Where Do Firms Locate?

Arthur O'Sullivan

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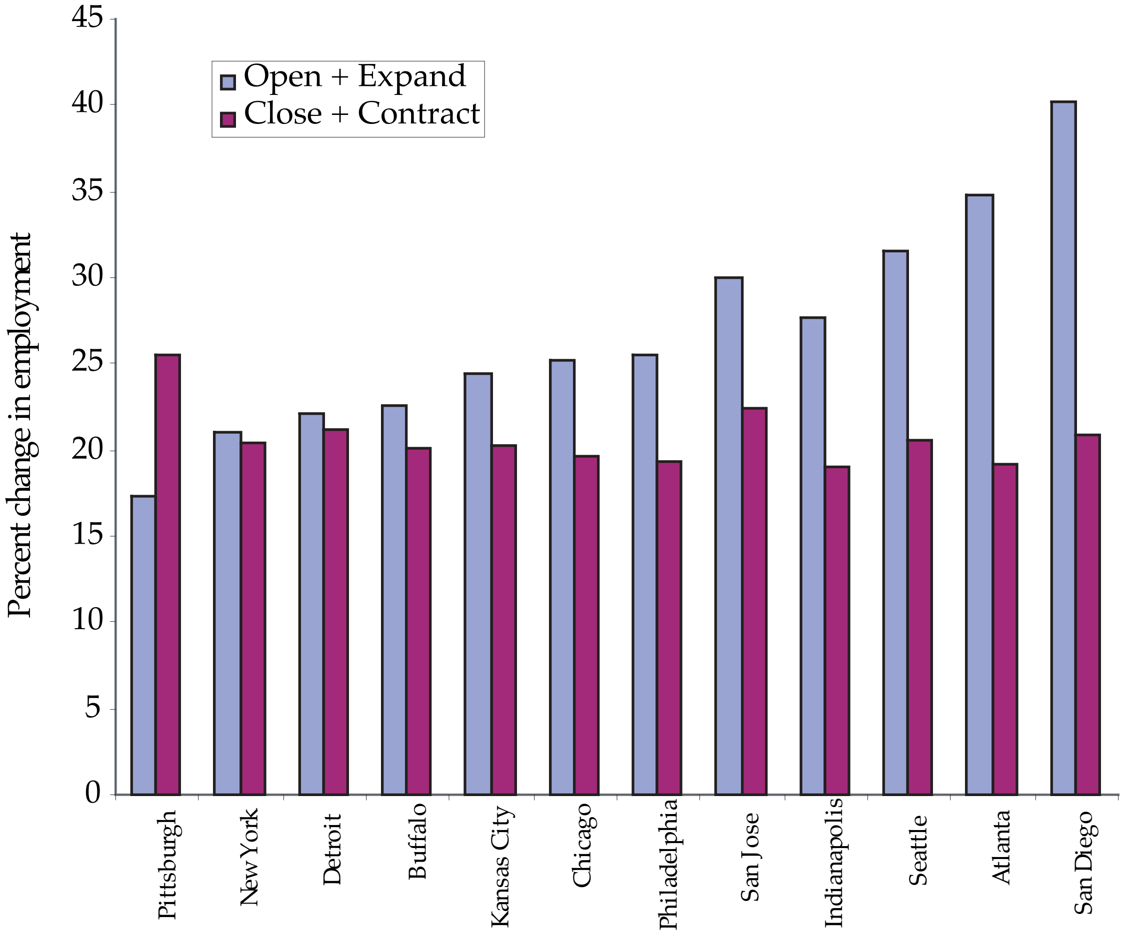
Part I of Urban Economics (McGraw-Hill/Irwin, 2007) explains why cities exist and why some cities are so big. This chapter, drawn from the Fifth Edition of *Urban Economics* (McGraw-Hill/Irwin, 2003) explores the *where* of cities. To address the *where* question, we'll examine the location decisions of firms. When a firm chooses a particular location for its production facility, the resulting concentration of employment either generates a new city, or, more often, causes an existing city to grow. Although location theory is usually cast in terms of where new firms locate, it applies as well to the expansion of existing firms. The economic conditions that attract new firms to a city also make it profitable for firms already in the city to expand their operations. In other words, location theory helps us explain both why cities arise in particular locations *and* why some cities grow more rapidly than others.

Figure 1 provides a useful backdrop for our discussion of location decisions and urban growth. A city will grow if the number of new jobs gained from the birth of new firms and the expansion of existing firms exceeds the number of old jobs lost from firm deaths and contractions. The question is whether growing cities have relatively large job gains, or relatively small job losses. The clear message from Figure 1 is that cities differ

Figure 1 Gross Gains and Losses in Employment in Selected Cities, 1984-1986



Source: Author's computations based on Randall Eberts and Joe A. Stone. Wage and Adjustment in Local Labor Markets. Kalamazoo, Michigan: Upjohn Institute, 1992.

in their job gains, not their job losses. Although most cities have roughly the same percentage of job losses, growing cities have larger gains from births and expansions.

The location decisions of firms are based on profit maximization. A firm's potential profit varies across space for several reasons. First, it is costly to transport inputs and outputs, and locations with relatively low transport costs will generate higher profits, *ceteris paribus* (everything else being equal). Second, some inputs cannot be transported at all, and locations with inexpensive local (nontransferable) inputs will generate higher profits, *ceteris paribus*. Third, some firms benefit from proximity to other firms in the same industry (localization economies) and other firms benefit from being in a large diverse city (urbanization economies). Fourth, the public sector levies taxes and provides public goods and services, and locations with a relatively efficient public sector will generate higher profits, *ceteris paribus*.

TRANSFERABLE INPUTS AND OUTPUTS

A **transfer-oriented** firm is defined as one for which transportation cost is the dominant factor in the location decision. The firm chooses the location that minimizes total transport costs, defined as the sum of procurement and distribution costs. Procurement cost is the cost of transporting raw materials from the input source to the production facility. Distribution cost is the cost of transporting the firm's output from the production facility to the consumer.

The classic model of a transfer-oriented firm has four assumptions that focus attention on transportation costs as the dominant location variable.

- **Single transferable output.** The firm produces a fixed quantity of a single product, which is transported from the production facility to a market at point *M*.
- **Single transferable input.** The firm may use several inputs, but only one input is transported from an input source (point *F*) to the firm's production facility. All other inputs are ubiquitous, meaning that they are available at all locations at the same price.
- **Fixed-factor proportions.** The firm produces its fixed quantity with fixed amounts of each input. In other words, the firm uses a single recipe to produce its good, regardless of the prices of its inputs. There is no factor substitution.
- **Fixed prices.** The firm is so small that it does not affect the prices of its inputs or its product.

Under these four assumptions, the firm maximizes its profit by minimizing its transportation costs. The firm's profit equals total revenue (price times the quantity of output) less input costs and transport costs. Total revenue is the same at all locations because the firm sells a fixed quantity of output at a fixed price. Input costs are the same at all locations because the firm buys a fixed amount of each input at fixed prices. The only costs that vary across space are procurement costs (the costs of transporting the firm's transferable input) and distribution costs (the costs of transporting the firm's output). Therefore, the firm will choose the location that minimizes its total transport costs.

The firm's location choice is determined by the outcome of a tug-of-war. The firm is pulled toward its input source because the closer to the input source, the lower the firm's procurement costs. On the other side, the firm is pulled toward the market because proximity to the market reduces the firm's distribution costs.

Resource-Oriented Firms

A resource-oriented firm is defined as a firm that has relatively high costs for transporting its input. Table 1 shows the transport characteristics for such a firm. The firm produces baseball bats, using 10 tons of wood to produce 3 tons of bats. The firm is involved in a weight-losing activity in the sense that its output is lighter than its transferable input.

TABLE 1 Monetary Weights for a Resource-Oriented Firm

	Input (wood)	Output (bats)
Physical weight (tons)	10	3
Transport rate (cost per ton per mile)	$1	$2
Monetary weight (physical weight times rate)	$10	$6

The key factors in the tug-of-war are the monetary weights of the firm's input and output. The monetary weight of the input is equal to the physical weight of the input (10 tons) times the transportation rate ($1 per ton per mile), or $10 per mile. Similarly, the monetary weight of the output is 3 tons times $2, or $6 per mile.

The firm is considered a resource-oriented firm because the monetary weight of its transferable input exceeds the monetary weight of its output. Although the unit cost of transporting output is higher (because finished bats must be packed carefully, but logs can be tossed onto a truck), the loss of weight in the production process generates a lower monetary weight for the output.

Figure 2 shows the firm's transportation costs. If we use x as the distance from the input source (the forest) to the production site (the factory), the firm's procurement cost is

$$PC = w_i \bullet t_i \bullet x$$

that is, the monetary weight of the input (the physical weight w_i times the transport cost rate t_i) times the distance between forest and factory. The slope of the procurement-cost curve is the monetary weight of the input, so *PC* rises by \$10 per mile, from zero at the forest to \$100 at the market 10 miles away.

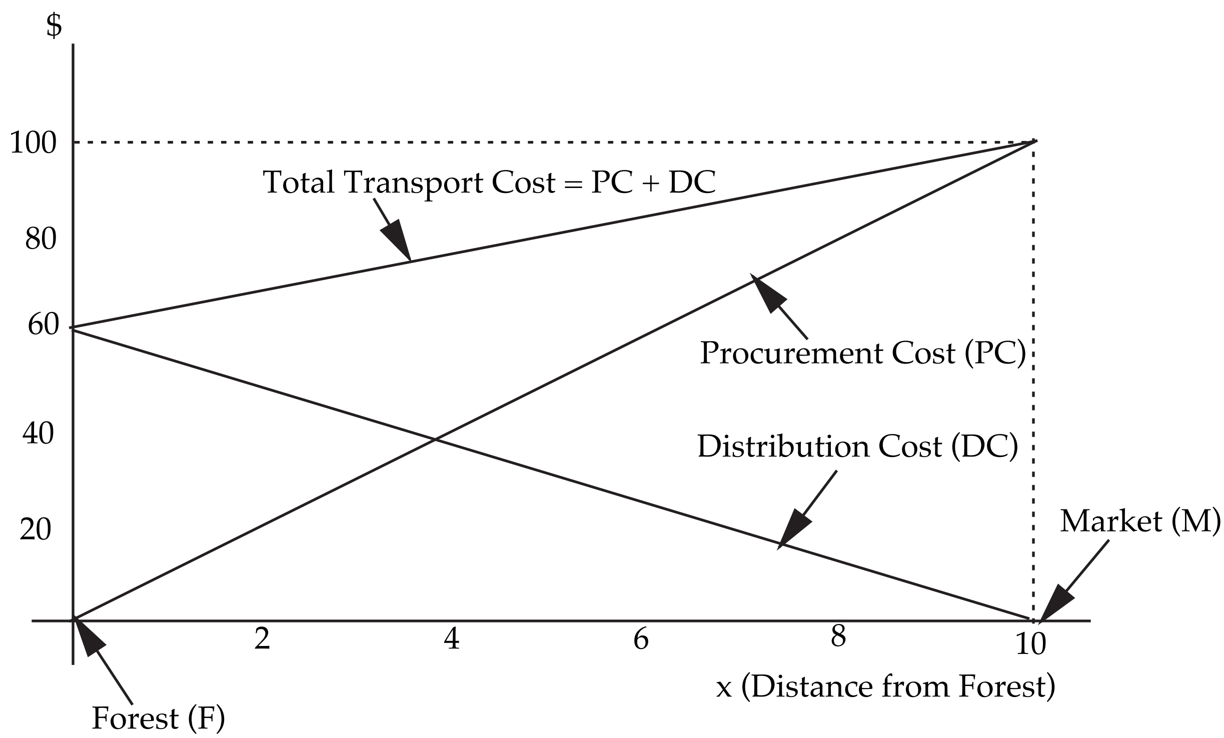
The distribution costs are computed in an analogous way. If xM is the distance between the forest and the market, the firm's distribution cost is

$$DC = w_o \bullet t_o \bullet (x_M - x)$$

that is, the monetary weight of the output (weight w_o times the transport cost rate t_o) times the distance from the factory to the market. The slope of the distribution-cost curve is the monetary weight of the output, so as we move from the forest toward the market, *DC* decreases by \$6 per mile, from \$60 at the forest (10 miles from the market) to zero at the market.

Total transport cost is the sum of procurement and distribution costs. In Figure 2, total transport cost is minimized at the forest site at \$60. To see why transport cost is minimized here, suppose the firm started at the forest site and then moved one mile toward the market. Its distribution cost would decrease by \$6 (the monetary weight of

Figure 2   Transport Costs for a Resource-Oriented Firm



Total Transport Cost (the sum of Procurement Cost and Distribution Cost) is minimized at the forest because the monetary weight of the input ($10) exceeds the monetary weight of the output ($6). The weight-gaining activity locates at its source of raw materials.

bats) but its procurement cost would increase by $10 (the monetary weight of the wood), so its total transport cost would increases by $4. The firm's total transport cost is minimized at the forest because the monetary weight of the input exceeds the monetary weight of the output. The resource-oriented firm locates near its input source.

The bat firm is resource-oriented because it is a weight-losing activity, using 10 tons of wood to produce only three tons of bats. The cost of transporting wood is large relative to the cost of transporting the finished output, so the firm saves on transport costs by locating near the forest. In this case, the tug-of-war is won by the input source because there is more physical weight on the input side. Here are some other examples of weight-losing firms.

1. Beet-sugar factories locate near sugar-beet farms because one pound of sugar beets generates only about 2.7 ounces of sugar.
2. Onion dehydrators locate near onion fields because one pound of fresh onions becomes less than one pound of dried onions.
3. Ore processors locate near mines because they use only a fraction of the materials extracted from the ground.

Some firms are resource oriented because their inputs are relatively expensive to transport. Consider a firm that cans fruit, producing one ton of canned fruit with roughly a ton of raw fruit. The firm's input is perishable, and must be transported in refrigerated trucks, while its output can be transported less expensively on regular trucks. Because the cost of shipping a ton of raw fruit exceeds the cost of shipping a ton of canned fruit, the monetary weight of the input exceeds the monetary weight of the output, and the firm will locate near its input source, a fruit farm.

In general, a firm's input will be more expensive to ship if it is more bulky, perishable, fragile, or hazardous than the output. Hoover (1975) provides some examples of such activities:

- **Cotton baling.** The input (raw cotton) is more bulky than the output (baled cotton). The cost of shipping a ton of fluffy cotton exceeds the cost of shipping a ton of compacted cotton, so the monetary weight of the input is higher and the resource-oriented cotton baler will locate near the cotton field.
- **Skunk deodorizing.** The input (fully armed skunks) is more fragile and hazardous than the output (disarmed skunks). The cost of shipping a ton of armed skunks exceeds the cost of shipping a ton of disarmed ones, so the skunk deodorizer will locate near the skunk farm.

In general, when a firm's input is relatively bulky, perishable, fragile, or hazardous, the tug-of-war will be won by the input source, not because the input is heavier, but because it is more expensive to transport.

There are many examples of industries that locate close to their transportable inputs (Ellison and Glaeser, 1999). The producers of soybean and vegetable oil are concentrated in Nebraska, North Dakota, and South Dakota, close to the farms that supply soybeans and corn. Milk and cheese producers are concentrated in South Dakota, Nebraska, and Montana, close to dairy farms. Sawmills and other wood processors are concentrated in Arkansas, Montana, and Idaho, close to vast timberlands.

Market-Oriented Firms

A market-oriented firm is defined as a firm that has relatively high costs for transporting its output to the market. Table 2 shows the transport characteristics for such a firm. The bottling firm uses one ton of sugar and three tons of water (a ubiquitous input) to produce four tons of bottled beverages. The firm is involved in a weight-gaining activity in the sense that its output is heavier than its transferable input. The monetary weight of the output exceeds the monetary weight of the input, so this market-oriented firm will locate near its market.

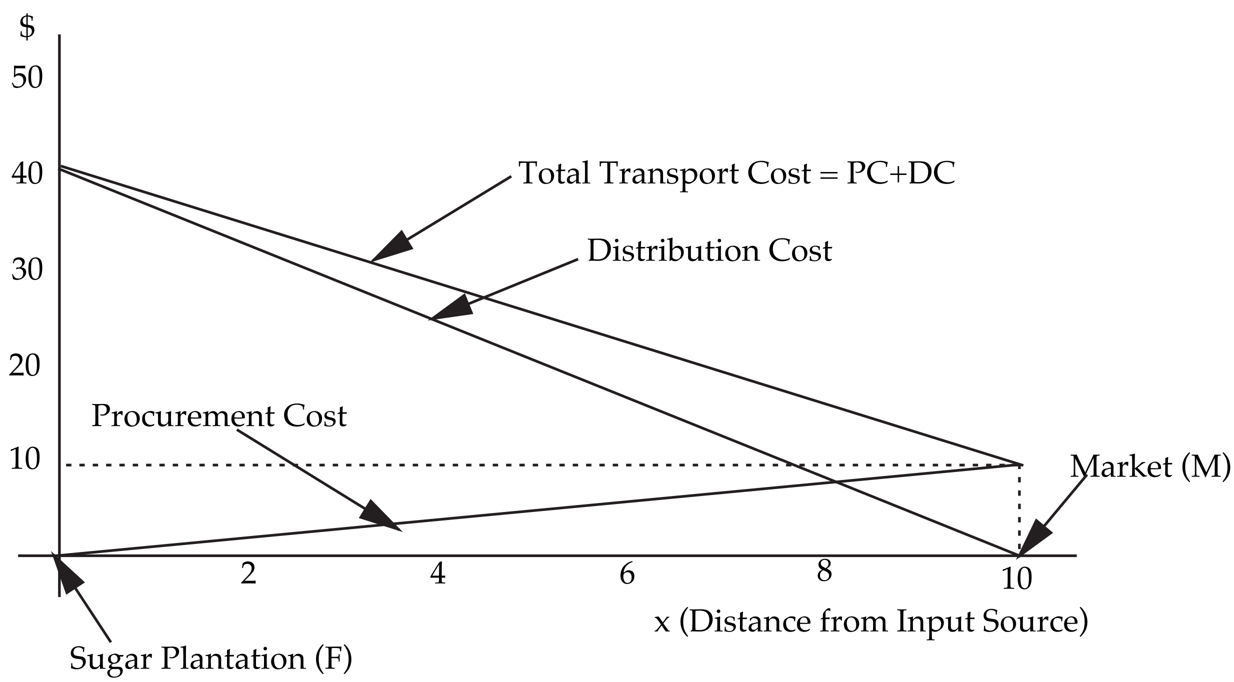
As shown in Figure 3, the firm's transport cost is minimized at the market. Because the monetary weight of the output exceeds the monetary weight of the input, a one-mile move away from the market increases the distribution cost by more than it decreases procurement cost. Specifically, such a move increases distribution cost by $4, but decreases procurement cost by only $1, for a net loss of $3. For this weight-gaining activity, the tug-of-war between input source and market is won by the market because there is more physical weight on the market side.

TABLE 2 Monetary Weights for a Market-Oriented Firm

	Input (sugar)	Output (beverages)
Physical weight (tons)	1	4
Transport rate (cost per ton per mile)	$1	$1
Monetary weight (physical weight times rate)	$1	$4

Some firms are market-oriented because their output is relatively expensive to transport. firm's output will be relatively costly to transport if it is bulky, perishable,

Figure 3 Transport Costs for a Market-Oriented Firm



Total Transport Cost (PC + DC) is minimized at the market because the monetary weight of the output ($4) exceeds the monetary weight of the transferrable input ($1). The weight-gaining activity locates at its market.

fragile, or hazardous. Hoover (1975) provides several examples of such firms: ¥ For an automobile assembly firm, the output is more bulky than the inputs--the metal, plastic, and rubber parts that become part of the assembled automobile.

Because the cost of shipping a ton of automobiles exceeds the cost of shipping a ton of component parts, the monetary weight of the output exceeds the monetary weight of the inputs, pulling the firm toward the market.

- For a bakery, the output is more perishable than its inputs: bread becomes stale in a matter of hours, while flour can be stored for months without spoiling. To ensure timely delivery of fresh bread, the bakery locates near its market.
- A weapons producer combines harmless inputs into a lethal output. The firm locates near its output market to avoid transporting the hazardous (or fragile) output long distances.

In general, when a firm's output is relatively bulky, perishable, fragile, or hazardous, the tug-of-war will be won by the market, not because the output is heavier, but because it is more expensive to transport.

Scale Economies in Transportation

Up to this point, we have assumed that the cost of transporting inputs and outputs is proportional to the distance transported, regardless of distance. In fact, we expect the average cost of transportation to decrease with distance for two reasons.

- **Fixed cost.** There are fixed costs associated with processing paperwork, and loading and unloading a shipment. Therefore, the average cost of transportation decreases as the distance increases.

- **Line-haul economies.** The transport cost per mile decreases as the distance increases, reflecting the efficiencies from using different modes for different distances. A firm may use a truck for a short haul, but a train or a ship for a long haul. The unit transport cost is lower for trains and ships, so the average cost decreases as distance increases.

The presence of scale economies in transportation reinforces the tendency for a firm to locate at either its input sources or its markets. In the absence of scale economies, if the monetary weight of the output equals the monetary weight of the input, the firm would be indifferent between the two locations and any points in between, and could choose some location in the middle. But if there are scale economies in transportation, it would not be sensible to locate anywhere between the two points. It will be more efficient to make one long trip (transporting either the input or the output) instead of two short trips (transporting both the input and the output).

The Principle of Median Location

The classic model of the transfer-oriented firm assumes that the firm has a single input source and a single market. For more complex cases involving multiple inputs or markets, we can use **the principle of median location** to predict where a firm will locate: The optimum location is the median transport location, the location that splits the total monetary weight of the firm into two equal halves. At the median location, half the monetary weight comes from one direction, and half from the other direction.

Consider the location decision of Ann, who makes and delivers pizzas to consumers along a highway. The characteristics of her operation are as follows.

1. All inputs (labor, dough, toppings) are ubiquitous (available at all locations for the same price), so input transport costs are zero.
2. The price of pizzas is fixed, and each consumer along the highway demands one pizza per day.
3. Ann bears the delivery cost, which is $2 per pizza per mile traveled. Each pizza delivery requires a separate trip.

Ann will pick the location that minimizes her total delivery cost.

Figure 4 shows the distribution of consumers along the highway. Distances are measured from the western end of the highway (point *W*). There are 2 customers at point *W*, 8 customers at point *X* (one mile from *W*), 1 customer at *Y* (two miles from *W*), and 10 customers at *Z* (nine miles from *W*). Because each customer buys one pizza and the delivery cost is $2 per pizza per mile, the monetary weight of a particular location (the sales volume times the delivery cost per pizza per mile) is twice the number of consumers at that location.

Using the principle of median location, Ann will minimize her transport cost at the median location. Point *Y* divides the monetary weights into two equal halves, so it is the median location. For the locations to the west of *Y* , the monetary weight is $10 (equal to $2 for *W* plus $8 for *X*); for the locations to the east, the monetary weight is $10 (equal to $10 for *Z*). The median location divides Ann's customers into two equal halves; she has 10 customers to the east, and 10 to the west.

To show that the median location minimizes total transport costs, suppose that Ann starts at the median location, and then moves to point *S*, one mile east of *Y*. As she moves to the east, the good news is that she spends less on delivery to point *Z*: she saves

Figure 4 The Principle of Median Location

Distance From W	0	1	2	3	9
Number of Consumers	2	8	1		10
Monetary Weight	$4	$16	$2		$20

Ann locates her pizza parlor at point Y because it is the median location: she delivers 10 pizza to consumers to the west of Y, and 10 to consumers tothe east of Y. A move from Y to S would decrease delivery cost for the 10 consumers at point E (savings of $20), but increase delivery costs for the 11 consumers at points W, X, and Y (increase in cost of $22). A move in the opposite direction would also increase total transport costs.

$2 per trip to *Z*, saving a total of $10 in eastward delivery costs. The bad news is that westward costs increase: she pays $2 more per trip to points *W, X*, and *Y* ; since there are 11 customers to the west of *S*, her westward delivery costs increase by a total of $22 ($4 for *W*, $16 for *X*, and $2 for *Y*). Since the increase in westward costs exceeds the decrease in eastward costs, the move from *Y* to *S* increases total delivery costs. The same is true for a move in the opposite direction; if Ann moves from *Y* toward *W*, her delivery costs will increase.

The median location minimizes total transport costs because it splits pizza consumers into two equal parts. As Ann moves eastward away from *Y* , she moves further away from 11 customers, but moves closer to only 10 customers. Similarly, a westward move will cause her to move closer to 10 customers, but further from 11 customers. In general, any move away from the median location will increase delivery costs for the majority of consumers, so total delivery cost increases. It is important to note that the distance between the consumers is irrelevant to the firm's location choice. For example, if the *Z* consumers were located 100 miles from *W* instead of 9 miles from *W*, the median location would still be point *Y* . Total delivery costs would still be minimized (at a higher level, of course) at point *Y* .

The principle of median location provides another explanation of why large cities become larger. Consider a firm that delivers its product to consumers in five different cities. In Figure 5, there is a large city at location *L*, and four small cities at locations *S*1, *S*2, *S*3, and *S*4. The firm sells 4 units in each small city, and 17 units in the large city. The median location is in the large city, even though the large city is at the end of the line. A one-mile move westward from *L* would decrease transport costs by $16 (as the firm moved closer to consumers in the small cities), but would increase transport costs by $17 (as the firm moved away from consumers in the large city). The lesson from this example is that the concentration of demand in large cities causes large cities to grow.

Transshipment Points and Port Cities

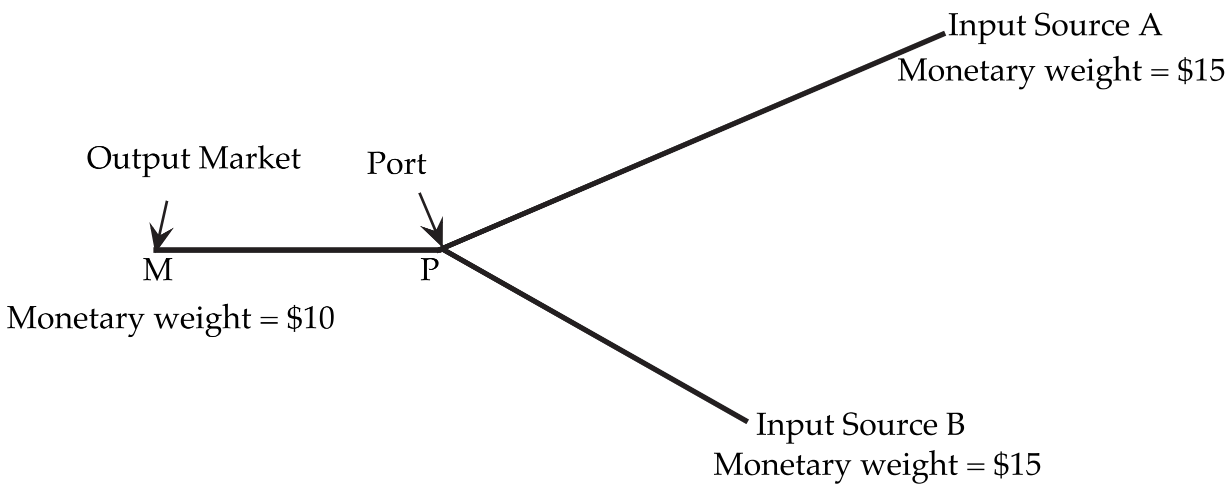
The principle of median location also explains why some industrial firms locate at transshipment points. A transshipment point is defined as a point at which a good is transferred from one transport mode to another. At a port, goods are transferred from trucks or trains to ships; at a railroad terminal, goods are transferred from trucks to the train.

Figure 6 shows the location options for a sawmill. The firm harvests logs from locations *A* and *B*, processes the logs into lumber, and then sells the lumber in an overseas market at point *M*. Highways connect points *A* and *B* to the port, and ships travel from the port to point *M*. The sawmill is a weight-losing activity: The monetary weights of the inputs are $15 for point *A* and $15 for point *B*, and the monetary weight of the output is $10.

Where will the firm locate its sawmill? Although there is no true median location, the port is the closest to a median location. If the firm starts at the port (*P*), it could move either toward one of its input sources or to its market.

- **Toward input source *A*.** A one-mile move from *P* toward point *A* will cause offsetting changes in the costs of transporting logs from the two input sources: the cost of logs from *A* would decrease, but the cost of logs from *B* would increase. At the same time, the cost of transporting output would increase by $10. Given the

Figure 6   Median Location and Ports



The firm locates its sawmill at the port (P) because it is the median transport location. A move from P toward either A or B would increase output transport costs by $10 without affecting input transport costs. A move from P toward M would increase input transport costs by $30 but decrease output transport costs by only $10.

offsetting changes in input transport costs and the increase in output costs, the port location is superior to locations between *P* and *A*. The same argument applies for a move from *P* toward *B*.

- **To market (*M*).** Unless the firm wants to operate a floating sawmill, it would not move to points between the port and the overseas market at *M*. It could, however, move all the way to the market. A move from *P* to *M* would decrease output transport cost by $10 (the monetary weight of output) times the distance between *M* and *P*, and increase input transport cost by $30 (the monetary weight of the inputs) times the distance. Therefore, the port location is superior to the market location.

Although the sawmill is a weight-losing activity, it will locate at the port, not at one of its input sources. The port location is efficient because it provides a central collection point for the firm's inputs.

There are many examples of port cities that developed as a result of the location decisions of industrial firms. Seattle started in 1880 as a sawmill town: Firms harvested trees in western Washington, processed the logs in Seattle sawmills, and then shipped the wood products to other states and countries. Baltimore was the nation's first boomtown: Flour mills processed wheat from the surrounding agricultural areas for export to the West Indies. Buffalo was the Midwestern center for flour mills, providing consumers in eastern cities with flour produced from Midwestern wheat. Wheat was shipped from Midwestern states across the Great Lakes to Buffalo, where it was processed into flour for shipment, by rail, to cities in the eastern United States. In contrast with Baltimore, which exported its output (flour) by ship, Buffalo imported its input (wheat) by ship.

LABOR MARKETS AND LOCATION CHOICES

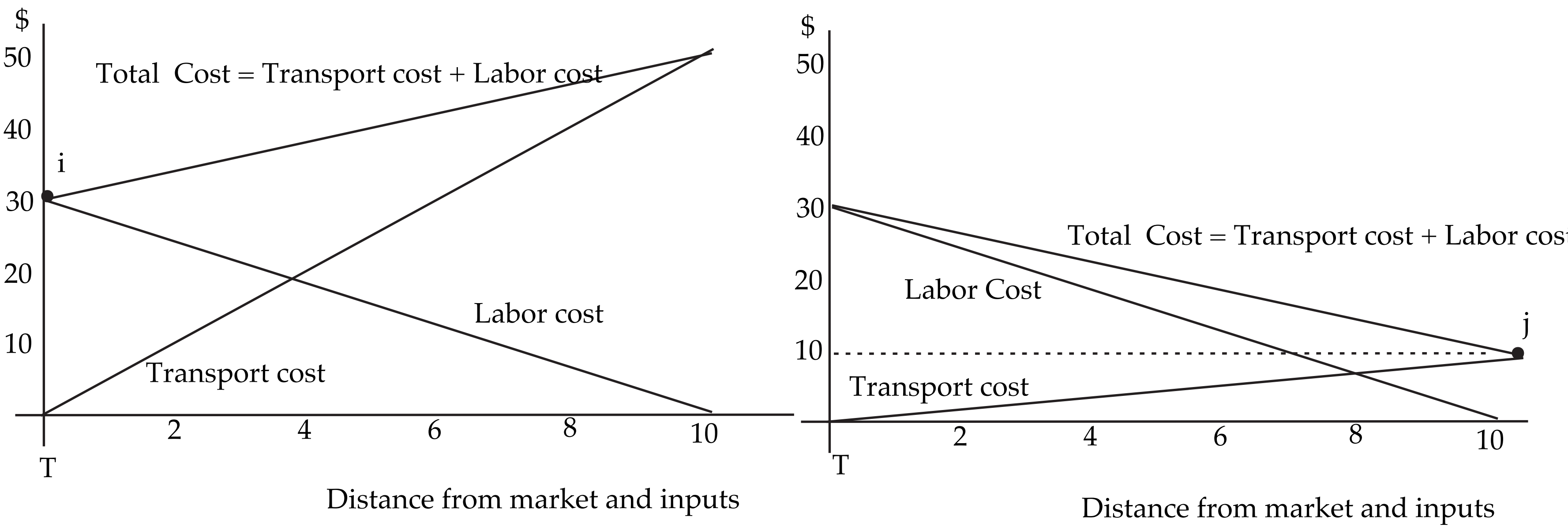
What is the role of labor in location choices? On average, labor is responsible for about three-fourths of the cost of production, so firms' location decisions are sensitive to the cost of labor and labor productivity. Labor is a local input in the sense that it is impractical for workers to commute outside metropolitan areas.

Transport Cost versus Labor Cost

We can modify our model of a firm's location choice to incorporate the cost of labor. To simplify matters, suppose the firm gets its inputs and sells its output at the same location (T). The productivity of labor is the same at all locations, but the price of labor (the wage) decreases as the firm moves away from location T. In Figure 7, the firm's total cost is the sum of labor costs and transport costs, which is minimized at point T. In this case, transport costs are high relative to the variation in labor costs, meaning that the transport-cost curve is relatively steep. As a result, the forces pulling the firm toward location T are stronger than the forces pulling the firm toward locations with lower wages and labor costs, so the tug-of-war is won by location T.

In the last several decades, transport costs have become less important in firms' location decisions. In many industries that have traditionally been resource-oriented or market-oriented, firms now locate far from their input sources and markets. The changes in locational orientation resulted from innovations in transportation and production that have decreased transport costs.

Figure 7 Transport Costs versus Labor Costs



A: Firm locates close to market and inputs

B: Firm locates far from market and inputs

When inputs and outputs are relatively heavy and costly to transport, the firm minimizes the sum of transport and labor costs by locating close to the market and inputs (Panel A, with cost = $30 as shown by point i). A decrease in the physical weight or unit freight cost causes the firm to locate far from the market and inputs, where labor costs are lower (Panel B, with total cost = $10 as shown by point j).

- **Transportation technology.** The development of fast ocean ships and container technology decreased shipping costs, while improvements in railroads and trucks lowered the cost of overland travel. Faster and more efficient aircraft have decreased the cost of air travel.
- **Production technology.** Improvements in production techniques decreased the physical weight of inputs. For example, the amount of coal and ore required to produce one ton of steel has decreased steadily, a result of improved production methods and the use of scrap metal (a local input) instead of iron ore (a transportable input).

Panel B of Figure 7 shows the effects of a decrease in the unit transport costs and the physical weights of inputs. These changes flatten the transport-cost curve, shifting the cost-minimizing location to a location 10 miles from the market and inputs, where labor costs are lower. The decrease in transport costs causes the firm to switch from transfer orientation to labor orientation.

As unit transport costs and input weights decrease, firms are more likely to base their location decisions on access to inexpensive local inputs rather than access to transportable inputs. A recent example is the movement of the assembly operations of many U.S. manufacturers to sites along the Mexican border. The steel industry has moved from the eastern United States, with its rich coal and ore deposits, to Brazil, Korea, and Mexico--far from both raw materials and steel markets. Similarly, manufacturers have moved from the United States to Asia and Mexico, far from U.S. markets, because the savings in labor costs are greater than the increase in transport costs.

Labor in the Long Run

In the long run, workers can move between cities. In the typical year, about 6 percent of the U.S. population move across county lines, and about 3 percent move across state borders (Black, 2000). A firm that locates in one city could hire workers currently living in another city with the expectation that the workers will transfer to the firm's city. According to Bartik (1991), the vast majority of new jobs in cities are filled with people who relocate from other cities: When the number of jobs in a city increases by 1,000, on average, only 230 jobs go to current residents; the rest go to workers who transfer from other cities.

Labor and Natural Amenities

Consider a nation that has two regions--with warm weather in the North and cold weather in the South--and workers prefer warm weather. To achieve locational equilibrium for workers, wages in the South must be lower than wages in the North; otherwise, there would be an incentive for workers to move to the South, getting the same wage and better weather as well. In equilibrium, the wage for a given skill level will be lower in the South, and northern workers will be compensated for bad weather by a higher wage.

The lower wage caused by weather will encourage firms to locate their production facilities in the South. In this case, the local nature of weather and workers' preference for warm weather makes labor a local input. The firm's location depends on the location choice of its workforce: instead of workers following firms, firms follow workers. Graves (1979) and Porell (1982) provide empirical support for this phenomenon. There is evidence that weather has played an important role in location decisions and urban growth. In the past few decades, the most rapidly growing urban areas are ones with warm, dry weather (Black and Henderson, 1999; Glaeser, Kolko, and Saiz, 2001). Natural amenities appear to be most important for firms that employ high-income workers. Since the demands for these amenities are income-elastic, high-income workers are attracted to locations with amenities, and the firms hiring these people follow. For example, research and development firms employ engineers and computer scientists, who place a high value on good weather and a clean environment.

One explanation for the shift of employment from northern states to the southern and western states is that rising income has increased the demand for natural amenities, causing workers to move to areas that provide these amenities.

CASE STUDIES AND EMPIRICAL RESULTS

This section discusses some of the facts on the location choices of firms. We'll look at case studies of the location decisions of companies in the semiconductor industry, Japanese and American auto firms, Mexican garment manufacturers, and the carpet industry. We'll also discuss empirical evidence concerning the effects of labor costs and unions on location decisions.

The Semiconductor Industry

The semiconductor industry illustrates some of the complexities of locational choices in modern industry. The industry's output is light and compact relative to its value, so transport costs are relatively unimportant in location decisions. What matters are localization economies and access to different types of labor.

As explained by Castells (1988), the making of semiconductors involves several distinct operations, requiring three different types of labor:

1. **Research and development.** Engineers and scientists design new circuits and prepare the circuits for implantation into silicon chips.
2. **Wafer fabrication.** Skilled technicians and manual workers make the chips holding the circuits.
3. **Assembly into components.** Unskilled workers assemble the chips into electronic components.

Many semiconductor firms split their operations into three parts. Research and development occurs in the Silicon Valley to exploit localization economies generated by the large concentration of semiconductor firms. The Silicon Valley is also considered a desirable location by engineers and scientists. Advanced manufacturing (wafer production) is typically located outside the Silicon Valley. For example, National Semiconductor has manufacturing facilities in Utah, Arizona, and the state of Washington; Intel has plants in Oregon, Arizona, and Texas; and Advanced Micro Devices has a plant in Texas. These facilities are located in areas that provide (1) a plentiful supply of skilled manual laborers, (2) an environment attractive to engineers and technicians, and (3) easy access, by air transportation, to the Silicon Valley. The firm's assembly facilities are typically overseas, in locations such as Southeast Asia that provide a plentiful supply of low-skilled workers.

Japanese Automobile Firms

A recent study of Japanese firms in the automobile industry (Smith and Florida, 1994) explores the relative importance of various locational attributes. Under the just-in-time inventory system, a firm links the delivery of intermediate inputs with its production schedule, the idea being that the inputs should arrive just in time for production. This inventory system requires geographic proximity to input suppliers to both save on shipping time and facilitate communication between firms. The study suggests that the major factor in the location of Japanese-affiliated automotive suppliers in the United States is proximity to Japanese-affiliated automotive assemblers. In other words, agglomeration is the key feature in the location choices of such firms.

The study of Japanese firms provides some other insights into locational choices. Japanese-affiliated automotive suppliers prefer locations with relatively large populations, a high density of manufacturing activity, an educated workforce, and better transportation. Furthermore, these firms tend to pick locations with relatively high wages, reflecting their willingness to pay higher wages in exchange for higher labor productivity. Finally, Japanese-affiliated manufacturers tend to locate in areas with relatively high concentrations of minority workers.

Mexican Garment Industry

Hanson (1996) describes the locational patterns of firms in the Mexican garment industry. Until the 1920s, most garments in Mexico were made by housewives and neighborhood tailors, who used factory-made cloth to produce custom garments for family members and local patrons. The first garment factories, built by Lebanese and

Jewish immigrants, were located in downtown Mexico City. For several decades, the industry was highly concentrated in the Federal District (the area containing Mexico City), with about 60 percent of Mexico's garment jobs there.

During the 1970s and 1980s, garment employment in the Federal District decreased in relative and absolute terms. The district's share of national garment employment dropped from 60 percent in 1965 to 33 percent by 1985, with jobs moving to states with lower wages (Aguascalientes, Jalisco, Mexico, Nuevo Leon, and Puebla). Each state specialized in a particular type of garment, and garment employment in each state is concentrated in one or two cities. For example, the city of Aguascalientes is the employment center for children's outerwear, with over 44 percent of the national employment in that sector.

Although many garment jobs moved out of the Federal District, the district retained its role as the center for marketing and design. In 1980, about 70 percent of the wholesale trade in garments, textiles, and leather goods was conducted in the Federal District, suggesting that the bulk of marketing and design still happens there.

Most of the jobs that moved to the outlying areas were low-skill assembly jobs. In other words, there is a hierarchy of functions, with the activities subject to large agglomerative economies (marketing and design) concentrated in one location, and activities with smaller agglomerative economies (assembly) dispersed to outlying areas.

Carpet Manufacturing and Localization Economies

As an example of localization economies, consider Dalton, Georgia, the preeminent carpet manufacturing center of the United States (Krugman, 1991). In 1895, Catherine Evans of Dalton used an outdated technique--known as tufting or candle wicking--to make a bedspread as a wedding gift. The gift was a big hit, and in the next few years, Ms. Evans made a few tufted items for her friends and even sold a few. After she discovered a few production tricks such as a technique for locking the tufts onto the backing, she and her neighbors launched a local handicraft industry, producing handmade tufted items for sale.

Immediately after World War II, a machine for producing tufted carpets was developed, making tufted carpet a cheaper alternative to woven carpet. New carpet makers sprung up in the Dalton area because that's where they could find workers **86**
with knowledge and experience in tufting. Support firms located nearby, supplying dyes, backing, and other intermediate inputs. Some of the old firms that had produced woven carpets went out of business because they were underpriced by tufting firms, while others moved from the Northeast to the Dalton area and switched to the new technique. By the middle of the 1950s, Dalton was the carpet capital of the nation. Of the top 20 carpet manufacturers in the United States, 6 are located in Dalton, and 13 others are located nearby.

GM's Saturn Plant

In 1985, General Motors announced that its new Saturn plant would be located in Spring Hill, Tennessee, a crossroads community about 30 miles from Nashville. The plant, which cost several billions of dollars to build, employs about 3,000 workers and supports thousands of jobs in the Nashville area. Why did GM choose Nashville over the dozens of other communities that sought the plant?

A case study by Bartik, Becker, Lake, and Bush (1987) explored differences in transportation, labor costs, and taxes for alternative locations. The first step in the case study addressed the issue of transportation costs and market access. The authors estimated the costs of shipping finished cars from seven alternative production sites to GM's markets in the continental United States. Based on the distribution of projected sales in 2000, the location offering the best market access was Terre Haute, Indiana.

As shown in Table 3, the variation in transportation cost among the seven sites was relatively small. The gap between Terre Haute and the site with the highest transportation cost (Kalamazoo) was only $17 per car. Nashville was ranked fifth, with transport costs only $13 per car higher than Terre Haute.

The second step of the study incorporated labor costs into the analysis. A labor contract between GM and its unionized workers stipulated that the Saturn workers will be paid the same wage regardless of the plant's location, so GM would not decrease its own wage bill by locating in Tennessee, a state with low wages. However, GM would purchase a large fraction of its inputs from nearby suppliers, who would pay low wages and pass on the savings to GM. As shown in Table 3, the variation in labor cost was relatively large. The difference between the lowest-cost site (Nashville) and the highest-cost site (Kalamazoo) was $85 per car.

TABLE 3   Case Study of GM's Saturn Plant

	Estimated Cost ($ per car)			
	Transport Costs	Labor Cost: Local Suppliers	Local/State Taxes (pre-subsidy)	Total Measured Cost
Nashville, TN	$426	$159	$118	$703
Lexington, KY	423	186	106	715
St. Louis, MO	419	172	134	725
Bloomington, IL	417	202	162	781
Kalamazoo, MI	430	244	116	790
Terre Haute, IN	413	209	168	790
Marysville, OH	427	219	169	815

Source: Timothy J. Bartik, Charles Becker, Steve Lake, and John Bush, "Saturn and State Economic Development," *Forum for Applied Research and Public Policy* (Spring 1987), pp. 29-40.

The third step was to estimate taxes for the seven possible sites. Table 3 shows the tax cost per car in the absence of special subsidies and exemptions. The difference between the site with the highest taxes (Marysville) and the site with the lowest taxes (Lexington) was $63 per car. Nashville was ranked third, with tax costs per car $12 higher than Lexington.

This case study suggests that in the absence of special tax treatment, Nashville had the lowest total cost. The most important factor was the lower labor costs in Nashville. Although the city had a slight disadvantage to Terre Haute in terms of market access, this disadvantage was more than offset by Nashville's lower labor costs.

The state of Tennessee offered three types of inducements to GM. The first was a $30 million highway project that connected the plant with Interstate 65. The second was a subsidized job-training program for Saturn workers, worth about $4 per car. The third was a program of property tax subsidies, worth about $30 per car. As shown by the numbers in Table 3, these subsidies would not have been necessary in the absence of special subsidies from other states. Other states did offer special subsidies, and Tennessee responded in kind to stay competitive in the bidding for the plant.

Effects of Wages and Unions

How do wages affect firms location decisions? Carlton (1983) examines the relationship between the number of new firms in a metropolitan area and several variables, including local wages. He looks at firm births in three industries: plastics products, electronic transmitting equipment, and electronic components. These industries have relatively low transport costs, so they are oriented toward local inputs, not toward output markets or natural resources. His results suggest that for the electronic components industry the elasticity of the number of plant births with respect to the metropolitan wage is -1.07. In other words, a 10 percent increase in the wage decreases the number of births by 10.7 percent. Bartik (1991) examines and summarizes the results of dozens of studies and concludes that the long-run elasticity of business activity with respect to the wage is between -1.0 and -2.0. This means that a 10 percent decrease in the metropolitan wage will increase business activity between 10 percent and 20 percent.

How do unions affect location decisions and the volume of business activity? One of the effects of unions is to increase wages, so a highly unionized metropolitan area is likely to have relatively high wages. Since the elasticity of business activity with respect to the wage is relatively large, to the extent that unions increase wages, they decrease business activity. Unions may have other (nonwage) effects that influence business location decisions. For example, unions may affect labor productivity.

According to Bartik (1991), empirical studies of the nonwage effects of unions have generated mixed results. Although most studies found that the presence of unions decreases business activity, many studies suggested that the negative effects are rather small.

SUMMARY

1. Cities develop around the concentrations of employment generated by firms, so the location choices of firms determine the location of cities and urban growth.

2. A resource-oriented firm has relatively high transport costs for its inputs, so it locates near its input source.

3. A market-oriented firm has relatively high transport costs for its output, so it locates close to its market.

4. A market-oriented firm with multiple inputs and outputs will locate at its median transport location. The median location is often in large cities, providing one reason for the growth of big cities.

5. Some firms are oriented toward local inputs. Energy-intensive firms are drawn toward locations with cheap energy, while firms that benefit from agglomeration economies are pulled toward industry clusters or large cities.

6. In the last several decades, the relative importance of transport costs has decreased, reflecting decreases in unit transport costs and the physical weight of inputs.

7. Natural amenities attract workers, and the resulting lower wages attract firms.

EXERCISES AND DISCUSSION QUESTIONS

1. Comment on the following from the owner of a successful plywood mill: "Firms don't use location theory to make location decisions. I chose this location for my plywood mill because it is close to my favorite fishing spot."

2. Depict graphically the effects of the following changes on the bat firm's cost curves (shown in Figure 2). Explain any changes in the optimum location.

a. The cost of shipping bats increases from $1 per ton to $4 per ton, while the cost of shipping wood remains at $1 per ton.

b. The forest at point *F* burns down, forcing the firm to use wood from point *G* which is 10 miles west of point *F* (20 miles from the market).

c. The firm starts producing bats with wood and cork, using three tons of wood and two tons of cork to produce three tons of bats. Cork is ubiquitous (available at all locations for the same price).

3. Why do breweries typically locate near their markets (far from their input sources), while wineries typically locate near their input sources (far from their markets)?

4. The building of wooden ships was a weight-losing activity, as evidenced by the piles of scrap wood generated by shipbuilders. Yet shipbuilders located in ports, far from their input sources (inland forests). Why?

5. Consider a firm that delivers video rentals to its customers. The spatial distribution of customers is as follows: 10 videos are delivered to location *W*, 10 miles due west of the city center; 50 videos are delivered to the city center; 25 videos are delivered to *E*, 1 mile due east of the city center; and 45 videos are delivered to point *F*, 2 miles east of the city center. Production costs are the same at all locations.

a. Using a graph, show where the firm should locate. Explain your location choice.

b. Suppose that point *W* is in a valley and point *F* is at the top of a mountain. Therefore, the unit cost of easterly transport (shipments from west to east) is twice the unit cost of westerly transport. If production costs are the same at all locations, where should the firm locate? Explain.

6. Figure 4 shows the location choice of Ann's pizza firm. Discuss the effects of the following changes on Ann's location choice.

a. A tripling of the distance between *Y* and *Z* (from 7 miles to 21 miles).

b. A tripling of the number of customers at point *W*. Instead of two customers at *W* there are six.

c. Ann stops delivery service, forcing consumers to travel to the pizza parlor.

7. In Figure 6, the weight-losing firm is located at point *P* (the port). If the monetary weight of location *B* is $27 instead of $15, will the firm still locate at point *P*?

8. There is some evidence that people have become more sensitive to air pollution. In other words, people are willing to pay more for clean air. If this is true, what influence will it have on the location decision of firms?

9. Consider a firm that uses one transferable input to produce one output. The monetary weight of the output is $4, and the monetary weight of the input is $3. The distance between *M* (the market) and *F* (the input source) is 10 miles.

a. Suppose that production costs are the same at all locations. Using a diagram like the one in Figure 2, explain where the firm will locate.

b. Suppose that the cost of land (a local input) increases as one approaches the market. Specifically, suppose that the cost of land is zero at *F* but increases at a rate of $2 per mile as the firm approaches *M*. Depict the location choice of the firm graphically.

10. Chapter 3 of Urban Economics (6th edition, 2006) discusses the incubator process. When industries mature, they move from single-activity clusters to areas with lower land and labor costs. Explain this process in terms of changes in the orientation of firms as they mature.

11. Suppose that country *L* has a plentiful supply of labor (and low wages) but a relatively low supply of raw materials. In contrast, *H* has a plentiful supply of raw materials, but a relatively low supply of labor (and high wages). The two countries are separated by a mountain range that makes travel between the two countries prohibitively costly. Suppose that a weight-losing product is initially produced in *H* (close to the supply of raw materials). Suppose that a tunnel is bored through the mountain, decreasing the costs of shipping raw materials and output between the two countries. Assume that laborers do not migrate from one country to the other.

a. How will the tunnel affect the location choices of weight-losing firms?

b. How will the tunnel affect wages in the two countries?

c. How might this analysis be used to explain (1) the shift in manufacturing from the United States to East Asian countries and (2) the narrowing of the wage differential between the United States and East Asian countries?

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