Chapter 4- Income distribution and factor pricing

Syllabus-Input markets: demand for inputs; labour markets, land markets, profit maximisation condition in input markets, input demand curves, distribution of Income.

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In this unit, we will begin developing a more complete and comprehensive understanding of how firms choose the inputs for production (and hence, production technologies) in a profit-maximizing manner. We will show how the demand for inputs is ultimately derived from the value of the input in the production process and examine what causes input demand to change. By the end of this chapter, you should be able to answer the following questions:¹

1. How is the demand for an input dependent upon the demand for an output?

2. Given a wage, how does a firm decide how many people to hire?

3. What is the difference between the factor substitution effect and the output effect of a factor price change?

4. What makes the land market different from many other markets?

5. What will cause firms to demand more or demand less of a single input when the price of the input does not change?

6. What is the profit-maximizing rule for the firm’s demand of inputs?

Input Markets: Basic Concepts

The three main inputs used by firms are labor, land, and capital. Transactions in the labor and land markets are fairly straightforward. Households supply their labor to firms that demand it in exchange for a salary or wage. Landowners sell or rent land to others. Capital markets are a bit more complex, but are conceptually very similar (they will be discussed in the next chapter).

Before we begin our discussion of input markets, it will be helpful to establish some basic concepts: derived demand, complementary and substitutable inputs, diminishing returns, and Marginal revenue product.

- Demand for Inputs: A Derived Demand
- Inputs: Complementary and Substitutable and Diminishing Returns
- Marginal Revenue Product

Demand for Inputs: A Derived Demand

The demand for a firm’s product determines how much of it the firm will produce. That, in turn, determines how much of the inputs the firm will demand in order to produce that quantity of the

¹ This unit focuses on the labor and land markets; the capital market will be discussed in next chapter.

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product. We therefore say that the demand for inputs is derived from the demand for the firm’s product, or input demand is derived from output demand.

The value attached to a product and the inputs needed to produce that product define the input’s productivity. The productivity of an input is the amount of output produced per unit of that input.

Prices in competitive input markets depend on firms’ demand for inputs, households’ supply of inputs, and the interaction between the two. In the labor market, for example, firms will demand workers as long as the value of what those workers produce exceeds what they must be paid. Households will supply labor as long as the wage they receive exceeds the value of leisure or the value that they derive from nonpaid work.

**Inputs: Complementary and Substitutable and Diminishing Returns**

Inputs can be used together (complementary) or instead of each other (substitutable). For example, a new machine is probably useless without someone to run it. But the machine may also replace some workers.

The significance of this is that a firm’s input demands are tightly linked to one another. Sometimes changes in capital can make labor more productive (think, for example, of what a worker with a fast computer can accomplish!). Changes that affect the demand for labor (for example, a change in the wage) will also affect the demand for capital or land.

**Diminishing Returns**

We learned in an earlier chapter that the short run is a period during which some fixed factor of production limits a firm’s capacity to expand. Under these conditions, the firm that decides to increase output will eventually encounter diminishing returns, and the marginal product of the variable input will eventually decline.

<table>
<thead>
<tr>
<th>(1) TOTAL LABOR UNITS (EMPLOYEES)</th>
<th>(2) TOTAL PRODUCT (SANDWICHES PER HOUR)</th>
<th>(3) MARGINAL PRODUCT OF LABOR (MP) (SANDWICHES PER HOUR)</th>
<th>(4) PRICE ($P_x$) (VALUE ADDED PER SANDWICH)</th>
<th>(5) MARGINAL REVENUE PRODUCT (MRP) ($MP_x \times P_x$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>1</td>
<td>10</td>
<td>10</td>
<td>$0.50</td>
<td>$5.00</td>
</tr>
<tr>
<td>2</td>
<td>25</td>
<td>15</td>
<td>0.50</td>
<td>7.50</td>
</tr>
<tr>
<td>3</td>
<td>35</td>
<td>10</td>
<td>0.50</td>
<td>5.00</td>
</tr>
<tr>
<td>4</td>
<td>40</td>
<td>5</td>
<td>0.50</td>
<td>2.50</td>
</tr>
<tr>
<td>5</td>
<td>42</td>
<td>2</td>
<td>0.50</td>
<td>1.00</td>
</tr>
<tr>
<td>6</td>
<td>42</td>
<td>0</td>
<td>0.50</td>
<td>0</td>
</tr>
</tbody>
</table>

*The “price” is essentially profit per sandwich; see discussion in text.*

Notice that after the second worker, marginal product declines. In this example, the grill’s capacity ultimately limits output. But to see how the firm might make a rational choice about how many workers to hire, we need to know more about the value of the firm’s product and the cost of labor.
Marginal Revenue Product

If labor is the variable input, as in the example above, then hiring an additional unit will lead to added output (the marginal product of labor). The sale of that added output will yield revenue. **Marginal revenue product** (MRP) is the revenue produced by selling the good or service that is produced by the marginal unit of labor. In a competitive firm, **marginal revenue product** is the value of a factor’s marginal product.

Using labor as the variable factor, we can state this proposition more formally by saying that if MPL is the **marginal product of labor** and PX is the price of output, then the **marginal revenue product** of labor is:

\[
MRP_L = MPL \times PX
\]

**Labor Markets: A Firm Using Only One Variable Factor of Production: Labor**

**Labor Markets**

We will begin our discussion of input markets by considering a firm that uses only one variable factor of production.

**A Firm Using Only One Variable Factor of Production: Labor**

Demand for an input depends on that input’s **marginal revenue product** and its unit cost or price. The price of labor is the wage determined in the labor market. A profit-maximizing firm will hire workers as long as the **marginal revenue product** of the worker exceeds the wage.

To put this another way, as long as the wage is less than (or equal to) the MRPL, the firm will hire the worker.

Look again at the data in column 5 of the table below.
Suppose that the wage for sandwich makers is $5 per hour. A profit-maximizing firm would hire three workers. If the wage were lower, say $2 per hour, the firm would hire more workers (the marginal revenue product would exceed the wage for four workers).

This is illustrated graphically in Figure 9.3.

The figure shows that the wage rate is determined by the interaction of wage-suppliers and wage-demanders in the labor market. Since the labor market is an input market, the suppliers are the households, and the demanders are the firms (as opposed to output markets).

The demand for labor by the firm, in this case, is simply the downward sloping portion of the MRPL curve. The firm will hire workers up to the point where the MRPL equals the wage rate. If the wage is $10 as shown in the figure, the firm will hire 210 units of labor.

### Labor Markets: A Firm Using Two Variable Factors of Production in the Short and Long Run

But what if the firm has a choice of how much labor and how much capital to use? Input choices become more complicated if there is more than one input to choose from. Intuitively, the firm looks at the amount of money it gets from each type of input and then looks at the cost of each type of input. The firm then chooses the input that is a better deal--the input where the additional revenue less the additional cost is highest.

Let us say that wages increase in response to a change in labor supply. Imagine the price of capital is $1, and wages rise from $1 to $2.

### TABLE 9.1 Marginal Revenue Product Per Hour of Labor in Sandwich Production (One Grill)

<table>
<thead>
<tr>
<th>Total Labor Units (Employees)</th>
<th>Total Product (Sandwiches Per Hour)</th>
<th>Marginal Product of Labor (MP) (Sandwiches Per Hour)</th>
<th>Price ($/MP)</th>
<th>Marginal Revenue Product (MP x P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>10</td>
<td>0.50</td>
<td>5.00</td>
</tr>
<tr>
<td>1</td>
<td>10</td>
<td>10</td>
<td>0.5</td>
<td>7.5</td>
</tr>
<tr>
<td>2</td>
<td>15</td>
<td>0</td>
<td>0.5</td>
<td>5.0</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>0</td>
<td>0.5</td>
<td>2.5</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>0</td>
<td>0.5</td>
<td>1.0</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0.5</td>
<td>0</td>
</tr>
</tbody>
</table>

Note: The above table shows the marginal revenue product for different levels of labor input. The marginal revenue product is calculated as the product of the marginal product of labor and the price per unit of labor.
Chapter 4: Income distribution and factor pricing

Not surprisingly, higher wages make the labor-intensive production choice less desirable than the capital-intensive production technology. Given the choice, the rational firm will choose to use the capital-intensive technology, using more capital and less labor. The choice to demand less labor in response to the increase in wages is based upon the substitution of capital for labor, since capital is cheaper.

When a firm changes inputs because the relative price of the other input becomes cheaper, this change is called the factor substitution effect. If the firm was using a capital-intensive process and then capital became more expensive, it might make sense for the firm to switch to a more labor-intensive process.

There is a second reason why firms with multiple inputs will demand less of an input when the price of the input rises. As learned in chapter 7, when a firm has an increase in the price of a variable input, the marginal cost of production will rise. When the marginal cost rises, the profit-maximizing level of production decreases, ceteris paribus. If the firm produces less, it demands less of the variable input. This effect is called the output effect of factor price increase (or decrease). Therefore, if wages rise, the MC curve will shift up. If the MC curve shifts up and the MR curve stays the same, a firm will make fewer goods. With fewer goods being made, fewer workers are needed.

The output effect helps explain why input demand curves slope downward. Output effects and factor substitution effects work in the same direction. Both effects lead to a decrease in the demand for labor when the wage rate rises.

### Many Labor Markets

The circular flow diagram presented at the beginning of this chapter refers to “the labor market” as if there were just one, but in truth, many labor markets exist. There is a market for baseball players, for construction workers, for lawyers, etc. Each market has a set of skills associated with it and a supply of people with the requisite skills.

### Land Markets: Rent and the Value of Output Produced on Land

Unlike labor and capital, land has a special feature that we have not yet considered: it is in strictly fixed (perfectly inelastic) supply. The only real questions about land thus center around how much it is worth and to what use it will be put.

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TABLE 9.2 Response of a Firm to an Increasing Wage Rate

<table>
<thead>
<tr>
<th>TECHNOLOGY</th>
<th>INPUT REQUIREMENTS</th>
<th>UNIT COST IF (P_l = $1)</th>
<th>UNIT COST IF (P_k = $1)</th>
<th>UNIT COST IF (P_l = $2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) (capital intensive)</td>
<td>10 3 5</td>
<td>$15 ((P_l \times L) + (P_k \times K))</td>
<td>$13 ((P_l \times L) + (P_k \times K))</td>
<td>$20 ((P_l \times L) + (P_k \times K))</td>
</tr>
<tr>
<td>(B) (labor intensive)</td>
<td>3 10</td>
<td>$13 ((P_l \times L) + (P_k \times K))</td>
<td>$20 ((P_l \times L) + (P_k \times K))</td>
<td>$23 ((P_l \times L) + (P_k \times K))</td>
</tr>
</tbody>
</table>

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Because land is fixed in supply, we say that its price is demand determined. This means that the only thing that raises and lowers its price is a change in demand. The return to any factor of production in fixed supply is called a pure rent. A typical market for land is shown below.

It should be noted that even though the figure above shows that the supply of land is a vertical line (perfectly inelastic), the supply of land for a given use might not be perfectly inelastic or fixed. For example, in many parts of the United States, what had been farmland is being developed for housing. As the demand for housing grows around cities, pushing up the price of land, farmers sell their land to developers; the supply curve would then be upward sloping, showing that the amount of land available for that use increases with the price.

**Rent and the Value of Output Produced on Land**

The theory behind the firm’s profit-maximizing use of land is similar to the theory behind the firm’s use of any input. The firm compares the marginal revenue from using one more acre of land to the cost of an acre of land. If the marginal revenue product is more than the price, the firm will buy the land. Land has declining MRP, much like labor and capital, and the marginal revenue product (of one more acre) is referred to as MRP\(_A\). Since the firm uses land up to the point where MRP\(_A\) = \(P_A\) (the price of land), the profit-maximizing conditions are similar to those in the labor market.

**The Firm’s Profit-Maximizing Condition in Input Markets**

For all three input markets to be used in a profit-maximizing way for the firm, it must be the case that:

- For the land market, \(P_A = MRP_A\).
- For the capital market, \(P_K = MRP_K\).
- For the labor market, \(P_L = MRP_L\).
Since the marginal revenue product is the marginal product multiplied by the value added by the input, these three equations can be written as:

• \( P_A = MP_A \times P_X \)
• \( P_K = MP_K \times P_X \)
• \( P_L = MP_L \times P_X \)

Then, by rearranging the equations:

• \( P_X = MP_A \times P_A \)
• \( P_X = MP_K \times P_K \)
• \( P_X = MP_L \times P_L \)

Which implies that \( MP_A \times P_A = MP_K \times P_K = MP_L \times P_L \). This equation can be rewritten as:

\( \frac{MP_A}{P_A} = \frac{MP_K}{P_K} = \frac{MP_L}{P_L} \)

Therefore, the marginal product divided by the input price needs to be the same in all input markets for profit maximization. If the firm is using too much capital, the marginal product will be lower than it should be. Thus, the MP/P will be lower than the other input markets. The firm should then use less capital (raising the MP of capital) and more of the other inputs (decreasing the MP of the other inputs) until all of the ratios are equal.

**Input Demand Curves and Shifts in Factor Demand Curves**

Factor demand curves are derived from information about technology (production functions) and output price. Factor demand curves will shift if there are changes in the demand for outputs, changes in the quantity of complementary or substitutable inputs, changes in the prices of other inputs, or technological change. Such shifts in demand are important because they directly affect the allocation of resources among alternative uses, as well as the level and distribution of income.

**The Demand for Outputs**

To understand how the demand curve for inputs will change, the key is to remember that the demand curve for inputs is the marginal revenue product (MRP). If product demand increases, product price will rise and marginal revenue product will increase. The MRP will shift right, meaning an increase in the demand for the input. When the price of the output falls, the MRP falls, and the demand for the input falls.

**The Quantity of Complementary and Substitutable Inputs**
If there is an increase in the use or availability of complementary inputs, then the demand for the input will rise. As an example, think of the personal computer. At one time, it was thought that computers would replace workers and reduce employment. In fact, what has happened is that workers are so much more productive when working with computers, that, in many industries, computers have increased the demand for labor. The demand for technologically skilled workers is at an all-time high. The increase in the availability of computers (a complement to labor) has increased the demand for labor.

On the other hand, an increase in the availability of a substitute will decrease the demand for the input. An example is elevators. Years ago, there were attendants inside the elevator who manually opened the doors and stopped the elevator at different floors. Over time, computers have taken over the role of the elevator attendant. As a result of the availability of a substitute (computers), the demand for elevator attendants has essentially disappeared.

REALITY CHECK: Other examples of the substitution of capital for labor are automated directory assistance (how often do you call information and not get connected to a person?) and the replacement of toll collectors with reading devices in tollbooths.

The Prices of Other Inputs

As discussed earlier in this chapter, the demand for inputs is affected by changes in the price of other inputs. If a firm can produce using capital-intensive or labor-intensive technologies, it may change technologies from capital to labor if the price of labor (wages) decreases. A decrease in the demand for capital results from a decrease in the price of labor. Likewise, if the price of the alternative input goes up, that may increase the demand for the cheaper input.

Technological Change

The last factor that can change the demand for inputs is technological change. An improvement in production technology will increase the marginal product of the input. When the marginal product rises, so will the marginal revenue product, and hence the demand. A company with an inefficient production process may reorganize the process through technological change. By reorganizing, the company may be able to increase the output per worker. If the output per worker increases, the firm can now hire more workers to capture this potential increase in profits.

Resource Allocation and the Mix of Output in Competitive Markets

In the competitive environment, profit-maximizing firms make three fundamental decisions: (1) how much to produce and supply in output markets, (2) how to produce (which technology to use), and (3) how much of each input to demand. In earlier chapters, we looked at these three decisions from the point of view of output markets. In this chapter, we have looked at them another way, from the point of view of input markets.

The Distribution of Income

Income is earned by households as payment for the factors of production that household members supply in input markets. Workers receive wages in exchange for their labor, owners of capital receive
profits and interest in exchange for supplying capital (saving) and landowners receive rents in exchange for the use of their land.

The incomes of households therefore depend on the prices of the inputs they supply. If markets are competitive, the equilibrium price of each input is equal to its marginal revenue product. Thus, at equilibrium, each factor ends up receiving rewards determined by its productivity as measured by its marginal revenue product. This is referred to as the marginal productivity theory of income distribution.