Industry

Huffy bicycles were manufactured in Ohio for more than a century, first in Dayton, where George P. Huffman founded the company's predecessor Davis Sewing Machine Co. in 1892, and beginning in 1954 at the world's largest bicycle factory in Celina. Huffy closed the Celina plant in 1998 and moved production to Farmington, Missouri. Less than a year later, Huffy stopped making bicycles altogether.

After it closed its U.S. bicycle factory, Huffy Corp. contracted with a Mexican company Elamex to manufacture bicycles in Nuevo Laredo. The arrangement lasted only 3 years. In 2001, Huffy moved production from Mexico to the small town of Sha Jiang in Shenzhen province China.


The United States lost 20 percent of its manufacturing jobs during the first 6 years of the twenty-first century. Americans alarmed by this loss heard "a giant sucking sound" of manufacturing jobs being "sucked" into other countries from recently closed U.S. factories. The future of manufacturing in the United States was "now in jeopardy," according to the National Association of Manufacturers, a leading industry group.

Americans' fears of manufacturing job losses were echoed elsewhere in the world. A former president of the European Union warned against the "deindustrialization of Europe." Japan's loss of manufacturing jobs to overseas locations was called a "hollowing out" by Japanese politicians. In Mexico, the loss of manufacturing jobs during the early twenty-first century led to "a wave of soul-searching."

Manufacturing jobs are viewed as a special asset by communities around the world. Communities mourn when factories close and rejoice when they open. To attract and retain them, officials offer financial support considered excessive when scrutinized by independent analysts.
For companies like Huffy, the changing geography of production was clearly justified by its corporate balance sheet. Huffy lost $2.2 million during the last year it made bicycles in Celina and $33.3 million during the year it made them in Farmington. In 2000, the first year of overseas production, Huffy earned $35 million. Reducing labor costs was critical to the turnaround: Instead of paying workers an average of about $10.50 an hour in Celina, or $8 an hour in Farmington, or even $5 an hour in Nuevo Laredo, Huffy was able to find workers for only 25¢ an hour in China.

Ultimately responsible for the changing geography of manufacturing is the American consumer. When Huffy bicycles were made in Celina, they sold for $80. After production was shifted overseas, the price came down to $40. For nearly all consumers, low price is much more important than place of origin.

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**CASE STUDY**

**Maquiladoras in Mexico**

Edi Bencomo is a factory worker in Ciudad Juárez, Mexico. Her job is to clip together several color-coded wires for Alambrados y Circuitos Eléctricos, a factory that is owned by Delphi Automotive Systems.

Bencomo migrated to Ciudad Juárez 4 years ago, at age 16, from Madera, a village in the Sierra Madre Occidental, a mountain range 300 kilometers (200 miles) to the southwest. One of seven children, Bencomo saw no future for herself in remaining on her parents’ corn farm. Had she remained in Madera, Bencomo probably would have been unemployed, along with 25 percent of the villagers.

In Ciudad Juárez, Bencomo lives with her husband in a two-room shack more than an hour from the plant. They can afford to rent a somewhat better dwelling, but none are available in this rapidly growing city. She leaves home each weekday at 4 a.m. to battle hordes of workers who crowd onto buses that serve the factory area.

Bencomo earns about $2 an hour. She also receives two important benefits by working for Alambrados—a bus pass so that she can reach the plant at no cost, and two meals in the cafeteria, paid for almost entirely by the company. She considers her job to be superior to that of her husband, who makes piñatas; both are paid minimum wage, but he receives no benefits.

Delphi’s Ciudad Juárez plant is known as a maquiladora, from the Spanish verb maquilar, which means to receive payment for grinding or processing corn. The term originally applied to a tax when Mexico was a Spanish colony. Under U.S. and Mexican laws, companies receive tax breaks if they ship materials from the United States, assemble components at a maquiladora plant in Mexico, and export the finished product back to the United States. Altogether, 1.3 million Mexicans are employed at 3,000-some maquiladoras. Delphi has two dozen maquiladoras employing 25,000 people and is one of Mexico’s largest employers.

The title of this chapter, “Industry,” refers to the manufacturing of goods in a factory. The word is appropriate, because it also means persistence or diligence in creating value. A factory utilizes a large number of people, machinery, and money to turn out valuable products.

In the previous chapter we looked at agriculture, practiced throughout the inhabited world, because the need for food is universal. Industry is much more highly clustered in space than is agriculture. In this chapter we look at the regions where factories are located and why. A particular place may be well suited or poorly suited for industry, depending on the distinctive characteristics of land, labor, and capital there. Geographers also recognize that connections with the rest of the world are critical in determining whether a particular place is suitable for industry. Two connections are critical in determining the best location for a factory—where the markets for the product are located and where the resources needed to make the product are located.

A generation ago, industry was highly clustered in a handful of communities within a handful of more developed countries (MDCs), but industry has diffused to many communities in many less developed countries (LDCs). Transnational corporations operate at a global scale of concern for the distribution of markets and resources. Raw materials may be collected from many places, sent to factories located in several other places for a succession of specialized manufacturing procedures, and shipped to consumers located in yet other places.

Government officials everywhere recognize the powerful role of such an industry in the economic health of a community. With globalization of competition to attract new industries—or, in many places, to retain existing ones—each place possesses distinctive location characteristics. Geographers identify the local diversity in assets that enable some communities to compete successfully for industries, as well as handicaps that must be overcome to retain older companies.
KEY ISSUE 1
Where Is Industry Distributed?

- Europe
- North America
- East Asia

Approximately three-fourths of the world’s industrial production is concentrated in four regions: Northwestern Europe, Eastern Europe, Eastern North America, and East Asia (Figure 11–1). Industrial distribution differs from that of agriculture. Agriculture occupies one-fourth of Earth’s land area and covers extensive areas throughout the inhabited world. In contrast, less than 1 percent of Earth’s land is devoted to industry. Described in this section are each of the four industrial regions, as well as important industrial subareas within each region.

Europe

Western Europe appears as one industrial region on a world map. In reality, four distinct districts have emerged, primarily because European countries competed with one another to develop their own industrial areas. Eastern Europe has six major industrial regions. Four are entirely in Russia, one is in Ukraine, and one is in southern Poland and northern Czech Republic. Russia also contains one major industrial region in the eastern or Asian portion of the country.

Western Europe

Western Europe’s four main industrial districts are the United Kingdom, the Rhine–Ruhr Valley, the mid-Rhine, and northern Italy (Figure 11–2). Each of these areas is divided into subareas. These four became important for industry because of their proximity to raw materials (coal and iron ore) and markets (large concentrations of wealthy European consumers).

UNITED KINGDOM. The United Kingdom dominated world manufacturing during the nineteenth century, producing more than the rest of the world combined. The country was responsible for more than one-half of the world’s cotton fabric and iron and two-thirds of its coal.

The Industrial Revolution originated in northern England and southern Scotland, in part because the region during the late eighteenth century contained a remarkable concentration of innovative engineers and mechanics (Figure 11–3). The Industrial Revolution was the collective invention of hundreds of mechanical devices, a large percentage of which were developed in the United Kingdom. The revolution in industrial technology created an unprecedented expansion in productivity, resulting in substantially higher standards of living.

The term Industrial Revolution is somewhat misleading, because it was far more than industrial, and it didn’t happen...
The Industrial Revolution resulted in new social, economic, and political inventions, not just industrial ones. The changes involved a gradual diffusion of new ideas and techniques over decades, rather than an instantaneous revolution. Nonetheless, the term is commonly used to define the process that began in the United Kingdom in the late 1700s.

The United Kingdom lost its international industrial leadership in the twentieth century. As the first country to enter the Industrial Revolution, Britain was saddled with what became outmoded and deteriorating factories and support services. The British referred ironically to their “misfortune” of winning World War II. The losers, Germany and Japan, became industrial powers in part because they received American financial assistance to build modern factories, replacing those destroyed during the war.

Although no longer a world leader in steel, textiles, and other early Industrial Revolution industries, the United Kingdom expanded industrial production in the late twentieth century by attracting new high-tech industries that serve the European market. Japanese companies have built more factories in the United Kingdom than in any other European country.

The British have done more than the other major European countries to lower taxes on businesses, reduce government regulations, convert government monopolies to private ownership, and utilize computers.

Today, British industries are more likely to locate in southeastern England, near London. Southeastern England has the country’s largest concentrations of population and wealth, and is closest to the Channel Tunnel, which has substantially reduced the time needed to ship goods to Europe.

**RHINE–RUHR VALLEY.** From its beginnings in the north of the United Kingdom in the eighteenth century, the Industrial Revolution diffused to Europe and North America in the nineteenth century and to the rest of the world in the twentieth century. Western Europeans developed many early inventions of the Industrial Revolution in the late 1700s. The Belgians led the way in new coal-mining techniques, the French opened the first coal-fired blast furnace for making iron, and the Germans had the first industrial cotton mill.

Political instability delayed the diffusion of the Industrial Revolution in Europe. The French Revolution (1789–1799) and Napoleonic Wars (1796–1815) disrupted Europe, and
Germany did not become a unified country until the 1870s. Other revolutions and wars plagued Europe throughout the nineteenth century.

Europe’s political problems retarded the development of modern transportation systems, especially the railway. Cooperation among small neighboring states was essential to build an efficient rail network, and to raise money for constructing and operating the system. Because such cooperation could not be attained, railways in some parts of Europe were delayed 50 years after their debut in Britain (Figure 11–4).

Europe’s most important industrial area became the Rhine–Ruhr Valley. The region lies mostly in northwestern Germany, but extends into nearby Belgium, France, and the Netherlands. Because of each country’s political uniqueness, each country established its own industrial complex. At the heart of the region lie two rivers—the Rhine, which flows northward through Germany and westward through the Netherlands, and the Ruhr, which flows westward across Germany into the Rhine. Within the region, industry is dispersed rather than concentrated in one or two cities. Although more than 20 million people live in the region, no individual city has more than 1 million inhabitants. Larger cities in the German portion include Dortmund, Düsseldorf, and Essen. The city of Duisburg is located near where the Ruhr flows into the Rhine.

The Rhine divides into multiple branches as it passes through the Netherlands. The city of Rotterdam is near to where several major branches flow into the North Sea. This location at the mouth of Europe’s most important river has made Rotterdam the world’s largest port.

Iron and steel manufacturing has concentrated in the Rhine–Ruhr Valley because of proximity to large coalfields. Access to iron and steel production stimulated other heavy-metal industries, such as locomotives, machinery, and armaments, to locate in the area.

**MID-RHINE.** The second most important industrial area in Western Europe includes southwestern Germany, northeastern France, and the small country of Luxembourg. In contrast to the Rhine–Ruhr Valley, the German portion of the Mid-Rhine region lacks abundant raw materials, but it is at the center of Europe’s most important consumer market.

The Mid-Rhine region became a major industrial center when Germany was split into two countries after World War II. Then, it was close to the population center of West Germany (Federal Republic of Germany). Although the Mid-Rhine region is once again on the periphery of a reunified Germany, it remains the most central industrial area within the European Union.

The three largest cities in the German portion are Frankfurt, Stuttgart, and Mannheim. Frankfurt became West Germany’s most important financial and commercial center and the hub of its road, rail, and air networks. Consequently, Frankfurt attracted industries that produce goods for consumers country-wide, and the city is well situated to play a comparable role in the European Community. Stuttgart’s industries specialize in high-value goods and require skilled labor; Mercedes-Benz and Audi automobiles are among the city’s best-known products. Mannheim, an inland port along the Rhine, has a large chemical industry that manufactures synthetic fibers, dyes, and pharmaceuticals.

The French portion of the Mid-Rhine region—Alsace and Lorraine—contains Europe’s largest iron-ore field and is the production center for two-thirds of France’s steel. Tiny Luxembourg is also one of the world’s leading steel producers, because the Lorraine iron-ore field extends into the southern part of the country.

**NORTHERN ITALY.** Southern and Eastern European countries joined the Industrial Revolution during the twentieth century. A fourth European industrial region of some importance emerged in the Po River Basin of northern Italy.

Modern industrial development in the Po Basin began with establishment of textile manufacturing during the nineteenth century. The Po Valley contains about one-fifth of Italy’s land area but approximately half of the country’s population and two-thirds of its industries.

The Po Basin has attracted textiles and other industries because of two key assets, compared to Europe’s other industrial regions—numerous workers willing to accept lower wages and inexpensive hydroelectricity from the nearby Alps. Industries concentrated in this region include raw-material processors and mechanical-parts assemblers.
Eastern Europe

Russia’s four leading industrial areas in the European part of the country are the Central industrial district, St. Petersburg, Volga, and Urals (Figure 11-5). The first two regions became manufacturing centers during the nineteenth century, whereas the Communists established the Volga and Urals regions during the twentieth century. Kuznetsk, the leading industrial area in the east, was also established by the Communists during the twentieth century.

CENTRAL INDUSTRIAL DISTRICT. Russia’s oldest industrial region is centered around Moscow, the country’s capital and largest city. Although not well endowed with natural resources, the Central industrial district produces one-fourth of Russian industrial output, primarily because it is situated near the country’s largest market. Products of this region tend to be of high value relative to their bulk and require a large pool of skilled labor. One-third of Moscow’s industrial workforce is employed making linen, cotton, wool, and silk fabrics. Moscow factories also specialize in chemicals and light industrial goods.

ST. PETERSBURG INDUSTRIAL DISTRICT. St. Petersburg, Eastern Europe’s second largest city, was one of Russia’s early nodes of industrial innovation. Railways were built in the St. Petersburg area several decades earlier than in the rest of Russia. Given its proximity to the Baltic Sea, the St. Petersburg area specializes in shipbuilding and other industries serving Russia’s navy and ports. The area also produces goods that meet the needs of the local market, such as processed food, textiles, and chemicals.

VOLGA INDUSTRIAL DISTRICT. Situated along the Volga and Kama rivers, this district grew rapidly during World War II, when many plants in the Central and Eastern Ukraine districts were occupied by the invading German army. The Volga district contains Russia’s largest petroleum and natural gas fields. Within the district, the motor vehicle industry is concentrated in Togliatti, oil refining in Kuybyshev, chemicals in Saratov, metallurgy in Volgograd, and leather and fur in Kazan.

URAL INDUSTRIAL DISTRICT. The Ural mountain range contains more than 1,000 types of minerals, the most varied collection found in any mining region in the world. Valuable deposits include iron, copper, potassium, manganese, bauxite (aluminum ore), salt, and tungsten. Proximity to these raw materials encouraged the Communists to locate in this region iron and steel manufacturing, chemicals, and machinery and metal fabricating.

Although well endowed with metals, industrial development is hindered by a lack of nearby energy sources. Coal must be shipped nearly 1,500 kilometers (900 miles) from Kuznetsk, and oil and natural gas are piped in from the Volga-Ural, Bukhara, and central Siberian fields. Russia controls nearly all the Ural minerals, although the southern portion of the region extends into Kazakhstan.

KUZNETSK INDUSTRIAL DISTRICT. Kuznetsk is Russia’s most important manufacturing district east of the Ural Mountains. The region contains the country’s largest reserves of coal and an abundant supply of iron ore. Soviet planners took advantage of these natural assets to invest considerable capital in constructing iron, steel, and other factories in the region.

EASTERN UKRAINE. The Donets coalfield, in the far eastern portion of Ukraine, contains one of the world’s largest coal reserves. Eastern Ukraine also possesses large deposits of iron ore, manganese, and natural gas. These assets make the region Eastern Europe’s largest producer of pig iron and steel. Major plants are located at Krivoy Rog, near iron-ore fields, and at Donets, near coalfields.

SILESIA. Outside the former Soviet Union, Eastern Europe’s leading manufacturing area is in Silesia, which includes southern Poland and the northern Czech Republic. It is an important steel production center because it is near coalfields, although iron ore must be imported.

North America

Industry arrived a bit later in the United States than in Western European countries like France and Belgium, but it grew much faster. At the time of independence in 1776, the United States was a predominantly agricultural society, dependent on the import of manufactured goods from Britain. Manufacturing was more expensive in the United States than in Britain because labor and capital were scarce, and shipping to European markets was expensive.

The first U.S. textile mill was built in Pawtucket, Rhode Island, in 1791, by Samuel Slater, a former worker at Arkwright’s factory in England. The textile industry grew rapidly after 1808, when the U.S. government imposed an embargo on European trade to avoid entanglement in the Napoleonic Wars. The textile industry grew rapidly from 8,000 spindles in 1808 to 31,000 in 1809 and 80,000 in 1811.

By 1860, the United States had become a major industrial nation, second only to the United Kingdom. However, except for textiles, leading U.S. industries did not widely use the new
industrial processes. Instead, many engaged in processing North America’s abundant food and lumber resources. Industries such as iron and steel did not apply new manufacturing techniques on a large scale in the United States until the final third of the nineteenth century.

**U.S. Industrial Areas**

Manufacturing in North America traditionally concentrated in the northeastern quadrant of the United States and in southeastern Canada (Figure 11–6). The region comprises only 5 percent of the land area of these countries but contains one-third of the population and nearly two-thirds of the manufacturing output.

This manufacturing belt has achieved its dominance through a combination of historical and environmental factors. As the first area of European settlement in the Western Hemisphere, the U.S. East Coast was tied to European markets and industries during the first half of the nineteenth century. The early date of settlement gave eastern cities an advantage in creating the infrastructure needed to become the country’s dominant industrial center.

The Northeast also had essential raw materials, including iron and coal. Good transportation moved raw materials to factories and manufactured goods to markets. The Great Lakes and major rivers (Mississippi, Ohio, St. Lawrence) were supplemented in the 1800s by canals, railways, and highways. All helped to connect the westward-migrating frontier with manufacturing centers.

Within the North American manufacturing belt, several heavily industrialized areas developed.

**NEW ENGLAND.** The oldest industrial area in the northeastern United States is southern New England. It developed as an industrial center in the early nineteenth century, beginning with cotton textiles. Cotton was imported from southern states, where it was grown, and finished cotton products were shipped to Europe. European immigrants provided abundant, inexpensive labor throughout the 1800s. New England is now known for relatively skilled but expensive labor.

**MIDDLE ATLANTIC.** The Middle Atlantic area, between New York City and Washington, is the largest U.S. market. It has long attracted industries that need proximity to a large number of consumers. Many industries that depend on foreign markets or imported raw materials have also located near one of this region’s main ports—New York City (the country’s largest port), Baltimore, Philadelphia, and Wilmington, Delaware. Other firms seek locations near the financial, communications, and entertainment industries, which are highly concentrated in New York.

**MOHAWK VALLEY.** A linear industrial belt developed in upper New York State along the Hudson River and Erie Canal, which connected New York City and the Great Lakes. Buffalo, near the confluence of the Erie Canal and Lake Erie, was the region’s most important industrial center, especially for steel and food processing. Inexpensive, abundant electricity, generated at nearby Niagara Falls, has attracted aluminum, paper, and electrochemical industries to the region.

**PITTSBURGH–LAKE ERIE.** The area between Pittsburgh and Cleveland was the nation’s most important steel-producing area in the nineteenth century. Steel manufacturing originally concentrated in the region because of its proximity to Appalachian coal and iron ore. Proximity to steel makers attracted other manufacturers that made heavy use of steel in their own products.

**WESTERN GREAT LAKES.** The western Great Lakes area extends from Detroit and Toledo, Ohio, on the east to Chicago and Milwaukee, Wisconsin, on the west. Chicago, the third-largest U.S. urban area, is the dominant market center between the Atlantic and Pacific coasts and the hub of the nation’s transportation network. Because road, rail, air, and sea routes converge on Chicago, the city has become a transfer point among transportation systems (water, rail, truck, air) or between routes within the same type of transportation system.

Automobile manufacturers and other industries that have a national market locate in the western Great Lakes region to take advantage of this convergence of transportation routes. The region’s industries are also the main suppliers of machine tools, transportation equipment, clothing, furniture, agricultural machinery, and food products to people living in the interior of the country.

**Canada’s Industrial Areas**

Canada’s most important industrial area is the St. Lawrence Valley—Ontario Peninsula area, which stretches across southern Canada along the U.S. border. The region has several assets—centrality to the Canadian market, proximity to the Great Lakes, and access to inexpensive hydroelectric power from Niagara Falls. Most of Canada’s steel production is concentrated in Hamilton, Ontario, while most automobiles are assembled in the Toronto area. Inexpensive electricity has attracted aluminum manufacturing, paper making, flour mills, textile manufacturing, and sugar refining.
East Asia

Faced with isolation from world markets and a shortage of nearly all essential resources, East Asia has taken advantage of its most abundant resource—a large labor force. Although its industries were devastated during World War II, Japan became an industrial power in the 1950s and 1960s, initially by producing goods that could be sold in large quantities at cut-rate prices to consumers in other countries. Prices were kept low, despite high shipping costs, because workers received much lower wages in Japan than in North America or Western Europe.

Aware that South Korea, Taiwan, and other Asian countries were building industries based on even lower-cost labor, Japan started training workers for highly skilled jobs. Because wages remained lower than in other more developed countries, Japan could manufacture high-quality products at a lower cost than those made in North America or Western Europe. As a result, during the 1970s and 1980s, Japan earned a reputation for high-quality electronics, precision instruments, and other products that required well-trained workers. The country became the world's leading manufacturer of automobiles, ships, cameras, stereos, and televisions. Japan's manufacturing is concentrated in the central region between Tokyo and Nagasaki, especially in the two large urban areas of Tokyo-Yokohama and Osaka-Kobe-Kyoto.

China has emerged as the world's second-largest manufacturer measured in output and has the largest labor force employed in manufacturing. Manufacturing is clustered in the eastern coastal portion of the country (Figure 11-7).

Although industry is located elsewhere in the world, the four industrial regions of Northwestern Europe, Eastern Europe, North America, and East Asia account for most of the world's industrial production. Having looked at the "where" question for industrial location, we can now consider the "why" question: Why are industries located where they are?

**Key Issue 2**

**Why Do Industries Have Different Distributions?**

- Situation factors
- Site factors

Industry seeks to maximize profits by minimizing production costs. Geographers try to explain why one location may prove more profitable for a factory than others. A company ordinarily faces two geographical costs—situation and site.

- **Situation factors** involve transporting materials to and from a factory. A firm seeks a location that minimizes the cost of transporting inputs to the factory and finished goods to the consumers.

- **Site factors** result from the unique characteristics of a location. Land, labor, and capital are the three traditional production factors that may vary among locations.

Although a variety of situation and site costs explain the location of factories, the particular combination of critical factors varies among firms.

**Situation Factors**

Manufacturers buy from companies and individuals who supply inputs, such as materials, energy, machinery, and supporting services. They sell to companies and individuals who purchase the product. All manufacturers try to minimize the aggregate cost of transporting inputs to their factories and transporting finished products from their plants to consumers.

The farther something is transported, the higher the cost, so a manufacturer tries to locate its factory as close as possible to both buyers and sellers. A company that obtains all inputs from one source and sells all products to one customer can easily compute the location for its factory that minimizes transport costs. If the cost of transporting the product exceeds the cost of transporting inputs, then the optimal plant location is as close as possible to the customer. Conversely, if inputs are more expensive to transport, a factory should locate near the source of inputs.

For some manufacturers minimizing transport costs is the most critical factor in determining where to locate a factory. For others, site factors may be more important, as discussed in the next section of the chapter.
Proximity to Inputs

Every industry uses some inputs. These may be resources from the physical environment (minerals, wood, or animals), or they may be parts or materials made by other companies. If the weight and bulk of any one input is particularly great, the firm may locate near the source of that input to minimize transportation cost.

**COPPER INDUSTRY.** The North American copper industry is a good example of locating near the source of heavy, bulky inputs to minimize transportation cost. In copper production, the first step is mining the copper ore. Most copper ore mined in North America is low grade, less than 0.7 percent copper, whereas the rest is waste, known as gangue. Obviously, the weight and bulk of this low-grade ore are considerable.

The next step is to concentrate the copper. Concentration mills crush and grind the ore into fine particles, mix them with water and chemicals, and filter and dry them. Copper concentrate is about 25 percent copper. Concentration mills are always near the mines, because concentration transforms the heavy, bulky copper ore into a product of much higher value per weight. Copper concentration is a bulk-reducing industry, an economic activity in which the final product weighs less than its inputs.

The concentrated copper then becomes the input for smelters, which remove more impurities from the copper. Smelters produce copper matte (about 60 percent copper), blister copper (about 97 percent copper), and anode copper (about 99 percent copper). As another bulk-reducing industry, smelters are built near their main inputs—the concentration mills—again to minimize transportation cost.

The purified copper produced by smelters is further treated at refineries to produce copper cathodes, about 99.99 percent pure copper. Little further weight loss occurs, so proximity to the mines, mills, and smelters is a less critical factor in determining the location of refineries.

A U.S. map demonstrates the locational needs for copper processing (Figure 11–8). Two-thirds of U.S. copper is mined in Arizona, so the state also has most of the concentration mills and smelters. Refineries are also located in Arizona, but others are located elsewhere. Refineries outside Arizona import much of their copper anode from abroad.

Another important locational consideration is the source of energy to power these energy-demanding operations. In general, metal processors such as the copper industry also try to locate near economical electrical sources and to negotiate favorable rates from power companies.

**ORIGIN OF STEEL INDUSTRY.** Steelmaking is another bulk-reducing industry that traditionally located to minimize the cost of transporting inputs. Steel is an alloy of iron that is manufactured by removing impurities in iron, such as silicon, phosphorus, sulfur, and manganese, and adding desirable elements such as limestone and chromium. Although wrought iron can be used to make rivets, bolts, and fences, and cast iron can be used to make pipes, engines, and machines, steel is better for making weapons, tools, and structures.
a maker of mathematical instruments in Glasgow, Scotland. The steam engine provided a practical way to keep the ovens constantly heated for a sufficiently long period of time. When water is boiled into steam, its volume increases about 1,600 times, producing a force that can be used to move a piston back and forth inside a cylinder. If it is attached to a crankshaft, a piston’s back-and-forth motion can be converted into rotary motion suitable for driving machinery.

Watt built the first useful steam engine that could pump water far more efficiently than the watermills then in common use, let alone human or animal power. Inventors as far back as the ancient Greek Hero of Alexandria had built engines operated by steam, but those built by Watt’s predecessors were not practical, because virtually all of the energy they generated was used in their own operation. Watt’s steam engine provided a separate chamber for condensing the steam and used the steam pressure to move the piston in both directions.

Henry Cort, a navy agent, patented two processes known as puddling and rolling, in 1783. Puddling involved reheating pig iron until it was pasty and then stirring it with iron rods until carbon and other impurities burned off. The rolling process involved passing pig iron between iron rollers to remove remaining dross (a scum of impurities that forms on the surface of melted metal). Cort established an iron forge near Fareham, England, to shape iron into useful objects. The combination of Watt’s engine and Cort’s iron purification process increased iron-manufacturing capability.

Iron production requires a source of carbon to mix with the iron ore as well as to run the furnaces, forges, and steam engines. Wood, the main energy source prior to the Industrial Revolution, was becoming scarce in England because it was in heavy demand for construction of ships, buildings, and furniture, as well as for heat. Manufacturers turned to coal, which was then plentiful in England. Abraham Darby of Coalbrookdale in Shropshire, England, produced high-quality iron smelted with purified carbon made from coal, known as coke. Coke is richer in carbon and more combustible than coal, so it is a better source for the heat and gases needed to melt iron ore.

Because it is more durable than iron, steel can withstand greater stress and bear greater weight. However, steelmaking was still not cost effective in the early years of the Industrial Revolution, and steel remained a luxury item, until Henry Bessemer (1813–98) patented an efficient process for casting steel in 1855. The Bessemer process remained the most common method of manufacturing steel until the mid-twentieth century.

Because of the need for large quantities of bulky, heavy iron ore and coal, during the nineteenth century, the iron and steel industry clustered near sources of the two key raw materials. In the United Kingdom, iron and steel plants clustered in four locations—Staffordshire, South Yorkshire, Clydeside, and South Wales (refer to Figure 11–3).

**U.S. STEEL INDUSTRY.** During the mid-nineteenth century, the U.S. steel industry concentrated around Pittsburgh in southwestern Pennsylvania, where iron ore and coal were both mined. Steel mills were built during the late 1800s around Lake Erie, in the Ohio cities of Cleveland, Youngstown, and Toledo, and around Detroit. The locational shift was largely influenced by the discovery of rich iron ore in the Mesabi Range, a series of low mountains in northern Minnesota. This area soon became the source for virtually all iron ore used in the U.S. steel industry. The ore was transported by way of Lake Superior, Lake Huron, and Lake Erie. Coal was shipped from Appalachia by train.

New steel mills were located farther west around 1900, near the southern end of Lake Michigan—Gary in Indiana, Chicago, and other communities (Figure 11–9). The main raw materials

![U.S. Steel integrated steel mill at Gary, Indiana. Iron ore is stored in the foreground. Blast furnaces and other production facilities are in the background.](image)
continued to be iron ore and coal, but changes in steelmaking required more iron ore in proportion to coal. Thus, new steel mills were built closer to the Mesabi Range to minimize transportation cost. Coal was available from nearby southern Illinois, as well as from Appalachia.

Most large U.S. steel mills built during the first half of the twentieth century were located in communities near the East and West coasts, including Baltimore, Los Angeles, and Trenton, New Jersey. These coastal locations partly reflected further changes in transportation cost. Iron ore increasingly came from other countries, especially Canada and Venezuela, and locations near the Atlantic and Pacific oceans were more accessible to those foreign sources. Further, scrap iron and steel—widely available in the large metropolitan areas of the East and West coasts—had become an important input in the steel-production process.

**CHANGING U.S. STEEL INDUSTRY.** Recently, many of the steel plants in the United States have closed. Among the survivors, plants around southern Lake Michigan and along the East Coast have significantly increased their share of national production. This success derives primarily from access to markets rather than inputs.

In contrast to the main historical location factor—transportation cost of raw materials—successful steel mills today are located near major markets. Coastal plants provide steel to large East Coast population centers, and southern Lake Michigan plants are centrally located to distribute their products nationwide.

The growth of steel minimills also demonstrates the increasing importance of access to markets rather than to inputs. Traditionally, most steel was produced at large, integrated mills. They processed iron ore, converted coal into coke, converted the iron into steel, and formed the steel into sheets, beams, rods, or other shapes. Minimills, generally limited to one step in the process—steel production—have captured one-fourth of the U.S. steel market. Less expensive than integrated mills to build and operate, minimills can locate near their markets because their main input—scrap metal—is widely available (Figure 11-10).

**Proximity to Markets**

For many firms, the optimal location is close to markets, where the product is sold. The cost of transporting goods to consumers is a critical locational factor for three types of industries—bulk gaining, single market, and perishable.

**BULK-GAINING INDUSTRIES.** A bulk-gaining industry makes something that gains volume or weight during production. Soft-drink bottling is a good example of an industry that gains weight. Empty cans or bottles are brought to the bottler, filled with the soft drink, and shipped to consumers.

Two main inputs are placed in the container—syrup (relatively concentrated and easy to transport) and water (relatively bulky, heavy, and expensive to transport). Major soft-drink companies like Coca-Cola and PepsiCo manufacture syrups according to proprietary recipes and ship them to bottlers in hundreds of communities.

If water were only available in a few locations around the country, then bottlers might cluster near the source of such a scarce, bulky input. But because water is available where people live, bottlers can minimize costs by producing soft drinks near their consumers instead of shipping water (their heaviest input) long distances. A filled container has the same volume as an empty one, but it is much heavier—the container itself accounts for less than 5 percent of the weight of a filled 355 milliliter (12 fluid ounce) can or 1 liter (33.8 fluid ounce) bottle.

Because they are heavier, the filled containers are more expensive to ship than the empty ones, and bottlers locate near their customers rather than the manufacturers of the containers. Most major bottlers of beer, such as Anheuser-Busch and Miller, follow a similar pattern of locating a number of facilities around the country, near major population centers, to minimize the cost of shipping to consumers (Figure 11-11).

Scotch whiskey is another weight-gaining product, but its spatial distribution differs from that of soft drinks. Although the product is mostly water, it does not have sufficient consumers to justify a bottling plant in each city. One Scotch distiller must serve more than one market and charge higher prices to cover the delivery cost to dispersed consumers.

**FABRICATED METALS AND MACHINERY.** A prominent example of a bulk-gaining industry is the fabrication of parts and machinery from steel and other metals. A fabricated-metal factory brings together metals such as steel and previously manufactured parts as the main inputs and transforms them into a more complex product.
Because fabricated and machined products typically occupy a larger volume than the sum of their individual parts and metals, the cost of shipping the final product to consumers is usually the most critical factor. Whereas steelmakers have traditionally located near raw materials, steel fabricators have traditionally located near markets.

The largest sales among fabricated metal and machinery manufacturers are for motor vehicles. The typical passenger car, which weighs about 3,300 pounds, contains about 54 percent steel, 11 percent iron, 8 percent plastic, 7 percent aluminum, 6 percent fluids and lubricants, 4 percent rubber, 3 percent glass, and 6 percent other materials. Total value of the parts attached to new vehicles produced annually in the United States is more than $200 billion.

Motor vehicles are fabricated in the United States at about 60 final assembly plants, from parts made at several thousand other plants. Most of the assembly plants are located in the interior of the country, between Michigan and Alabama, centered in a corridor known as “auto alley,” formed by north–south interstate highways 65 and 75. For a fabricated product like a motor vehicle, the critical location factor is minimizing transportation to the market, in this case the 15 million North Americans who buy new vehicles each year (see Contemporary Geographic Tools box).

The distribution of motor-vehicle assembly plants has changed during the past three decades. Historically, manufacturers such as Ford and General Motors divided North America into regions and located an assembly plant in or near a large metropolitan area within each region (Figure 11–12 left). Recently, assembly plants near East Coast and West Coast population centers have been closed, while new ones have been built in the interior of the United States (Figure 11–12 right).
General Motors announced in January 1985 that it was designing an entirely new car called Saturn, and it would need a factory somewhere in the United States to build it. The announcement touched off a fierce competition among states and localities to become the home for the plant. All 1,700 schoolchildren in New Hampton, Iowa, wrote letters to G.M. executives urging that their town be selected. Thousands of Cleveland residents sent General Motors “We Want Saturn” coupons clipped from their local newspapers. Swamped with material from competing communities, General Motors used geographic factors of situation and site to narrow the choice of locations and to make the final selection.

General Motors considered situation factors to be most critical, especially the cost of delivering assembled vehicles from the factory to consumers. Based on its marketing plan for the distribution of the car’s targeted customers, the company calculated the optimal location for the plant to be within a 1.2-million-square-kilometer (450,000-square-mile) area with a radius of roughly 500 kilometers (300 miles) centered on south central Ohio (Figure 11-1.1). Locations outside the circle were computed to add between $400 and $500 per vehicle in freight charges, in part because truck drivers would be required to stop overnight more often, as well as drive longer distances.

General Motors then turned to site factors. The search was limited to 400-hectare (1,000-acre) sites less than 50 kilometers (30 miles) from a metropolitan area of at least 250,000 inhabitants containing a major university and airport. The site also had to be near two major long-distance interstate highways and a main rail line. Eleven metropolitan areas met these constraints—Chicago, Illinois; Cincinnati, Cleveland, Columbus, Dayton, and Toledo, Ohio; Detroit, Michigan; Indianapolis, Indiana; Louisville, Kentucky; Nashville, Tennessee; and Pittsburgh, Pennsylvania.

Essential to the narrowing process were topographic sheets published by the U.S. Geological Survey at the 1:24,000 scale. Topographic maps display elements of the human-built environment, such as roads, rail lines, dams, and buildings, as well as physical features, such as lakes, rivers, and forests. Topographic maps are especially useful in the industrial site selection process because they contain contour lines, which connect points of equal elevation. Contour lines permit determination of whether the site is flat or hilly, through computation of slope (the difference in elevation between two points divided by distance between the two points).

Additional information was collected for sites that passed the initial screening on topographic sheets, including suitability of soil for constructing a large plant, neighboring land-use activities, and number of owners of the land within the site. Also of concern were local tax rates and cost and availability of utilities, such as water, sewer, natural gas, and electricity. Secret on-site visits exposed problems not identified on topographic maps.

After 7 months of study, General Motors announced its factory site—Spring Hill, Tennessee, then a village of 1,000 inhabitants, 50 kilometers (30 miles) south of Nashville. The first Saturn rolled off the assembly line in 1990. Since then, a dozen more assembly plants have been built in the United States, nearly all within or near the same area considered by Saturn, for similar situation reasons.

Proximity to markets is still the most critical factor, but the market has changed, and with it the optimal location for factories. The market has changed through greater diversity of products. The number of distinct vehicle models made in North America has increased from about 100 in 1950 to 700 in 2000, with the addition of sport utility vehicles, minivans, and a wide variety of large and small passenger cars. So instead of building the identical Ford or Chevrolet model at several assembly plants for regional distribution, producers now operate specialized assembly plants that build single models for distribution throughout North America.

Japanese and German companies that have entered the North American market in recent decades have also located assembly plants in the interior. In geographic terms, if a company has a product that is made at only one plant, and the critical locational factor is to minimize the cost of distributing it to U.S. and Canadian consumers, then the optimal factory location is in the U.S. interior, rather than on the East Coast or West Coast.
SINGLE-MARKET MANUFACTURERS. The manufacturers of parts for motor vehicles are specialized manufacturers with only one or two customers—the major motor vehicle producers such as General Motors and Toyota. In the past, most motor vehicle parts were made in Michigan and shipped to nearby warehouses and distribution centers maintained in that state by the major producers. From the warehouses, the producers sent the parts to branch assembly plants located around the country near major metropolitan areas.

Parts makers now ship most of their products directly to assembly plants clustered in “auto alley.” Proximity to the assembly plant is increasingly important for parts producers because of the diffusion of “just-in-time” delivery (see Key Issue 4). Under “just-in-time,” parts are delivered to the assembly plant just in time to be used, often within minutes, rather than weeks or months in advance. The clustering of parts manufacturers around their customers—the new Japanese-operated U.S. assembly plants—clearly illustrates the adoption of “just-in-time” (Figure 11-13).

PERISHABLE PRODUCTS. To deliver their products to consumers as rapidly as possible, perishable-product industries must be located near their markets. Food producers such as bakers and milk bottlers must locate near their customers to assure rapid delivery, because few people want stale bread or sour milk.

Processors of fresh food into frozen, canned, and preserved products can locate far from their customers. Cheese and butter, for example, are manufactured in Wisconsin because rapid delivery to the urban markets is not critical for products with a long shelf life, and the area is well-suited agriculturally for raising dairy cows.

The daily newspaper is an example of a product other than food that is highly perishable because it contains dated information. People demand their newspaper as soon after its printing as possible. Therefore, newspaper publishers must locate near markets to minimize transportation cost.

Difficulty with timely delivery is one of the main factors in the demise of afternoon newspapers. Morning newspapers are printed between 9 P.M. and 6 A.M. and delivered during the night, when traffic is light. Afternoon newspapers, published between 9 A.M. and 5 P.M., had to be delivered in heavy daytime traffic, which slowed delivery and thereby raised total production cost.

In European countries, national newspapers are printed in the largest city during the evening and delivered by train throughout the country overnight. This has been possible because of the comparatively compact size of most European states.

Publishers once considered the United States to be too large to make a national newspaper feasible. With satellite technology, however, The New York Times, USA Today, and The Wall Street Journal could initiate national delivery. These newspapers are composed in New York or Washington. Digitized page images are transmitted by satellite to other locations, such as Atlanta and Chicago, where the papers are printed. The papers are then delivered by air and surface transport to consumers nearest each city where printing is done.

Ship, Rail, Truck, or Air?

Inputs and products are transported in one of four ways—via ship, rail, truck, or air. Firms seek the lowest-cost mode of transport, but the cheapest of the four alternatives changes with the distance that goods are being sent.

The farther something is transported, the lower is the cost per kilometer (or mile). Longer-distance transportation is cheaper per kilometer in part because firms must pay workers to load goods on and off vehicles, whether the material travels 10 kilometers or 10,000. The cost per kilometer decreases at different rates for each of the four modes, because the loading and unloading expenses differ for each mode.

Trucks are most often used for short-distance delivery and trains for longer distances, because trucks can be loaded and unloaded more quickly and cheaply than trains. If a water route is available, ship transport is attractive for very long distances, because the cost per kilometer is even less.
Most goods that are shipped long distances are packed in uniformly sized containers, which can be quickly transferred between ships and trucks or trains. This container ship is docked in Seattle harbor.

Air is normally the most expensive alternative for all distances, but an increasing number of firms transport by air to ensure speedy delivery of small-bulk, high-value packages. Air-transport companies such as FedEx, Airborne, and UPS promise overnight delivery for most packages. They pick up packages in the afternoon and transport them by truck to the nearest airport. Late at night, planes filled with packages are flown to a central hub airport in the interior of the country, such as Memphis, Tennessee, and Dayton, Ohio. The packages are then transferred to other planes, flown to airports nearest their destination, transferred to trucks, and delivered the next morning.

**BREAK-OF-BULK POINTS.** Regardless of transportation mode, cost rises each time that inputs or products are transferred from one mode to another. For example, workers must unload goods from a truck and then reload them onto a plane. The company may need to build or rent a warehouse to store goods temporarily after unloading from one mode and before loading to another mode.

Some companies may calculate that the cost of one mode is lower for some inputs and products, whereas another mode may be cheaper for other goods. Many companies that use multiple transport modes locate at a break-of-bulk point. A break-of-bulk point is a location where transfer among transportation modes is possible.

Important break-of-bulk points include seaports and airports. For example, a steel mill near the port of Baltimore receives iron ore by ship from South America and coal by train from Appalachia.

**Site Factors**

Three main site factors are labor, land, and capital. The cost of these three factors varies from one location to another, both within countries and between regions of the world. The most important site factor at a global scale is labor. Minimizing labor costs is important for some industries, and the variation of labor costs around the world is large.

**Labor**

Around the world, approximately 150 million people are employed in manufacturing, according to the UN International Labor Organization (ILO). China has around 20 percent of the world's manufacturing workers, and the United States around 10 percent (refer to Figure 11–1).

A labor-intensive industry is one in which wages and other compensation paid to employees constitute a high percentage of expenses. Labor costs an average of 11 percent of overall manufacturing costs in the United States, so a labor-intensive industry would have a much higher percentage than that. The reverse case, an industry with a much lower than average percentage of expenditures on labor, is considered capital intensive.

The average wage paid to manufacturing workers exceeds $20 per hour in North America, Western Europe, and other MDCs. Health care, retirement pensions, and other benefits add substantially to the compensation. In LDCs, average wages are less than $5 per hour with limited additional benefits. For some manufacturers—but not all—the difference between paying workers $5 and $20 per hour is critical.

A labor-intensive industry is not the same as a high-wage industry. “Labor-intensive” is measured as a percentage, whereas “high-wage” is measured in dollars or other currencies. For example, auto workers are paid much higher hourly wages than textile workers, yet the textile industry is labor-intensive whereas the auto industry is not. Although auto workers earn relatively high wages, most of the value of a car is accounted for by the parts and the machinery needed to put the parts together. On the other hand, labor accounts for a large percentage of the cost of producing a towel or shirt when compared with materials and machinery.

Production of apparel and textiles, which are woven fabrics, is a prominent example of an industry that generally requires less-skilled, low-cost workers. The textile and apparel industry accounts for 6 percent of the dollar value of world manufacturing but a much higher 14 percent of world manufacturing employment, an indicator that it is a labor-intensive industry. The industry accounts for an even higher percentage of the world’s women employed in manufacturing.

Textile and apparel production involves three principal steps:

- Spinning of fibers to make yarn and other preparatory work from natural or human-made materials
- Weaving or knitting of yarn into fabric (as well as finishing of fabric by bleaching or dyeing)
- Cutting and sewing of fabric for assembling into clothing and other products

Spinning, weaving, and sewing are all labor-intensive compared to other industries, but the importance of labor varies somewhat among them. As a result their global distributions are not identical, because the three steps are not equally labor-intensive.

**TEXTILE AND APPAREL SPINNING.** Prior to the Industrial Revolution, thread was spun at home on spinning wheels operated by hand and foot. Spinning was a job for women, often an unmarried daughter still living at home, called a spinster, a term that came to be applied to any unmarried
The Industrial Revolution transformed the production of textiles beginning in Great Britain in the late eighteenth century. Many spools of thread could be spun simultaneously if they were all connected to a steam engine through belts and pulleys. Child labor was common in nineteenth century textile mills.

woman. Children usually performed carding, which involved preparing the fibers for spinning by untangling them onto rolls called cards.

People known as putters-out were hired by merchants to drop off cotton or wool at homes, where women and children sorted, cleaned, and spun it into thread. The putters-out then picked up the finished work and paid according to the number of pieces that were completed (“piece-rate”). Because the work was done in the home, manufacturing such as spinning was known as a cottage industry.

Spinning was transformed during the eighteenth century from a cottage industry dispersed across the countryside to a highly clustered industry. A key invention, designed by Richard Arkwright in 1768, was the spinning frame, which used rollers to untangle the twisted cotton fibers before being spun around a spindle. Arkwright, a Preston, England, barber and wigmaker, then patented a process for carding (untwisting the fibers prior to spinning). The spinning frames were too large to fit inside a cottage, so they had to be placed in large buildings erected near sources of rapidly flowing water, which supplied the power. Because the buildings resembled large watermills, they were known as mills.

Fibers can be spun from natural or synthetic elements. Cotton is the principal natural fiber—three-fourths of the total—followed by wool. Historically, natural fibers were the sole source, but today synthetics account for three-fourths and natural fibers only one-fourth of world thread production.

Synthetic fibers include regenerated synthetics and true synthetics. Regenerated synthetic fibers are produced from natural raw materials modified to produce fibers suitable for weaving. The first commercially successful regenerated synthetic was rayon, made by processing the cellulose in wood pulp. True synthetic fibers are produced from substances like petrochemicals that do not naturally form fibers. The first true synthetic fiber, nylon, was developed from petroleum in 1937. Polyester is now the leading true synthetic, accounting for one-third of synthetic fiber production.

Because it is a labor-intensive industry, spinning is done primarily in low-wage countries. Less developed countries thus account for around three-fourths of world spinning production (Figure 11–14). Natural fiber spinning is even more highly clustered in LDCs—more than 80 percent of world total—synthetics less so. Spinning of cotton fiber is concentrated in the LDCs where the principal input, cotton, is grown. China produces 40 percent of the world’s cotton thread, India and Pakistan about 10 percent each. Among MDCs, the United States, the only major cotton grower, is also the only major cotton thread producer.

Synthetic fibers were once spun primarily in a handful of MDCs where the chemical industry was concentrated. Less developed countries now account for about half of world spinning of synthetics, with especially rapid expansion in China and Indonesia.

TEXTILE AND APPAREL WEAVING. Fabric has been woven or laced together by hand for thousands of years on a loom, which is a frame on which two sets of threads are placed at right angles to each other. One set of threads, called a warp, is strung lengthwise. A second set of threads, called a weft, is carried in a shuttle that is inserted over and under the warp. As the process of weaving was physically hard work, weavers were traditionally men.

Edmund Cartwright, a church rector in Goadby, Leicestershire, patented a power loom in 1785 and set up a weaving mill in Doncaster 2 years later. A better inventor than businessman, Cartwright went bankrupt in 1797, but the British House of Commons awarded him a then-generous sum of £10,000 in 1809 in recognition of his contribution to the textile industry.

Labor constitutes an even higher percentage of total production cost for weaving than for the spinning and assembly steps. Consequently, weaving is especially highly clustered in low-wage countries: 86 percent of the world’s woven cotton fabric is produced in LDCs (Figure 11–15). China alone accounts for one-half of the world’s woven cotton fabric production, and India another one-fourth. Despite their remoteness from European and North American markets, China and India have become the dominant fabric producers because lower labor cost offsets the expense of shipping inputs and products long distances.

Woven cloth is bleached and dyed before being cut into patterns. Traditionally, cotton fabric was bleached either by exposing it to the Sun or boiling it, first in a solution of ashes and then in sour milk. John Roebeck and Samuel Garbett established a factory in 1749 in Prestonpans, Scotland, to bleach with sulfuric acid, obtained from burning coal, instead of with sour milk. Charles Tennant opened the largest chemical factory in the world in 1799, in Glasgow, Scotland, to produce a bleaching powder from chlorine gas and lime, a safer product than sulfuric acid.
Sulfuric acid was also used to dye clothing. When combined with various metals, sulfuric acid produced another acid, called vitriol, the color of which varied with the metal. Sulfuric acid produced a blue vitriol when combined with copper, green with iron, and white with zinc.

The chemical industry was also critical in processing food for the increasing number of urban factory workers, who could not grow their own food or obtain fresh produce. While some preserving techniques, such as drying, fermenting, and pickling, had been known since ancient times, these had limited application to the needs of nineteenth-century urban residents.

French confectioner Nicholas Appert developed canning in 1810, a method of preserving food in glass bottles that had been sterilized in boiling water. The process was made more practical by Peter Durand's 1839 invention of the tin can, which was lighter, cheaper, and easier to handle than a glass bottle. The tin can was actually 98.5 percent steel, with only a thin coating of tin.

Canning works by killing the bacteria that cause food to spoil. It requires high temperature over time. The major obstacle to large-scale canning was the time that cans had to be kept in boiling water, some 4 to 5 hours, depending on the product. This is where chemical experiments contributed. In 1861, calcium chloride was added to the water, raising its boiling temperature from 100°C to 116°C (212°F to 240°F). This reduced the time for proper sterilization to only 25 to 40 minutes. Consequently, production of canned foods increased tenfold that year.
TEXTILE AND APPAREL ASSEMBLY. Textiles are assembled into four main types of products—garments, carpets, home products such as bed linens and curtains, and industrial uses such as headliners inside motor vehicles.

Sewing is probably an even older human activity than spinning and weaving. Needles made from animal horns or bones date back tens of thousands of years, and iron needles date from the fourteenth century. The first functional sewing machine was invented by a French tailor Barthelemy Thimonnier in 1830. Thimonnier installed 80 sewing machines in a factory in 1841 in St.-Etienne, France, to sew uniforms for the French army. However, Parisian tailors, fearing the machines would put them out of work, stormed the factory and destroyed the machines. Isaac Singer manufactured the first commercially successful sewing machine in the United States during the 1850s, but he was convicted of infringing a patent filed by Elias Howe in 1846.

Most of the 80 billion articles of clothing sold worldwide in a year are produced in Asia (Figure 11-16). The percentage varies according to the article of clothing. More than three-fourths of shirts and other tops are manufactured in Asia, compared to less than one-half of suits and dresses. Most underwear, lingerie, and nightwear are also made in Asia. European and North American countries produce more woolens. The percentage has been increasing in Asia and decreasing in North America and Europe.

Land
Availability of land, in the narrow sense of a portion of Earth's surface, is not a critical factor in industrial location at the scale of world region or country. Land suitable for constructing a factory can be found in many places.
“Land” is a critical site factor if considered to encompass natural and human resources in addition to terra firma. Not every location has the same climate, topography, recreational opportunities, cultural facilities, and cost of living. Some executives select locations because they are attracted to the distinctive amenities of a site. Attractions could be relatively mild climates and opportunities for year-round outdoor recreation activities, or proximity to cultural facilities and major-league sports franchises.

Industries may be attracted to specific parcels of land that are accessible to low-cost energy sources. Prior to the Industrial Revolution, many economic activities were located near rivers and close to forests, because running water and burning of wood were the two most important sources of energy. When coal became the dominant form of industrial energy in the late eighteenth century, location near coalfields became more important. Because coalfields were less ubiquitous than streams or forests, industry began to concentrate in fewer locations.

In the twentieth century, electricity became an important source of energy for industry. Electricity is generated in several ways, by using coal, oil, natural gas, running water (hydroelectricity), nuclear fuel, and, to a very limited degree, solar energy and wind. In the United States, electricity usually is purchased from utility companies, which are either publicly owned or privately owned but regulated by the state government.
Like home consumers, industries are charged a certain rate per kilowatt hour of electricity consumed, although large industrial users usually pay a lower rate than do home consumers. Each utility company sets its own rate schedule, subject to approval by its state’s regulatory agency. Industries with a particularly high demand for energy may select a location with lower electrical rates.

The aluminum industry, for example, requires a large amount of electricity to separate pure aluminum from bauxite ore. Aluminum producers locate near dams to take advantage of the large amount of cheap hydroelectric power generated there. The oldest continuously operating aluminum production and fabricating plant in the United States at Massena, New York, was established in 1902 by the Pittsburgh Reduction Co. (now Alcoa, Inc.) near a dam constructed by the St. Lawrence River Power Co. as part of a three-mile canal linking the St. Lawrence and Grasse rivers.

Alcoa, the world’s largest aluminum producer, also makes aluminum near other sources of inexpensive hydroelectric power. The company established facilities during the 1910s at Alcoa, Tennessee, along the Little River near the Tennessee River in the Great Smoky Mountains, and at Badin, North Carolina, along the Yadkin River. Aluminum smelting and fabricating plants were added during the mid-twentieth century at Wenatchee, Washington, near the Rocky Reach Dam on the Columbia River; near the Newburgh, Indiana, dam on the Ohio River; and at Goose Creek, South Carolina, along the Cooper River. A reflection of the importance of inexpensive electricity for aluminum production, a subsidiary of Alcoa even owns dams that generate power along the Cheoah, Little Tennessee, and Yadkin rivers in eastern Tennessee and western North Carolina.

Capital
Manufacturers typically borrow funds to establish new factories or expand existing ones. The U.S. motor vehicle industry concentrated in Michigan early in the twentieth century largely because this region’s financial institutions were more willing than eastern banks to lend money to the industry’s pioneers.

The most important factor in the clustering of high-tech industries in California’s Silicon Valley—even more important than proximity to skilled labor—was the availability of capital. Banks in Silicon Valley have long been willing to provide money for new software and communications firms even though lenders elsewhere have hesitated. High-tech industries have been risky propositions—roughly two-thirds of them fail—but Silicon Valley financial institutions have continued to lend money to engineers with good ideas so that they can buy the software, communications, and networks they need to get started. One-fourth of all capital in the United States is spent on new industries in the Silicon Valley.

The ability to borrow money has become a critical factor in the distribution of industry in LDCs. Financial institutions in many LDCs are short of funds, so new industries must seek loans from banks in MDCs. But enterprises may not get loans if they are located in a country that is perceived to have an unstable political system, a high debt level, or ill-advised economic policies.

KEY ISSUE 3
Where is Industry Expanding?

- Changing distribution within MDCs
- New industrial regions

Economic restructuring since the 1970s has resulted in major changes in the location of manufacturing facilities. Internationally, manufacturing has declined in MDCs and increased in LDCs. Within MDCs, changes have occurred at the intraregional scale and at the interregional scale.

Changing Distribution Within MDCs

At the intraregional scale, factories in MDCs have relocated from the center of cities to peripheral locations. At the interregional scale, factories have relocated from traditional clusters to regions not traditionally associated with manufacturing.

Intraregional Shifts in Manufacturing

Historically, most factories located inside cities for a combination of situation and site factors. A city offered an attractive situation—proximity to a large local market and convenience in shipping to a national market by rail. A city also offered an attractive site—proximity to a large supply of labor as well as to sources of capital. The site factor that cities found increasingly difficult to provide was land suitable for manufacturing. Factories require space to accommodate large machinery and maneuver bulky inputs and products. To get enough space, early factories in cities were typically multistory buildings. Raw materials were hoisted to the upper floors to make smaller parts, which were