Microeconomics

NINTH EDITION

Jeffrey M. Perloff

Microeconomics

9th edition
Global Edition

faces the much flatter C^3 isocost line, which hits the isoquant at the stepper technology, it switches technologies. (If the isocost line were even flatter, it could hit the isoquant at the aligner technology.)

Even if the wage change is small so that the firm's isocost is C^2 and the firm does not switch technologies abroad, the firm's cost will be lower abroad with the same technology because C^2 is less than C^1. However, if the wage is low enough that it can shift to a more labor-intensive technology, its costs will be even lower: C^3 is less than C^2.

Thus, the firm's decision about whether to use a different technology in its foreign plant than in its domestic plant depends on the relative factor prices in the two locations and whether the firm's isoquant is smooth. If the isoquant is smooth, even a slight difference in relative factor prices will induce the firm to shift along the isoquant and use a different technology with a different capital-labor ratio. However, if the isoquant has kinks, the firm will use a different technology only if the relative factor prices differ substantially.

Key Terms

average cost (*AC*), p. 214
average fixed cost (*AFC*), p. 214
average variable cost (*AVC*), p. 214
cost (total cost, *C*), p. 212
cost efficient, p. 207
diseconomies of scale, p. 233
durable good, p. 210

economic cost or opportunity
   cost, p. 209
economies of scale, p. 233
economies of scope, p. 241
expansion path, p. 229
fixed cost (F), p. 212
isocost line, p. 223

learning by doing, p. 239
learning curve, p. 239
marginal cost (*MC*), p. 214
production possibility frontier, p. 242
sunk cost, p. 211
variable cost (VC), p. 212

Summary

From all technologically efficient production processes, a firm chooses the cost-efficient one. The cost-efficient production process is the technologically efficient process for which the cost of producing a given quantity of output is lowest or for which the output at a given cost is highest.

1. **The Nature of Costs.** In making production decisions, managers need to consider the opportunity cost of an input, which is the value of the input's best alternative use. For example, suppose the owner of the company runs it and does not receive a salary. Then, the salary that the owner could have earned elsewhere—the forgone earnings—is the opportunity cost of the owner'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 input is sunk—cannot be recovered—then that input has no opportunity cost and should not influence current production decisions.

2. **Short-Run Costs.** In the short run, the firm can vary the costs of the factors that it can adjust, but other factors' costs are fixed. The firm's average fixed cost falls as its output rises. If a firm has a short-run average cost curve that is U-shaped, its marginal cost curve is below the average cost curve when average cost is falling and above the average cost curve when average cost is rising. Thus, the marginal cost curve crosses the average cost curve at its minimum.

3. **Long-Run Costs.** In the long run, all factors can be varied, so all costs are variable. As a result, average

cost and average variable cost are identical. The firm chooses the combination of inputs that minimize its cost. To produce a given output level, it 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. Cost is a function of the input prices and the output level. By calculating the cost of producing every possible output level given current input prices, the firm knows its cost function. If the firm's average cost falls as output increases, it has economies of scale. If its average cost rises as output increases, the firm suffers from diseconomies of scale.

4. **Lower Costs in the Long Run.** The firm can always do in the long run what it does in the short run, so its long-run cost can never be greater than its short-run cost. Because some factors are fixed in the short run, to produce more output, the firm must increase its use of only variable factors, which is relatively costly. In the long run, the firm can adjust all factors, which keeps its cost down. Also, long-run cost may be less than short-run cost due to technological progress or learning by doing.

5. **Cost of Producing Multiple Goods.** For some goods, it is less expensive to produce two goods jointly rather than separately due to economies of scope. For other goods, diseconomies of scope make it is less expensive to produce the goods separately.

Questions

* = Answer appears at the back of this book; **A** *= algebra problem;* **C** *= calculus problem.*

1. The Nature of Costs

1.1 The Danish company Maersk Line is the largest shipping container company in the world, covering 15–16% of the global container market. According to an article in *ShippingWatch* (Kristiansen, 2012), the trade imbalance between Europe and Asia causes Maersk Line to spend about $1 billion every year shipping 2 million empty containers to Asia to be filled with products for European consumers. Use the concept of opportunity cost to explain the pros and cons of shipping companies coordinating their container transport to use competitors' empty containers situated closer to markets, compared with transporting their own thousands of kilometers away.

1.2 You bought a ticket to a show at a button museum in Finland for €80 and cannot resell it. However, you can buy a ticket for €40 to attend a paper clip event that runs at the same time as the button museum show. You are willing to pay up to €70 to attend the paper clip event. Given that you incur no other costs from attending either event, what is your opportunity cost of attending the button museum show? (*Hint*: See Solved Problem 7.1.)

*1.3 " 'There are certain fixed costs when you own a plane,' [Andre] Agassi explained during a break in the action at the Volvo/San Francisco tennis tournament, 'so the more you fly it, the more economic sense it makes . . . . The first flight after I bought it, I took some friends to Palm Springs for lunch.' " (Scott Ostler, "Andre Even Flies Like a Champ," *San Francisco Chronicle*, February 8, 1993, C1.) Discuss whether Agassi's statement is reasonable.

*1.4 A firm purchased copper pipes a few years ago at $10 per pipe and stored them, using them only as the need arose. The firm could sell its remaining pipes in the market at the current price of $9. What is the opportunity cost of each pipe, and what is the sunk cost?

1.5 Platinum Pipeline Inc. needs a Caterpillar D6T dozer to install water and sewer lines. How does its fixed cost change if it can rent a dozer rather than buy one? (*Hint*: See the Application "The Sharing Economy and the Short Run.")

1.6 Erik is under contract with a textbook publisher to provide interesting and current examples to reinforce key theoretical concepts. He makes €50 per hour for doing this work. Erik also wants to repaint a number of rooms in his house. A professional painter estimated the cost of this work to be €500 (including the paint) and guarantees it will be completed in eight hours. If Erik instead paints the rooms himself, he believes it would take him at least twice that long. What is Erik's opportunity cost of painting the rooms himself?

2. Short-Run Costs

2.1 Many corporations allow CEOs to use the firm's corporate jet for personal travel. 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 the least expensive, and the chartered flight is the most expensive.

   a. What factors (such as fuel) determine the marginal explicit cost to a corporation of an executive's personal flight? Do any 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?

2.2 During the Covid-19 pandemic, many supermarkets and stores, even small shops with no previous online presence, resorted to selling online to survive. Many of these stores continued marketing their online shopping options beyond the lockdowns as consumers found it more efficient to shop online. 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 travel and a variable cost that rises with the number of different types of items the consumer tries to buy. By shopping from various kinds of stores online, like clothing stores, supermarkets, and specialty foods shops, consumers can avoid some of the fixed transaction costs of traveling to those various stores, even after factoring in the shipping fees for online shopping. Use math or figures to explain why a shopper's average costs are lower when buying online than when actually traveling to the various physical stores. (*Hint*: Define the goods as the items purchased and shipped home.)

2.3 Using the information in Table 7.1, construct another table showing how a lump-sum franchise tax of $30 affects the various average cost curves of the firm.

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 was 5 pfennigs (Scherer, 2001).

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

   b. Is the cost of only one music publisher printing a given composition lower than if several firms print it? Why?

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

2.5 The only variable input a janitorial service firm uses to clean offices is workers who are paid a wage, w, of $8 an hour. Each worker can clean four offices in an hour. Use math to determine the variable cost, the average variable cost, and the marginal cost of cleaning one more office. Draw a diagram like Figure 7.1 to show the variable cost, average variable cost, and marginal cost curves. **A**

2.6 Give the formulas for and plot AFC, MC, AVC, and AC if the cost function is

   a. $C = 10 + 10q$.

   b. $C = 10 + q^2$.

   c. $C = 10 + 10q - 4q^2 + q^3$. **A**

2.7 Johannes works in a bicycle garage, where he fixes five bicycles per hour. He is paid €20 an hour for the first six hours he works and €30 an hour for each additional hour he works. If Johannes's wage is the garage's only variable cost, what is the garage's cost function? What are its AC, AVC, and MC functions? Draw the AC, AVC, and MC curves. **A**

2.8 A firm has the cost curve $C(q) = 100 + 150q - 46q^2 + 5q^3$. What are the equations of the firm's marginal cost, average variable cost, and average cost curves? What are the minimum values of marginal cost, average variable cost, and average cost, and at what levels of output do they occur? What is the value of marginal cost when average variable cost and average cost are at a minimum? **C**

2.9 A firm has two plants that produce identical output. The cost functions are $C_1 = 10q - 4q^2 + q^3$ and $C_2 = 10q - 2q^2 + q^3$.

a. At what output levels does the average cost curve of each plant reach its minimum?

b. If the firm wants to produce four units of output, how much should it produce in each plant? **C**

*2.10 A firm has the cost curve $C(q) = 25 + q^2$. Show how the firm's average cost varies with output. Is there a minimum average cost and, if so, at what level of output is average cost minimized?

2.11 A Chinese high technology manufacturing firm has a production function of $q = 10L^{0.28}K^{0.64}$ (based on Zhang et al., 2012). It faces factor prices of $w = 10$ and $r = 20$. What are its short-run marginal cost and average variable cost curves? (*Hint*: See Appendix 7B.) **A**

2.12 Suppose in Solved Problem 7.2 that the government charges the firm a franchise tax each year (instead of only once). Describe the effect of this tax on the marginal cost, average variable cost, short-run average cost, and long-run average cost curves.

2.13 In the Application "A Beer Manufacturer's Short-Run Cost Curves," the short-run variable cost function for Japanese beer is $VC = 0.55q^{1.67}$. 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? **A**

3. Long-Run Costs

3.1 A firm in Saudi Arabia uses capital and labor in its production process. The hourly cost of labor is SAR 30 and the initial rental rate of capital is SAR 60 per hour. What is the firm's isocost line? How does the slope of its isocost line change if the rental rate of capital falls to SAR 40 per hour? If the firm responds to the lower cost of capital by using three more units, how would it have to vary its labor input to keep its costs from changing?

*3.2 You have 60 minutes to take an exam with two questions. You want to maximize your score. Toward the end of the exam, the more time you spend on either question, the fewer extra points per minute you get for that question. How should you allocate your time between the two questions? (*Hint*: Think about producing an output of a score on the exam using

inputs of time spent on each of the problems. Then use Equation 7.8.)

*3.3 A bottling company uses two inputs to produce bottles of the soft drink Sludge: bottling machines (K) and workers (L). The isoquants have the usual smooth shape. The machine costs $1,000 per day to run. The workers earn $200 per day. At the current level of production, the marginal product of the machine is an additional 200 bottles per day, and the marginal product of labor is 50 more bottles 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: Equations 7.5 or 7.8. See Solved Problem 7.3.)

3.4 Use the tangency rule to determine the cost-minimizing bundles of labor and capital for a Japanese synthetic rubber firm's production function $q = L^{0.5}K^{0.5}$ (Flath, 2011) where $w = 10$ and $r = 10$. How does your answer change if $w = 20$ and $r = 10$? (*Hint*: See Solved Problem 7.3.)

3.5 Canada removed all duties and quotas on imports from Bangladesh in 2003. Since that time, Bangladesh has become the second largest source (after India) of Canadian merchandise imports from South Asia. Totaling over CAD 1 billion, the vast majority of these imports are garments and textile products. Low labor costs are a key attraction for Canadian retailers. Suppose the production function for a textile firm is $q = K^{0.5}L^{0.5}$. What would be the minimum cost of producing 1,000 units of output if the cost of capital is the same in Country 1 and Country 2 (that is, $r = ₹20,000$ per month in each), but the cost of labor in Country 1 is half of that in the other country (that is, $w_2 = 2w_1 = ₹10,000$ per month)? (*Hint*: See Solved Problem 7.3.) **A**

*3.6 A firm is looking to locate its production facilities in one of two countries. The wage rate in Country 1 is 10 and the cost of capital is also 10. The wage rate in Country 2 is 20% higher, but the rental rate of capital is 20% lower. The firm's production function is $q = K^{0.2}L^{0.8}$. How much capital and labor would the firm use to produce 100 units of output in each country, and what would be the total cost of production in each? (*Hint*: See Solved Problem 7.4.) **A**

*3.7 While processes differ somewhat among the three main manufacturers of cricket balls in international matches, all top-quality cricket balls are hand-crafted to exacting specifications and standards. Their cork cores are tightly wound with layers of yarn and covered with a leather case with a slightly raised seam that is hand stitched. Once finished, the balls are shaped, stamped, and polished. The labor required is highly skilled and a single craftsman can stitch up to eight cricket balls per day. The yarn used is high-quality linen. Alternatives to leather from cowhide have been tested but found to be of lesser quality. Given this information, what can you conclude about the production function for cricket balls? What is the cost function? (*Hint*: See Solved Problem 7.5.)

3.8 Governments may use, and have used, wage subsidies to reduce unemployment in times of economic recession. For example, from January to August 2009, Mexico provided wage subsidies to certain firms in eligible industries; they reduced work schedules rather than lay workers off in response to the fall in demand (Bruhn, 2016). The percentage of workers laid off had to be no more than one-third of the percentage drop in sales. The amount of the subsidy per worker was essentially MXN 110 per day to a maximum of MXN 5,100 every two months, adjusted by the firm's percentage decrease in sales and the percentage of workers retained. If a firm reduces its production in response to a fall in demand and the government covers 30% of the wage cost, what effect will this subsidy have on a cost-minimizing firm's choice of labor and capital to produce at the lower output level? Assume the firm has strictly convex isoquants and that labor and capital are normal inputs (that is, the use of each varies directly with the level of production).

3.9 A firm in the state of Karnataka in India can source one of its factors of production either within the state, F_K, or from the neighboring state of Maharashtra, F_M. Assume the quality and rental price of the input is identical in both states, $r = ₹1,000$ per hour, and there is no significant difference in the cost of transporting the input for use in the firm's production facilities. However, the rate of value-added tax in Karnataka is $t_K = 14.5\%$, while it is 2 percentage points lower in Maharashtra, $t_M = 12.5\%$. Use an isocost-isoquant diagram to explain how the cost-minimizing firm would likely respond to this tax rate differential.

3.10 The Bouncing Ball Ping Pong Co. sells table tennis sets that consist of two paddles and one net. What is the firm's long-run expansion path if it incurs no costs other than what it pays for paddles and nets, which it buys at market prices? How does its expansion path depend on the relative prices of paddles and nets? (*Hint*: See Solved Problem 7.5.)

3.11 A firm manufactures boxes of cereal using a fixed-proportion production function: One box and one unit (12 ounces) of cereal produce one box of cereal. What is the expansion path? What is the cost function? (*Hint*: See Solved Problem 7.5.)

*3.12 What is the long-run cost function if the production function is $q = L + K$?

3.13 Suppose that your firm's production function has constant returns to scale. What is the expansion path? (*Hint*: See Solved Problem 7.5.)

3.14 A firm's production function is $q = K^{0.4}L^{0.6}$. What is the firm's cost-minimizing input bundle when $w = 3$ and $r = 4$? Draw a diagram depicting the firm's long-run expansion path. What is the firm's long-run cost function, $C(q)$? **A**

3.15 See the Application "3D Printing." When fully incorporated by firms, how will 3D printing affect the shape of short-run and long-run cost curves?

3.16 Trader Joe's sells very cheap and popular wine produced by Bronco Wine.[6] When asked why the wine is so inexpensive, Bronco winemaker Ed Moody emphasizes the volume of output. He stated that it is easier to make wine "in a 700,000-gallon tank than . . . in a 700-gallon one because there is less exposure to air and oxygen is the enemy in wine-making." Wine educator Keith Wallace emphasizes the role of machines: "The company uses machines to harvest the grapes, which helps keep labor costs low, but also increases the chances that bad grapes end up in the wine." One of these reasons is based on choosing input proportions to minimize cost. The other is based on economies of scale. State which is which and explain.

4. Lower Costs in the Long Run

4.1 A U-shaped long-run average cost curve is the envelope of U-shaped short-run average cost curves. On what part of the short-run curve (downward sloping, flat, or upward sloping) does the short-run curve touch the long-run curve? (*Hint*: Your answer should depend on where on the long-run curve the two curves touch.)

---

[6]Hayley Peterson, "The Real Reasons Trader Joe's Wine Is So Cheap," *Business Insider*, May 6, 2017.

*4.2 If a firm's long-run average cost function is $AC(q) = 2/q$, what happens to average cost as q increases? What is this relationship between average cost and returns to scale called? If the firm also learns by doing, what happens to average cost as q increases? How would learning by doing be reflected in the average cost function? **A**

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

*4.4 Suppose that a firm's learning curve (that is, the relationship between its average cost, AC, and cumulative output, Q) is $AC = 10 + 2Q^a$, where $a \leq 0$. If $a = 0$ and cumulative output increases from 1 to 2,000 units, what can you say about average cost and the firm's ability to learn by doing? Would your answer change if $a = -0.5$? **A**

4.5 In the Application "Solar Power Learning Curves," the cost of solar power installations fell as the installed base (cumulative experience) in a given country rose. If N represents cumulative national experience, would the average cost curve $AC = a + bN^{-r}$, where a, b, and r are positive constants, exhibit such learning by doing? Explain. **A**

5. Cost of Producing Multiple Goods

5.1 What can you say about Laura's economies of scope if her time is valued at $10 an hour and her production possibility frontier is PPF^1 in Figure 7.12?

*5.2 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?

5.3 According to Haskel and Sadun (2012), 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. What implications would such a restriction on size have on a store's average costs? Discuss in terms of economies of scale and scope.

6. Challenge

*6.1 In the figure in the Challenge Solution, show that there are wage and cost of capital services such that 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 isocost lines?

6.2 The harvesting of many crops can be done manually or by using a combination of machinery and labor. Suppose that a crew of 15 workers using one machine produces as much output as a crew of 25 workers. If these two technologies are perfect substitutes, what is the equation of an isoquant? If the daily cost of the machine is 1,200 and the daily cost of one worker is 600, what is the equation of the isocost line for the unassisted crew and for the machine-assisted crew? Comparing the two isocost lines, which technology will a cost-minimizing firm use to harvest its crops? Draw a diagram showing the isoquants and isocost curves associated with 2.5 and 5 units of output per day.

7. 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 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

---

[7]The spreadsheet exercises in this chapter are based largely on the work of Satyajit Ghosh in cooperation with James A. Brander.