CHAPTER 26

FACTOR MARKETS

In our examination of factor demands in Chapter 19 we only considered the case of a firm that faced a competitive output market and a competitive factor market. Now that we have studied monopoly behavior, we can examine some alternative specifications of factor demand behavior. For example, what happens to factor demands if a firm behaves as a monopolist in its output market? Or what happens to factor demands if a firm is the sole demander for the use of some factors? We investigate these questions and some related questions in this chapter.

26.1 Monopoly in the Output Market

When a firm determines its profit-maximizing demand for a factor, it will always want to choose a quantity such that the marginal revenue from hiring a little more of that factor just equals the marginal cost of doing so. This follows from the standard logic: if the marginal revenue of some action didn't equal the marginal cost of that action, then it would pay for the firm to change the action.

This general rule takes various special forms depending on our assumptions about the environment in which the firm operates. For example, suppose that the firm has a monopoly for its output. For simplicity we will suppose that there is only one factor of production and write the production function as $y = f(x)$. The revenue that the firm receives depends on its production of output so we write $R(y) = p(y)y$, where $p(y)$ is the inverse demand function. Let us see how a marginal increase in the amount of the input affects the revenues of the firm.

Suppose that we increase the amount of the input a little bit, Δx. This will result in a small increase in output, Δy. The ratio of the increase in output to the increase in the input is the **marginal product** of the factor:

$$MP_x = \frac{\Delta y}{\Delta x} = \frac{f(x + \Delta x) - f(x)}{\Delta x}. \tag{26.1}$$

This increase in output will cause revenue to change. The change in revenue is called the **marginal revenue**.

$$MR_y = \frac{\Delta R}{\Delta y} = \frac{R(y + \Delta y) - R(y)}{\Delta y}. \tag{26.2}$$

The effect on revenue due to the marginal increase in the input is called the **marginal revenue product**. Examining equations (26.1) and (26.2) we see that it is given by

$$\begin{aligned} MRP_x &= \frac{\Delta R}{\Delta x} = \frac{\Delta R}{\Delta y}\frac{\Delta y}{\Delta x} \\ &= MR_y \times MP_x. \end{aligned}$$

We can use our standard expression for marginal revenue to write this as

$$\begin{aligned} MRP_x &= \left[p(y) + \frac{\Delta p}{\Delta y}y\right] MP_x \\ &= p(y)\left[1 + \frac{1}{\epsilon}\right] MP_x \\ &= p(y)\left[1 - \frac{1}{|\epsilon|}\right] MP_x. \end{aligned}$$

The first expression is the usual expression for marginal revenue. The second and third expressions use the elasticity form of marginal revenue, which was discussed in Chapter 15.

Now it is easy to see how this generalizes the competitive case we examined earlier in Chapter 19. The elasticity of the demand curve facing an individual firm in a competitive market is infinite; consequently the marginal revenue for a competitive firm is just equal to price. Hence the "marginal revenue product" of an input for a firm in a competitive market is just the **value of the marginal product** of that input, pMP_x.

How does the marginal revenue product (in the case of a monopoly) compare to the value of the marginal product? Since the demand curve has a negative slope, we see that the marginal revenue product will always be less than the value of the marginal product:

$$MRP_x = p\left[1 - \frac{1}{|\epsilon|}\right] MP_x \leq pMP_x.$$

As long as the demand function is not perfectly elastic, the MRP_x will be strictly less than pMP_x. This means that at any level of employment of the factor, the marginal value of an additional unit is less for a monopolist than for a competitive firm. In the rest of this section we will assume that we are dealing with this case—the case where the monopolist actually has some monopoly power.

At first encounter this statement seems paradoxical since a monopolist makes higher profits than a competitive firm. In this sense the total factor input is "worth more" to a monopolist than to a competitive firm.

The resolution of this "paradox" is to note the difference between total value and marginal value. The total amount employed of the factor is indeed worth more to the monopolist than to the competitive firm since the monopolist will make more profits from the factor than the competitive firm. However, at a *given* level of output an increase in the employment of the factor will increase output and *reduce* the price that a monopolist is able to charge. But an increase in a competitive firm's output will not change the price it can charge. Thus on the margin, a small *increase* in the employment of the factor is worth less to the monopolist than to the competitive firm.

Since increases in the factor employment are worth less to a monopolist than to a competitive firm on the margin in the short run, it makes sense that the monopolist would usually want to employ less of the input. Indeed this is generally true: the monopolist increases its profits by reducing its output, and so it will usually hire lower amounts of inputs than a competitive firm.

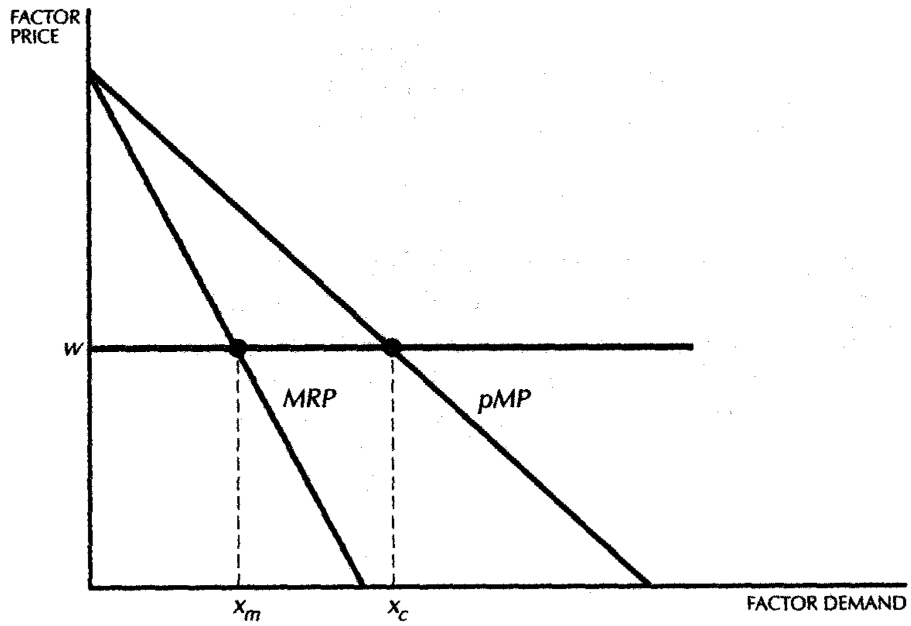
In order to determine how much of the factor a firm employs, we have to compare the marginal revenue of an additional unit of the factor to the marginal cost of hiring that factor. Let us assume that the firm operates in a competitive factor market, so that it can hire as much of the factor as it wants at a constant price of w. In this case, the competitive firm wants to hire x_c units of the factor, where

$$pMP(x_c) = w.$$

The monopolist, on the other hand, wants to hire x_m units of the factor, where

$$MRP(x_m) = w.$$

We have illustrated this in Figure 26.1. Since $MRP(x) < pMP(x)$, the point where $MRP(x_m) = w$ will always be to the left of the point where $pMP(x_c) = w$. Hence the monopolist will hire less than the competitive firm.



Factor demand by a monopolist. Since the marginal revenue product curve (MRP) lies beneath the curve measuring the value of the marginal product (pMP), the factor demand by a monopolist must be less than the factor demand by the same firm if it behaves competitively.

26.2 Monopsony

In a monopoly there is a single seller of a commodity. In a **monopsony** there is a single buyer. The analysis of a monopsonist is similar to that of a monopolist. For simplicity, we suppose that the buyer produces output that will be sold in a competitive market.

As above, we will suppose that the firm produces output using a single factor according to the production function $y = f(x)$. However, unlike the discussion above, we suppose that the firm dominates the factor market in which it operates and recognizes the amount of the factor that it demands will influence the price that it has to pay for this factor.

We summarize this relationship by the (inverse) supply curve $w(x)$. The interpretation of this function is that if the firm wants to hire x units of the factor it must pay a price of $w(x)$. We assume that $w(x)$ is an increasing function: the more of the x-factor the firm wants to employ, the higher must be the factor price it offers.

A firm in a competitive factor market by definition faces a flat factor supply curve: it can hire as much as it wants at the going factor price. A monopsonist faces an upward-sloping factor supply curve: the more it wants to hire, the higher a factor price it must offer. A firm in a competitive factor market is a **price taker**. A monopsonist is a **price maker**.

The profit-maximization problem facing the monopsonist is

$$\max_x \; pf(x) - w(x)x.$$

The condition for profit maximization is that the marginal revenue from hiring an extra unit of the factor should equal the marginal cost of that unit. Since we have assumed a competitive output market the marginal revenue is simply pMP_x. What about the marginal cost?

The total change in costs from hiring Δx more of the factor will be

$$\Delta c = w\Delta x + x\Delta w,$$

so that the change in costs per unit change in Δx is

$$\frac{\Delta c}{\Delta x} = MC_x = w + \frac{\Delta w}{\Delta x}x.$$

The interpretation of this expression is similar to the interpretation of the marginal revenue expression: when the firm increases its employment of the factor it has to pay $w\Delta x$ more in payment to the factor. But the increased demand for the factor will push the factor price up by Δw, and the firm has to pay this higher price on all of the units it was previously employing.

We can also write the marginal cost of hiring additional units of the factor as

$$\begin{aligned} MC_x &= w\left[1 + \frac{x}{w}\frac{\Delta w}{\Delta x}\right] \\ &= w\left[1 + \frac{1}{\eta}\right] \end{aligned}$$

where η is the *supply* elasticity of the factor. Since supply curves typically slope upward, η will be a positive number. If the supply curve is *perfectly* elastic, so that η is infinite, this reduces to the case of a firm facing a competitive factor market. Note the similarity of these observations with the analogous case of a monopolist.

Let's analyze the case of a monopsonist facing a linear supply curve for the factor. The inverse supply curve has the form

$$w(x) = a + bx,$$

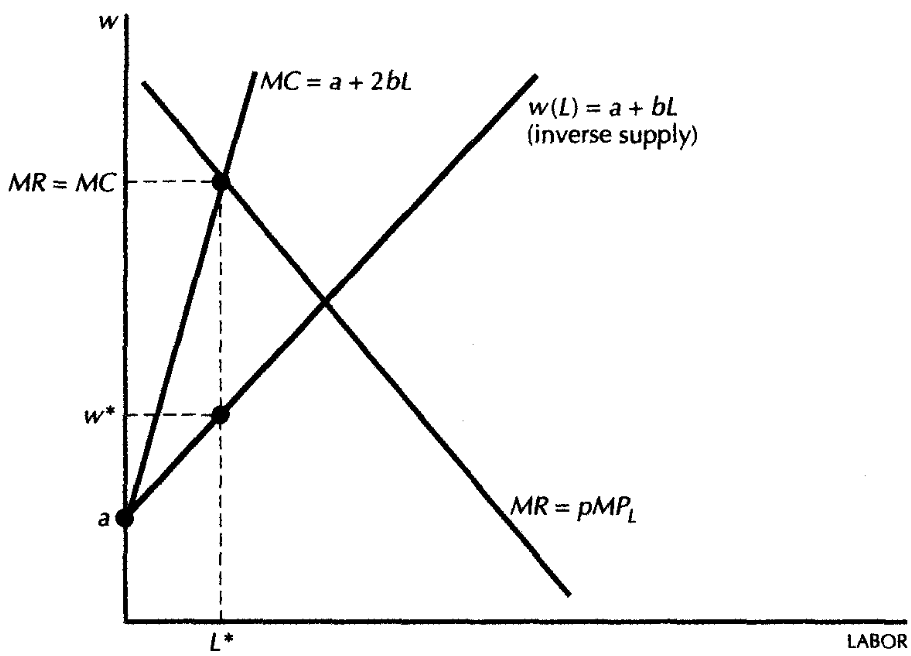
so that total costs have the form

$$C(x) = w(x)x = ax + bx^2,$$

and thus the marginal cost of an additional unit of the input is

$$MC_x(x) = a + 2bx.$$

The construction of the monopsony solution is given in Figure 26.2. We find the position where the value of the marginal product equals marginal cost to determine x^* and then see what the factor price must be at that point.

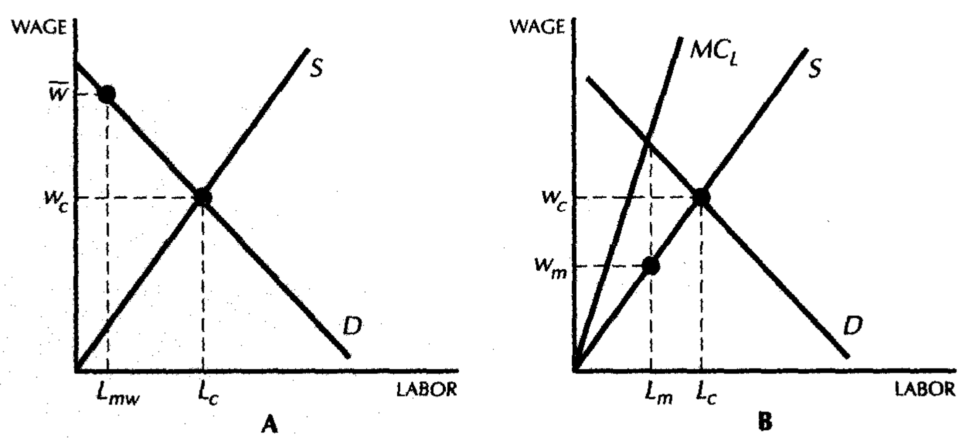


Monopsony. The firm operates where the marginal revenue from hiring an extra unit of the factor equals the marginal cost of that extra unit.

Since the marginal cost of hiring an extra unit of the factor exceeds the factor price, the factor price will be lower than if the firm had faced a competitive factor market. Too little of the factor will be hired relative to the competitive market. Just as in the case of the monopoly, a monopsonist operates at a Pareto inefficient point. But the inefficiency now lies in the factor market rather than in the output market.

EXAMPLE: The Minimum Wage

Suppose that the labor market is competitive and that the government sets a minimum wage that is higher than the prevailing equilibrium wage. Since demand equals supply at the equilibrium wage, the supply of labor will exceed the demand for labor at the higher minimum wage. This is depicted in Figure 26.3A.



Minimum wage. Panel A shows the effect of a minimum wage in a competitive labor market. At the competitive wage, w_c, employment would be L_c. At the minimum wage, $\overline{w}$, employment is only L_{mw}. Panel B shows the effect of a minimum wage in a monopsonized labor market. Under monopsony, the wage is w_m and employment is L_m, which is less than the employment in the competitive labor market. If the minimum wage is set to w_c, employment will increase to L_c.

Things are very different if the labor market is dominated by a monopsonist. In this case, it is possible that imposing a minimum wage may actually *increase* employment. This is depicted in Figure 26.3B. If the government sets the minimum wage equal to the wage that would prevail in a competitive market, the "monopsonist" now perceives that it can hire workers at a constant wage of w_c. Since the wage rate it faces is now independent of how many workers it hires, it will hire until the value of the marginal product equals w_c. That is, it will hire just as many workers as if it faced a competitive labor market.

Setting a wage floor for a monopsonist is just like setting a price ceiling for a monopolist; each policy makes the firm behave as though it faced a competitive market.

26.3 Upstream and Downstream Monopolies

We have now examined two cases involving imperfect competition and factor markets: the case of a firm with a monopoly in the output market but facing a competitive factor market, and the case of a firm with a competitive output market that faces a monopolized factor market. Other variations are possible. The firm could face a monopoly seller in its factor market for example. Or it could face a monopsony buyer in its output market. It doesn't make much sense to plod through each possible case; they quickly become repetitive. However, we will examine one interesting market structure in which a monopoly produces output that is used as a factor of production by another monopolist.

Suppose then that one monopolist produces output x at a constant marginal cost of c. We call this monopolist the **upstream monopolist**. It sells the x-factor to another monopolist, the **downstream monopolist** at a price of k. The downstream monopolist uses the x-factor to produce output y according to the production function $y = f(x)$. This output is then sold in a monopolist market in which the inverse demand curve is $p(y)$. For purposes of this example, we consider a linear inverse demand curve $p(y) = a - by$.

To make things simple, think of the production function as just being $y = x$, so that for each unit of the x-input, the monopolist can produce one unit of the y-output. We further suppose that the downstream monopolist has no costs of production other than the unit price k that it must pay to the upstream monopolist.

In order to see how this market works, start with the downstream monopolist. Its profit-maximization problem is

$$\max_{y} \; p(y)y - ky = [a - by]y - ky.$$

Setting marginal revenue equal to marginal cost, we have

$$a - 2by = k,$$

which implies that

$$y = \frac{a-k}{2b}.$$

Since the monopolist demands one unit of the x-input for each y-output that it produces, this expression also determines the factor demand function

$$x = \frac{a-k}{2b}. \tag{26.3}$$

This function tells us the relationship between the factor price k and the amount of the factor that the downstream monopolist will demand.

Turn now to the problem of the upstream monopolist. Presumably it understands this process and can determine how much of the x-good it will sell if it sets various prices k; this is simply the factor demand function given in equation (26.3). The upstream monopolist wants to choose x to maximize its profit.

We can determine this level easily enough. Solving equation (26.3) for k as a function of x we have

$$k = a - 2bx.$$

The marginal revenue associated with this factor demand function is

$$MR = a - 4bx.$$

Setting marginal revenue equal to marginal cost we have

$$a - 4bx = c,$$

or

$$x = \frac{a-c}{4b}.$$

Since the production function is simply $y = x$, this also gives us the total amount of the final product that is produced:

$$y = \frac{a-c}{4b}. \tag{26.4}$$

It is of interest to compare this to the amount that would be produced by a single integrated monopolist. Suppose that the upstream and the downstream firm merged so that we had one monopolist who faced an output inverse demand function $p = a - by$ and faced a constant marginal cost of c per unit produced. The marginal revenue equals marginal cost equation is

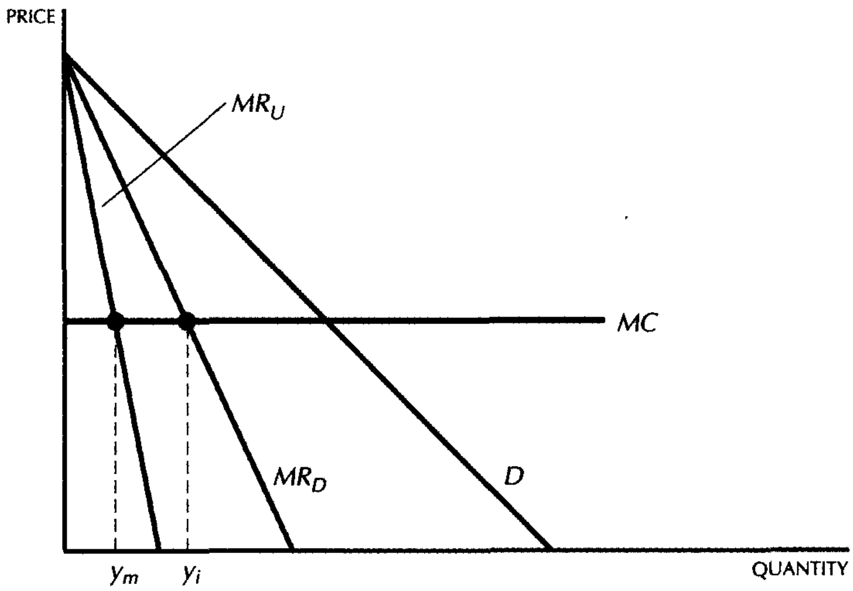
$$a - 2by = c,$$

which implies that the profit-maximizing output is

$$y = \frac{a-c}{2b}. \tag{26.5}$$

Comparing equation (26.4) to equation (26.5) we see that the integrated monopolist produces *twice* as much output as the nonintegrated monopolists.

This is depicted in Figure 26.4. The final demand curve facing the downstream monopolist $p(y)$, and the marginal revenue curve associated with this demand function is itself the demand function facing the upstream monopolist. The marginal revenue curve associated with this demand function



Upstream and downstream monopoly. The downstream monopolist faces the (inverse) demand curve $p(y)$. The marginal revenue associated with this demand curve is $MR_D(y)$. This in turn is the demand curve facing the upstream monopolist, and the associated marginal revenue curve is $MR_U(y)$. The integrated monopolist produces at y_i^*; the nonintegrated monopolist produces at y_m^*.

is therefore *four* times as steep as the final demand curve—which is why the output in this market is half what it would be in the integrated market.

Of course the fact that the final marginal revenue curve is exactly four times as steep is particular to the linear demand case. However, it is not hard to see that an integrated monopolist will always produce more than an upstream-downstream pair of monopolists. In the latter case the upstream monopolist raises its price above its marginal cost and then the downstream monopolist raises its price above this already marked-up cost. There is a **double markup**. The price is not only too high from a social point of view, it is too high from the viewpoint of maximizing total monopoly profits! If the two monopolists merged, price would go down and profits would go up.

Summary

1. A profit-maximizing firm always wants to set the marginal revenue of each action it takes equal to the marginal cost of that action.

2. In the case of a monopolist, the marginal revenue associated with an

increase in the employment of a factor is called the marginal revenue product.

3. For a monopolist, the marginal revenue product will always be smaller than the value of the marginal product due to the fact that the marginal revenue from increasing output is always less than price.

4. Just as a monopoly consists of a market with a single seller, a monopsony consists of a market with a single buyer.

5. For a monopsonist the marginal cost curve associated with a factor will be steeper than the supply curve of that factor.

6. Hence a monopsonist will hire an inefficiently small amount of the factor of production.

7. If an upstream monopolist sells a factor to a downstream monopolist, then the final price of output will be too high due to the double markup phenomenon.

REVIEW QUESTIONS

1. We saw that a monopolist never produced where the demand for output was inelastic. Will a monopsonist produce where a factor is inelastically supplied?

2. In our example of the minimum wage, what would happen if the labor market was dominated by a monopsonist and the government set a wage that was above the competitive wage?

3. In our examination of the upstream and downstream monopolists we derived expressions for the total output produced. What are the appropriate expressions for the equilibrium prices, p and k?

APPENDIX

We can calculate marginal revenue product by using the chain rule. Let $y = f(x)$ be the production function and $p(y)$ be the inverse demand function. Revenue as a function of the factor employment is just

$$R(x) = p(f(x))f(x).$$

Differentiating this expression with respect to x we have

$$\begin{aligned}\frac{dR(x)}{dx} &= p(y)f'(x) + f(x)p'(y)f'(x) \\ &= [p(y) + p'(y)y]f'(x) \\ &= MR \times MP.\end{aligned}$$

Let us examine the behavior of a firm that is a competitor in its output market and a monopsonist in its factor market. Letting $w(x)$ be the inverse factor supply function, the profit-maximization problem is

$$\max_x \; pf(x) - w(x)x.$$

Differentiating with respect to x, we have

$$pf'(x) = w(x) + w'(x)x = w(x)\left[1 + \frac{x}{w}\frac{dw}{dx}\right] = w(x)\left[1 + \frac{1}{\eta}\right].$$

Since the factor supply curve slopes upward, the right-hand side of this expression will be larger than w. Hence the monopsonist will choose to employ less of the factor than would a firm that behaves competitively in the factor market.