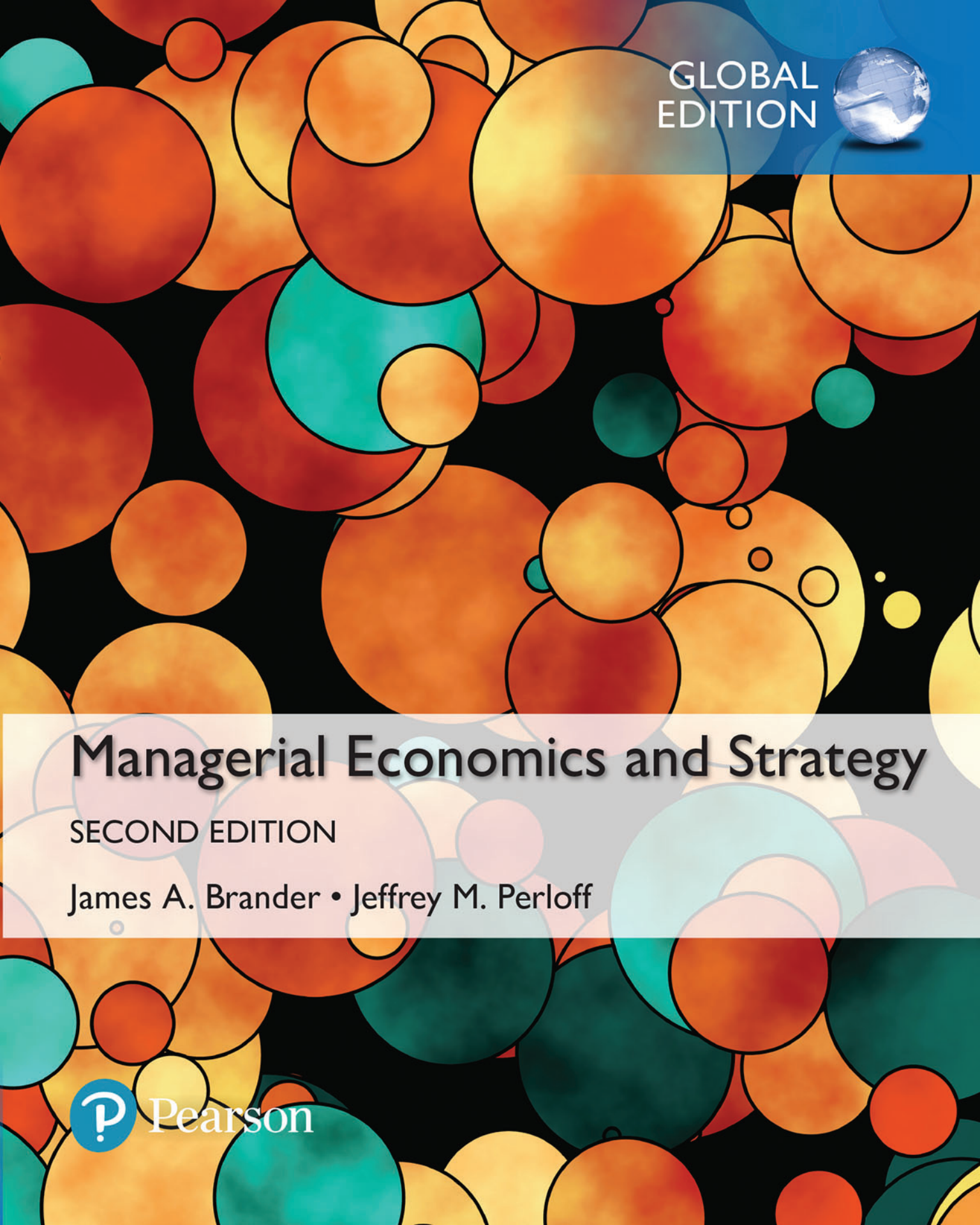

Managerial Economics and Strategy

SECOND EDITION

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Pearson

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SECOND EDITION
GLOBAL EDITION

SUMMARY

From all technically efficient production processes, a cost-minimizing firm chooses the one that is economically efficient. The economically efficient production process is the technically efficient process for which the cost of producing a given quantity of output is lowest.

1. **The Nature of Costs.** In making decisions about production, managers need to take into account the opportunity cost of an input, which is the value of the input's best alternative use. For example, if the manager is the owner of the company and does not receive a salary, the amount that the owner could have earned elsewhere—the foregone earnings—is the opportunity cost of the manager's time and is relevant in deciding whether the firm should produce or not. A durable good's opportunity cost depends on its current alternative use. If the past expenditure for a durable good is sunk—that is, it cannot be recovered—then that input has no opportunity cost and the sunk cost should not influence current production decisions.
2. **Short-Run Costs.** In the short run, the firm can adjust some factors, such as labor, while other factors, such as capital, are fixed. Consequently, total cost is the sum of variable costs and fixed costs. Average cost is total cost divided by the number of units of output produced. Similarly, average variable cost is variable cost divided by output. Marginal cost is the amount by which a firm's cost changes if the firm produces one more unit of output. At quantities where the marginal cost curve is below the average cost curve, the average cost curve is downward sloping. Where the marginal cost curve is above the average cost curve, the average cost curve is upward sloping. Thus, the marginal cost curve cuts the average cost curve at its minimum point. Given that input prices are constant, the shapes of the variable cost and the cost-per-unit curves are determined by the production function. If labor is the only variable factor in the short run, the shape of short-run cost curves reflects the marginal product of labor.
3. **Long-Run Costs.** Over a long-run planning horizon, all inputs can be adjusted. Therefore all costs are avoidable in the long run. The firm uses the combination of inputs that minimizes its cost. To produce a given output level, the firm chooses the lowest isocost line that touches the relevant isoquant, which is tangent to the isoquant. Equivalently, to minimize cost, the firm adjusts inputs until the last dollar spent on any input increases output by as much as the last dollar spent on any other input. If the firm calculates the cost of producing every possible output level given current input prices, it knows its cost function: Cost is a function of the input prices and the output level. If the firm's average cost falls as output expands, its production process has economies of scale. If its average cost rises as output expands, its production process has diseconomies of scale.
4. **The Learning Curve.** A firm that introduces a new product or service often benefits from increased productivity as it gains experience and learns how to produce at lower cost, a process called learning by doing. Workers who are given a new task will typically speed up and make fewer mistakes with practice. The learning curve describes the relationship between average cost and cumulative output over time. This curve typically slopes downward, reflecting the decline in cost that arises from learning by doing.
5. **The Costs of Producing Multiple Goods.** If it is less expensive for a firm to produce two goods jointly rather than separately, its production process exhibits economies of scope. If there are diseconomies of scope, it is less expensive to produce the goods separately. The presence of economies of scope is important in determining the goods that the firm produces.

QUESTIONS

*All exercises are available on MyLab Economics; * = answer at the back of this book;* **C** *= use of calculus may be necessary.*

1. The Nature of Costs

1.1 Executives at Leonesse Cellars, a premium winery in Southern California, were surprised to learn that shipping wine by sea to some cities in Asia was less expensive than sending it to the East Coast of the United States, so they started shipping to Asia (David Armstrong, "Discount Cargo Rates Ripe for the Taking," *San Francisco Chronicle*, August 28, 2005). Because of the large U.S. trade imbalance with major Asian nations, cargo ships arrive at West Coast seaports fully loaded but return to Asia half to completely empty. Use the concept of opportunity cost to help explain the differential shipping rates.

1.2 Samantha bought a £200 ticket for a music festival in London. Because it stars several of her favorite rock groups, she would have been willing to pay up to £300 to attend the festival. However, her friend Joanne invites her to go with her to a trip to Oxford on the same day. The trip would cost £80, but she would be willing to pay up to £150. What is Samantha's opportunity cost of going to the festival? (*Hint*: See Q&A 6.1.)

1.3 Many corporations allow CEOs to use the firm's corporate jet for personal travel (see the Mini-Case "Company Jets" in Chapter 7 for more details). The Internal Revenue Service (IRS) requires that the firm report personal use of its corporate jet as taxable executive income, and the Securities and Exchange Commission (SEC) requires that publicly traded corporations report the value of this benefit to shareholders. An important issue is the determination of the value of this benefit. The IRS values a CEO's personal flight at or below the price of a first-class ticket. The SEC values the flight at the "incremental" cost of the flight: the additional costs to the corporation of the flight. The third alternative is the market value of chartering an aircraft. Of the three methods, the first-class ticket is least expensive and the chartered flight is most expensive.

a. What factors (such as fuel) determine the marginal explicit cost to a corporation of an executive's personal flight? Does any one of the three valuation methods correctly determine the marginal explicit cost?

b. What is the marginal opportunity cost to the corporation of an executive's personal flight?

*1.4 A firm purchased copper pipes a few years ago at $20 per pipe and stored them, using them only as the need arises. The firm could sell its remaining pipes in the market at the current price of $15. What is the opportunity cost of each pipe and what is the sunk cost?

2. Short-Run Costs

*2.1 Nicolas has purchased a streaming audio service for $8.00 per month. As he listens to more songs in a month he spreads this fixed cost over a larger quantity, q. Derive an algebraic formula for his average fixed cost per song and draw it in a diagram. One of his friends says to Nicolas: "The more music you listen to, the less you pay per song so you should spend all your time listening to music." What is wrong with this reasoning?

2.2 In the twentieth century, department stores and supermarkets largely replaced smaller specialty stores, as consumers found it more efficient to go to one store rather than many. Consumers incur a transaction or search cost to shop, primarily the opportunity cost of their time. This transaction cost consists of a fixed cost of traveling to and from the store and a variable cost that rises with the number of different types of items the consumer tries to find on the shelves. By going to a supermarket that carries meat, fruits and vegetables, and other items, consumers can avoid some of the fixed transaction costs of traveling to a separate butcher shop, produce mart, and so forth. Use math to explain why a shopper's average costs are lower when buying at a single supermarket than from many stores. (*Hint*: Define the goods as the items purchased and brought home.)

2.3 For the following total cost functions, derive the equations for and plot *AFC*, *MC*, *AVC*, and *AC*.

a. $C = 36 + 20q$

b. $C = 36 + 4q^2$

c. $C = 36 + 20q - 6q^2 + q^3$ **C**

2.4 In 1796, Gottfried Christoph Härtel, a German music publisher, calculated the cost of printing music using an engraved plate technology and used these estimated cost functions to make production decisions. Härtel figured that the fixed cost of printing a musical page—the cost of engraving the plates—was 900 pfennigs. The marginal cost of each additional copy of the page is 5 pfennigs (Scherer, 2001).

a. Graph the total cost, average cost, average variable cost, and marginal cost functions.

b. Is cost lower if only one music publisher prints a given composition? Why?

c. Härtel used his data to do the following type of analysis. Suppose he expects to sell exactly 300 copies of a composition at 15 pfennigs per page of the composition. What is the greatest amount the publisher is willing to pay the composer per page of the composition?

2.5 Gail works in a flower shop, where she produces 10 floral arrangements per hour. She is paid $15 an hour for the first eight hours she works and $20 an hour for each additional hour she works. What is the firm's cost function? What are its *AC*, *AVC*, and *MC* functions? Draw the *AC*, *AVC*, and *MC* curves.

*2.6 A firm builds shipping crates out of wood. How does the cost of producing a 1-cubic-foot crate (each side is 1-foot square) compare to the cost of building an 8-cubic-foot crate if wood costs $1 a square foot and the firm has no labor or other costs? More generally, how does cost vary with volume?

2.7 The only variable input a hotel uses to clean rooms is housecleaning staff who are paid a wage, w, of €15 an hour. Each worker can clean five rooms in an hour. Use math to determine the variable cost, the average variable cost, and the marginal cost of cleaning one more room. Draw a diagram like Figure 6.1 to show the variable cost, average variable cost, and marginal cost curves.

2.8 A firm has a Cobb-Douglas production function, $q = AL^{\alpha}K^{\beta}$, where $\alpha + \beta < 1$. On the basis of this information, what properties does its cost function have? For example, a U.S. chemical firm has a production function of $q = 10L^{0.32}K^{0.56}$ (based on Hsieh, 1995). If it faces factor prices of $w = 10$ and $r = 20$ and its capital is fixed at $\overline{K} = 100$, what are its short-run cost, variable cost, average variable cost, and marginal variable cost functions? Plot these curves.

2.9 Equation 6.5 gives the short-run variable cost function for Japanese beer as $VC = 0.55q^{1.67}$. If the fixed cost is 600 and the firm produces 550 units, determine the C, VC, MC, AFC, and AVC. What happens to these costs if the firm increases its output to 600?

3. Long-Run Costs

3.1 A newly invented machine serves as a mobile station for receiving and accumulating packed flats of strawberries close to where they are picked, which reduces workers' time and burden of carrying full flats of strawberries. According to Rosenberg (2004), a machine-assisted crew of 15 pickers produces as much output, q^*, as that of an unaided crew of 25 workers. In a 6-day, 50-hour workweek, the machine replaces 500 worker-hours. At an hourly wage cost of $10, a machine saves $5,000 per week in labor costs, or $130,000 over a 26-week harvesting season. The cost of machine operation and maintenance expressed as a daily rental is $200, or $1,200 for a six-day week. Thus, the net savings equal $3,800 per week, or $98,800 for 26 weeks.

a. Draw the q^* isoquant assuming that only two production methods are available (pure labor and labor-machine). Label the isoquant and axes as thoroughly as possible.

b. Add an isocost line to show which technology the firm chooses (be sure to measure wage and rental costs on a comparable time basis).

c. Draw the corresponding cost curves (with and without the machine), assuming constant returns to scale, and label the curves and the axes as thoroughly as possible.

*3.2 A seafood-processing company in Nigeria uses two inputs: machines (K) and workers (L). The isoquants have the usual smooth shape. The machines cost ₦120,000 (Nigerian Naira) per day to run and the workers earn ₦20,000 per day. At the current level of production, the marginal product of the machine is an additional 400 pounds of seafood per day, and the marginal product of labor is 80 more pounds per day. Is this firm producing at minimum cost? If it is minimizing cost, explain why. If it is not minimizing cost, explain how the firm should change the ratio of inputs it uses to lower its cost. (*Hint*: Examine the conditions for minimizing cost in Equations 6.8, 6.9, and 6.10.)

3.3 Suppose that the government subsidizes the cost of workers by paying for 25% of the wage (the rate offered by the U.S. government in the late 1970s under the New Jobs Tax Credit program). What effect will this subsidy have on the firm's choice of labor and capital to produce a given level of output? What happens if both capital and labor are subsidized at 25%? (*Hint*: See Q&A 6.2.)

*3.4 The all-American baseball is made using cork from Portugal, rubber from Malaysia, yarn from Australia, and leather from France, and it is stitched (108 stitches exactly) by workers in Costa Rica. To assemble a baseball takes one unit each of these inputs. Ultimately, the finished product must be shipped to its final destination—say, Cooperstown, New York. The materials used cost the same anywhere. Labor costs are lower in Costa Rica than in a possible alternative manufacturing site in Georgia, but shipping costs from Costa Rica are higher. What production function is used? What is the cost function? What can you conclude about shipping costs if it is less expensive to produce baseballs in Costa Rica than in Georgia?

3.5 Cane sugar is an important input in a popular Mexican beverage. In response to a sharp increase in tax on cane sugar, the beverage's manufacturers reformulated the production process by largely switching over to corn sugar. After a year, the Mexican government collected only about Mex$50,000 (Mexican pesos) instead of the projected Mex$200 million as tax revenue from cane sugar. Use an isocost–isoquant diagram to explain the firms' response. (*Hint*: Cane sugar and corn sugar may be close to perfect substitutes.)

3.6 An auto manufacturer in India is considering moving its production to a plant in Vietnam. Its estimated production function is $q = 2L^{0.5}K^{0.5}$. The factor prices in India are $w = 300$ and $r = 1{,}200$. In Vietnam, the wage is 20% less, but the firm faces the same cost of capital: $w^* = 240$ and $r^* = r = 1{,}200$. What are L and K, and what is the cost of producing $q = 20$ units in both countries?

3.7 The Mini-Case "Economies of Scale at Google" describes economies of scale for Google Cloud Storage. The cost function for this service is well approximated by $C = F + cq$, where C is total cost, F is fixed cost, c is a constant, and q is output. What is marginal cost for this cost function? What is average cost? Over what range of output does Google have economies of scale?

*3.8 What is the long-run cost function for a fixed-proportions production function for which it takes two units of capital and one unit of labor to produce one unit of output as a function of the wage, w, and the price of capital, r? What is the cost function if the production function is $q = L + 2K$? (*Hint*: See Q&A 6.3.)

3.9 A U-shaped long-run average cost curve is the envelope of U-shaped short-run average cost curves. On what part of the curve (downward sloping, flat, or upward sloping) does a short-run curve touch the long-run curve?

4. The Learning Curve

4.1 In what types of industry would you expect to see substantial learning by doing? Why?

*4.2 A firm's learning curve, which shows the relationship between average cost and cumulative output (the sum of its output since the firm started producing), is $AC = a + bN^{-r}$; where AC is its average cost; N is its cumulative output; a, b, and r are constants; and $0 < r < 1$.

a. What is the firm's AC if $r = 0$? What can you say about the firm's ability to learn by doing?

b. If r exceeds zero, what can you say about the firm's ability to learn by doing? What happens to its AC as its cumulative output, N, gets extremely large? Given this result, what is your interpretation of a?

4.3 Panel a of Figure 6.8 shows that Intel's average cost in a given year falls with the quantity that it produces. In addition, extra production this year lowers the average cost curve next year. For example, in year 1, $AC = 50$ if quantity is 20 and $AC = 40$ if quantity is 60. If Intel produces 20 in year 1 and 40 in year 2, the average cost in year 2 will be 40. However, for every extra 10 units it produces in year 1, its AC for any given quantity in year 2 falls by 10%.

a. What is the total cost and the average cost over the two years combined if the firm produces 20 in year 1 and 40 in year 2?

b. What is the total cost and average cost over the two years combined if the firm produces 60 in year 1 and 40 in year 2?

c. Over the two years combined, what is the true additional cost of producing 60 instead of 20 in year 1?

4.4 In the Mini-Case "Learning by Drilling," an oil drilling firm's average cost when working with production company M depends partly on its own cumulative drilling experience, N, and partly on the cumulative amount of drilling it has done jointly with production company M. Would an average cost curve $AC = a + b_1N^{-r} + b_2M^{-s}$ exhibit such learning by doing? Explain. (*Note*: a, b_1, b_2, r, and s are all positive constants.)

5. The Costs of Producing Multiple Goods

5.1 The United Kingdom started regulating the size of grocery stores in the early 1990s, and today the average size of a typical U.K. grocery store is roughly half the size of a typical U.S. store and two-thirds the size of a typical French store (Haskel and Sadun, 2011). What implications would such a restriction on size have on a store's average costs? Discuss in terms of economies of scale and scope.

5.2 Yesbel sells wall hangings and sand candles to tourists. If Yesbel spends the morning (4 hours) making only wall hangings, she can make 6 wall hangings; if she spends the morning making only sand candles, she can make 10 candles. If she makes some of each, however, she can make 4 wall hangings and 8 sand candles. Suppose that Yesbel's time is valued at €16 an hour. What can you say about her economies of scope? That is, what is the sign of her measure of economies of scope, SC?

*5.3 A refiner produces heating fuel and gasoline from crude oil in virtually fixed proportions. What can you say about economies of scope for such a firm? What is the sign of its measure of economies of scope, SC?

5.4 The central activity of many acute-care hospitals is inpatient surgery, but some of these hospitals also provide outpatient services – services for patients who come to the hospital for treatment but do not stay for any significant period before or after. Such services include outpatient surgery and outpatient treatment and counseling for drug abuse. Based on the information in the Mini-Case "Medical Economies of Scale," is it cost effective to offer these two outpatient services? What do you think are the reasons for these economies or diseconomies of scope?

6. Managerial Problem

*6.1 In Figure 6.9, show that for some wages and capital rental costs the firm is indifferent between using the wafer-handling stepper technology and the stepper

technology. How does this wage/cost of capital ratio compare to those in the C^2 and C^3 isocosts?

7. MyLab Economics Spreadsheet Exercises[7]

7.1 The production function for a firm is

$$q = -0.6L^3 + 18L^2K + 10L,$$

where q is the amount of output, L is the number of labor hours per week, and K is the amount of capital. The wage is \$100 and the rental rate is \$800 per time period.

a. Using Excel, calculate the total short-run output, $q(L)$, for $L = 0, 1, 2, \ldots, 20$, given that capital is fixed in the short run at $\overline{K} = 1$. Also, calculate the average product of labor, AP_L, and the marginal product of labor, MP_L. (You can estimate the MP_L for $L = 2$ as $q(2) - q(1)$, and so on for other levels of L.)

b. For each quantity of labor in (a), calculate the variable cost, VC; the total cost, C; the average variable cost, AVC; the average cost, AC; and the marginal cost, MC. Using Excel, draw the AVC, AC, and MC curves in a diagram.

c. For each quantity of labor in (a), calculate w/AP_L and w/MP_L and show that they equal AVC and MC, respectively. Explain why these relationships hold.

7.2 A furniture company has opened a small plant that builds tables. Jill, the production manager, knows the fixed cost of the plant, $F = \$78$ per day, and includes the cost of the building, tools, and equipment. Variable costs include labor, energy costs, and wood. Jill wants to know the cost function. She conducts an experiment in which she varies the daily production level over a 10-day period and observes the associated daily cost. The daily output levels assigned are 1, 2, 4, 5, 7, 8, 10, 12, 15, and 16. The associated total costs for these output levels are 125, 161, 181, 202, 207, 222, 230, 275, 390, and 535, respectively.

a. Use the Trendline tool in Excel to estimate a cost function by regressing cost on output (Chapter 3). Try a linear specification ($C = a + bq$), a quadratic specification ($C = a + bq + dq^2$), and a cubic specification ($C = a + bq + dq^2 + eq^3$). Based on the plotted regressions, which specification would you recommend that Jill use? Would it make sense to use the *Set Intercept* option? If so, what value would you choose? (*Hint*: Put output in column A and cost in column B. To obtain quadratic and cubic cost specifications, select the *Polynomial* option from the *Trendline* menu and set *Order* at 2 for the quadratic specification and at 3 for the cubic function.)

b. Generate the corresponding average cost data by dividing the known cost by output for each experimental output level. Estimate an average cost curve using the Trendline tool.

7.3 A Korean electronic chip manufacturer has a production function given by $q = L^{0.5}K^{0.5}$.

a. Use Excel to determine the amount of capital, K, needed to produce 10 units of output for each value of labor, L, starting from $L = 2$ and going to $L = 20$ in increments of 1. Plot this isoquant. (*Hint*: The formula for that isoquant is $10 = L^{0.5}K^{0.5}$. Squaring both sides of this equation, we obtain $100 = LK$. Dividing both sides of the equation by L, we learn that $K = 100/L$.)

b. Use Excel to determine the cost of each of these combinations of labor and capital if the wage rate, w, and the cost of capital, r, are each \$30 per unit. Which combination of inputs minimizes the cost of producing 10 units of output?

c. The slope of the isoquant is $-100/L^2$. Calculate the slope of the isoquant for each combination of inputs. The slope of the isocost line is $-w/r = -30/30 = -1$. Verify that the cost minimizing input combination occurs where the slope of the isoquant equals the slope of the isocost line. Draw the isoquant and the isocost line and show that they are tangent at the cost-minimizing combination of inputs.

[7]The spreadsheet exercises in this chapter are based largely on the work of Satyajit Ghosh, in cooperation with the authors. The answers are available on MyLab Economics.

Appendix 6A Long-Run Cost Minimization

We can use calculus to derive the tangency rule, cost-minimization condition, Equation 6.9. The problem the firm faces in the long run is to choose labor, L, and capital, K, to minimize the cost of producing a particular level of output, $\bar{q}$, given a wage of w and a rental rate of capital of r.

The firm's production function is $q = f(L, K)$, so the marginal products of labor and capital are $MP_L(L, K) = \partial f(L, K)/\partial L > 0$ and $MP_K = \partial f(L, K)/\partial K > 0$. The firm's problem is to minimize its cost of production, C, through its choice of labor and capital,

$$\min_{L, K} C = wL + rK,$$

subject to the constraint that a given amount of output, $\bar{q}$, is to be produced:

$$f(L, K) = \bar{q}. \tag{6A.1}$$

Equation 6A.1 is the formula for the $\bar{q}$ isoquant.

We can change this constrained minimization problem into an unconstrained problem by using the Lagrangian technique. The corresponding Lagrangian, $\mathcal{L}$, is

$$\mathcal{L} = wL + rK - \lambda\left[f(L, K) - \bar{q}\right],$$

where λ is the Lagrange multiplier.

The first-order conditions are obtained by differentiating $\mathcal{L}$ with respect to L, K, and λ and setting the derivatives equal to zero:

$$\partial\mathcal{L}/\partial L = w - \lambda MP_L(L, K) = 0, \tag{6A.2}$$

$$\partial\mathcal{L}/\partial K = r - \lambda MP_K(L, K) = 0, \tag{6A.3}$$

$$\partial\mathcal{L}/\partial\lambda = f(L, K) - \bar{q} = 0. \tag{6A.4}$$

Using algebra, we can rewrite Equations 6A.2 and 6A.3 as $w = \lambda MP_L(L, K)$ and $r = \lambda MP_K(L, K)$. Taking the ratio of these two expressions, we obtain

$$\frac{MP_L(L, K)}{MP_K(L, K)} = \frac{w}{r}, \tag{6A.5}$$

which is the same as Equation 6.9. This condition states that cost is minimized when the ratio of marginal products is the same as the factor price ratio, w/r.