Chapter 5

The Demand for Labor

After reading this chapter, you should be able to:

1. **Explain the effects of the demand for labor being a derived demand.**
2. **Explain how a firm's short-run production function can be used to derive a demand curve for labor.**
3. **Contrast the labor demand curves of firms that operate in perfectly competitive versus imperfectly competitive output markets.**
4. **Discusses the differences between short-run and long-run labor demand.**
5. **Derive the market demand curve for labor from individual firm demands and explain why it is more inelastic than the simple summation of the labor demand curves of all firms in the market.**
6. **Identify and discuss the determinants of the elasticity of labor demand.**
7. **Identify and explain the determinants of the demand for labor.**
8. **Relate the concepts of labor demand to real-world applications.**

The previous three chapters have examined the supply of labor. In the present chapter, our attention shifts to the demand side of the labor market. Why do Microsoft, Micron, and Motorola wish to employ those willing to supply their particular labor services? How is Mattel's demand for labor affected by increases in the demand for the toys it produces? What factors alter Macy's and McDonald's demand for labor? Why might Monsanto adjust its level of employment more than Merck when wage rates change for a particular type of labor?

GP5.1

Answers to these and related questions motivate our discussion of labor demand. Then, in Chapter 6, we will combine our understanding of labor demand and labor supply to explain how wage rates are determined.

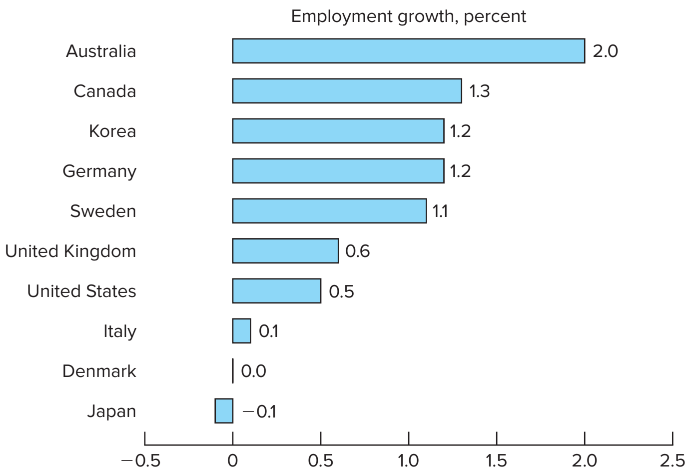
DERIVED DEMAND FOR LABOR

We should note at the outset that the demand for labor, or for any other productive resource, is a ***derived demand***. This means that the demand for labor depends on, or is derived from, the demand for the product or service it is helping to produce or provide. In manufacturing, labor is demanded for the contribution it makes to the

5.1 Global Perspective

Annual Net Employment Change as a Percentage of Total Employment

The United States had a relatively low rate of employment growth between 2003 and 2013.



Source: Organization for Economic Cooperation and Development **(www.oecd.org)**.

production of such products as automobiles, television sets, or loaves of bread. Thus, a decrease in the demand for automobiles will reduce the demand for automobile workers. In the service sector, labor is demanded by firms because it directly provides benefits to consumers. An increase in the demand for child care services, for example, will increase the derived demand for child care workers.

The fact that the demand for labor is a derived demand means that the strength of the demand for any particular type of labor will depend on (1) how productive that labor is in helping to create some product or service and (2) the market value of that item. If type A labor is highly productive in turning out product X, and if product X is highly valued by society, then a strong demand for type A labor will exist. Conversely, the demand will be weak for some kind of labor that is relatively unproductive in producing a good or service that is not of great value to society.

These observations point the way for our discussion. We will find that the immediate determinants of the demand for labor are labor's marginal productivity and the value (price) of its output. Let's begin by examining the short-run production function for a typical firm and then introduce the role of product price. Although our discussion will be cast in terms of a firm producing a particular good, the concepts developed apply equally to firms hiring workers to produce services.

A FIRM'S SHORT-RUN PRODUCTION FUNCTION

A ***production function*** is a relationship between quantities of resources (inputs) and the corresponding production outcomes (output). We will assume that the production process entails just two inputs—labor L and capital K. To simplify further, let's suppose that a single type of labor is being employed or, in other words, that the firm is hiring homogeneous inputs of labor. Furthermore, initially we examine the firm as it operates in the short run, *a period in which at least one resource is fixed*. In this case, the fixed resource is the firm's stock of capital—its plant, machinery, and other equipment. As shown in Equation (5.1),

$$TP_{SR} = f(L, \bar{K}) \tag{5.1}$$

the firm's total product in the short run (TP_{SR}) is a function of a variable input L (labor) and a fixed input K (capital).

Total, Marginal, and Average Product

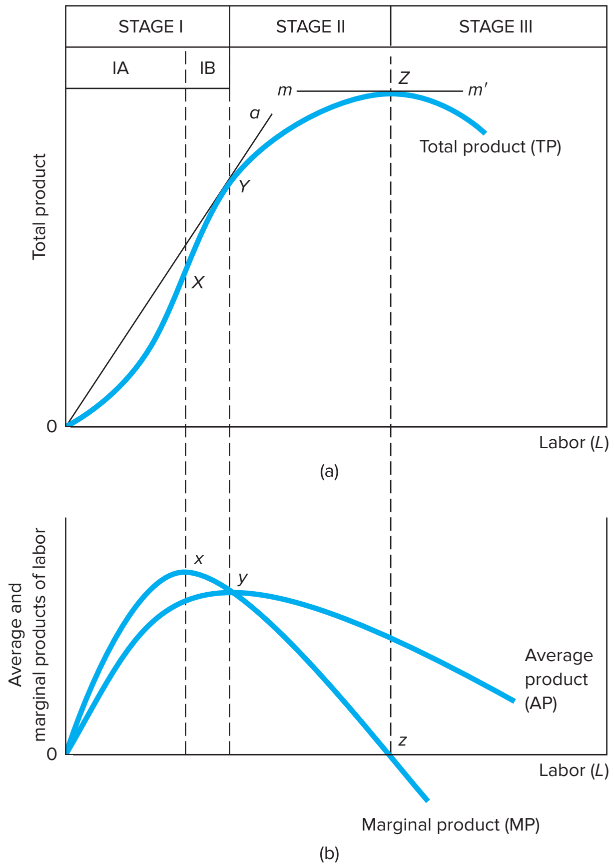
What happens to the total product (output) as successive inputs of labor are added to a fixed plant? The answer is provided in Figure 5.1, where the upper graph (a) shows a short-run production function or total product (TP) curve and the lower graph (b) displays the corresponding curves for the marginal product of labor (MP) and the average product of labor (AP).

In the short run, the ***total product*** (TP) shown in (a) is *the total output produced by each combination of the variable resource (labor) and the fixed amount of capital*. The ***marginal product*** (MP) of labor is *the change in total product associated with the addition of one more unit of labor*. It is the absolute change in TP and can be found by drawing a line tangent to the TP curve at any point and then determining the slope of that line. For example, notice line mm', which is drawn tangent to point Z on the TP curve. The slope of mm' is zero, and this is the marginal product MP as shown at point z on the MP curve in the lower graph. The ***average product*** (AP) of labor is *the total product divided by the number of labor units*. Geometrically, it is measured as the slope of any straight line drawn from the origin to or through any particular point on the TP curve. For example, observe line $0a$, which radiates from the origin through point Y on TP. The slope ($\Delta TP/\Delta L$) of $0a$ tells us the AP associated with this particular combination of TP and labor input L. For example, if TP were 20 at point Y, and L were 4, then AP would be 5 (= 20/4). This is the value of the slope of line $0a$, which as measured from the origin is the *vertical* rise (= 20) divided by the *horizontal* run (= 4). If we assume that labor units are labor hours, rather than workers, then this slope measures output per worker hour.

Stages of Production

The relationships between total, marginal, and average products are important. To show these relationships *and* to permit us later to isolate the region in which the firm will operate if it decides to do so, we have divided the total product curve (TP) into three stages, but we have also subdivided stage I into two parts. Over segment $0X$ of the TP curve—or stated alternatively, within part IA of stage I—the total product curve is increasing at an

FIGURE 5.1 A Firm's Short-Run Production Function
As labor is added to a fixed amount of capital, total product will eventually increase by diminishing amounts, reach a maximum, and then decline as shown in (a). Marginal products in (b) reflect the changes in total product associated with each additional input of labor. The relationship between marginal product and average product is such that MP intersects AP where AP is at its maximum. The *yz* segment of the MP curve in stage II is the basis for the short-run labor demand curve.



increasing rate. As observed in the lower graph, this implies that MP (= $\Delta TP/\Delta L$) necessarily is rising. For example, suppose the TPs associated with the first three workers were 3, 8, and 15, respectively. The corresponding MPs would be 3 (= 3 − 0), 5 (= 8 − 3), and 7 (= 15 − 8). Note, too, from the lower graph that because MP exceeds average product (AP), the latter also is rising. This is a matter of arithmetic necessity: Whenever a number that is greater than the average of some total is added to that total, the average must rise. In the present context, marginal product is the addition to total product while average product is the average of total product. Hence, when MP exceeds AP, AP must rise.[1]

[1] You raise your cumulative grade point average by earning grades in the most recent (marginal) semester that are higher than your current average.

Next observe segment XY—or stage IB—of the production function in Figure 5.1(a). The total product curve is now such that TP is still increasing as more workers are hired, but at a *decreasing* rate, and therefore MP [graph (b)] is declining. Notice that MP reached its maximum at point x in the lower graph and that this point corresponds to point X on the production function. But beyond points X and x, MP falls. We see, however, that even though MP is now falling, it still is above AP, and hence AP continues to rise. Finally, observe that the end of range IB of stage I is marked by the point at which AP is at its maximum and just equals MP (point y). The fact that AP is at a maximum at point Y on the TP curve is confirmed by ray $0a$. The slope of $0a$—which, remember, measures AP—is greater than would be the slope of any other straight line drawn between the origin and a specific point on the TP curve.

In stage II, later referred to as the *zone of production,* total product continues to rise at a diminishing rate. Consequently, MP continues to decline. But now AP also falls because MP finally is less than AP. Again, simple arithmetic tells us that when a number (MP) that is less than the current average of a total is added to that total (TP), the average (AP) must fall.

At the dividing line between stages II and III, TP reaches its maximum point Z and MP becomes zero (point z), indicating that beyond this point additional workers detract from total product. In stage III, TP falls and MP is therefore negative, the latter causing AP to continue to decline.

Law of Diminishing Marginal Returns

Why do TP, MP, and AP behave in the manner shown in Figure 5.1? Let's focus on marginal product, keeping in mind that changes in MP are related to changes in TP and AP. Why does MP rise, then fall, and eventually become negative? It is *not* because the quality of labor declines as more of it is hired; remember that all workers are assumed to be identical. Rather, the reason is that the fixed capital at first gets used increasingly productively as more workers are employed but eventually becomes more and more burdened. Imagine a firm that possesses a fixed amount of machinery and equipment. As this firm hires its initial workers, each worker will contribute more to output than the previous worker because the firm will be better able to use its machinery and equipment. Time will be saved because each worker can specialize in a task and will no longer have to scramble from one job operation to another. Successively greater increases in output will occur because the new workers will permit capital equipment to be used more intensively during the day. Thus, for a time the added, or marginal, product of extra workers will rise.

These increases in marginal product cannot be realized indefinitely. As still more labor is added to the fixed machinery and equipment, the **law of diminishing marginal returns** will take hold. This law states that *as successive units of a variable resource (labor) are added to a fixed resource (capital), beyond some point the marginal product attributable to each additional unit of the variable resource will decline*. At some point, labor will become so abundant relative to the fixed capital that additional workers cannot add as much to output as did previous workers. For example, an added worker may have to wait in line to use the machines. At the extreme, the

TABLE 5.1 **Production Function Variables: A Summar**

	Stage		Total Product, TP_L	Marginal Product, MP_L	Average Product, AP_L
	Stage I	IA	Increasing at an increasing rate	Increasing and greater than AP	Increasing
		IB	Increasing at a decreasing rate	Declining but greater than AP	Increasing
Zone of Production	Stage II		Increasing at a decreasing rate	Declining and less than AP	Declining
	Stage III		Declining	Negative and less than AP	Declining

continuous addition of labor will so overcrowd the plant that the marginal product of still more labor will become negative, reducing total product (stage III).

Zone of Production

The characteristics of TP, MP, and AP discussed in Figure 5.1 are summarized in Table 5.1. In reviewing this table, notice that stage II of the production function is designated as the ***zone of production***. To see why, let's establish that the left boundary of stage II in Figure 5.1 is where the efficiency of labor—as measured by its average product—is at a maximum. Similarly, the right boundary is where the efficiency of the fixed resource capital is maximized. Notice first that at point Y on TP and y on AP and MP, total product *per unit of labor* is at its maximum. This is shown both by ray $0a$, which is the steepest line that can be drawn from the origin to any point on TP, and by the AP curve, because AP *is* TP/L. Next, note that at point Z on TP and z on MP, total product is at a maximum. Because capital (K) is fixed, this implies that the average product of K is also at a maximum. That is, total product *per unit of capital* is greater at the right boundary of stage II than at any other point. The generalization here is that if a firm chooses to operate, *it will want to produce at a level of output where changes in labor contribute to increasing efficiency of either labor or capital.*[2]

This is *not* the case in either stage I or III. In stage I, additions to labor *increase* both the efficiency of labor *and* the efficiency of capital. The former can easily be seen by the rising AP curve; the latter is true because capital is constant and TP is rising, thereby increasing the average product of capital (= TP/K). The firm therefore will desire to move at least to the left boundary of stage II.

[2] This generalization applies only to a competitive firm. For an imperfectly competitive firm such as a monopoly, *only* stage III is necessarily a non-profit-maximizing area. In maximizing profits, a monopolist may restrict output and therefore employment to some point in stage I.

What about stage III? Inspection of Figure 5.1(a) and (b) shows that the addition of labor *reduces* the efficiency of *both* labor and capital. Notice that the average product of labor is falling. Also, because there is less total product than before, the TP/K ratio is declining. Stated differently, the firm will not operate in stage III because it can *add* to the efficiency of labor and capital and to its total product by *reducing* employment.

Conclusion? The profit-maximizing or loss-minimizing firm that chooses to operate will face a marginal product curve indicated by line segment *yz* in Figure 5.1(b). *This MP curve is the underlying basis for the firm's short-run demand for labor curve.*

SHORT-RUN DEMAND FOR LABOR: THE PERFECTLY COMPETITIVE SELLER

To see how segment *yz* in Figure 5.1(b) relates to labor demand, let's next (1) transform the TP and MP information in that figure to hypothetical numbers via a table and (2) convert our analysis from output to monetary terms. Employers, after all, decide how many workers to hire in terms of *revenues* and *costs* rather than in output terms.

Consider Table 5.2. Columns 1 to 3 are merely numerical illustrations of the relationships within the zone of production, showing total and marginal product but omitting average product. To simplify, we have identified only the range of labor inputs over which diminishing marginal productivity sets in. Recalling our earlier discussion of the demand for labor as a derived demand, note that column 4 shows the price of the product that is being produced. The fact that this $2 price does not decline as more output is produced and sold indicates that the firm is selling its output in a perfectly competitive market. In technical terms, the firm's *product* demand curve is perfectly elastic; the firm is a "price taker." For example, this firm may be selling standardized products such as grain or fresh fish.

Multiplying column 2 by column 4, we obtain total revenue (sometimes called *total revenue product*) in column 5. From these total revenue data, we can easily compute ***marginal revenue product*** (MRP), which is *the increase (change) in total revenue resulting from the employment of each additional labor unit*. These figures are shown in column 6. The MRP schedule shown by columns 1 and 6 is strictly proportional to the MP schedule, shown by columns 1 and 3. In this case, MRP is *twice* as large as MP because price is $2.

TABLE 5.2
Demand for Labor: Firm Selling in a Perfectly Competitive Product Market (Hypothetical Data)

(1) Units of Labor, L	(2) TP	(3) MP	(4) Product Price, P	(5) Total Revenue, TR	(6) MRP (ΔTR/ΔL)	(7) VMP (MP $\times$ P)
4	15		$2	$30		
5	27	12	2	54	$24	$24
6	36	9	2	72	18	18
7	42	6	2	84	12	12
8	45	3	2	90	6	6
9	46	1	2	92	2	2

Columns 1 and 6—the MRP schedule—constitute the firm's ***short-run labor demand curve***. To justify and explain this assertion, we must first understand the rule that a profit-maximizing firm will apply in determining the number of workers to employ. *A profit-maximizing employer should hire workers so long as each successive worker adds more to the firm's total revenue than to its total cost*. We have just noted that the amount that each successive unit of labor adds to total revenue is measured by MRP. The amount that a worker adds to total costs is measured by ***marginal wage cost*** (MWC), defined as *the change in total wage cost resulting from the employment of one more labor unit*. Thus, we can abbreviate our rule by saying that the profit-maximizing firm should hire units of labor up to the point at which MRP = MWC.[3] If at some level of employment MRP exceeds MWC, it will be profitable to employ more labor. If for some level of employment MWC exceeds MRP, the firm will increase its profits by hiring less labor.

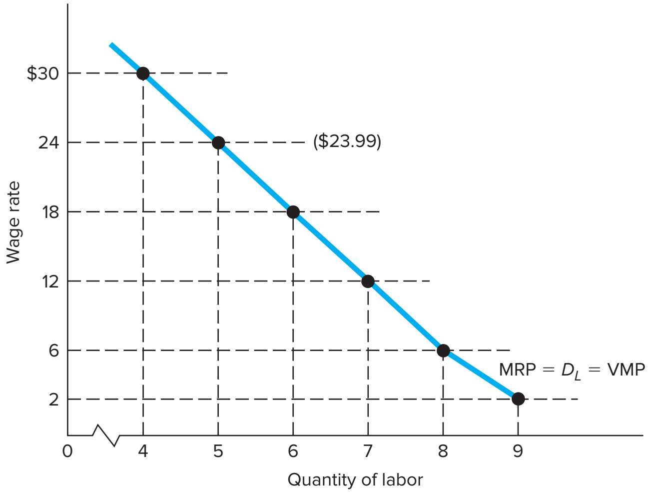
Let's now assume that the employer for whom Table 5.2 is relevant is hiring labor under purely competitive conditions. This means the firm is a "wage taker" in that it employs a negligible portion of the total labor supply and therefore exerts no perceptible influence on the wage rate. Perhaps this is a fish-processing firm that is hiring people to clean fish. The market wage rate is "given" to the employer, and it follows that the total wage cost (the wage bill) increases by the amount of the wage rate W for each additional unit of labor hired. In other words, the wage rate and the marginal wage cost are equal. We can thus modify our MRP = MWC rule for the firm hiring competitively and restate it as the MRP = W rule. The profit-maximizing firm that is a perfectly competitive employer of labor should employ units of labor up to the point at which marginal revenue product MRP equals the wage rate W.

We now can apply the MRP = W rule to demonstrate our earlier assertion: The MRP schedule shown in columns 1 and 6, derived directly from the MRP data from the zone of production, *is* the firm's short-run labor demand curve. The MRP data from columns 1 and 6 are graphed in Figure 5.2 to demonstrate this point. This schedule and curve indicate the amount of labor this firm would demand at several separate competitively determined wage rates. First let's suppose that the wage rate is \$23.99, an amount infinitesimally less than \$24. This firm will decide to employ five units of labor because it either adds to profits or subtracts from losses by hiring these units of labor. But the firm will not employ the sixth, seventh, and further units because MRP < W for each of them.

Next, suppose that the wage rate falls to \$11.99. The MRP = W rule indicates that the firm will now also hire the sixth and seventh units of labor. If the wage rate falls further to, say, \$1.99, it will employ nine units of labor. We conclude then that *the MRP curve in Figure 5.2 is the firm's short-run labor demand curve* because each point on it indicates the quantity of labor that a firm will demand at each possible wage rate. Any curve that embodies this information on wage rate and quantity of labor demanded is, by definition, the firm's labor demand curve.

[3] The rationale for this rule is the same as that for the marginal revenue equals marginal cost (MR = MC) rule, which identifies the profit-maximizing output in the product market. The difference is that the MRP = MWC rule is in terms of *inputs* of labor, whereas the MR = MC rule is in terms of *outputs* of product.

FIGURE 5.2 The Labor Demand Curve of a Perfectly Competitive Seller
Application of the MRP = W rule reveals that the MRP curve is the firm's short-run labor demand curve. Under perfect competition in the product market, MRP = VMP and the labor demand curve slopes downward solely because of diminishing marginal productivity.



One further point needs to be made: Where there is perfect competition in the product market, a firm's marginal revenue product or labor demand curve is also the ***value of marginal product*** (VMP) curve. *The value of marginal product is the extra output in dollar terms that accrues to society when an extra unit of labor is employed.* Columns 1 and 7 in Table 5.2 show the VMP schedule in our example. Notice that VMP is determined by multiplying marginal product MP (column 3) by the product price (column 4). We observe in this case that VMP, the value of the marginal product, is identical to MRP, the extra revenue accruing to the firm when it adds a unit of labor (column 6). For this reason, we label the demand for labor curve in Figure 5.2 as VMP, as well as MRP.

What is the logic underlying the equality of VMP and MRP when perfect competition prevails in the product market? Because the competitive firm is a price taker, it can sell as many units of output as it desires at the market price (= $2). The sale of *each* additional unit of the product adds the product price (= $2) to the firm's total revenue; therefore, the seller's *marginal revenue* (MR) is constant and is equal to the product price. In this situation, the extra *revenue* to the firm from employing an additional labor unit (= MR × MP) equals the social *value* of the extra output (= P × MP) contributed by that unit of labor.

SHORT-RUN DEMAND FOR LABOR: THE IMPERFECTLY COMPETITIVE SELLER

Most firms in our economy do *not* sell their products in purely competitive markets; rather, they sell under imperfectly competitive conditions. That is, the firms are monopolies, oligopolies, or monopolistically competitive sellers. When a firm can set its price—rather than being forced to accept a market-determined price—it has some monopoly power.

The change in assumptions about product market conditions from pure competition to imperfect competition alters our analysis in an important way. Because of product uniqueness or differentiation, the imperfectly competitive seller's product demand curve is downward-sloping rather than perfectly elastic. This means the firm must lower its price to sell the output contributed by each successive worker. Furthermore, because we assume that the firm cannot engage in price discrimination, it must lower the price not only on the last unit produced but also on all other units, which otherwise would have commanded a higher price. The sale of an extra unit of output therefore does *not* add its full price to the firm's marginal revenue, as it does in perfect competition. To obtain the marginal revenue for the imperfectly competitive seller, one must subtract the potential revenue lost on the other units from the new revenue gained from the last unit. Because marginal revenue is less than the product price, the imperfectly competitive seller's marginal revenue product (= MR × MP) is less than that of the perfectly competitive seller (= P × MP). Recall that the perfectly competitive firm suffers no decline in marginal revenue as it sells the extra output of added workers.

Thus, the MRP or labor demand curve of the purely competitive seller falls for a *single* reason—marginal product diminishes as more units of labor are employed. But the MRP or labor demand curve of the imperfectly competitive seller declines for *two* reasons—marginal product falls as more units of labor are employed *and* product price declines as output increases. Table 5.3 takes this second consideration into account. The production data of columns 1 to 3 are precisely the same as in Table 5.2, but in column 4, we recognize that product price must drop to sell the marginal product of each successive worker.

It is worth reemphasizing that the lower price accompanying each increase in output applies not only to the output produced by each additional worker but also to all prior units that otherwise could have been sold at a higher price. For example, the fifth worker's marginal product is 12 units, and these 12 units can be sold for \$2.40 each or, as a group, for \$28.80. This is the value of the marginal product (VMP) of labor—that is, the value of the added output from society's perspective (column 7). But the MRP of the fifth worker is only \$25.80. Why the \$3.00 difference?

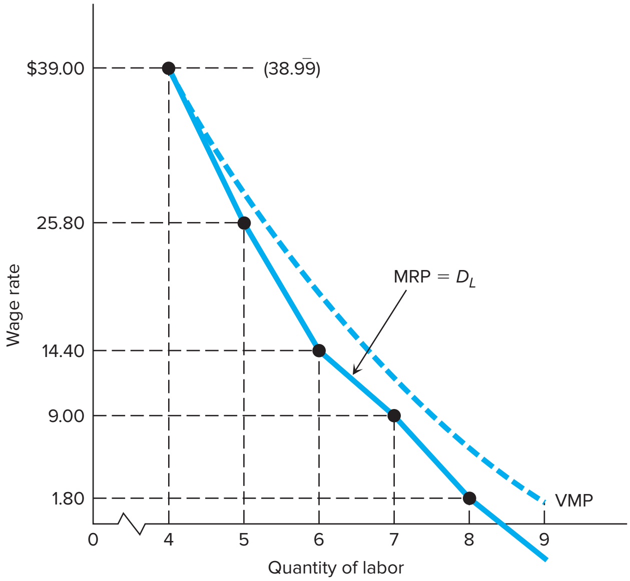
TABLE 5.3 Demand for Labor: Firm Selling in an Imperfectly Competitive Product Market (Hypothetical Data)

(1) Units of Labor, *L*	(2) TP	(3) MP	(4) Product Price, *P*	(5) Total Revenue, TR	(6) MRP ($\Delta TR/\Delta L$)	(7) VMP (MP × *P*)
4	15		\$2.60	\$39.00		
5	27	12	2.40	64.80	\$25.80	\$28.80
6	36	9	2.20	79.20	14.40	19.80
7	42	6	2.10	88.20	9.00	12.60
8	45	3	2.00	90.00	1.80	6.00
9	46	1	1.90	87.40	-2.60	1.90

To sell the 12 units associated with the fifth worker, the firm must accept a $.20 price cut on *each* of the 15 units produced by the previous workers—units that could have been sold for $2.60 each. Thus, the MRP of the fifth worker is only $25.80 [= $28.80 – (15 × $.20)]. Similarly, the sixth worker's MRP is only $14.40. Although the 9 units produced are worth $2.20 each in the market and therefore their VMP is $19.80, the worker does *not* add $19.80 to the firm's total revenue when account is taken of the $.20 price cut on the 27 units produced by the previous workers. Specifically, the sixth worker's MRP is $14.40 [= $19.80 – (27 × $.20)]. The other MRP figures in column 6 of Table 5.3 are similarly explained. Comparison of columns 6 and 7 reveals that at each level of employment, VMP (the value of the extra product to buyers) exceeds MRP (the extra revenue to the firm). The efficiency implications of this difference will be examined in Chapter 6.

As in the case of the purely competitive seller, application of the MRP = *W* rule to the MRP curve will yield the conclusion that the MRP curve *is* the firm's labor demand curve. However, by plotting the imperfectly competitive seller's MRP or labor demand curve D_L in Figure 5.3 and comparing it with the demand curve in Figure 5.2, we find visual support for an important generalization: *All else being equal, the imperfectly competitive seller's labor demand curve is less elastic than that of the purely competitive seller*. It is not surprising that a firm that possesses monopoly

FIGURE 5.3 The Labor Demand for an Imperfectly Competitive Seller
Under imperfect competition in the product market, the firm's demand curve will slope downward because marginal product diminishes as more units of labor are employed *and* because the firm must reduce the product price on all units of output as more output is produced. Also, the MRP (= MR × MP) for the imperfect competitor is less than the VMP (= *P* × MP) at all levels of employment beyond the first unit.



power is less responsive to wage rate changes than a purely competitive seller. The tendency for the imperfectly competitive seller to add fewer workers as the wage rate declines is merely the labor market reflection of the firm's restriction of output in the product market. Other things being equal, the seller possessing monopoly power will find it profitable to produce less output than it would in a purely competitive industry. In producing this smaller output, the seller with monopoly power will employ fewer workers.

Finally, notice that the VMP schedule that is also plotted in Figure 5.3 lies to the right of the firm's D_L = MRP curve. This visually depicts our previous conclusion: The marginal revenue accruing to an imperfectly competitive seller from hiring an additional unit of labor is less than the market value of the extra output the unit of labor helps produce [(MRP = MR × MP) < (VMP = P × MP)].

5.1 *Quick Review*

- The demand for labor is derived from the demand for the product or service that it helps produce.
- As labor is added to a fixed amount of capital, the total product of labor first increases at an increasing rate, then increases at a diminishing rate, and then declines; this implies that the marginal product of labor first rises, then falls, and finally becomes negative.
- Because a perfectly competitive firm will hire employees up to where WR = MRP, the MRP curve is the firm's labor demand curve.
- The labor demand curve for an imperfectly competitive seller will not be as strong as for a perfectly competitive seller because the former must lower its product price on all units of output as more output is produced (MR < P).

Your Turn

Assume labor is the only variable input and that an additional unit of labor increases total output from 65 to 73 units. If the product sells for $4 per unit in a perfectly competitive market, what is the MRP of this additional worker? Would the MRP be higher or lower than this amount if the firm were a monopolist and had to lower its price to sell all 73 units? (*Answer:* See page 599.)

THE LONG-RUN DEMAND FOR LABOR[4]

Thus far, we have derived and discussed the firm's short-run production function [Equation (5.1)] and demand for labor, which presuppose that labor is a variable input and that the amount of capital is fixed. We now turn to the long-run production

[4] We provide a more advanced derivation of the long-run demand for labor curve in the appendix of this chapter. There, and in the discussion that follows, we ignore the long-run "profit-maximizing effect" of a wage rate change. For simplicity, we focus on the short-run output effect and the long-run substitution effect.

relationship shown in Equation (5.2), where we find that *both* labor and capital are variable. Once again, we assume that L and K are the only two inputs and that labor is homogeneous.

$$TP_{LR} = f(L, K) \tag{5.2}$$

The **long-run demand for labor** is *a schedule or curve indicating the amount of labor that firms will employ at each possible wage rate when both labor and capital are variable*. The long-run labor demand curve declines because a wage change produces a short-run output effect and a long-run substitution effect, which together alter the firm's optimal level of employment.

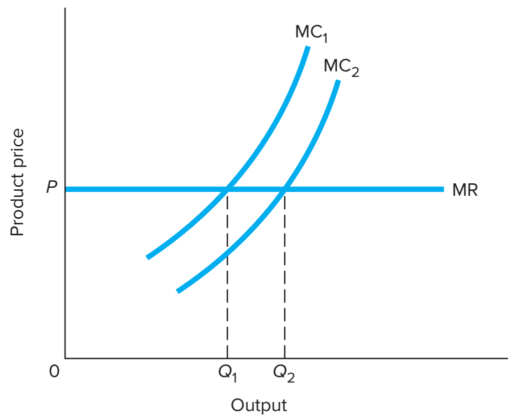
Output Effect

As it relates to labor demand, the **output effect** (also called the *scale effect*) is *the change in employment resulting solely from the effect of a wage change on the employer's costs of production*. This effect is present in the short run and is demonstrated in Figure 5.4. Under normal circumstances, a decline in the wage rate shifts a firm's marginal cost curve downward, as from MC_1 to MC_2. That is, the firm can produce any additional unit of output at less cost than before. The reduced marginal cost (MC_2) relative to the firm's marginal revenue (MR) means that marginal revenue now exceeds marginal costs for each of the Q_1 to Q_2 units. Adhering to the MR = MC profit-maximizing rule, the firm will now find it profitable to increase its output from Q_1 to Q_2. To accomplish this, it will wish to expand its employment of labor.

Substitution Effect

As it relates to long-run labor demand, the **substitution effect** is *the change in employment resulting solely from a change in the relative price of labor, output being held constant*. In the short run, capital is fixed, and therefore substitution in production

FIGURE 5.4 The Output Effect of a Wage Rate Decline
All else being equal, a decline in the wage rate will reduce marginal cost (from MC_1 to MC_2) and increase the profit-maximizing level (MR = MC) of output (from Q_1 to Q_2). To produce the extra output, the firm will wish to employ more labor.



5.1 World of Work

Has Health Care Reform Increased Involuntary Part-Time Work?*

When enacted in 2010, the Patient Protection and Affordable Care Act (PPACA) required that firms with 50 or more employees provide health insurance for their full-time workers or be subjected to penalties beginning in 2014. Although the implementation date was later delayed until 2015 or 2016 depending on firm size, there is evidence that employers were making adjustments to the costs associated with the PPACA as early as 2012.

One way firms can avoid the penalties contained in the PPACA is to provide health insurance to their full-time workers. However, providing health insurance coverage is costly and employers have an incentive to shift this cost to their employees by requiring worker contributions or reducing wages. These approaches are less effective for low-wage workers since the PPACA limits how much low wage workers can be required to contribute to the cost of health insurance and the minimum wage may prevent firms to completely passing on the cost to workers through wage reductions. Thus, employers have an incentive to find an alternative method to avoid the insurance coverage requirement particularly for low-wage employees. One such way to avoid the penalty and the cost of providing health coverage is to shift from full-time to part-time (<30 hours per week) workers. A failure to provide part-time workers with coverage does not result in a penalty.

Even and Macpherson examine the impact of the PPACA on the share of workers who are involuntarily part-time. They define affected workers as those who worked 30 or more hours per week without employer-provided health insurance at a firm with 100 or more workers. They report that as the share of those affected by the PPACA increased in an occupation, the share of workers who are part-time as well as involuntary part-time also rose after 2010. Their estimates indicate that in 2014 about one million additional workers were involuntarily employed part-time instead of full-time as a result of the PPACA. Over 85 percent of these additional involuntary part-time workers were lower-wage workers since they had less than a college degree.

* William E. Even and David A. Macpherson, "The Affordable Care Act and the Growth of Involuntary Part-Time Employment," IZA Discussion Paper 9324, September 2015.

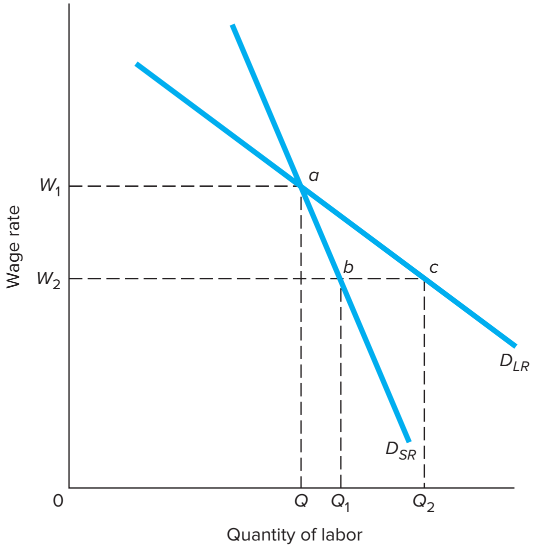
between labor and capital *cannot* occur. In the long run, however, the firm can respond to a wage reduction by substituting the relatively less expensive labor in the production process for some types of capital. This fact means that the long-run response to a wage change will be greater than the short-run response. In other words, the long-run demand for labor will be more elastic than the short-run demand curve.

WW5.1

The Combined Effects

In Figure 5.5 we use these ideas to depict a long-run labor demand curve D_{LR}. Initially, suppose that the firm faces the short-run labor demand curve D_{SR} and also that the initial equilibrium wage rate and equilibrium quantity of labor are W_1 and Q as shown by point *a*. Now suppose that the wage rate declines from W_1 to W_2, resulting in an *output effect* that increases employment to Q_1 at *b*. In the long run, however, capital is variable, and therefore, a *substitution effect* also occurs that further increases the quantity of labor employed to Q_2 at point *c*. Although the short-run adjustment is from *a* to *b*, the additional long-run adjustment is from *b* to *c*. The locus of the long-run adjustment points *a* and *c* determines the location of the *long-run* demand for labor curve. As observed in Figure 5.5, the long-run curve D_{LR} is more elastic than the short-run labor demand curve.

FIGURE 5.5 The Long-Run Labor Demand Curve
A wage reduction from W_1 to W_2 increases the equilibrium short-run quantity of labor from Q to Q_1 *(output effect)*. In the long run, however, the firm also substitutes labor for capital, resulting in a *substitution effect* of $Q_1 Q_2$. The long-run labor demand curve, therefore, results from both effects and is found by connecting points such as *a* and *c*.



Other Factors

Several other factors tend to make a firm's long-run labor demand curve more elastic than its short-run curve. Three such factors in particular deserve mention.

1 Product Demand

As we will explain shortly in our discussion of the determinants of the elasticity of labor demand, *product demand* is more elastic in the long run than in the short run, making the demand for labor more elastic over longer periods. Other things being equal, the greater the consumer response to a product price change, the greater the firm's employment response to a wage rate change.

2 Labor–Capital Interactions

Under production conditions described as "normal," a change in the quantity of one factor causes the marginal product of another factor to change in the same direction. This idea relates to the demand for labor as follows. Let's again assume that the wage rate for a particular type of labor falls, causing the quantity of labor demanded in the short run to rise. This increase in the quantity of labor itself becomes important to the long-run adjustment process: It increases the marginal product and hence the MRP of capital. Just as the MRP of labor *is* the firm's short-run demand for labor, the MRP of capital *is* the firm's short-run demand for capital (labor being constant). Given the price of capital, we would therefore expect more capital to be employed, which in turn will increase the marginal product and demand for labor. Thus, the long-run employment response resulting from the wage decrease will be greater than the short-run response.

3 Technology

In the long run, the technology implicitly assumed constant when we constructed our short-run production function can be expected to change in response to major, permanent movements in relative factor prices. Investors and entrepreneurs direct their greatest effort toward discovering and implementing new technologies that reduce the need for relatively higher-priced inputs. When the price of labor falls relative to the price of capital, these efforts get channeled toward technologies that economize on the use of capital and that increase the use of labor. The long-run response to the wage rate decline therefore exceeds the short-run response.

Here's an important point: We have cast our entire discussion of the downward-sloping long-run labor demand curve in terms of a wage *decline*. You are urged to reinforce the conclusion that labor demand is more elastic in the long run than in the short run by analyzing the short- versus long-run effects of an *increase* in the wage rate.

WW5.2

THE MARKET DEMAND FOR LABOR

We have now demonstrated that the MRP curve derives from the MP curve in the firm's zone of production and *is* the firm's short-run demand curve for labor. We also have established that a firm's long-run demand for labor is more elastic than its short-run demand. Let's next turn our attention to the market demand for labor. At first thought, we might reason that the total or ***market demand for labor*** of a particular type can be determined by simply summing (horizontally on a graph) the labor demand curves of all firms that employ this kind of labor. Thus if there were, say, 200 firms with labor demand curves identical to the firm portrayed in Table 5.2, we would simply multiply the amounts of labor demanded at the various wage rates by 200 and thereby determine the market demand curve. However, this simple process ignores an important aggregation problem. The problem arises because certain magnitudes (such as product price), which are correctly viewed as constant from the vantage point of the *individual firm*, must be treated as variable from the standpoint of the *entire market*.

To illustrate, let's suppose there are, say, 200 competitive firms, each with a labor demand curve identical to that shown earlier in Figure 5.2. Assume also that these firms are all producing a given product that they are selling in competition with one another. From the perspective of the *individual firm*, when the wage rate declines, the use of more labor will result in a *negligible* increase in the market supply of the product and, therefore, no change in product price. But because *all firms* experience the lower wage rate and respond by hiring more workers and increasing their outputs, there will be a *substantial* increase in the supply of the product. This change in supply will reduce the product price. This point is critical because, as we showed earlier in Table 5.2, product price is a determinant of each firm's labor demand curve.

5.2 World of Work

Why Has Manufacturing Employment Fallen?

Recently there has been increasing concern about the dramatic drop in U.S. manufacturing employment. In 2014, 9 percent of workers were employed in manufacturing, down from 31 percent in 1950. The number of manufacturing workers declined from 18.7 million in 1980 to 12.2 million in 2014.

There are four reasons for the decrease in manufacturing employment. First, consumer spending, in the United States as well as other industrialized countries, has shifted away from manufactured goods. In 2014, 33 percent of U.S. consumer spending was on goods. The corresponding figures for 1979 and 1950 were 53 percent and 67 percent. The likely reasons behind this shift are the rise in real wages and labor force participation of married women, which caused households to substitute purchased services for tasks previously done at home.

Second, U.S. manufacturing firms have been investing in more and higher-quality capital equipment to keep competitive in global markets. This investment has permitted them to increase their output and at the same time use fewer workers. Since 1979, the productivity of manufacturing workers has been rising at an annual rate of 3.2 percent, which is much greater than the 1.9 percent annual increase for overall nonfarm labor productivity.

Third, the expansion of international trade has changed the mix of goods produced in the United States. Gains from trade occur when countries specialize in goods they can produce more efficiently relative to other nations. The United States has specialized in goods that are produced using relatively more capital and skilled workers than other countries. As a result, employment has fallen in industries, such as apparel, that are labor-intensive and use less skilled workers.

Finally, U.S. manufacturers have increasingly used workers from temporary help agencies to handle short-term fluctuations in demand rather than hire permanent workers. These temporary workers are counted as service workers, not manufacturing workers. Also, manufacturing firms have hired service companies to provide support functions such as janitorial and payroll processing.

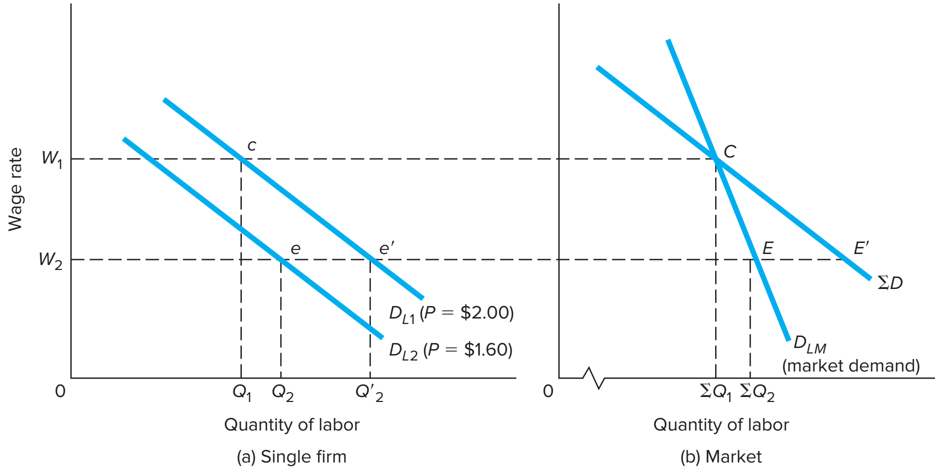
Sources: Congressional Budget Office, "What Accounts for the Decline in Manufacturing Employment?" Economic and Budget Issue Brief, February 18, 2004; and Congressional Budget Office, "Factors Underlying the Decline in Manufacturing Employment Since 2000" Economic and Budget Issue Brief, December 23, 2008. Updated statistics from **http://www.bls.gov** and **http://www.bea.gov.**

Specifically, a lower product price will reduce MRP and shift the labor demand curve of each firm to the left. This implies that the market demand for labor is in fact *less elastic* than that yielded by a simple summation of each firm's labor demand curve.[5]

Consider Figure 5.6, in which the diagram on the left (a) shows labor demand for one of the 200 firms and the diagram on the right (b) shows the market demand for labor. The individual firm is initially in equilibrium at point c, where the wage rate is W_1 and employment is Q_1. The labor demand curve D_{L1} is based on a product price of \$2.00, as shown in column 4 of Table 5.2. If the wage rate falls to W_2, ceteris paribus (other things being equal), the firm would now find it profitable to

[5] If *all* employers are monopolists in their distinct product markets, our conclusion does not hold. As pointed out in the discussion of Figure 5.3, the monopolist's labor demand curve already incorporates the declines in product price that accompany output increases. Thus to get the market labor demand curve, one can sum the labor demand curves of the monopolists.

FIGURE 5.6 The Market Demand Curve for Labor
The market demand curve for labor is less elastic than the simple horizontal summation of the labor demand curves of the individual employers. A lower wage induces all firms to hire more labor and produce more output, causing the supply of the product to increase. The resulting decline in product price shifts the firms' labor demand curves to the left. Consequently, total employment rises from C to E in graph (b), rather than from C to E'.



move to a new equilibrium at e', where it would hire Q'_2, workers. But our ceteris paribus assumption does *not* hold in the context of a number of firms that are hiring this kind of labor to produce the same product. The lower wage induces *all* of the firms to hire more labor. This increases output or product supply, which then reduces product price. This lower price—say \$1.60 as compared to the original \$2.00—feeds back to the labor demand curve for each firm, shifting those curves leftward as indicated by the move from D_{L1} to D_{L2} in Figure 5.6(a). In effect, each firm then recalculates its MRP or labor demand using the new lower price. Thus, each firm achieves equilibrium at point e by hiring only Q_2, as opposed to Q'_2, workers at the wage rate W_2. The market labor demand curve in Figure 5.6(b) is therefore *not* curve CE', the simple horizontal summation of the demand for labor curves for all 200 firms. Rather, it is the horizontal summation of all quantities, such as Q_1 at wage rate W_1 on D_{L1}, *and* the summation of all quantities, such as Q_2 at wage rate W_2, that fall on the "price-adjusted" market demand curve that cuts through points CE in Figure 5.6(b). As shown there, the correct price-adjusted market demand curve CE is less elastic than the incorrect "simple summation" CE' curve.

5.2 *Quick Review*

- The long-run demand curve for labor is more elastic than the short-run curve because in the long run there are both output and substitution effects; only an output effect occurs in the short run.
- The output effect of a wage rate change is the change in employment resulting from a change in the employer's costs of production; the substitution effect is the employment change caused by the altered price of labor relative to the price of capital.

- The market demand curve for labor is less elastic than the simple summation of the labor demand curves of individual employers; by inducing all firms to hire more labor and produce more output, the lower wage increases product supply, reduces product price, and lowers each firm's MRP.

Your Turn

WW5.3

In 2009, the United Automobile Workers reduced wage rates in the American auto industry. Referring to the output and substitution effects, explain how these lower wages might have contributed to the rebound in auto employment experienced by General Motors, Ford, and Chrysler since 2010. (*Answer:* See page 599.)

5.3 World of Work

Comparative Advantage and the Demand for Labor

As it applies to international trade, the principle of comparative advantage states that total output will be greatest when each good is produced by the nation with the lower opportunity cost. For example, suppose that in the United States 15 units of chemicals must be sacrificed to produce 1 unit of raincoats, whereas in South Korea 10 units of chemicals must be sacrificed for each unit of raincoats. The opportunity cost of a unit of raincoats in South Korea thus is lower (= 10 units of chemicals) than it is in the United States (= 15 units of chemicals). South Korea, therefore, should specialize in raincoats. Similarly, the United States should specialize in producing chemicals because it has lower opportunity costs (= 1/15 raincoat) than South Korea (= 1/10 raincoat). South Korea will specialize in raincoats and trade them for chemicals; the United States will specialize in chemicals and trade them for raincoats.

How will this specialization and trade affect labor demand in the United States and South Korea? Most obviously, the demand for workers employed in chemical production will rise in the United States, and the demand for workers who produce raincoats will fall. The opposite outcomes will occur in South Korea. Because international trade causes both positive and negative shifts in the demand for labor, the impact on the total demand for labor in each country is uncertain.

It is clear, however, that specialization will increase the total output available in the two nations. Specialization promotes the expansion of relatively efficient industries that have a comparative advantage and indirectly causes the contraction of relatively inefficient industries. This means that specialization shifts resources—including labor—toward more productive uses. If the total number of workers remains constant in each nation, each worker on average will be able to buy more output. That is, either wages will rise or the prices of goods will fall so that real earnings (= nominal earnings/price level) will increase.

It is important to note that comparative advantage, not differences in wage rates between two nations, drives international trade. Low wage rates in South Korea do *not* give it a special international advantage. High American wage rates do *not* condemn the United States to be a net importer of goods. Even if low wages in South Korea would have permitted it to produce chemicals more cheaply in dollar terms than the United States, South Korea would still benefit by specializing in raincoats and buying chemicals from the United States. By so doing, South Korea could reduce its true costs of obtaining chemicals (raincoats forgone), just as trade permits the United States to get raincoats at a lower true cost (chemicals forgone) than if it had to use domestic resources for this purpose.

ELASTICITY OF LABOR DEMAND

We have concluded that the long-run demand curve is more elastic than the short-run curve and that the market demand for labor is less elastic than a curve derived by a simple summation of labor demand curves of individual firms. These references to elasticity raise an important unanswered question: What determines the *sensitivity* of employment to a change in the wage rate? That is, what determines the ***elasticity of labor demand***? Let's examine this topic in more detail.

The Elasticity Coefficient

The sensitivity of the quantity of labor demanded to wage rate changes is measured by the ***wage elasticity coefficient*** E_d, as shown in Equation (5.3):

$$E_d = \frac{\text{percentage change in quantity of labor demanded}}{\text{percentage change in the wage rate}} \qquad \textbf{(5.3)}$$

Because the wage rate and the quantity of labor demanded are inversely related, the elasticity coefficient will always be negative. By convention, the minus sign is taken as understood and therefore is ignored. Also, you should be aware that percentage calculations present a "reversibility" problem. For example, a wage rate increase from \$5 to \$10 is a *100 percent* increase, whereas a wage decrease from \$10 to \$5 is only a *50 percent* decline. Economists therefore use the *averages* of the two wages and the *averages* of the two quantities as the bases when computing wage elasticity coefficients. In terms of our previous example, a wage change from \$10 to \$5 and one from \$5 to \$10 are each considered to be 67 percent changes $\{= 5/[(\$10 + \$5)/2]\}$.

The equation that incorporates the averaging technique when computing wage elasticity is known as a *midpoints formula* and is shown as Equation (5.4):

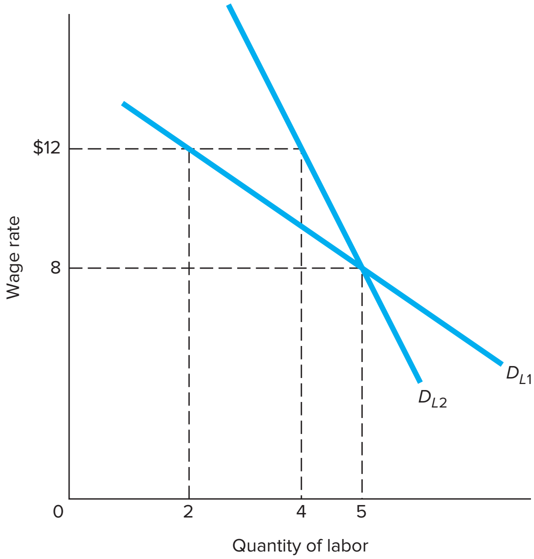
$$E_d = \frac{\text{change in quantity}}{\text{sum of quantities}/2} \div \frac{\text{change in wage}}{\text{sum of wages}/2} \qquad \textbf{(5.4)}$$

Demand is *elastic*—meaning that employers are quite responsive to a change in wage rates—if a given percentage change in the wage rate results in a larger percentage change in the quantity of labor demanded. In this case, the absolute value of the elasticity coefficient will be greater than 1. Conversely, demand is *inelastic* when a given percentage change in the wage rate causes a smaller percentage change in the amount of labor demanded. In this instance, E_d will be less than 1, indicating that employers are relatively insensitive to changes in wage rates. Finally, demand is *unit elastic*—meaning that the coefficient is 1—when a given percentage in the wage rate causes an equal percentage change in the amount of labor demanded.

The Total Wage Bill Rules

You may recall from basic economics that we can determine the price elasticity of demand for a product by observing what happens to total revenue when product price changes. Similar rules, called the ***total wage bill rules***, are used to assess the wage elasticity of demand.

FIGURE 5.7 The Total Wage Bill Rules
If a change in the wage rate causes the total wage bill ($W \times Q$) to change in the opposite direction, then labor demand is elastic. This is the case along the \$8 to \$12 segment of D_{L1}, where the total wage bill falls from \$40 (= \$8 × 5) to \$24 (= \$12 × 2) when the wage rate rises from \$8 to \$12. In the case of labor demand D_{L2}, however, this same wage increase causes the total wage bill to rise from \$40 to \$48 (= \$12 × 4). This second situation supports the generalization that when demand is inelastic, the wage rate and the total wage bill change in the same direction.



Consider Figure 5.7, which displays two separate labor demand curves D_{L1} and D_{L2}. Suppose initially that the wage rate is \$8, at which the firm hires five units of labor. The *total wage bill*, defined as $W \times Q$, in this case is \$40 (= \$8 × 5). This amount also happens to be the *total wage income* as viewed by the five workers. Now let's suppose the wage rate rises to \$12. This increase produces two opposing effects on the wage bill. The higher wage rate increases the wage bill, but the decrease in employment reduces it. With D_{L1}, the firm responds to the \$4 higher wage rate by reducing the amount of labor employed from five to two units. The wage increase boosts the wage bill by \$8 (= \$4 × 2), while the decline in employment lowers it by \$24 (= \$8 × 3). The net effect is that the wage bill falls by \$16 from \$40 (= \$8 × 5) to \$24 (= \$12 × 2). *When labor demand is elastic, a change in the wage rate causes the total wage bill to move in the opposite direction.*

On the other hand, notice that for labor demand D_{L2}, the \$4 higher wage adds more to the wage bill (\$4 × 4 = \$16) than the one-unit decline in employment subtracts (\$8 × 1 = \$8), causing the total wage bill to rise from \$40 (= \$8 × 5) to \$48 (= \$12 × 4). *When labor demand is inelastic, a change in the wage rate causes the total wage bill to move in the same direction*. Finally, *where labor demand is unit elastic (= 1), a change in the wage rate leaves the total wage bill unchanged.*

We can confirm the results of the total wage bill tests by using the midpoints formula [Equation (5.4)] to compute elasticity coefficients for the appropriate segments of D_{L1} and D_{L2} in Figure 5.7. The \$8 to \$12 wage change is a 40 percent increase {= \$4/[(\$8 + \$12)/2]}, whereas we see from D_{L1} that the three-unit change in quantity is an 86 percent decline {= 4/[(5 + 2)/2]}. Because the percentage decrease in quantity exceeds the percentage increase in the wage, labor demand is elastic (the wage bill falls as the wage increases). In the case of D_{L2}, the same 40 percent rise in the wage produces only a 22 percent employment decline {=1/[(5 + 4)/2]}; hence, demand is inelastic (the wage bill increases as the wage rises).

Determinants of Elasticity

What determines the elasticity of the market demand for labor? The theoretical generalizations are as follows.[6]

1 Elasticity of Product Demand

Because the demand for labor is a derived demand, the elasticity of demand for labor's output will influence the elasticity of demand for labor. Other things being equal, *the greater the price elasticity of product demand, the greater the elasticity of labor demand*. It is simple to see why this is so. If the wage rate falls, the cost of producing the product will decline. This cuts the price of the product and increases the quantity demanded. If the elasticity of product demand is great, that increase in the quantity of the product demanded will be large and thus necessitate a large increase in the quantity of labor to produce that additional output. This implies an elastic demand for labor. But if the demand for the product is inelastic, the increase in the amount of the product demanded will be small, as will be the increase in the quantity of labor demanded. This suggests that the demand for labor would be inelastic.

This generalization has two noteworthy implications. First, other things being equal, the greater the monopoly power an individual firm possesses in the product market, the less elastic is its demand for labor. This is confirmed by Figures 5.2 and 5.3, discussed previously. Recall that in Figure 5.2, the firm is selling its product in a perfectly competitive market, implying that it is a price taker facing a perfectly elastic product demand curve. The resulting demand for labor curve slopes downward solely because of diminishing returns. Contrast that curve to the one for the imperfectly competitive seller shown in Figure 5.3. This firm's product demand curve is less elastic, as evidenced by marginal revenue being less than price (Table 5.3). Thus, the labor demand curve in Figure 5.3 also is less elastic; it slopes downward not only because of diminishing marginal productivity but also because of the less than perfectly elastic product demand, meaning that product price falls with increased output.

A second implication is that labor demand will be more elastic in the long run than in the short run. Wage elasticity tends to be greater in the long run because

[6] These generalizations were developed in 1890 by Alfred Marshall in his *Principles of Economics* (London: Macmillan Publishing Company, 1890) and refined by John R. Hicks, *The Theory of Wages,* 2nd ed. (New York: St. Martin's Press, 1966), pp. 241–47. For this reason, they are often referred to as the "Hicks–Marshall rules of derived demand."

price elasticity of product demand is greater in the long run. Consumers are often creatures of habit and only slowly change their buying behavior in response to a price change. Coffee drinkers may not immediately reduce their consumption when the price of coffee rises; but given sufficient time, some may acquire a taste for tea. Another factor at work here is that some products are used mainly in conjunction with costly durable goods. For example, when the price of electricity rises, people who have electric furnaces and other appliances do not respond by greatly reducing their consumption of electricity. But as time transpires, the elasticity of the demand for electricity—*and the elasticity of the derived demand for workers in that industry*—become greater. People eventually replace their electric furnaces and water heaters with devices that use natural gas, solar energy, wood, or even coal.

2 Ratio of Labor Costs to Total Costs

In general, all other things being the same, *the larger the proportion of total production costs accounted for by labor, the greater will be the elasticity of demand for labor*.[7] The rationale here is straightforward. Compare these two cases. *Case one:* If labor costs were the only production cost—that is, if the ratio of labor to total costs were 100 percent—then a 20 percent increase in the wage rate would increase unit costs by 20 percent. Given product demand, this large cost increase eventually would cause a considerable increase in product price, a sizable reduction in sales of output, and therefore a large decline in the employment of labor. *Case two:* If labor costs were only 10 percent of total cost, then the same 20 percent increase in the wage rate would increase total unit costs by only 2 percent. Assuming the same product demand as in case one, this relatively small cost increase will generate a more modest decline in employment. Case one implies a more elastic demand for labor than case two. The same 20 percent wage increase caused a larger percentage decline in employment in case one than in case two.

Service industries such as education, temporary workers, and building maintenance exemplify situations in which firms' labor costs are a large percentage of total costs. In these industries, wage increases translate into large cost increases, resulting in relatively elastic labor demand curves. Conversely, highly capital-intensive industries such as electricity generation and brewing are examples of markets in which labor costs are small relative to total costs. Labor demand curves in these industries are relatively inelastic.

3 Substitutability of Other Inputs

Other things being equal, *the greater the substitutability of other inputs for labor, the greater will be the elasticity of demand for labor*. If technology is such that capital is readily substitutable for labor, then a small increase in the wage rate will elicit a substantial increase in the amount of machinery used and a large decline in the amount of labor employed. Conversely, a small drop in the wage rate will induce a large substitution of labor for capital. The demand for labor will tend to be elastic in this case. In other

[7] *Technical note:* This proposition assumes that the product demand elasticity is greater than the elasticity of substitution between capital and labor. See Hicks, op. cit., pp. 241–47.

instances, technology may dictate that a certain amount of labor is more or less indispensable to the production process; that is, the substitution of capital for labor is highly constrained. In the extreme, the production process may involve fixed proportions; for example, two airline pilots—no more and no fewer—may be required to fly a commercial airliner. In this case, a change in the wage rate will have little short-run effect on the number of pilots employed, and this implies an inelastic demand for labor.

It is worth noting that *time* plays an important role in the input substitution process, just as it does in the previously discussed process through which consumer goods are substituted for one another. The longer the period of elapsed time since a wage rate was changed, the more elastic are labor demand curves. For example, a firm's truck drivers may obtain a substantial wage increase with little or no immediate decline in employment. But over time, as the firm's trucks wear out and are replaced, the company may purchase larger trucks and thereby be able to deliver the same total output with significantly fewer drivers. Alternatively, as the firm's trucks depreciate, it might turn to entirely different means of transportation for delivery.

4 Supply Elasticity of Other Inputs

The fourth determinant of the elasticity of demand for labor is simply an extension of the third determinant. The generalization is that other things being equal, *the greater the elasticity of the supply of other inputs, the greater the elasticity of demand for labor*. In discussing our third generalization, we implicitly assumed that the prices of nonlabor inputs—such as capital—are unaffected by a change in the demand for them. But this may not be realistic.

To illustrate, assume once again that an increase in the wage rate prompts the firm to substitute capital for labor. This increase in the demand for capital will leave the price of capital unchanged only in the special case where the supply of capital is perfectly elastic. But let's suppose the supply of capital curve slopes upward, so that an increase in demand would increase its price. Furthermore, the less elastic the supply of capital, the greater the increase in the price of capital in response to any given increase in demand. Any resulting change in the price of capital is important because it will retard or dampen the substitution of capital for labor and reduce the elasticity of demand for labor. More specifically, if the supply of capital is inelastic, a given increase in the demand for capital will cause a large increase in the price of capital, greatly retarding the substitution process. This implies that the demand for labor will be inelastic. Conversely, if the supply of capital is highly elastic, the same increase in demand will cause only a small increase in the price of capital, dampening the substitution process only slightly. This suggests that the demand for labor will be elastic.

Estimates of Wage Elasticity

Hamermesh has summarized and compared more than 100 studies of labor demand and has concluded that the overall long-run labor demand elasticity in the United States is 1.0.[8] This coefficient implies a unitary elastic labor demand curve,

[8] Daniel S. Hamermesh, *Labor Demand* (Princeton, NJ: Princeton University Press, 1993), chap. 3.

which means that for every 10 percent change in the wage rate, employment changes in the opposite direction by 10 percent. Hamermesh concludes that about two-thirds of the long-run elasticity response takes the form of the output effect, with the other third consisting of the substitution effect. Other studies generally support Hamermesh's estimates, although problems of statistical design and incomplete data make research in this area difficult.

Studies also reveal that labor demand elasticities vary greatly by industry, type of labor, and occupational group. For example, Clark and Freeman estimate that the wage elasticity for all U.S. manufacturing is about 1.[9] Ashenfelter and Ehrenberg find that the wage elasticity in public education is 1.06.[10] Other studies show that the elasticity of labor demand is higher for teenagers than for adults, is greater for production workers than for nonproduction workers, is higher for low-skilled workers than for high-skilled workers, and is larger in nondurable goods industries than in durable goods industries.

Significance of Wage Elasticity

Of what practical significance are such estimates of labor demand elasticity? The answer is that private and public policies might be greatly affected by the size of the wage rate–employment trade-off suggested by the elasticity estimates.

In the private sphere, a union's bargaining strategy might be influenced by the elasticity of labor demand for its workers. We might expect a union of higher-skilled engineers in the aerospace industry (where the demand for labor is inelastic) to bargain more aggressively for higher wages than a union of restaurant workers (where the demand for labor is elastic). The reason? A given percentage increase in wage rates will generate a smaller decline in employment for the higher-skilled engineers than for the lower-skilled restaurant workers.

Similarly, a union will wish to know something about its employer's wage elasticity before agreeing to a wage reduction purportedly necessary to save jobs threatened by intense import competition. The more elastic the employer's demand for labor, the greater the likelihood that the union will agree to a wage concession. Under conditions of elastic labor demand, the wage cut will be more effective in preserving jobs than when demand is inelastic.

The effectiveness and impact of government policies often depend on the elasticity of labor demand. The employment consequences of a rise in the minimum wage rate, for example, will depend on the elasticity of demand for workers affected by the change. Similarly, the effectiveness of a program providing wage subsidies to employers who hire disadvantaged workers will depend on the elasticity of labor demand in the industries employing low-skilled labor. The more elastic the labor demand, the greater will be the increase in employment resulting from the wage subsidies.

[9] Kim B. Clark and Richard B. Freeman, "How Elastic Is the Demand for Labor?" *Review of Economics and Statistics,* November 1980, pp. 509–20.

[10] Orley Ashenfelter and Ronald G. Ehrenberg, "The Demand for Labor in the Public Sector," in Daniel Hamermesh (ed.), *Labor in the Public and Nonprofit Sectors* (Princeton, NJ: Princeton University Press, 1975), p. 71.

DETERMINANTS OF DEMAND FOR LABOR

The movement along a labor demand curve implied by the concept of elasticity is quite distinct from an increase or decrease in labor demand. The latter implies shifts of the demand for labor curve either rightward or leftward. What factors cause such shifts? The major ***determinants of labor demand*** are product demand, productivity, the number of employers, and the prices of other resources.

Product Demand

A change in the demand for the product that a particular type of labor is producing, all else being equal, will shift the labor demand curve in the same direction. For example, suppose that in Table 5.2 and Figure 5.2 an increase in product demand occurs, causing the product price to rise from \$2 to \$3. If we plotted the *new* MRP data onto Figure 5.2, we would observe that the demand for labor curve shifted rightward. A decline in the demand for the product would likewise shift the labor demand curve leftward.

Productivity

Assuming that it does not cause a fully offsetting change in product price, a change in the marginal product of labor (MP) will shift the labor demand curve in the same direction. Again return to Table 5.2 and Figure 5.2. Suppose technology improves, shifting the entire production function (column 2 in relationship to column 1 in Table 5.2) upward. More concretely, let's assume a doubling of the total product produced by each worker in combination with the fixed capital. Clearly MP in column 3 and consequently MRP in column 6 would increase. If the new MRP data were plotted in Figure 5.2, we would observe that labor demand had shifted rightward. Conversely, a decline in productivity would shift the labor demand curve leftward.

Number of Employers

Recall that we found the market demand for labor in Figure 5.6 by summing horizontally the "price-adjusted" labor demand curves of individual employers. *Assuming no change in employment by other firms, a change in the number of firms employing a particular type of labor will change the demand for labor in the same direction*. In terms of Figure 5.6, D_{LR} will shift rightward if additional firms enter this labor market to hire workers; it will shift leftward if firms leave, all else being equal.

Prices of Other Resources

Changes in the prices of other inputs such as capital, land, and raw materials can shift the demand curve for labor. To illustrate this idea, we focus solely on changes in the price of capital. Normally labor and capital are *substitutes in production,* meaning that a given quantity of output can be produced with much capital and little labor *or* much labor and little capital. Now suppose the price of capital falls. Our task is to determine the impact of this price decline on the demand for labor.

Gross Substitutes[11]

If labor and capital are **gross substitutes**, the decline in the price of capital will *decrease* the demand for labor. *Gross substitutes are inputs such that when the price of one changes, the demand for the other changes in the same direction*. This correctly implies that here the substitution effect outweighs the output effect. The decline in the price of capital lowers the marginal cost of producing the output, which taken alone would result in an expansion of output and an *increase* in the demand for labor (the output effect). But the lower-priced capital is substituted for labor, which taken alone would *reduce* the demand for labor (the substitution effect). Where labor and capital are gross substitutes, this latter substitution effect swamps the output effect, and labor demand falls. For example, the decline in the price of security equipment used by businesses to protect against illegal entries has reduced the demand for night guards.

Gross Complements

If, on the other hand, labor and capital are **gross complements**, a decline in the price of capital will *increase* the demand for labor. *Gross complements are inputs such that when the price of one changes, the demand for the other changes in the opposite direction*. In this case of a decline in the price of capital, the output effect outweighs the substitution effect, and the demand for labor increases. Restated, the fall in the price of capital reduces production costs and increases sales so much that the resulting increased demand for labor overwhelms the substitution of capital for

5.3
Quick Review

GP5.2

GP5.3

WW5.4

- Wage elasticity measures the sensitivity of the amount of labor demanded to wage rate changes; it is the percentage change in quantity of labor demanded divided by the percentage change in price.
- When changes in the wage rate cause the wage bill $(W \times Q)$ to move in the opposite direction, labor demand is elastic; when the wage bill remains constant, labor demand is unit elastic; and when the wage bill moves in the same direction, labor demand is inelastic.
- The major determinants of wage elasticity are the *(a)* elasticity of product demand, *(b)* ratio of labor costs to total costs, *(c)* substitutability of other inputs, and *(d)* supply elasticity of other inputs.
- The factors that shift the labor demand curve include *(a)* changes in product demand, *(b)* changes in labor productivity, *(c)* changes in the number of employers, and *(d)* changes in the prices of other inputs.

Your Turn

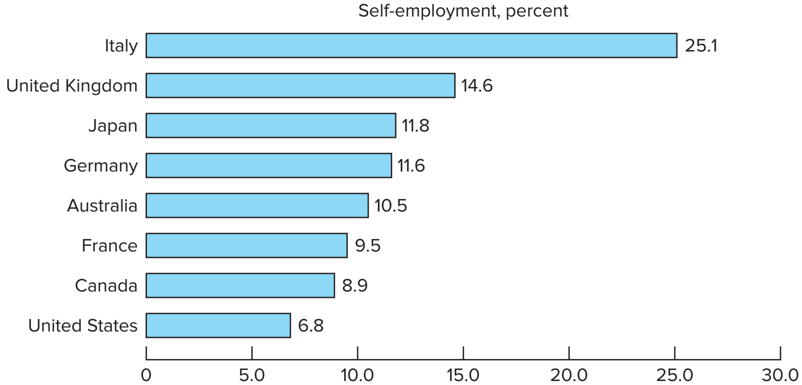
Suppose the price of capital falls relative to the wage rate and, as a result, the demand for labor increases. Are these inputs gross substitutes, or are they gross complements? What can you infer about the relative strengths of the output and substitution effects? (*Answers:* See page 599.)

[11] The term *gross* as a modifier of *substitutes* and *complements* in this discussion is in keeping with terminology used in advanced economics. As used here, the concepts are *gross* because they encompass both substitution and output effects. So-called *net* substitutes and complements, on the other hand, focus only on substitution effects, holding output constant.

5.2 Global Perspective

Self-Employment as a Percentage of Total Employment

The percentage of workers who are self-employed in the United States is the lowest among the major industrialized countries.



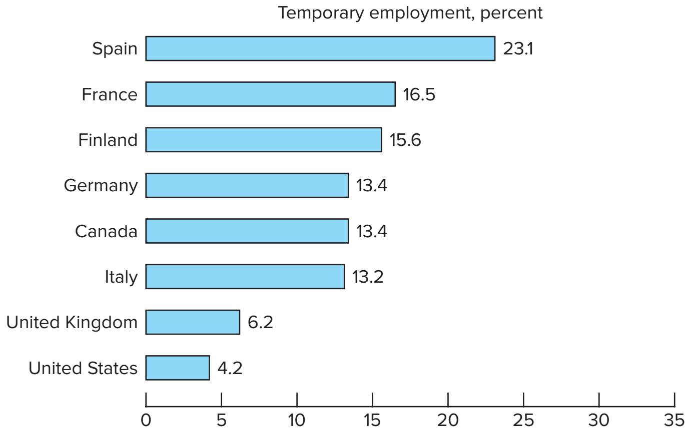
Source: Organization for Economic Cooperation and Development, *OECD Factbook 2014: Economic, Environmental, and Social Statistics.*

All data are for 2012, except for France, which is for 2011.

5.3 Global Perspective

Temporary Employment as a Percentage of Total Employment

The United States has a low rate of employment in jobs with time-limited contracts relative to other countries.



Source: Organization for Economic Cooperation and Development (**www.oecd.org**). Data are for 2012, except for the United States, which is for 2005.

5.4 World of Work

The Rapid Disappearance of U.S. Postal Service Workers*

The number of workers employed at the U.S. Postal Service has fallen significantly over the past decade, and it is projected to decline even more in the next decade. Between 2000 and 2012, the number of Postal Service workers fell from 901,000 to 611,000. By 2022, Postal Service employment is projected to drop to 442,000 workers. The Postal Service is forecasted to account for two-fifths of the decline in federal employment between 2012 and 2022.

Employment at the Postal Service is falling because of a decline in demand for its services. There is increasing use of e-mail, payment of bills online, and a decline in the circulation of magazines. Between 2000 and 2010, the number of pieces processed by the U.S. Postal Service fell from 208 billion to 171 billion. By 2020, mail volume is projected to fall to 127 billion pieces.

The occupation mix of the Postal Service will change significantly over the 2002–2022 period. The mail processing clerks' share of Postal Service employment is predicted to fall from 31 percent to 21 percent as technological improvements are projected to raise worker productivity and substantially lower the need for such workers. The employment level of mail carriers will drop more modestly as they will still be needed to deliver mail even though mail volume will fall. As a result, the mail carrier share of Postal Service employment is forecasted to rise from 41 percent to 49 percent.

* Based on Richard Henderson, "Industry Employment and Output Projections to 2022," *Monthly Labor Review*, December 2013, http://www.bls.gov/opub/mlr/2013/article/pdf/industry-employment-and-output-projections-to-2022.pdf; Emily Richards and Dave Terkanian, "Occupational Employment Projections to 2022," *Monthly Labor Review*, December 2013, http://www.bls.gov/opub/mlr/2013/article/pdf/occupational-employment-projections-to-2022.pdf; U.S. General Accountability Office, "Mail Trends Highlight Need to Fundamentally Change Business Model," GAO-12-159SP Report, October 14, 2011; and http://www.bls.gov/cew.

labor occurring in the production process. When labor and capital are gross complements, a decrease (increase) in the price of capital increases (decreases) the demand for labor. For example, the decline in the price of computers over the past three decades increased the demand for computer programmers.

Thus far, we have assumed that labor and capital are substitutes in production. What can we conclude about the impact of a change in the price of capital on the demand for labor in the extreme case in which labor and capital are *not* substitutable in the production process? Suppose instead that labor and capital are *pure complements in production,* meaning they are used in direct proportion to one another in producing the output. An example would be crane operators and cranes; more cranes require more operators on a one-for-one basis. The decline in the price of capital in this instance will unambiguously increase the demand for labor. Pure complements in production are always gross complements because there is no substitution effect. The lower price of capital will reduce the firm's marginal cost and cause it to increase its output, bolstering its demand for labor.

Remember these generalizations: *(1) A change in the price of a resource that is a substitute in production for labor may change the demand for labor either in the same or in the opposite direction, depending on whether the resources are gross substitutes or gross complements, respectively; (2) a change in the price of a resource that is a pure complement in production (used in a fixed proportion with labor) will change the demand for labor in the opposite direction—it will always be a gross complement.*

REAL-WORLD APPLICATIONS

The concepts of labor demand and the elasticity of labor demand have great practical significance, as seen in the following examples.

Textile and Apparel Industries

In 1973, there were 2.4 million U.S. textile and apparel workers; by 2012 this figure had dropped to 383,000 workers. An additional 137,000 workers are expected to lose their jobs by 2022. Several factors help explain this dramatic decline in jobs. First, foreign competition, due to decreased trade barriers, has reduced the demand for American textiles and apparel. The share of total American textile and apparel sales accounted for by domestic producers has fallen from 95 percent in 1970 to less than 60 percent today.

Another factor has been the spread of automation in textile and apparel manufacturing. Industrial robots and assembly-line labor are gross substitutes, meaning that lower prices for robots have produced substitution effects exceeding output effects. The net effect has been a decline in the demand for textile and apparel workers. Coupled with the reduced demand for the product, the substitution of robots for workers has sharply reduced employment in these industries.[12]

WW5.5

Fast-Food Workers

In the past several years, McDonald's and other fast-food establishments have undertaken advertising campaigns to attract homemakers and older people to work in their restaurants. One important reason for these efforts has been the rapid increase in the demand for fast-food workers. The labor force participation rate of women and the number of two-worker families have increased, raising the opportunity cost of time (recall the Becker model in Chapter 3). In Becker's terms, people have substituted goods (restaurant meals) for time (home-prepared meals). The growing demand for restaurant meals has increased the demand for fast-food workers. Because the labor supply of traditional fast-food workers—teenagers—has not kept pace, many restaurants are now recruiting homemakers and semiretired workers.

Personal Computers

The last two decades has seen a remarkable drop in the average price of personal computers and an equally amazing rise in the computing power of the typical machine. The effects of these developments on labor demand have been pervasive. For example, the demand for workers in some segments of the computer industry has significantly increased. Between 1990 and 2014, employment in the computer systems design industry (programming and software) expanded at an an nual 6.3 percent growth rate. Apple Corporation, which was founded in 1976, boasted 92,600 workers in 2014. Microsoft, a major producer of software, employed 122,935 people in 2014, up from 476 workers in 1983.

[12] For more about employment trends in the textile and apparel industries, see Mark Mittelhauser, "Employment Trends in Textiles and Apparel, 1973–2005," *Monthly Labor Review,* August 1997, pp. 24–35.

5.5 World of Work

Occupational Employment Trends

Labor demand shifts are important because they alter wage rates and employment in specific occupations. An increase in labor demand for a particular occupation will raise employment in the occupation, and declines in labor demand will lower it. For example, let's examine occupations that are facing increases in labor demand (wage rates are discussed in the next chapter).

The table below lists the 10 fastest-growing occupations, in percentage terms, for 2012–2022. Not surprisingly, service and construction occupations dominate the list. Overall, the demand for service and construction workers is growing faster than the demand for manufacturing and mining workers.

Seven of the top 10 fastest-growing occupations are linked to health care. The rising demand for industrial-organization psychologists, personal care aides, home health aides, diagnostic medical sonographers, occupational therapy assistants, genetic counselors, and physical therapy assistants arises from several factors: (a) the aging of the U.S. population with its increased extended illnesses; (b) rising income, which has led to greater spending on health care; and (c) the rising rate of health insurance, which enables more people to be able to buy health care.

Two of the fastest-growing occupations are related to construction. The construction industry lost 2 million jobs over the 2006 to 2010 period. As a result, the rapid growth rate for these occupations is due to the construction industry rebounding from this low starting point.

One of the most rapidly growing occupations is related to foreign languages. The increasing diversity of the U.S. population and globalization of the economy have increased the demand for interpretation and translation services.

The 10 Fastest-Growing Occupations in Percentage Terms, 2012–2022

	Employment (Thousands of Jobs)		
Occupation	**2012**	**2022**	**Percentage Increase**
Industrial–organizational psychologists	2	3	53%
Personal care aides	1,191	1,771	49
Home health aides	875	1,299	49
Insulation workers, mechanical	29	42	47
Interpreters and translators	64	93	46
Diagnostic medical sonographers	59	86	46
Helpers—brickmasons, blockmasons, stonemasons, and tile and marble setters	24	35	43
Occupational therapy assistants	30	43	43
Genetic counselors	2	3	41
Physical therapist assistants	71	101	41

Source: Bureau of Labor Statistics, "Employment Projections" **(http://www.bls.gov/emp)**.

In some offices, personal computers have been gross substitutes for labor, thus reducing the demand for labor and allowing these firms to use fewer workers to produce their outputs. But in other instances, computers and labor have proven to be gross complements. The decline in computer prices has reduced production costs to the extent that product prices have dropped, product sales have increased, and the derived demand for workers has risen. Also, keyboard personnel and computers are pure complements. Thus, there is no substitution effect; a keyboard worker is needed for each computer.

Today 77 million people work with personal computers at least sometime during the day. Krueger has estimated that workers who use computers earn 10 to 15 percent more than otherwise similar workers who do not use this technology.[13]

Minimum Wage

As we detail in Chapter 13, federal law requires that covered workers earn an hourly wage rate of at least $7.25. Critics contend that an above-equilibrium minimum wage moves employers upward along their downward-sloping labor demand curves and causes unemployment, particularly among teenage workers. Workers who remain employed at the minimum wage will receive higher incomes than otherwise. The amount of income lost by job losers and the income gained by those who keep their jobs will depend on the elasticity of demand for minimum-wage labor. Studies have generally found that a 10 percent increase in the minimum wage reduces employment from 1 to 3 percent, meaning that demand is inelastic. Thus, the minimum wage increases the wage income to minimum-wage workers as a group (increases the wage bill). The case made by critics of the minimum wage would be stronger if the demand for low-wage labor were elastic.

Contingent Workers

A dramatic labor market change of recent years has been that many employers have reduced the size of their core workforce. Simultaneously, they have increased the use of contingent workers (temporary help, independent contractors, and on-call workers). Between 1990 and 2014, employment in the temporary help industry grew at the rapid rate of 3.7 percent per year, which was more than three times the growth rate of nonfarm employment. The number of workers in the industry rose from 1,156,000 to 2,767,000 over this period.

Why has the demand for contingent workers increased so rapidly? Several factors have been at work. These workers are usually paid less than permanent workers. Also, increasingly expensive fringe benefits are minimal or nonexistent for many contingent workers.

[13] Alan B. Krueger, "How Computers Have Changed the Wage Structure: Evidence from Microdata, 1984–1989," *Quarterly Journal of Economics,* February 1993, pp. 33–60. For additional evidence regarding the impact of computers on wages, see Harry A. Krashinsky, "Do Marital Status and Computer Usage Really Change the Wage Structure?," *Journal of Human Resources,* Summer 2004, pp. 774–791; and Peter Dolton and Panu Pelkonen, "The Wage Effects of Computer Use: Evidence from WERS 2004," *British Journal of Industrial Relations,* December 2008, pp. 587–630.

A second and closely related reason for the growing demand for contingent workers is that these workers give firms more flexibility in responding to changing economic conditions. As product demand shifts, firms can readily increase or decrease the sizes of their workforces through altering their temporary, on-call, and subcontracted employment. This flexibility enhances the competitive positions of firms and improves their ability to succeed in international markets.

Chapter Summary

1. The demand for labor is a derived demand and therefore depends on the marginal productivity of labor and the price or market value of the product.
2. The segment of the marginal product curve that is positive and lies below the average product curve is the basis for the short-run labor demand curve. More specifically, the short-run demand curve for labor is determined by applying the MRP = W rule to the firm's marginal revenue product data.
3. Other things being equal, the demand for labor curve of a perfectly competitive seller is more elastic than that of an imperfectly competitive seller. This difference occurs because the imperfectly competitive seller needs to reduce product price to sell additional units of output, whereas the purely competitive seller does not. This also means that the imperfectly competitive seller's marginal revenue product curve lies to the left of the corresponding value of marginal product curve, whereas marginal revenue product and the value of the marginal product are identical for the perfectly competitive seller.
4. A firm's long-run labor demand curve is more elastic than its short-run curve because in the long run the firm has sufficient time to adjust nonlabor inputs such as capital. In the short run, a wage change produces only an output effect; in the long run, it also creates a substitution effect. In addition, such factors as product demand elasticity, labor–capital interactions, and technology contribute to the greater long-run wage elasticity.
5. The market demand for a given type of labor is less elastic than a simple horizontal summation of the short- or long-run demand curves of individual employers. The reason for this is that as employers as a group hire more workers and produce more output, product supply will increase significantly and product price will therefore decline.
6. The elasticity of labor demand is measured by comparing the percentage change in the quantity of labor demanded with a given percentage change in the wage rate. If the elasticity coefficient is greater than 1, demand is relatively elastic. If it is less than 1, demand is relatively inelastic. When demand is elastic, changes in the wage rate cause the total wage bill to change in the *opposite* direction. When demand is inelastic, changes in the wage rate cause the total wage bill to move in the *same* direction.

7. The demand for labor generally is more elastic *(a)* the greater the elasticity of product demand, *(b)* the larger the ratio of labor cost to total cost, *(c)* the greater the substitutability of other inputs for labor, and *(d)* the greater the elasticity of supply of other inputs.
8. The location of the labor demand curve depends on *(a)* product demand, *(b)* the marginal productivity of labor, *(c)* the number of employers, and *(d)* the prices of other inputs. When any of these determinants of demand change, the labor demand curve shifts to a new location.
9. Labor and capital can be either substitutes or pure complements in production. If they are substitutes in production, they can be either gross substitutes or gross complements. When the price of a gross substitute changes, the demand for the other resource changes in the same direction. When the price of gross complement changes, the demand for the other resource changes in the opposite direction.
10. The concepts of labor demand, changes in labor demand, and the elasticity of labor demand have great applicability to real-world situations.

Terms and Concepts

derived demand
production function
total product
marginal product
average product
law of diminishing marginal returns
zone of production
marginal revenue product
short-run labor demand curve
marginal wage cost
value of marginal product
long-run demand for labor
output effect
substitution effect
market demand for labor
elasticity of labor demand
wage elasticity coefficient
total wage bill rules
determinants of labor demand
gross substitutes
gross complements

Questions and Study Suggestions

1. Graph a short-run production function (one variable resource) showing the correct relationships between total product, average product, and marginal product.
2. "Only that portion of the MP curve that lies below AP constitutes the basis for the firm's short-run demand curve for labor." Explain.
3. Explain how marginal revenue product is derived. Why is the MRP curve the firm's short-run labor demand curve? Explain how and why the labor demand curves of a perfectly competitive seller and an imperfectly competitive seller differ.
4. Given the data in Table A, complete the labor demand schedule shown in Table B. Contrast this schedule to the value of marginal product schedule that would exist given these data. Explain why the labor demand and VMP schedules differ.

Table A

Inputs of Labor	Total Product	Product Price
0	0	$1.10
1	17	1.00
2	32	.90
3	45	.80
4	55	.70
5	62	.65
6	68	.60

Table B

Labor Demand Schedule	
Wage Rate	Quantity Demanded
$18	
14	
11	
6	
2	
1	

5. Explain how each of the following would affect the demand schedule you derived in Question 4: *(a)* an increase in the price of a gross substitute for labor, *(b)* a decrease in the price of a pure complement in production with labor, *(c)* a decrease in the demand for the product that the labor helps produce.
6. Referring to the output and substitution effects, explain why an increase in the wage rate for autoworkers will generate more of a negative employment response in the long run than in the short run. Assume there is no productivity increase and no change in the price of nonlabor resources.
7. "It would be incorrect to say that an industry's labor demand curve is simply the horizontal sum of the demand curves of the individual firms." Do you agree? Explain.
8. Suppose marginal productivity tripled while product price fell by half in Table 5.2. What would be the net impact on the location of the short-run labor demand curve in Figure 5.2?
9. Use the concepts of *(a)* substitutes in production versus pure complements in production and *(b)* gross substitutes versus gross complements to assess the likely impact of the rapid decline in the price of computers and related office equipment on the labor demand for secretaries.
10. Use the total wage bill rules and the labor demand schedule in Question 4 to determine whether demand is elastic or inelastic over the $6 to $11 wage rate range. Compute the elasticity coefficient using Equation (5.4).
11. The productivity of farm labor has increased substantially since World War II. How can this be reconciled with the fact that labor has moved from agricultural to nonagricultural occupations over this period?
12. Contrast and explain changes in the demand for textile workers and fast-food workers over the past two decades. Why is the elasticity of labor demand crucial to the debate about the effects of increasing the minimum wage?

Internet Exercise

WWW...

Which Industries Are Growing and Which Are Declining?

Go to the Bureau of Labor Statistics Current Employment Statistics website **(www.bls.gov/ces/home.htm)** and in sequence select "CES Databases" and "Top Picks" to find inf ormation about employment by industry. Click on "reformat" to change the years of data extracted.

What was the amount for total nonfarm employment in January 1980 and for the most recent month shown? What is the percentage change in employment over this period?

What was the employment level for manufacturing and services in January 1980 and for the most recent month shown? In which industry has employment increased over this period? In which has it declined? What has been the percentage change in employment for both sectors? Suggest a possible explanation for the difference in employment growth between these sectors.

Provide *one* other specific statistic of your choice from the data on employment levels. For example, "In January 2012, the employment level for the mining and logging industry was *xxx.x* thousand workers."

Internet Links

The Bureau of Labor Statistics Employment and Unemployment website provides information about layoffs and job turnover, as well as employment by state, occupation, and industry **(www.bls.gov/bls/employment.htm)**.

Appendix

Isoquant–Isocost Analysis of the Long-Run Demand for Labor

A more advanced derivation of the firm's long-run downward-sloping labor demand curve is based on (1) isoquant and (2) isocost curves.

ISOQUANT CURVES

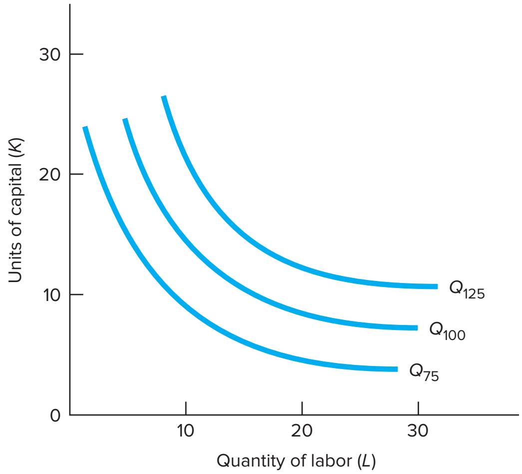
An ***isoquant curve*** *shows the various possible combinations of two inputs that are capable of producing a specific quantity of physical output*. By definition, then, output is the same at all points on a *single* isoquant. For example, total output is 100 units of some product or service on curve Q_{100} in Figure 5.8 when 20 units of capital are combined with 7 units of labor *or* when 10 units of capital and 15 units of labor are employed.[14] Isoquants—or equal output curves—possess several other characteristics.

1 Downward Slope

Assuming that capital and labor are substitutes in production, if a firm employs less capital (K), then to maintain a specific level of output, it must employ more labor (L). Conversely, to hold total output constant, using less of L will require it to employ more of K. There is thus an *inverse* relationship between K and L at each output level, implying a downward-sloping isoquant curve.

[14] For simplicity, we will assume that the only two resources are capital and labor, disregarding all combinations of capital and labor that are not within a firm's zone of production.

FIGURE 5.8 Isoquant Curves
Every point on a specific isoquant represents some combination of inputs (in this case, capital and labor) that produces a given level of total output. Isoquants, or "equal output curves," farther to the northeast indicate higher levels of total output.



2 Convexity to the Origin

Isoquants are convex to the origin because capital and labor are not perfect substitutes for one another. For example, an excavating company can substitute labor and capital to produce a specific level of output—perhaps clearing 1,000 acres of wooded land in a fixed amount of time. But labor and capital are not perfectly substitutable for this purpose. To understand this and see why the firm's isoquant curve is convex to the origin, compare the following circumstances. First suppose the firm is using a single bulldozer and hundreds of workers. Clearly an extra bulldozer would compensate, or substitute, for many workers in producing this output. Contrast that to a second situation in which the firm has 100 bulldozers but relatively fewer workers. The addition of still another machine would have a relatively low substitution value; for example, it might compensate for only one or two workers. Why? The firm already has numerous bulldozers; it needs people to operate them, supervise the operation, and cut down the trees that cannot be bulldozed.

This same concept can be viewed in the opposite way. When the firm is employing only a small amount of labor and a large amount of equipment, an extra worker will possess a relatively high substitution value—that is, compensate for the reduction of a large amount of capital. As more labor is added, however, the decrease in capital permitted by an added unit of labor will decline. Stated in technical terms, the absolute value of the ***marginal rate of technical substitution*** of labor for capital will fall as more labor is added. This MRTS *L, K,* shown symbolically in Equation (5.5), is the absolute value of the slope of the isoquant at a given point.

$$\text{MRTS } L, K = \frac{\Delta K}{\Delta L} \quad \textbf{(5.5)}$$

Returning to Figure 5.8, we see that each isoquant is convex to the origin. As one moves along Q_{75} from left to right, the absolute value of the slope of the curve declines; in other words, the curve gets flatter. A curve that gets flatter (whose absolute slope declines) as one moves southeast is convex to the origin.

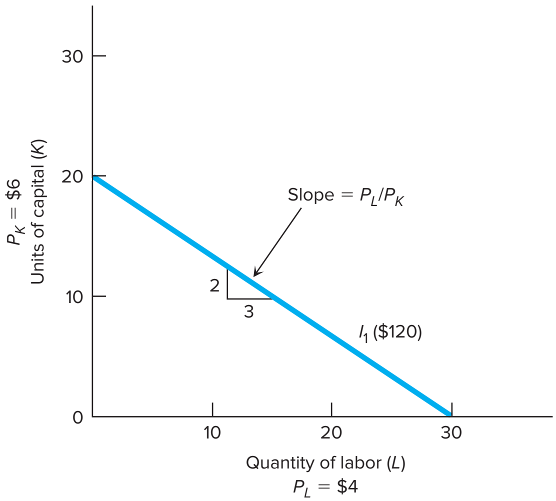
3 Higher Output to the Northeast

Each isoquant farther to the northeast reflects combinations of K and L that produce a greater level of total output than the previous curve. Isoquant Q_{125} represents greater output than Q_{100}, which in turn reflects more output than Q_{75}. Two other points are relevant here. First, we have drawn only three of the many possible isoquant curves. Second, just as equal elevation lines on a contour map never intersect, neither do these equal output lines.

ISOCOST CURVES

A profit-maximizing firm will seek to minimize the costs of producing a given output. To accomplish this task, it will need to know the prices of K and L. These prices let the firm determine the various combinations of K and L that are available to it for a specific expenditure. For example, if the prices of K and L are \$6 and \$4 per unit, respectively, the input combinations that can be obtained from a given outlay, say \$120, would be \$6 times the quantity of K plus \$4 times the quantity of L. One possibility would be to use 20 units of K (= \$120 = \$6 × 20) and no labor. At the other extreme, this firm could use zero units of capital and 30 units of labor (= \$120 = 30 × \$4). Another such combination would be 10K and 15L. In Figure 5.9, we plot

FIGURE 5.9 An Isocost Curve
An isocost (equal expenditure) curve shows the various combinations of two inputs—in this case, capital and labor—that can be purchased with a specific dollar outlay, given the prices of the two inputs. The slope of an isocost line measures the price of one input divided by the price of the other.



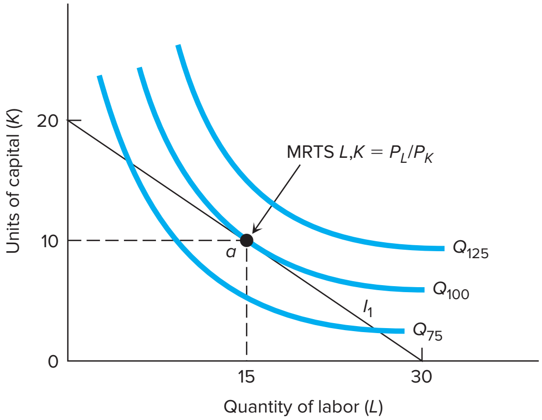
these three points and connect them with a straight line. This line is an ***isocost curve****; it shows all the various combinations of capital and labor that can be purchased by a particular outlay, given the prices of K and L*. Note that the absolute value of the slope of this "equal expenditure" line is the ratio of the price of labor to the price of capital; that is, the slope is ⅔(= \$4/\$6).

The location of a particular isocost curve depends on (1) the total expenditure and (2) the relative prices of L and K. Given the prices of K and L, the greater the total expenditure, the farther the isocost curve will lie outward from the origin. If the total outlay were enlarged from \$120 to \$150, and the prices of K and L remained unchanged, the isocost curve shown in Figure 5.9 would shift outward in a parallel fashion. Similarly, a smaller outlay would shift it inward. Second, the location of an isocost curve depends on the relative prices of L and K. Given the total expenditure, the higher the price of L relative to the price of K, the *steeper* the isocost curve; the lower the price of L relative to the price of K, the *flatter* the curve.

LEAST-COST COMBINATION OF CAPITAL AND LABOR

By overlaying the isocost curve in Figure 5.9 onto Figure 5.8's isoquant map, we can determine the firm's cost-minimizing combination of K and L for a given quantity of total output. Stated somewhat differently, this allows us to determine the lowest cost *per unit of output*. This ***least-cost combination of resources*** occurs at the *tangency point* of the isoquant curve Q_{100} and the isocost curve I_1 (point *a*) in Figure 5.10. At point *a* the slope of the isoquant, the MRTS *L, K,* just equals the ratio of the prices of labor and capital—the slope of the isocost curve. The firm

FIGURE 5.10 The Least-Cost Combination of Capital and Labor
The least-cost combination of capital and labor used to produce 100 units of output is at point *a,* where the isocost line is tangent to isoquant Q_{100}. At *a*, the marginal rate of technical substitution of labor for capital (MRTS *L*, *K*) equals the ratio of the price of labor to the price of capital. In this case, the firm will use 10 units of capital, employ 15 units of labor, and in the process expend \$120.



will use 10 units of capital and employ 15 units of labor. This expenditure of \$120 is the minimum outlay possible in achieving this level of output. To reinforce this proposition, you should determine why combinations of K and L represented by other points on Q_{100} are *not* optimal.

DERIVING THE LONG-RUN LABOR DEMAND CURVE

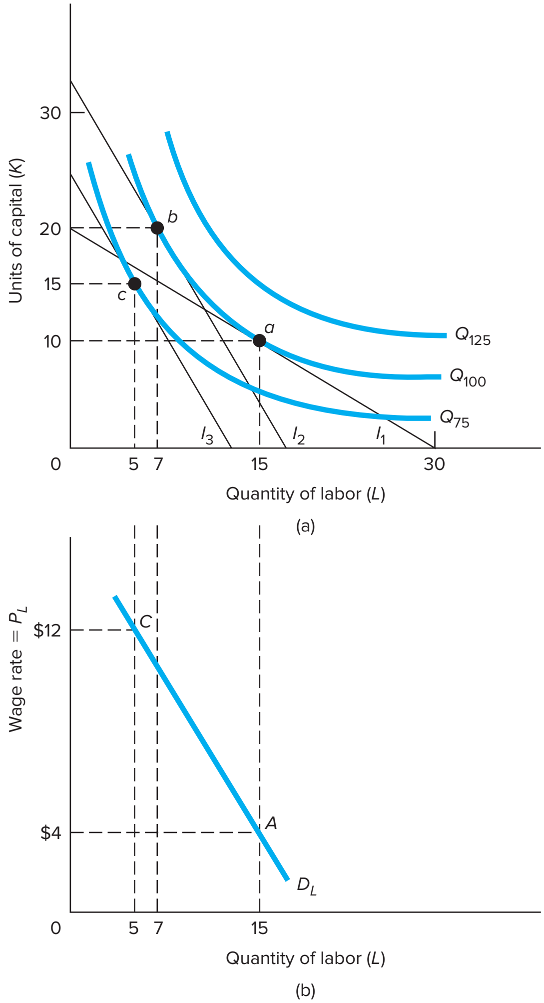
Earlier in this chapter, we derived a *short-run* labor demand curve by holding capital constant, adding units of labor to generate a marginal product schedule, multiplying MP times the extra revenue gained from the sale of additional product, and graphing the resulting marginal revenue product schedule. By applying the W = MRP rule, we demonstrated that the MRP curve *is* the short-run labor demand curve. Now we derive a *long-run* labor demand curve directly from our isoquant–isocost analysis. In Figure 5.11(a), we reproduce our \$120 isocost line I_1 and the isoquant Q_{100}, which is tangent to it at point a. We then drop a perpendicular dashed line down to the horizontal axis of graph (b), which also measures units of labor, but measures the price of labor, or wage rate, vertically. Recall that the price of L is assumed to be \$4, at which the optimal level of employment is 15 units of labor. This gives us point A in the lower graph.

Now suppose some factor (perhaps emigration) reduces the labor supply and increases the price of labor from \$4 to \$12. We need to ascertain graphically the effect of this increase of the wage rate on the quantity of labor demanded. To accomplish this, let's proceed in several steps. First, we must draw a new isocost curve, reflecting the new ratio of the price of L to K. Inasmuch as the price of labor is now \$12 while the price of K is assumed to remain constant at \$6, the new isocost curve will have a slope of 2 (= \$12/\$6). Because we wish initially to hold the level of output constant at Q_{100}, we construct isocost curve I_2, which has a slope of 2 and is tangent to Q_{100} at point b in Figure 5.11(a).

Our next step is to determine the new combination of K and L that would be used *if* output were to be held constant. This is shown at point b, where the marginal rate of technical substitution on isoquant curve Q_{100} equals the slope of isocost curve I_2 (20K and 7L). Notice what has happened thus far: In response to the higher wage rate, the firm has substituted more capital (+10) for less labor (−8). This is the ***substitution effect*** of the wage increase. It is defined as *the change in the quantity of an input demanded resulting from a change in the price of the input, with the output remaining constant*.

The final step is to acknowledge that the increase of the price of labor from \$4 to \$12 will cause the firm to reassess its profit-maximizing level of output. In particular, production costs are now higher and, given product demand, the firm will find it profitable to produce less output. Let's assume that this reevaluation results in the firm's decision to reduce its output from Q_{100} to Q_{75}. Given the new \$12 to \$6 price ratio of L and K, we simply push the I_2 line inward in a parallel fashion until it is tangent with this lower isoquant. The new tangency position is at c, where the firm is using 15K and 5L. This ***output effect*** further reduces the

FIGURE 5.11
Deriving the Long-Run Labor Demand Curve
When the price of labor rises from \$4 to \$12, the substitution effect causes the firm to use more capital and less labor, while the output effect reduces the use of both. The labor demand curve is determined in (b) by plotting the quantity of labor demanded before and after the increase in the wage rate from \$4 to \$12.



cost-minimizing quantity of labor: Not as much labor is needed to produce the smaller quantity of output. This effect is defined as *the change in employment of an input resulting from the cost change associated with the change in the input's price*. Dropping a dashed perpendicular line downward from point *c*, we derive point *C* in the lower graph. At the new wage rate of \$12, the firm desires to hire only 5 units of labor. By finding a series of points such as *a* and *c* in the upper graph and *A* and *C* in the lower one, and then by determining the locus of these latter points, we derive a long-run labor demand curve such as D_L in graph (b). This curve slopes downward because of both a *substitution effect* (−8 labor units) and an *output effect* (−2 units).

Appendix Summary

1. An isoquant curve shows the various possible combinations of two inputs that are capable of producing a specific quantity of physical output.
2. An isocost curve shows the various combinations of two inputs that a firm can purchase with a given outlay or expenditure.
3. The firm's cost-minimizing combination of inputs in achieving a given output is found at the tangency point between the isocost and isoquant curves, where the marginal rate of technical substitution of labor for capital (slope of the isoquant curve) equals the ratio of the input prices (slope of the isocost curve).
4. Changing the price of either input while holding the price of the other resource and the level of output constant produces a new isocost curve that has a new tangency position on the given isoquant curve. This generates a *substitution effect* that results in the use of less of the resource that rose in price and more of the resource that did not experience a price change.
5. An increase in the price of a resource also increases the cost per unit of the product. This creates an *output effect* tending to reduce the employment of both labor and capital.
6. A downward-sloping long-run labor demand curve can be derived by plotting the wage rate–quantity combinations associated with changing the price of labor (wage rate).

Appendix Terms and Concepts

isoquant curve	isocost curve	substitution effect
marginal rate of technical substitution	least-cost combination of resources	output effect

Appendix Questions and Study Suggestions

1. Explain why isoquant curves for inputs that are substitutes in production *(a)* are negatively sloped, *(b)* are convex to the origin, and *(c)* never intersect.
2. Suppose the quantity of capital is fixed at 10 units in Figure 5.8. Explain, by drawing a horizontal line rightward from $10K$, the short-run law of diminishing marginal returns discussed in the body of this chapter. *Hint:* Observe the distance between the isoquants along your horizontal line.
3. Explain how each of the following, other things being equal, would shift the isocost curve shown in Figure 5.9: *(a)* a decrease in the price of L, *(b)* a simultaneous and proportional increase in the prices of both K and L, and *(c)* an increase in the total outlay, or expenditure, from \$120 to \$150.
4. Explain graphically how isoquant–isocost analysis can be used to derive a long-run labor demand curve. Distinguish between the substitution and output effects.
5. By referring to Figure 5.11(a), explain the impact of the increase of the price of labor on the cost-minimizing quantity of capital. What can you conclude about the relative strengths of the substitution and output effects as they relate to the demand for capital in this specific situation?
6. Is labor demand *(a)* elastic, *(b)* unit elastic, or *(c)* inelastic over the \$4 to \$12 wage rate range of D_L in Figure 5.11(b)? Explain by referring to the total wage bill rules (Figure 5.7) and the midpoint formula for elasticity [Equation (5.4)].