This is the first of a three-chapter sequence that examines the distribution of income and related issues. This chapter develops the neoclassical theory of income distribution, in which each factor of production earns a price that equals the value of its marginal product.

This chapter builds on concepts from the earlier chapters entitled “The Costs of Production” and “Firms in Competitive Markets.” I highly recommend you cover those chapters before this one.

Most students find this chapter to be of average difficulty.
### Two Assumptions

1. We assume all markets are competitive.
   - The typical firm is a price taker
     * in the market for the product it produces
     * in the labor market
2. We assume that firms care only about maximizing profits.
   - Each firm’s supply of output and demand for inputs are derived from this goal.

### Our Example: Farmer Jack

- Farmer Jack sells wheat in a perfectly competitive market.
- He hires workers in a perfectly competitive labor market.
- When deciding how many workers to hire, Farmer Jack maximizes profits by thinking at the margin:
  - If the benefit from hiring another worker exceeds the cost, Jack will hire that worker.

We used this example in Chapter 13 to introduce the following concepts:

* production function
* marginal product of labor
* diminishing marginal product

Here, we briefly review these concepts and then use them to derive Farmer Jack’s demand for labor.

### Farmer Jack’s Production Function

<table>
<thead>
<tr>
<th>L (no. of workers)</th>
<th>Q (bushels of wheat per week)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1000</td>
</tr>
<tr>
<td>2</td>
<td>1800</td>
</tr>
<tr>
<td>3</td>
<td>2400</td>
</tr>
<tr>
<td>4</td>
<td>2800</td>
</tr>
<tr>
<td>5</td>
<td>3000</td>
</tr>
</tbody>
</table>

![Graph of Farmer Jack's Production Function]
Marginal Product of Labor (MPL)

- **Marginal product of labor**: the increase in the amount of output from an additional unit of labor
  
  \[ MPL = \frac{\Delta Q}{\Delta L} \]
  
  where
  
  \( \Delta Q \) = change in output
  
  \( \Delta L \) = change in labor

The Value of the Marginal Product

- **Problem**: 
  
  * cost of hiring another worker (wage) is measured in dollars
  * benefit of hiring another worker (MPL) is measured in units of output

- **Solution**: convert MPL to dollars

- **Value of the marginal product**: the marginal product of an input times the price of the output
  
  \[ VMPL = value\ of\ the\ marginal\ product\ of\ labor \]
  
  \[ VMPL = P \times MPL \]

This exercise should not be difficult. But students are more likely to remember how to compute MPL and VMPL if we make them do it instead of just showing them the results.

And students have computed lots of marginal things from preceding chapters, so all they should need to do this exercise is the definitions of MPL and VMPL from the preceding slides.
Farmer Jack’s VMPL curve is downward sloping, due to diminishing marginal product.

The VMPL curve

Some students may not offset the points between the L values, as shown here and in the table on the preceding slide.

For our purposes, that’s okay. What matters is they see that VMPL is a downward-sloping curve. They will get the rest from the following slides.

A student may wonder why we are measuring the wage in dollars per week rather than dollars per hour. If a student asks this question, before giving the answer, see if another student can explain the answer.

The answer is: our task here is to compare the cost and benefit of hiring an extra worker. The benefit, P x MPL, is extra revenue per week from having one more workers (recall, the production function and hence MPL are measured in units per week). So we must compare that to the cost per week of having one more worker.

The logic behind the answer L = 3 is the same marginal analysis that students have seen in many other contexts in previous chapters.

At any L smaller than L = 3, can increase profit by hiring another worker.

For example, suppose Jack has 2 workers. At L = 2, VMPL > W. In other words, the increase in revenue from hiring one more worker exceeds the increase in cost (the wage). So, hiring one more worker would increase profit.

At any L larger than L = 3, can increase profit by hiring one fewer worker.

For example, suppose Jack has 4 workers. At L = 4, VMPL < W. In other words, the revenue from the 4\textsuperscript{th} worker is less than the cost of that worker, so can increase profit by hiring one fewer worker.
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Shifts in Labor Demand

Labor demand curve = VMPL curve.

VMPL = P x MPL

Anything that increases P or MPL at each L will increase VMPL and shift labor demand curve upward.

Things that Shift the Labor Demand Curve

- Changes in the output price, P
- Technological change (affects MPL)
- The supply of other factors (affects MPL)

Example:
If firm gets more equipment (capital), then workers will be more productive; MPL and VMPL rise, labor demand shifts upward.

The example in the third point implies that the firm sees factor inputs as complements, not substitutes.

While this is true in many cases, one can also think of examples in which the firm would see inputs as substitutes. For example, industrial robots have displaced some workers in the auto industry. Though, they have increased demand for other kinds of workers in that industry.

The Connection Between Input Demand & Output Supply

Recall: marginal cost (MC) = cost of producing an additional unit of output = \( \Delta TC / \Delta Q \), where TC = total cost

Suppose \( W = 2500 \), MPL = 500 bushels

If Farmer Jack hires another worker, \( \Delta TC = 2500 \), \( \Delta Q = 500 \) bushels

MC = $2500/500 = 55 per bushel

In general: \( MC = \frac{W}{MPL} \)

This and the next two slides cover material from the FYI box entitled “Input Demand and Output Supply: Two Sides of the Same Coin.”

This slide establishes the relationship between marginal cost and marginal product.

The Connection Between Input Demand & Output Supply

In general: \( MC = \frac{W}{MPL} \)

Notice:
* To produce additional output, hire more labor.
* As L rises, MPL falls...
* causing W/MPL to rise...
* causing MC to rise.

Hence, diminishing marginal product and increasing marginal cost are two sides of the same coin.

This slide shows the connection between diminishing marginal product and increasing marginal cost.
This slide shows that when a competitive firm hires labor to the point where \( W = VMPL \), it is also producing output up to the point where \( P = MC \).

Hence, input demand and output supply are two sides of the same coin.

At this point, the book briefly discusses the income and substitution effects. (The discussion is intuitive, and the actual terms “income and substitution effects” appear only parenthetically.)

The book concedes the possibility that the labor supply curve might bend backward if the income effect exceeds the substitution effect, but states that we will ignore this possibility for now and assume the labor supply curve is positively sloped.

Regarding the first point: The textbook notes that a change in attitudes about female labor force participation over the past 50 years has dramatically shifted the labor supply curve rightward.
Equilibrium in the Labor Market

The wage adjusts to balance supply and demand for labor.
The wage always equals VMPL.

ACTIVE LEARNING 2:
Changes in labor-market equilibrium

In each of the following scenarios, use a diagram of the market for auto workers to find the effects on the wage and number of auto workers employed.
A. Baby Boomers in the auto industry retire.
B. Widespread recalls of U.S. autos shift car buyers’ demand toward imported autos.
C. Technological progress boosts productivity in the auto manufacturing industry.

Again, these exercises should not be difficult, but it’s better to have students do them than to have students watch the instructor do them.

The exercise in Part C segues nicely into the case study on productivity and wages that follows.

This scenario, in fact, will occur over the coming 10-15 years.

Digression:

Unfortunately, just as the remaining workers see their wages going up, they will likely see their payroll taxes going up to fund the increasing outlays of Social Security and Medicare.
Productivity and Wage Growth in the U.S.

<table>
<thead>
<tr>
<th>time period</th>
<th>growth rate of productivity</th>
<th>growth rate of real wages</th>
</tr>
</thead>
<tbody>
<tr>
<td>1959-2003</td>
<td>2.1%</td>
<td>2.0%</td>
</tr>
<tr>
<td>1959-1973</td>
<td>2.9</td>
<td>2.8</td>
</tr>
<tr>
<td>1973-1995</td>
<td>1.4</td>
<td>1.2</td>
</tr>
<tr>
<td>1995-2003</td>
<td>3.0</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Recall one of the Ten Principles: A country’s standard of living depends on its ability to produce goods and services. Our theory implies wages tied to labor productivity ($W = VMPL$). We see this in the data.

This slide covers material discussed in the chapter in a case study entitled “productivity and wages.”

The data on this slide and the analysis on the preceding one show that technological progress benefits workers by increasing real wages.

Unfortunately, technological progress makes some jobs obsolete. For example, the demand for typewriter repair technicians has fallen sharply over the past 25 years.

A Luddite is someone who opposes technological progress. A Luddite would have argued in the 1980s that policymakers should restrict the spread of computers and word processing software to protect the jobs of typewriter repair technicians. Most students will readily agree that such a policy would have been a huge mistake – the productivity gains from computers and word processing software far outweigh the welfare losses of workers displaced from the typewriter repair industry.

Moreover, this change has created other kinds of jobs, such as the technicians who charge $100/hour to recover your data from Windows crashes, spyware, and virus attacks.

The textbook has a box entitled “The Luddite Revolt” that provides historical background on this issue.

We have seen how workers are compensated.

What determines how much the owners of land and capital earn for their contribution to the production process?

First, we distinguish between the purchase price and rental price of these factors.

Then, we apply the lessons we learned about wage determination to help us understand the determination of the rental prices of capital and land.
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How the Rental Price of Land Is Determined
Firms decide how much land to rent by comparing the price with the value of the marginal product (VMP) of land.
The rental price of land adjusts to balance supply and demand for land.

The market

D = VMP

S

P

Q

Q

D = VMP

P

S

Q

How the Rental Price of Capital Is Determined
Firms decide how much capital to rent by comparing the price with the value of the marginal product (VMP) of capital.
The rental price of capital adjusts to balance supply and demand for capital.

The market

D = VMP

S

P

Q

Q

D = VMP

P

S

Q

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Rental and Purchase Prices
§ Buying a unit of capital or land yields a stream of rental income.
§ The rental income in any period equals the value of the marginal product (VMP).
§ Hence, the equilibrium purchase price of a factor depends on both the current VMP and the VMP expected to prevail in future periods.

Regarding the first point:

When a firm buys a unit of capital, it will likely use that capital in its own production rather than rent it in the capital rental market.

However, the opportunity cost of using its capital is the stream of rental income it could earn.

So, if the firm is using its own capital, we can infer that the capital is generating at least as much income as the stream of rental income it would command in the rental market.

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Linkages Among the Factors of Production
§ In most cases, factors of production are used together in a way that makes each factor’s productivity dependent on the quantities of the other factors.
§ Example: an increase in the quantity of capital
  * The marginal product and rental price of capital fall.
  * Having more capital makes workers more productive, MPL and W rise.
CONCLUSION

§ The theory in this chapter is called the neoclassical theory of income distribution.

§ It states that
  • factor prices determined by supply and demand
  • each factor is paid the value of its marginal product

§ Most economists use this theory as a starting point for understanding the distribution of income.

§ The next two chapters explore this topic further.

CHAPTER SUMMARY

§ The economy’s income distribution is determined in the markets for the factors of production. The three most important factors of production are labor, land, and capital.

§ A firm’s demand for a factor is derived from its supply of output.

§ Competitive firms maximize profit by hiring each factor up to the point where the value of its marginal product equals its rental price.

CHAPTER SUMMARY

§ The supply of labor arises from the trade-off between work and leisure, and yields an upward-sloping labor supply curve.

§ The price paid to each factor adjusts to balance supply and demand for that factor. In equilibrium, each factor is compensated according to its marginal contribution to production.

§ Factors of production are used together. A change in the quantity of one factor affects the marginal products and equilibrium earnings of all factors.