania
1950	29.8	14.7	17.4	52.4	41.9	63.9	61.6
2000	47.2	37.2	37.5	73.4	75.4	77.4	74.1
2030	60.2	52.9	54.1	80.5	84	84.5	77.3

Percent in urban areas

Source: United Nations: World Urban Prospects, 2001 Revision.

metropolitan area over the period 2000 to 2005. The most rapidly growing metropolitan areas were in the South, the Mountain States, and the West. In three metropolitan areas—Detroit, Pittsburgh, and Cleveland—population decreased over this period, continuing a two-decade trend of decreasing population. These metropolitan areas experienced large losses in manufacturing employment.

Table 1–2 (page 7) shows the population figures for the world's largest metropolitan areas outside the United States. The table shows actual populations in 1975 and 2005, and projected populations for the year 2015. Eight metropolitan areas, all of which are in the developing world, are expected to grow by at least 20 percent over the 10-year period. In contrast, three cities in the developed world (Tokyo,

TABLE 1–1 Largest Metropolitan Areas in the United States, 2009

Metropolitan Area	Population in 2009	Percentage Change 2000–2009	Rank
New York-Northern New Jersey-Long Island, NY-NJ-PA	19,069,796	4.1	1
Los Angeles-Long Beach-Santa Ana, CA	12,874,797	4.1	2
Chicago-Naperville-Joliet, IL-IN-WI	9,580,567	5.3	3
Dallas-Fort Worth-Arlington, TX	6,447,615	24.9	4
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	5,968,252	4.9	5
Houston-Sugar Land-Baytown, TX	5,867,489	24.4	6
Miami-Fort Lauderdale-Pompano Beach, FL	5,547,051	10.8	7
Washington-Arlington-Alexandria, DC-VA-MD-WV	5,476,241	14.2	8
Atlanta-Sandy Springs-Marietta, GA	5,475,213	28.9	9
Boston-Cambridge-Quincy, MA-NH	4,588,680	4.5	10
Detroit-Warren-Livonia, MI	4,403,437	–1.1	11
Phoenix-Mesa-Scottsdale, AZ	4,364,094	34.2	12
San Francisco-Oakland-Fremont, CA	4,317,853	4.7	13
Riverside-San Bernardino-Ontario, CA	4,143,113	27.3	14
Seattle-Tacoma-Bellevue, WA	3,407,848	12.0	15
Minneapolis-St. Paul-Bloomington, MN-WI	3,269,814	10.1	16
San Diego-Carlsbad-San Marcos, CA	3,053,793	8.5	17
St. Louis, MO-IL	2,828,990	4.8	18
Tampa-St. Petersburg-Clearwater, FL	2,747,272	14.7	19
Baltimore-Towson, MD	2,690,886	5.4	20
Denver-Aurora-Broomfield, CO	2,552,195	17.1	21
Pittsburgh, PA	2,354,957	–3.1	22
Portland-Vancouver-Beaverton, OR-WA	2,241,841	16.3	23
Cincinnati-Middletown, OH-KY-IN	2,171,896	8.1	24
Sacramento–Arden-Arcade–Roseville, CA	2,127,355	18.4	25
Cleveland-Elyria-Mentor, OH	2,091,286	–2.6	26
Orlando-Kissimmee, FL	2,082,421	26.6	27
San Antonio, TX	2,072,128	21.1	28
Kansas City, MO-KS	2,067,585	12.6	29
Las Vegas-Paradise, NV	1,902,834	38.3	30

Source: U.S. Census Bureau, "Table 1–Annual Estimates of the Population of Metropolitan and Micropolitan Statistical Areas: April 1, 2000 to July 1, 2009 (CBSA-EST2009-01)," March 2010.

Osaka, and Paris) are expected to grow slowly. In the United States, New York is expected to grow 6 percent over the period, and Los Angeles is expected to grow 7 percent.

Figure 1–3 (page 8) shows the time trend of large urban agglomerations in the world, defined as metropolitan areas with at least 1 million people. The figure distinguishes between cities in the developed and less developed regions. In 1970, the two types of regions had roughly the same number of large cities. By 1996, however, the number of large cities in the less developed regions nearly doubled, and by 2015 there will be roughly four times as many large cities in less developed regions.

TABLE 1–2 Populations and Projected Populations of Large World Cities

Metropolitan Area	Nation	Population 1975 (million)	Population 2005 (million)	Population 2015 (million)	Percent Change 2005–2015
Tokyo	Japan	26.6	35.2	35.5	1
Ciudad de México (Mexico City)	Mexico	10.7	19.4	21.6	11
Sao Paulo	Brazil	9.6	18.3	20.5	12
Mumbai (Bombay)	India	7.1	18.2	21.9	20
Delhi	India	4.4	15.0	18.6	24
Shanghai	China	7.3	14.5	17.2	19
Kolkata (Calcutta)	India	7.9	14.3	17.0	19
Jakarta	Indonesia	4.8	13.2	16.8	27
Buenos Aires	Argentina	8.7	12.6	13.4	7
Dhaka	Bangladesh	2.2	12.4	16.8	35
Karachi	Pakistan	4.0	11.6	15.2	31
Rio de Janeiro	Brazil	7.6	11.5	12.8	11
Osaka-Kobe	Japan	9.8	11.3	11.3	0
Al-Qahirah (Cairo)	Egypt	6.4	11.1	13.1	18
Lagos	Nigeria	1.9	10.9	16.1	48
Beijing	China	6.0	10.7	12.9	20
Manila	Philippines	5.0	10.7	12.9	21
Moskva (Moscow)	Russian Federation	7.6	10.7	11.0	3
Paris	France	8.6	9.8	9.9	0
Istanbul	Turkey	3.6	9.7	11.2	15

Source: United Nations. Urban Agglomerations 2005.

THE FIVE AXIOMS OF URBAN ECONOMICS

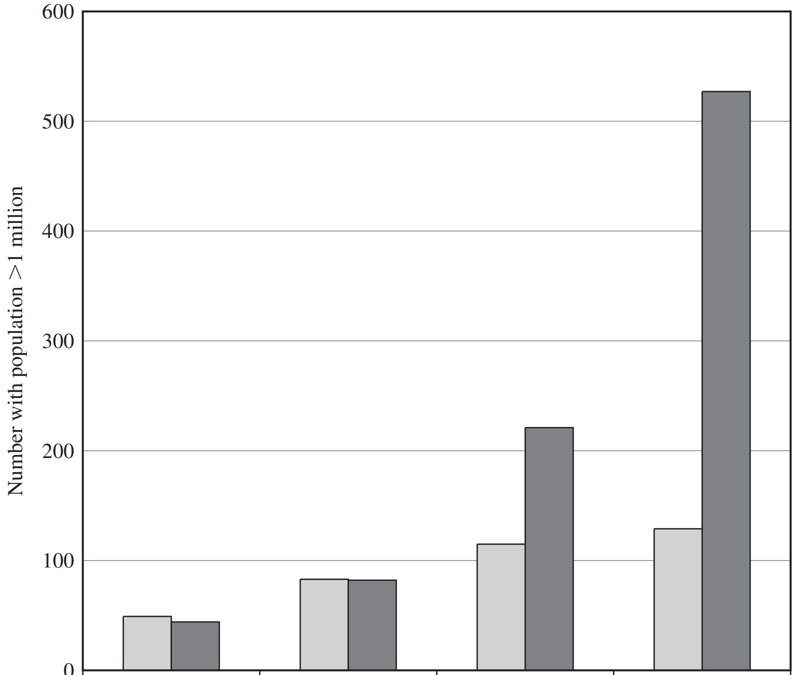
Urban economics explores the location choices of households and firms, and so it is natural to assume that people and firms are mobile. Of course, people don't instantly change their workplaces and residences when circumstances change; therefore, a model of perfect mobility tells us more about long-term changes than short-term ones. The average household changes its residence every seven years, meaning that about 14 percent of the population moves every year. Although most models of urban economics assume perfect mobility, there are exceptions, and we will highlight the analysis that assumes less than perfect mobility.

In this part of the chapter, we introduce five axioms of urban economics. An axiom is a self-evident truth, something that most people readily understand and accept. For our purposes, "most people" are people who have taken at least one course in economics. The five axioms lie at the heart of urban economics and together provide a foundation for the economic models of location choices. As you go through the book, these five axioms will appear repeatedly.

1. Prices Adjust to Achieve Locational Equilibrium

A locational equilibrium occurs when no one has an incentive to move. Suppose that you and Bud are competing for two rental houses, one along a beautiful beach

FIGURE 1–3 The Number of Large Agglomerations in the World, 1950–2015



	1950	1970	1996	2015
More developed regions	49	83	115	129
Less developed regions	44	82	221	527

Source: United Nations World Population Prospects (New York: United Nations, 2001).

and one along a noisy highway. If the two houses have the same price (the same monthly rent), you would prefer the beach house, and so would Bud. Flipping a coin and giving the beach house to the winner wouldn't generate a locational equilibrium because the unlucky person in the highway house would have an incentive to move to the more desirable house.

Locational equilibrium requires a higher price for the beach house. To eliminate the incentive to move, the price of the beach house must be high enough to fully compensate for the better environment. The question is, How much money are you willing to sacrifice to live on the beach? If your answer is $300 and Bud agrees, then the equilibrium price of the beach house will be $300 higher than the price of the highway house. In general, prices adjust to generate the same utility level in different environments, getting people to live in both desirable and undesirable locations.

The same sort of economic forces operate in the labor market. Workers compete for jobs in desirable locations, causing lower wages in more desirable locations. Suppose you are competing with Ricki for two jobs, one in Dullsville and one in Coolsville, a city with a more stimulating social environment. If a $500 gap in the monthly wage fully compensates for the difference in the social environment, the equilibrium wage will be $500 lower in Coolsville. The two workers will be indifferent between the two cities because a move to Coolsville means a $500 wage cut. In the labor market, wages adjust to get people to work in both desirable and undesirable environments.

The price of land also adjusts to ensure locational equilibrium among firms. Office firms compete for the most accessible land in a city, and land at the center is the most accessible and thus the most expensive. In equilibrium, office firms on less accessible land far from the center pay lower prices for land, and can be just as profitable as firms on the most accessible land.

2. Self-Reinforcing Effects Generate Extreme Outcomes

A self-reinforcing effect is a change in something that leads to additional changes in the same direction. Consider a city where the sellers of new automobiles are initially spread evenly throughout the city. If one seller relocates next to another seller on Auto Road, what happens next? Auto consumers compare brands before buying, and the pair of sellers on Auto Road will facilitate comparison shopping and thus attract buyers. The increased consumer traffic on Auto Road will make it an attractive site for other auto sellers, so they will move too. The ultimate result is an "auto row," a cluster of firms that compete against one another, yet locate nearby.

Self-reinforcing changes also happen in the location decisions of people. Suppose artists and creative types are initially spread out evenly across a dozen cities in a region. If by chance one city experiences an influx of artists, its creative environment will improve as artists (1) are exposed to more ideas and fabrication techniques and (2) can share studios, print shops, tool suppliers, and other facilities. The cluster of artists will attract other artists from the region, causing a concentration of artistic production in one city. In recent decades, cities that have attracted artists and creative folks have experienced relatively rapid growth (Florida, 2002).

3. Externalities Cause Inefficiency

In most transactions, the costs and benefits of the exchange are confined to the individual buyer and seller. The consumer pays a price equal to the full cost of producing the good, so no one else bears a cost from the transaction. Similarly, the consumer is the only person to benefit from the product. In contrast, an externality occurs when some of the costs or benefits of a transaction are experienced by someone other than the buyer or seller, that is, someone *external* to the transaction.

An external cost occurs when a consumer pays a price that is less than the full cost of producing a product. The price of a product always includes the costs of the labor, capital, and raw materials used to produce the product, but it usually does not include the environmental costs of producing the product. For example, if burning gasoline in automobiles generates air pollution, part of the cost of driving is borne by people who breathe dirty air. Similarly, when you enter a crowded highway, you slow down everyone else, meaning that other drivers bear a cost.

An external benefit occurs when a product purchased by one person generates a benefit for someone else. For example, painting my peeling house improves the appearance of my neighborhood, increasing the value of my neighbor's house as well as mine. Education generates external benefits because it improves communication and thinking skills, making a person a better team worker. In other words, some of the benefits of education are experienced by a person's fellow workers, who become more productive and thus earn higher wages.

When there are external costs or benefits, we do not expect the market equilibrium to be socially efficient. In the case of external cost, people pay less than the full social cost of an action like driving, so they drive too much. In the case of external benefit, people get less than the full social benefit from an action like education, so they stop short of the socially efficient level of education. As we'll see later in the book, cities have all sorts of external costs and benefits. In many cases there is a simple solution: Internalize the externality with a tax or a subsidy, and let individuals, who then bear the full social cost and benefits of their actions, decide what to do.

4. Production Is Subject to Economies of Scale

Economies of scale occur when the average cost of production decreases as output increases. For most products, if we start with a relatively small production operation and double all inputs, the average cost of production decreases. In the jargon of economics, when the long-run average cost curve is negatively sloped, we say that there are scale economies in production. Scale economies occur for two reasons:

- **Indivisible inputs.** Some capital inputs are "lumpy" and cannot be scaled down for small operations. As a result, a small operation has the same indivisible inputs as a large operation. For example, to manufacture frisbees you need a mold, whether you produce one frisbee per day or a thousand. Similarly, to produce microprocessors you need a clean room and other expensive equipment, whether you produce one processor per day or a thousand. As output increases, the average cost decreases because the cost of the indivisible input is spread over more output.
- **Factor specialization.** In a small one-person production operation, a worker performs a wide variety of production tasks. In a larger operation with more workers, each worker specializes in a few tasks, leading to higher productivity because of continuity (less time is spent switching from one task to another) and proficiency (from experience and learning). The notion of factor specialization is captured in the old expression, "A jack of all trades is master of none." Adding to this expression, we can say that a specialized worker is a master of one task.

As we'll see later in the book, scale economies play a vital role in urban economies. In fact, as we'll see in Chapter 2, if there are no scale economies, there will be no cities. It is costly to transport products from a production site to consumers, so centralized production in cities will be sensible only if there is some advantage that more than offsets transport costs.

The extent of scale economies in production varies across products. Microprocessors are produced in $5 billion fabrication facilities with a highly specialized workforce performing hundreds of complex tasks, resulting in large scale economies in production. In contrast, pizza is produced with a $5,000 pizza oven with just a few production tasks, so scale economies are exhausted sooner. In general, the extent of scale economies is determined by the lumpiness of indivisible inputs and the opportunities for factor specialization.

5. Competition Generates Zero Economic Profit

When there are no restrictions on the entry of firms into a market, we expect firms to enter the market until economic profit is zero. Recall that economic profit equals the excess of total revenue over total economic cost, where economic cost includes the opportunity costs of all inputs. Two key components of economic costs are the opportunity cost of the entrepreneur's time and the opportunity cost of funds invested in the firm. For example, suppose an entrepreneur could earn $60,000 in another job and invests $100,000 in the firm, taking the money out of a mutual fund that earns 8 percent. The economic cost of the firm includes $60,000 in time cost and $8,000 in investment cost. Once we account for all the opportunity costs, the fact that economic profit is zero means that a firm is making enough money to stay in business, but not enough for other firms to enter the market. Earning zero economic profit means earning "normal" accounting profit.

In urban economics, competition has a spatial dimension. Each firm enters the market at some location, and the profit of each firm is affected by the locations of other firms. Spatial competition looks a lot like monopolistic competition, a market structure in which firms sell slightly differentiated products in an environment of unrestricted entry. Although this sounds like an oxymoron such as "tight slacks" and "jumbo shrimp," the words are revealing. Each firm has a monopoly for its differentiated product, but unrestricted entry leads to keen competition for consumers who can easily switch from one differentiated product to another. With spatial competition, each firm has a local monopoly in the area immediately surrounding its establishment, but unrestricted entry leads to keen competition. Firms will continue to enter the market until economic profit drops to zero.

WHAT'S NEXT?

This introductory chapter sets the stage for the economic analysis of cities in the rest of the book. Here are some of the big questions we'll address in coming chapters:

- Why do cities exist?
- Are cities too big or too small?
- What causes urban economic growth?
- Why is employment in modern cities so widely dispersed?
- Why is there so much segregation with respect to race and income?

- Why do economists advocate a tax of about 7 cents per mile for all driving and about 27 cents per mile for driving on congested roads?
- Why do so few people take mass transit?
- What are the key inputs in the education production function?
- Why is crime higher in cities?
- Why does the typical metropolitan area have dozens of municipalities?

In answering these and other questions, we will use the five axioms of urban economics. In addition, we will use a number of economic models to explore the spatial aspects of decision making. It's worth noting that much of the analysis in the book reflects advances in urban economics in the last 10 to 15 years, in both theoretical modeling and empirical analysis.

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Appendix: Census Definitions

The U.S. Census Bureau has developed a variety of geographical definitions relevant to urban economics. Since much of the empirical work in urban economics is based on census data, a clear understanding of these definitions is important. This appendix provides the details of the census definitions.

URBAN POPULATION

The first three definitions deal with the urban population and are based on the census block, the smallest geographical unit in census data. A *census block* is defined as an area bounded on all sides by visible features (streets, streams, or tracks) or invisible features (property lines or political boundaries). The typical census block has between a few dozen and a few hundred residents. A *block group* is a group of contiguous census blocks. There are two types of urban areas:

1. **Urbanized area.** An *urbanized area* is a densely settled core of census block groups and surrounding census blocks that meet minimum population density

requirements. In most cases, the density requirement is 1,000 people per square mile for the core block groups and 500 people per square mile for the surrounding blocks. Together, the densely settled blocks must encompass a population of at least 50,000 people. In 2000, there were 464 urbanized areas in the United States.

2. **Urban clusters.** An *urban cluster* is a scaled-down version of an urbanized area. The total population of the census blocks that make up an urban cluster is between 2,500 and 50,000 people. In 2000, there were 3,112 urban clusters in the United States.
3. **Urban population.** The Census Bureau defines the nation's *urban population* as all people living in urbanized areas and urban clusters. Based on this definition, 79 percent of the population lived in urban areas in 2000.

METROPOLITAN AND MICROPOLITAN STATISTICAL AREAS

The census bureau has a long history of changing its definitions of metropolitan areas. The general idea is that a metropolitan area includes a core area with a substantial population nucleus, together with adjacent communities that are integrated, in an economic sense, with the core area. Over the years, the labels for metropolitan areas have changed from standard metropolitan area (SMA) in 1949, to standard metropolitan statistical area (SMSA) in 1959, to metropolitan statistical area (MSA) in 1983, to metropolitan area (MA) in 1990, which referred collectively to metropolitan statistical areas (MSAs), consolidated metropolitan statistical areas (CMSAs—the largest metropolitan areas), and primary metropolitan statistical areas (PMSAs—parts of CMSAs).

The new label for areas considered metropolitan, implemented in 2000, is *core based statistical area* (CBSA). Each CBSA contains at least one urban area (either an urbanized area or an urban cluster) with at least 10,000 people and is designated as either a metropolitan area or a micropolitan area.

1. **Metropolitan area.** A *metropolitan statistical area* includes at least one urbanized area with at least 50,000 people.
2. **Micropolitan area.** A *micropolitan statistical area* includes at least one urban cluster of between 10,000 and 50,000 people.

In 2000, there were 361 metropolitan statistical areas and 559 micropolitan statistical areas in the United States.

The building blocks for metropolitan and micropolitan areas are counties. For a particular CBSA, central counties are ones in which at least 5,000 people or 50 percent of the population resides within urban areas with at least 10,000 people. Additional outlying counties are included in the CBSA if they meet minimum thresholds of commuting rates to or from the central counties. Specifically, at least 25 percent of workers in an outlying county must work in one of the central counties, or at least 25 percent of the jobs in an outlying county must be filled by residents of one of the central counties.

Together CBSAs contain 93 percent of the nation's population, with 83 percent in metropolitan areas and 10 percent in the smaller micropolitan areas. The percentage of the population in CBSAs (93 percent) exceeds the percentage in urban areas (79 percent) because CBSAs encompass entire counties, including areas outside urban areas (defined by the smallest geographical unit, the census block).

PRINCIPAL CITY

The largest municipality in each metropolitan or micropolitan statistical area is designated a *principal city*. Additional cities qualify as "principal" if they meet minimum requirements for population size (at least 250,000 people) and employment (at least 100,000 workers). The title of each metropolitan or micropolitan statistical area consists of the names of up to three of its principal cities and the name of each state into which the metropolitan or micropolitan statistical area extends. For example, the name for Minneapolis metropolitan area is Minneapolis-St. Paul-Bloomington, MN-WI, indicating that it includes parts of two states with two other municipalities large enough to merit listing. For most metropolitan areas, the label includes only one principal city. About a dozen large metropolitan areas are divided into smaller groupings of counties called metropolitan divisions.

PART ONE

Market Forces in the Development of Cities

In a market economy, individuals exchange their labor for wage income, which they use to buy consumer goods and services. How do these market transactions affect cities? As we'll see in Chapter 2, cities exist because of the benefits of centralized production and exchange. We'll look at the rationale for the development of cities based on trade, production, and processing raw materials. Chapter 3 explores agglomeration economies, the economic forces that cause firms to cluster in cities to share the suppliers of intermediate inputs, share a labor pool, get better skills matches between workers and firms, and share knowledge. Chapter 4 explores the economic forces behind the development of cities of different size and scope. We'll look at how worker utility varies with city size and see why the equilibrium city size often exceeds the optimum size. Chapter 5 explores the sources of urban economic growth (increases in per-capita income) and urban employment growth. It also addresses the question of who benefits from employment growth and describes some of the techniques used by economists to predict future employment growth.

CHAPTER 2

Why Do Cities Exist?

Nobody ever saw a dog make a fair and deliberate exchange of one bone for another with another dog.

—Adam Smith

Cities exist because individuals are not self-sufficient. If each of us could produce everything we consumed and didn't want much company, there would be no reason to live in dirty, noisy, crowded cities. We aren't self-sufficient, but instead specialize in a labor task—writing software, playing the accordion, performing brain surgery—and use our earnings to buy the things we don't produce ourselves. We do this because labor specialization and large-scale production allow us to produce and consume more stuff. As we'll see in this chapter, production happens in cities, so that's where most of us live and work. By living and working in cities, we achieve a higher standard of living but put up with more congestion, noise, and pollution.

To explain why cities exist, we'll start with a model that implies that they don't. In the model of backyard production, every consumer is a producer, and all production occurs in backyards (or apartment roofs). In other words there is no need for concentrated production or population. As we drop the assumptions of the backyard-production model, the new models imply that cities will develop. In other words, the short list of assumptions in the model identifies the key factors behind the development of cities.

A REGION WITHOUT CITIES—BACKYARD PRODUCTION

Consider a region that produces and consumes two products, bread and shirts. People use the raw materials from land (wool and wheat) to produce the two consumer products. The following assumptions eliminate the possibility of cities.

- **Equal productivity.** All land is equally productive in producing wheat and wool, and all workers are equally productive in producing shirts and bread.
- **Constant returns to scale in exchange.** The unit cost of exchange (the cost of executing one transaction, including transportation cost) is constant, regardless of how much is exchanged.

- **Constant returns to scale in production.** The quantity of shirts produced per hour is constant, regardless of how many shirts a worker produces. The same is true for bread production.

Together these assumptions eliminate the possibility of exchange and guarantee that each household will be self-sufficient. If a person were to specialize in bread and then trade some bread for shirts, she would incur a transaction cost equal to the product that could be produced in the time required to execute the trade. Under the assumption of equal productivity, there is no benefit from specialization because everyone is equally productive. Under the assumption of constant returns to scale, there is no benefit from producing shirts in factories because an individual is just as efficient as a shirt factory. In sum, exchange has costs without any benefits, so every household will be self-sufficient, producing everything it consumes.

The absence of exchange guarantees a uniform distribution of population. If population were concentrated at some location, competition for land would bid up its price. People in the city would pay a higher price for land without any compensating benefit, so they would have an incentive to leave the city. In the locational equilibrium, the price of land would be the same at all locations, and population density would be uniform. Recall the first axiom of urban economics:

Prices adjust to ensure locational equilibrium

In this case, all sites are equally attractive, so locational equilibrium requires the same price of land at all locations.

A TRADING CITY

Now that we have a short list of assumptions under which cities don't develop, let's drop the assumptions, one by one, and see what happens. We'll start by dropping the assumption of equal productivity for all workers. Suppose households in the North are more productive in producing both bread and shirts. This could result from differences in soil conditions, climate, or worker skills. Table 2–1 shows the output per hour for the two regions. While each worker in the South can produce one shirt or one loaf per hour, workers in the North are twice as productive in producing bread and six times as productive in producing shirts.

TABLE 2–1 Comparative Advantage

	North		South	
	Bread	Shirts	Bread	Shirts
Output per hour	2	6	1	1
Opportunity cost	3 shirts	1/3 loaf	1 shirt	1 loaf

Comparative Advantage and Trade

A region has a comparative advantage in producing a particular product if it has a lower opportunity cost. For every shirt produced, the North sacrifices 1/3 loaf of bread, so that's the opportunity cost of a shirt. In the South, the opportunity cost of a shirt is one loaf. The North has a lower opportunity cost for shirts, so it has a comparative advantage in producing shirts. It is sensible for the North to specialize in shirts (and not produce any bread) because, although the North is twice as productive as the South in producing bread, the North is *six* times as productive in producing shirts.

Comparative advantage may lead to specialization and trade. Suppose the two regions are initially self-sufficient, with each household producing all the bread and shirts it consumes. Table 2–2 shows what happens if a North household switches one hour from bread to shirt production, and a South household goes the other direction, switching two hours from shirt to bread production. The first row shows the changes in production: −2 loaves and +6 shirts for North; +2 loaves and −2 shirts for South. As shown in the second and third rows, if the households exchange two loaves and four shirts, each has a gain from trade of two shirts. After specialization and exchange, each household has just as much bread as before and two additional shirts.

What about transaction costs? The transaction cost is the opportunity cost of the time required to exchange products and is equal to the amount of output that could be produced during that time. For example, a North household can produce six shirts per hour, so the opportunity cost for a 10-minute (1/6 hour) transaction is one shirt. In this case, the net gain from trade is the gross gain of 2 shirts minus the transaction cost of 1 shirt, or a net gain of one shirt. As long as the transaction time is less than 1/3 hour (two shirts), trade is beneficial for a North household. The South household, with lower productivity and thus a lower opportunity cost, has a lower transaction cost. For example, if the opportunity cost is 1/6 hour, the transaction cost is 1/6 loaf of bread, and the net gain is 2 shirts minus 1/6 shirt, or 11/6 loaves. For a South household, the threshold transaction time is 2 hours (2 loaves of bread).

Scale Economies in Exchange

The presence of specialization and trade will not necessarily cause a city to develop. The second assumption of the backyard-production model is that there are constant returns to scale in exchange. Under this assumption, an individual household is just as efficient in executing trades as a trading firm, so there is no reason to pay a firm

TABLE 2–2 Specialization and Gains from Trade

	North		South	
	Bread	Shirts	Bread	Shirts
Change in production from specialization	−2	+6	+2	−2
Exchange 4 shirts for 2 loaves	+2	−4	−2	+4
Gain from trade	0	+2	0	+2

to execute an exchange. Therefore, each North household will link up with a South household to exchange shirts and bread directly, without intermediaries.

Trading firms will emerge if there are economies of scale associated with exchange and trade. Recall the fourth axiom of urban economics:

Production is subject to economies of scale

A trading firm could use indivisible inputs such as a large truck to transport output between North and South. Similarly, workers who specialize in transportation tasks will be more efficient in transporting goods than workers who spend most of their time producing bread or shirts. In general, because trading firms have lower transaction costs, individual households will pay trading firms to handle exchanges.

The emergence of trading firms will cause the development of a trading city. To fully exploit scale economies, trading firms will locate at places that can efficiently collect and distribute large volumes of output. The concentration of trade workers will bid up the price of land near crossroads, river junctions, and ports. The increase in the price of land will cause people to economize on land by occupying smaller residential lots. The result is a place with a relatively high population density—a city.

TRADING CITIES IN URBAN HISTORY

Our simple model of the trading city suggests that trading cities develop when comparative advantage is combined with scale economies in transport and exchange. This observation provides some important insights into the history of cities before the Industrial Revolution of the 1800s. Most of the workers in these trading cities didn't produce goods, but instead collected and distributed goods produced elsewhere, such as agricultural products from the hinterlands and handcrafted goods from various locations. Trade was a risky business, and firms in the trading city provided insurance, credit, investment opportunities, banking, and legal services.

Trading Cities in World History

Trading cities have a long history. In the third millennium B.C., Phoenicians used fast sailing ships to serve as traders for the entire Mediterranean basin, trading dye, raw materials, foodstuffs, textiles, and jewelry. They established trading cities along the Mediterranean coast in present-day Lebanon. Around 500 B.C., Athens was a thriving site for regional trade, exchanging household crafts and olive products for food and raw materials from the countryside. During the 11th and 12th centuries, Italian city-states forged agreements with the Byzantine and Islamic rulers for trade with North Africa and the East. The Europeans traded wood, iron, grain, wine, and wool cloth for medicines, dyes, linen, cotton, leather, and precious metals. This trade was the major force behind the growth of Venice, Genoa, and Pisa.

Some cities were built on coercive transfer payments rather than voluntary trade. The Athenian empire developed in the aftermath of the successful war against Persia in the fifth century B.C. After the Greek city-states repelled the Persian invasion, they formed the Delian League for joint defense and later to carry the war into

Asia Minor. By the end of the successful campaign, Athens controlled the league and transformed the voluntary contributions of member city-states into payments of tribute to Athens. The system of homage and tribute led to the Peloponnesian War between the Athenian Empire and Sparta (431 to 404 B.C.). The war ended when Athens renounced control over its empire and demolished its defensive walls.

By the third century A.D., Rome had a population exceeding 1 million. The Romans established colonial cities throughout Europe and focused on collecting the agricultural surplus while they neglected urban production activity (Hohenberg and Lees, 1985). Instead of exchanging urban goods for agricultural products, Rome used conquest and tribute to feed its population. In the fourth and fifth centuries, attacks from Germanic tribes disrupted the Roman collection system. It appears that there was little interest outside of Rome in restoring the "trade" routes, so the losses from successive attacks were cumulative. If Rome had relied to a greater extent on voluntary exchange, the colonies would have had a greater stake in maintaining the exchange network and the Western empire might have recovered from the Germanic raids.

What are the lessons from the rise and fall of Athens and Rome? Early in its history, Athens thrived under a system of voluntary trade with other areas, exchanging urban goods for food from the countryside. The Athenians eventually switched to a system of conquest and tribute, resulting in war and the decline of the city. Mumford (1961) suggests that the city of Rome should have been called "Parasitopolis" to indicate its dependence on the labors of outsiders. The decline of Rome was caused in part by the disruption of its collection system by the Germanic raids. Perhaps the lesson is that cities based on coercive transfer payments are not sustainable.

Trading Cities in American History

The history of urban America illustrates the role of transport costs and comparative advantage in trading cities (Bartlett, 1998). In the 1700s, most cities served largely as trading posts for ocean trade. On the eastern seaboard, cities collected agricultural products from their hinterlands to the west and shipped them overseas. The volume of trade was limited by the dirt roads serving the interior: Travel was always slow and, in times of rain and melting snow, slippery. The Pennsylvania Turnpike, built with stone and gravel in 1792, increased travel speeds to a steady two miles per hour, increasing the market area and trading volume of the city of Philadelphia.

Farther to the north, New York State took more drastic steps, completing the 360-mile Erie Canal in 1825. The canal linked New York City, with its natural harbor, to vast agricultural areas to the north and west, and it cut freight costs from about 20 cents per ton mile to 1.5 cents. An additional canal connecting Lake Champlain to the Hudson River extended the market area of New York City to northern New England. The vast transportation network increased the volume of trade through New York City, increasing its size. By 1850, the city had a population of half a million, about 20 times its size at the end of the American Revolution. Other cities, including competitors to the south (Baltimore and Philadelphia), responded by building canals to connect hinterlands and ports, and by 1845 there were over 3,300 miles of artificial waterways in the United States.

Comparative advantage also plays a role in urban history. Eli Whitney's cotton gin (1794) provided a means of removing the sticky seeds of green-seed cotton, which could be grown throughout the south. The total output of cotton increased by a factor of 50 over a 15-year period, with most of the output coming from inland areas far from the east coast ports. American cotton was transported along rivers to New Orleans for shipment to textile firms in New England and Europe. The increase in cotton trade caused the rapid growth of New Orleans at the mouth of the Mississippi, and the development of upriver commercial cities such as Mobile, Alabama, and Natchez, Mississippi.

Later innovations in transportation reduced transport costs and contributed to the development of trading cities. Before the introduction of the steamboat in 1807, traffic was strictly downstream: After cargo was unloaded at the terminal point, wooden boats were broken up for lumber. The steamboat allowed two-way traffic and cut river freight costs, increasing the volume of trade and the size of river cities. Later, the steam engine was used to power locomotives, and railroad freight replaced river shipping as the principal means of transporting goods. Between 1850 and 1890, the ratio of railroad freight to river freight went from 0.10 to 2.0, and the volume of railroad freight increased by a factor of 240. The shift from river to railroad caused the decline of commercial cities along rivers and the rise of cities along the vast railroad network.

A FACTORY CITY

The third assumption of the backyard-production model is constant returns to scale in production. We'll maintain this assumption for bread production, but apply the fourth axiom of urban economics to shirt production:

Production is subject to economies of scale

A shirt factory will use indivisible inputs (machines) and allow workers to specialize in narrowly defined tasks, leading to a higher output per worker and lower average cost. Suppose a household can produce either a loaf of bread or one shirt per hour. A worker in a shirt factory is six times as productive as a home worker, so the factory worker produces six shirts per hour.

Determining Wages and Prices

We assume that workers are perfectly mobile, so the utility level of a city worker must be the same as the utility level for a rural worker. Recall the first axiom of urban economics:

Prices adjust to ensure locational equilibrium

A factory must pay its workers enough to make them indifferent between working in the factory city and in the rural area. A rural worker earns one loaf of bread

TABLE 2–3 Cost of Factory Shirt

Labor cost per hour	3⁄2 loaves
Cost of indivisible inputs per hour	1⁄2 loaf
Total cost per hour	2 loaves
Cost per shirt with 6 shirts produced per hour	1⁄3 loaf

per hour, so city workers must earn one loaf per hour plus an amount high enough to offset the higher cost of living in the factory city, such as higher land prices. For example, if the cost of urban living is 50 percent higher, locational indifference requires an hourly wage of 3⁄2 loaves of bread. A city worker will pay 1⁄2 loaf for land, leaving one loaf per hour of factory work, the same that she could earn producing bread in a rural area.

What's the price of factory shirts? The price must be high enough to cover the costs of labor and the indivisible inputs used to produce shirts. In Table 2–3 the labor cost per hour is the wage (3⁄2 loaves) and the hourly cost of indivisible inputs is 1⁄2 loaf. Adding these together, the hourly cost of producing shirts is two loaves of bread. To translate this into a cost per shirt, recall that a factory worker produces six shirts per hour, so the cost per shirt is one-sixth of the cost per hour, or 2⁄6 = 1⁄3 loaf. Therefore, for zero economic profit, the price per shirt must be 1⁄3 loaf of bread.

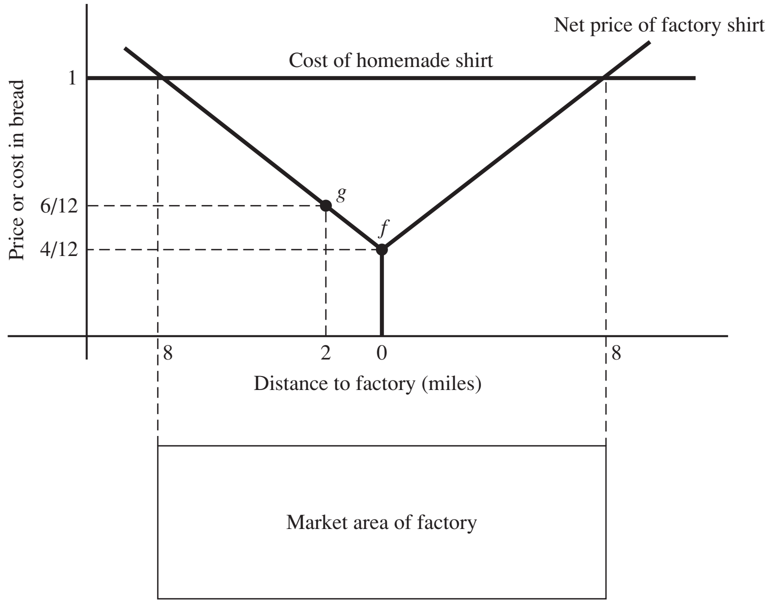
Suppose there is a single shirt factory in the region. The factory competes with homemade shirts, and will sell shirts to any household for which the net price of factory shirts is less than the cost of a homemade shirt. The cost of a homemade shirt is the one loaf of bread that is sacrificed to produce a shirt. The net price of a factory shirt equals the price charged by the factory (1⁄3 loaf) plus the opportunity cost of travel to and from the factory to buy the shirt.

The Market Area of a Factory City

Figure 2–1 (page 24) shows the net price of factory shirts and the market area of the shirt factory. As shown by point *f*, the net price for a consumer located just across the road from the factory (distance = 0) is the factory price, equal to 1⁄3 = 4⁄12 loaf of bread. Other consumers bear a travel cost when they buy factory shirts, so the net price is higher. Suppose the travel time is 1⁄12 hour per round-trip mile: It takes 1⁄12 hour to complete a round-trip of one mile in each direction. In an hour, a rural household can produce one loaf of bread, so in 1⁄12 of an hour of travel, it sacrifices 1⁄12 loaf. For example, at point *g* (two miles from the factory), the net price of a factory shirt is 6⁄12 loaves, equal to 4⁄12 paid at the factory plus 2⁄12 in travel cost (forgone bread production at home).

The market area of the factory is the area over which it underprices the home production of shirts. In Figure 2–1, the horizontal line shows the opportunity cost of homemade shirts, which is one loaf of bread. The net price of factory shirts is 4⁄12 at the factory and increases by 1⁄12 per mile, reaching one loaf at a distance of eight miles (4⁄12 + 8⁄12). In other words, the factory underprices home

FIGURE 2–1 Market Area of Factory



The net price of a factory shirt is the factory price (1⁄3 = 4⁄12 loaf of bread) plus transport cost (1⁄12 loaf per round-trip mile). The market area of the factory is the area over which the net price of a factory shirt is less than the cost of a homemade shirt (one loaf).

production up to eight miles away, so households within eight miles of the factory buy shirts rather than producing them at home. Beyond this point, households are self-sufficient, producing their own bread and shirts.

A factory city will develop around the shirt factory. Workers will economize on travel costs by living close to the factory, and competition for land will bid up its price. The higher price of land will cause workers to economize on land, leading to a higher population density. The result is a place of relatively high population density, a factory city. Note that we have already incorporated the higher land price into the factory wage and the factory price: Workers receive an hourly wage of 3⁄2 loaves to cover the opportunity cost of their time (1 loaf) and land rent (1⁄2 loaf).

THE INDUSTRIAL REVOLUTION AND FACTORY CITIES

Our simple model of the factory city suggests that a factory city develops because scale economies make factory shirts cheaper than homemade shirts. The Industrial Revolution of the 19th century produced innovations in manufacturing and transportation that shifted production from the home and the small shop to large factories in industrial cities. In contrast to the earlier trading cities, workers in factory cities produced products rather than simply distributing products produced elsewhere.

Innovations in Manufacturing

One of the key innovations of the Industrial Revolution was Eli Whitney's system of interchangeable parts for manufacturing, developed around 1800. Under the traditional craftsman approach, the component parts of a particular product were made individually—and imprecisely. Skilled craftsmen were necessary to produce the parts and then fit them all together. Under Whitney's system, the producer made a large batch of each part, using precise machine tools to generate identical parts. The identical parts were interchangeable, so unskilled workers could be quickly trained to assemble the parts. The replacement of handcraft production with standardized production generated large scale economies, causing the development of factories and factory cities.

Whitney applied this system to the production of muskets for the army. To prove to President-elect Jefferson and other government officials that his system would work with unskilled labor, he unloaded a random collection of parts onto the floor and had the officials assemble the muskets. He got the contract to manufacture 10,000 muskets and built a factory in New Haven, Connecticut, close to a stream that he used to power the factory. His system, which became known as the American System of Manufacturing, became the standard system for mass production.

The new system of manufacturing caused the development of factory cities. New machines, made of iron instead of wood, were developed to fabricate products in large factories. Manual production by skilled artisans was replaced by mechanized production using interchangeable parts, specialized labor, and steam-powered machines. Mass production decreased the relative cost of factory goods, causing the centralization of production and employment in large industrial cities.

As an illustration of the role of scale economies in the development of cities, consider the sewing machine, which was developed in the middle of the 19th century. At the beginning of the century, about four-fifths of the clothing worn in the United States was hand-sewn in the home for members of the household, and the rest was hand-sewn by tailors. The sewing machine (patented in 1846) allowed factories to underprice home producers, and by 1890 nine-tenths of U.S. clothing was being made in factories. New cities developed around the clothing factories.

A similar story line applies to shoes. Before 1700, most shoes were produced in the home or the local village. The cost of transportation was so high that local production was efficient. Over time, transportation costs decreased, and the putting-out system was implemented in the 1700s: Shoe producers distributed raw materials to cottage workers, collected their rough output, and finished the shoes in a central shop. As new shoemaking machines were developed, the number of operations performed in the central shops increased. The McKay sewing machine (for which a patent was granted to Lyman Blake in 1858) mechanized the process of sewing the soles to the uppers. The scale economies in shoe production increased to the point that shops became genuine factories, and cities developed around the shoe factories.

Innovations in Transportation

Innovations in intercity transportation contributed to industrialization and urbanization. As we saw earlier in the chapter, the dirt roads of the 1700s were replaced by turnpikes, and the construction of canals allowed a more dense network of inland water transport. The development of the steamship allowed two-way travel on major rivers, and the railroad system increased the speed and reach of the transportation system. All of these innovations decreased the relative price of factory goods, contributing to the growth of factory cities.

Innovations in Agriculture

One of the three conditions for the development of cities is an agricultural surplus to feed city dwellers. The Industrial Revolution generated a number of innovations that increased agricultural productivity. Farmers substituted machinery for muscle power and simple tools, increasing the output per farmer. The increased agricultural productivity freed people to work in urban factories and commercial firms. Between 1800 and 1900, the share of the population living in cities increased from 6 percent to 35 percent, reflecting the decrease in the number of agricultural workers required to feed city dwellers.

Consider first the sowing side of agriculture. At the start of the 19th century, plows were fragile, awkward, and often made of wood. These inefficient plows were replaced in the 1830s by the cast-iron plow, which was produced in factories in Pittsburgh and Worcester. In the 1840s, John Deere introduced the steel plow, which was lighter, stronger, and easier to handle. Later innovations allowed the farmer to adjust the depth and angle of the plow blade, increasing productivity further.

Consider next the reaping side of agriculture. In 1831, McCormick combined several earlier innovations into a horse-drawn harvesting machine that increased the productivity of the most labor-intensive part of agriculture. Using a horse-drawn reaper, two people could harvest the same amount of grain as eight people using traditional harvesting methods.

Other innovations contributed to higher agricultural productivity. The development of agricultural science led to innovations in planting, growing, harvesting, and processing. Innovations in transportation cut transport costs and allowed each farmer to serve a wider market area. Because of rising productivity, the share of employment in agriculture decreased over the 19th and 20th centuries, from over 90 percent to less than 3 percent.

Energy Technology and Location Decisions

During the Industrial Revolution, the location pattern of factory cities reflected changes in energy technology. The first factories used waterwheels turned by waterfalls and fast-moving streams to translate moving water into mechanical motion. The power was transmitted by systems of belts and gears. Textile manufacturers built factories along backcountry streams in New England and used waterwheels to run their machines. Some examples of waterwheel cities are Lowell, Lawrence, Holyoke, and Lewiston.

The refinement of the steam engine in the second half of the 19th century made energy a transportable input. A key innovation was John McNaught's development of a compounding engine (using steam twice, at descending pressures, to drive pistons) in 1845. The steam engine could be operated anywhere, with the only constraint being the availability of coal to fuel the engine. Some energy-intensive manufacturers located near the coal mines in Pennsylvania. Others located along navigable waterways and shipped coal from the mines to their factories. In New England, textile firms shifted from backcountry waterfall sites to locations along navigable waterways. Production shifted to the Fall River–New Bedford area along the south coast of New England. The later development of the railroad gave coal users another transport option, causing the development of factories along the vast network of rail lines. In general, the steam engine widened the location options for factories.

The development of electricity changed the location patterns of factories. Electricity generators were refined in the 1860s, and the electric motor was developed in 1888. Factories replaced belt-and-gear systems driven by a central steam engine with small electric motors for individual machines. The first factory to use electric power was adjacent to a hydroelectric generating facility at Niagara Falls. Rapid improvements in the electricity transmission soon allowed factories to be hundreds of miles from hydroelectric and coal-powered generating plants. Between 1900 and 1920, the share of factory horsepower from electric motors increased from 2 percent to 33 percent.

The development of electricity made factories more footloose. A firm could tap water power without locating close to the stream and use coal without shipping the bulky fuel to the factory. In general, the development of electricity decreased the importance of energy considerations in location decisions, causing firms to base their location choices on the accessibility to other inputs and to consumers.

A SYSTEM OF FACTORY CITIES

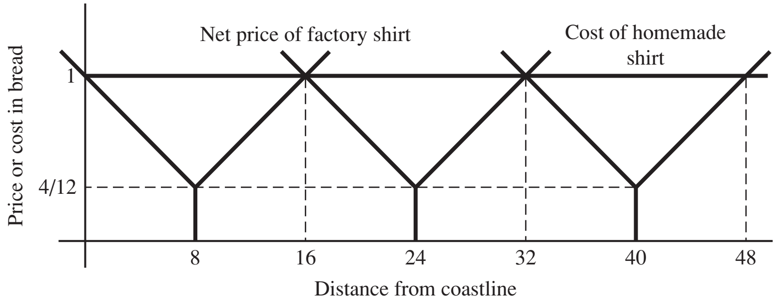
We can widen our horizon by looking at the entire region and consider the possibility of additional factory cities. Firms can enter the shirt industry by building shirt factories at different locations, and each firm will have a local monopoly in the area surrounding its factory. Recall the fifth axiom of urban economics:

Competition generates zero economic profit

If there are no restrictions on entry, firms will continue to enter the market until economic profit is zero.

Figure 2–2 (page 28) shows the equilibrium in the region. The horizontal axis measures distance from a coastline. The rectangular region is 48 miles wide, and in equilibrium has three shirt factories, each with a market area 16 miles wide. The

FIGURE 2–2 System of Factory Cities



Each factory's market area is 16 miles wide, so a system of factory cities develops with a distance of 16 miles between cities. In this equilibrium, workers specialize, with shirt workers in cities and bread producers in rural areas between the cities.

market areas of the factories span the region: Every location in the region lies within the market area of some factory. There is complete labor specialization: Workers in factory cities produce shirts (and receive bread as wages), and workers in rural areas produce bread (and pay bread to get factory shirts).

This is an equilibrium because each firm makes zero economic profit and workers are indifferent between rural and city life:

- **Zero economic profit.** The factory price of 4/12 loaf equals the average cost of producing shirts, including the cost of urban workers and the cost of indivisible inputs.
- **Locational indifference for workers.** The wage for factory workers is high enough to cover (1) the opportunity cost of working in factories rather than producing bread in the rural area and (2) the higher cost of urban living (land rent).

What about rural residents? For a rural resident just outside the factory cities, the net price of a factory shirt is 4/12 loaf of bread, compared to a homemade cost of one loaf. At the other extreme, a rural household eight miles from the factory pays a net price of one loaf per shirt (4/12 + 8/12 in travel cost). Recall the first axiom of urban economics:

Prices adjust to ensure locational equilibrium

In this case, the price of land in rural areas will adjust to make people indifferent between locations that differ in their accessibility to the shirt factory. The shorter the distance to the factory, the lower the net price of factory shirts, and the more a household is willing to pay for land. In other words, the price of land adjusts to fully compensate for differences in accessibility.

Landowners benefit from the scale economies in production that generate the regional system of factory cities. In the rural areas, the price of land is higher at locations close to the factory city. In the factory city itself, competition among workers for locations near the factory bids up the price of land.

RESOURCES-ORIENTED FIRMS AND PROCESSING CITIES

Up to this point, we have ignored the cost of transporting the raw materials required to produce urban goods (shirts). We have implicitly assumed that factory workers harvest wool from wild sheep who wander by the factory at just the right time to be sheared for shirts. In the language of urban economics, we have assumed that the raw materials required for production are ubiquitous—available at all locations at the same price. This is an extreme case of a market-oriented industry, defined as an industry in which the cost of transporting output is large relative to the cost of transporting inputs. The Appendix to this chapter explores the location decisions of market-oriented firms.

Consider the opposite extreme. Suppose it is costly to transport material inputs, but output can be transported at zero cost. This is the extreme case of a materials-oriented industry, defined as an industry for which the cost of transporting material inputs is large relative to the cost of transporting output. The Appendix to this chapter explores the location decisions of materials-oriented firms. For example, the sugar content of sugar beets is roughly 15 percent, so it takes seven tons of beets to produce one ton of sugar. Beet-sugar firms locate their plants close to the beet fields to economize on transport costs (Holmes and Stevens, 2004). Beet-sugar producers will cluster in the regions of the country where weather and soil conditions are favorable for the production of sugar beets.

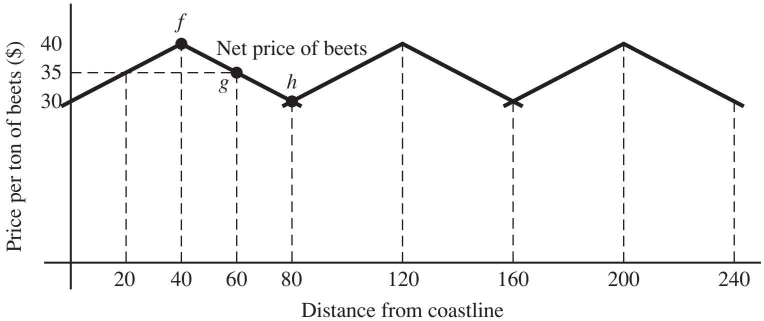
Scale Economies and Market Areas

The process of transforming sugar beets into sugar is subject to scale economies. Processors use indivisible inputs and engage in factor substitution, so the average processing costs decrease as the quantity increases. The typical sugar-beet processing plant employs 186 workers, about four times the average number of employees per plant in manufacturing.

The market area of a processing plant is determined by the net price farmers receive. The net price equals the price paid by the processor minus the cost of transporting the beets from the farm to the processing plant. In Figure 2–3, the horizontal axis measures the distance from a coastline. Consider a processing plant located 40 miles from the coastline. If the price paid by the processor is $40, the net price is $40 for a farmer across the road from the processor (point *f*), and drops to $35 for a farmer 20 miles away (point *g*). Farmers naturally sell to the processing plant that generates the highest net price, so this processing plant has a market from the coastline to 80 miles inland.

Figure 2–3 shows a regional equilibrium with three processing plants, each with a market area of 80 miles. Each firm is the single buyer of sugar beets within

FIGURE 2–3 System of Processing Cities



The net price of beets (received by farmers) decreases as the distance to the processing plant increases. The market area of the typical sugar-beet processing plant is 80 miles wide, so a system of processing cities develops with a distance of 80 miles between them.

its 80-mile market area, so it has a local monopsony (as opposed to monopoly for a single seller). Recall the fifth axiom of urban economics:

Competition generates zero economic profit

If there are no restrictions on entry, firms will continue to enter the market until economic profit is zero.

System of Processing Cities

The location of sugar-beet processing plants leads to the development of a system of processing cities. The people who work in the processing plants live nearby to economize on commuting, resulting in a place with a relatively high population density. As Holmes and Stevens (2004) show, beet-sugar processing plants locate in the regions where beet production occurs, and they carve out input market areas within each beet-growing region.

Note the similarities of the beet-sugar industry and the shirt industry. In the shirt industry, with relatively high cost of transporting output, each firm gets a local monopoly, with all consumers patronizing the nearest factory. In the beet-sugar industry, with relatively high cost of transporting input, each firm gets a local monopsony, with all farmers selling their output to the nearest beet-sugar plant.

Other Examples of Resources-Oriented Industries

The same logic applies to other resources-oriented industries (Kim, 1999). The production of leather requires hides and tannin (from tree bark) for the tanning process. The tannin content of bark is only 10 percent, so it takes a lot of bark to produce a ton of leather. In 1900, U.S. leather producers located close to forests to economize on the transport costs of tannin. In the 20th century, improvements in the extraction process and the development of synthetic tannin reduced the orientation toward forest sites, and firms moved closer to other input sources.

The location decisions of steel producers reflected changes in the input requirements of coal and iron ore. Early in the history of the industry, a ton of steel required five tons of coal and two tons of ore, and steel production was concentrated near coal deposits. Technological innovations reduced the coal content, and steel producers were pulled toward locations that provided access to ore deposits, including sites on the Great Lakes that offered water access to ore from the Masabi Range in Minnesota. Each ton of steel required 175 tons of water, and the Great Lakes sites also provided a plentiful supply of water.

The location decisions of these and other resources-oriented industries caused the development of processing cities. Leather cities developed around tanneries and steel cities developed around steel mills. Lumber producers locate near forests, causing the development of lumber cities centered on sawmills. Ore processors locate near mineral deposits, causing the development of mining cities.

INNOVATION CITIES

Cities are centers of innovation because they facilitate knowledge spillovers, the exchange of knowledge and ideas among innovators. The bulk of patents for new products and production processes are issued to people in cities. As we'll see in the next chapter, the incidence of patents (the number of patents per capita) increases with city size and employment density. A key factor in innovation is the education level of the metropolitan workforce: an increase in the share of the population with college degrees increases patent intensity.

To illustrate the role of knowledge spillovers in urban development, consider a region that does not experience scale economies in production or exchange. The absence of scale economies means that there will be no trading cities or factory cities. Unless a worker finds an alternative source of income, he or she will be self-sufficient. The alternative activity is innovation—generating ideas that can be sold to people outside the region. The innovations could be in consumer goods, or in production—new intermediate goods used in production or improved techniques for producing goods.

The key assumption of the model is that innovation is facilitated by collaboration. The larger the number of people who share knowledge and ideas—either formally or informally—the higher the payoff to innovation. In the upper panel of Figure 2–4, the return to innovation increases with the number of workers in the cluster, but at a decreasing rate. The cost of living in a city increases with the number of workers, a result of increased competition for land and higher prices. In the lower panel of Figure 2–4, the payoff to innovation (the return minus the cost of city living) is shaped like a hill, with a peak at point c.