7. **The Theory of the Firm – Production**

In this chapter you will learn:
- Organization of a firm;
- Efficiency concepts;
- Principal Agent problem;
- Production functions, average product, marginal product;
- Short run decisions versus long run decisions;
- Short run and long run productivity (returns to scale)

### 7.1 What is a Firm?

What is a firm? This might seem like a silly question. We read about "firms" everyday in the newspaper or see them mentioned on the evening news. GM, McDonald's, IBM, Ford, Exxon, Microsoft, General Dynamics, Wal-Mart, Coca-Cola, Hewlett-Packard, Amazon.com, Enron, Adelphia, Hilton, and so on, are common names. But why do these firms exist? Why are they organized the way they are? Some firms own their suppliers, e.g., auto part companies, but most do not. Why? Why are they in the particular business they are in? How do they grow and develop and respond to market signals? How do they provide the goods and services they do? How do they compete? How do they avoid competition? These are some of the questions we will be interested in.

One useful definition of a firm is the following. A firm is an **institutional arrangement** that is designed to **economize** on the number of transactions required to sell an output. This definition is due to Nobel Laureate **Ronald Coase**. Indeed, the optimal size of a firm is such as to economize on transactions such that no smaller firm, nor any larger one, can out compete the firm in its efficiency at economizing on transactions. The sole purpose of the firm is to maximize profit by selling an output produced from a variety of inputs. If a firm does not do this, it will lose out to a firm that does.

Consider the following example. Suppose you want to get your car fixed. You would have to undertake the following steps.

1. Hire a mechanic to diagnose the problem.
2. Hire a cost estimator to estimate the cost of the parts required to fix the car.
3. Buy the parts.
4. Rent the tools necessary to do the job.
5. Hire someone to do the work.

Each step of the way there will be a separate market with a supply and a demand that will determine the price. For example, in the "cost estimator" market, the supply of people who do estimates and the need for such people will determine the value of the estimation task.

We do not have our cars serviced this way. The individual firm economizes on these transactions by doing all of them for you. This is what firms are all about. Put a slightly different way, a **firm** is a loose collection of people who are organized in such a way so as to **economize on transactions** required to bring a product to market and sell it. Indeed, **most transactions that occur in any modern economy take place inside firms** and are not readily observable.

Sometimes a firm can be too small and can actually do better for itself by growing larger, i.e., hiring more people and taking on more tasks for itself. On the other hand, sometimes a firm can grow too large. In that case, the firm is trying to do too much and becomes inefficient as a result. Such a firm can increase its profitability by outsourcing some of its work, i.e., hiring outside contractors to do some of its work. For example, a firm can certainly hire several accountants to take care of its books. On the other hand, it might find it in its best interest to hire
an outside accounting firm to do its accounting for it. Indeed, there are firms who study efficiency and can provide advice to a company that is trying to improve its efficiency.

In the extreme case a firm might grow so large that it becomes very inefficient. In that case, another firm can successfully take over the first firm, rearrange its organization by scrapping some of its divisions, selling parts of the company, and outsourcing some of the work. This is basically what corporate raiders do; they look for profitable opportunities where a firm is being managed badly and has grown too large and inefficient. Indeed, it is the threat of a takeover that sometimes forces managers to behave in an efficient manner.

The main point is that firms are configured in order to minimize transactions costs. They will seek an efficient method of providing and servicing a product and in so doing undertake an efficient number of transactions within the firm. The firm is compelled to be efficient because it is trying to maximize its profit. A change in the economic environment may cause the firm to alter the set of transactions it undertakes within the firm and the transactions it takes outside the firm with other firms.

Example: GM has a choice. It can produce car parts within the company as a separate part of GM or it can buy the same parts from outside the company from a separate supplier. As it turns out GM does both. However, in the last decade they have been eliminating some of their own parts production divisions and have laid off hundreds of GM employees. Instead, they have been buying more parts from outside suppliers and relying on competition among suppliers to keep the price of its parts down. This has led to a number of strikes at GM parts production plants. In addition, General Motors has been trying to induce competition among its suppliers in order to lower its costs very vigorously. There is tremendous pressure on parts suppliers to lower the health care benefits and other fringe benefits they pay their employees in order to get their own costs down so they can compete for GM's business.

Example: outsourcing. Health care costs have been increasing in the last fifty years and especially in the last twenty years or so. Many firms have discovered they can lower their costs by eliminating some of these benefits. One way of doing so is to eliminate jobs and then contract outside the firm for the same work. This is known as outsourcing. So, for example, a firm may find that it can lower its cost by firing its accounting staff and then hiring an accounting firm to do its books. The net saving is that it doesn't have to pay health care benefits to the people doing its accounting. Accounting firms then have to compete for the company's business. This puts pressure on the accounting firm to lower the benefits that it gives its employees in order to get its cost down. It is probably no accident that outsourcing became very popular in the late 1980's just as health care costs began to increase dramatically.

Example: Outsourcing white-collar jobs. Outsourcing typically affected blue-collar type jobs until the early 2000s. A company would relocate a factory to Mexico, for example, because the labor costs were lower. Or a US company would set up a call center in India to take orders and handle customer complaints. The response to this by advocates of free trade was to tell workers to upgrade their skills. However, now white-collar jobs are being threatened. For example, the technology exists that will allow a doctor in India to read an X-ray of a patient in the US at a much lower cost than a US doctor reading the same X-ray. Engineering and computer design jobs are also being sent to India or China because the costs are much lower there. For example, there was a news story on ABC news in 2003 about a new computer firm starting up in Cambridge, MA. American computer programmers normally receive a salary of about $80,000. The owners of the firm discovered that they could hire computer programmers in India for about $40,000. Instead of shipping the job overseas, the owners advertised the job at $40,000 in Cambridge and within a week there were over 100 local applicants. One US student was given
the job and since then the company has hired another US student and upgraded the pay to about $50,000 plus bonuses.

**Examples:** There are numerous examples of outsourcing failing or leading to dispute. Boeing hired subcontractors to do most of the work on its 787 Dreamliner, some of whom hired sub subcontractors in turn. Many of the several dozen contractors failed to deliver parts on time, parts did not fit together, and there were cost over runs and legal disputes, which held up production of the plane.\(^1\) As another example, BskyB in Britain hired EDS to develop a computer resource management system and EDS failed to provide the system leading to a seven year legal dispute.\(^2\)

The basic idea should be clear though. If the firm is as efficient as it can be, outsourcing will not improve its efficiency. In addition to this, a corporate raider will be unable to buy such a firm and improve its ability to compete. The real tradeoff might be between firms providing health care and pensions versus keeping their costs low through outsourcing. This may become a hot political issue in the future.

However, sometimes a firm will want to be bought out by a larger firm. One reason is to protect it from being bought by another firm that is hostile to it, especially one that may break it up prematurely. Second, being bought out may be the only way a firm can obtain additional investment capital. Both of these possibilities are realistic. For example, we should expect a consolidation in the dot.com industry as investment capital becomes more scarce. This tends to be the pattern for new industries. Firms that are more efficient tend to buy up firms that are less so. By combining divisions within the newly formed company, the managers can improve efficiency through consolidation. This was the pattern in steel back in the 1880's and 1890's, autos back in the 1920's, and consumer electronics in the 1950's and again in the 1970's. Competition leads to efficiency.

**Application:** In *The Market Revolution* Charles Sellers chronicles the history of the development of the market as an institutional arrangement in the US. Initially, the 13 colonies were each self sufficient and mostly agriculturally oriented, producing their own food, rudimentary farm implements, shoes, clothing, and the like. Gradually, surpluses were produced and there was an incentive to trade with other colonies and with Britain. By 1800 the colonies, now the United States, were generally engaged in much trade amongst themselves and settlements to the west were being developed. As markets expanded, this allowed for the development of new methods of organizing production and new, innovative techniques of manufacturing. A perfect example of one of the most important developments is the rise of mass manufacturing.

Most clothing circa 1800 was produced literally at home with a few exceptions, e.g., shoes which were produced by a cobbler. Hence the term "homespun." If you wanted a fine suit made for special occasions like going to church, or getting married, you would go to a master tailor, who would measure you carefully, cut the pieces of fabric precisely to your measurements, and fittings would take place as the garment took shape so as to produce the best fit. Not surprisingly, such a suit of clothes would be expensive. It was discovered, however, that the process could be made more efficient by choosing general sizes, e.g., 32 regular, cutting out a template designed for that particular size, and then using the template to "mass produce" suits that would then be sold "off the rack." Workers, mostly women and children, working at home could produce large quantities of "precut" cloth from the templates to be sewn together into suits. Imagine a production process like the following. The first person sews several pieces of cloth together into

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an arm, a second person sews several pieces together for a jacket, a third person sews the arm to the jacket, and so on, to produce a suit of a particular size. At the end of the day they would have produced twenty-five suits of a particular size, where it would have taken a tailor several days to produce one suit. The next day they would switch to a different size and produce twenty-five suits of that size. The quality and fit were not quite as good as a tailor-made suit, but it was much less expensive. Of course, tailors were very upset by this development. Unskilled workers began replacing highly skilled tailors, and this led to great social tension. And, many of these unskilled workers were women and children who were paid on the basis of how much they produced, i.e., piece rate, at a very low rate.

The same process was occurring in other areas of the economy and in other countries, notably Great Britain. Protest movements took their name from the **Luddites**. The Scientific and Industrial Revolution led to innovations in manufacturing that began eliminating jobs in a number of sectors of the British economy especially in areas like textiles. The Luddites were skilled craftsmen whose jobs were threatened. They would demonstrate against such innovations and in several cases destroyed the new weaving looms that were taking jobs away from them. Anyone who feels threatened by technological innovation and protests it is labeled a “Luddite.”

### 7.2 Efficiency

There are three kinds of efficiency. **Organizational efficiency** occurs when the firm is structured or organized as efficiently as possible; no more output can be produced given the inputs by reorganizing the firm. **Technological efficiency** is a situation where the firm cannot obtain any more output from a given set of inputs, given the structure of the firm. **Economic efficiency** occurs when the firm is choosing its inputs so as to minimize cost, given the way it is organized and that it is technologically efficient.

The goal is to maximize profit. Minimizing cost is a necessary step that must be undertaken before profit can be maximized. To minimize cost, the firm must first be technologically efficient and must be organized efficiently. If it is producing in a technologically inefficient way, it can lower its cost by becoming more efficient.

The firm's revenue is given by $R = \text{revenue} = pY$, where $p =$ selling price, $Y =$ output. Cost ($C$) is the total cost of producing the given level of output. Typically, the cost function will look something like the left-hand diagram, which we will derive in the next chapter. If the firm takes price as given beyond its control, the revenue "curve" will actually be a line as in the middle diagram. When we put the two diagrams together on the far right, we look for the level of output that produces the largest gap between revenue and cost. This is where profit is at a maximum.

This occurs at a point like $Y^*$. At $Y^*$ the slopes of the line and curve are the same. The slope of the line is $\Delta R/\Delta Y$ and the slope of the curve is $\Delta C/\Delta Y$. Hence, at $Y^*$, $\Delta R/\Delta Y = \Delta C/\Delta Y$. We can define $\Delta C/\Delta Y = MC$ as the **marginal cost of production**. It measures the extra cost
(ΔC > 0) paid by the firm when it increases its production (ΔY > 0). Similarly, \( \Delta R/\Delta Y = MR \) is the marginal revenue. It measures the extra revenue obtained (\( \Delta R > 0 \)) when the firm changes its output (\( \Delta Y > 0 \)). If the firm takes its price as determined by the market and outside its immediate control, then \( \Delta R = P \Delta Y + Y \Delta p = P \Delta Y \) since \( \Delta P = 0 \), or \( \Delta R/\Delta Y = P \), i.e., the price is also the firm's marginal revenue when it takes price as given by the market. Then the rule \( MR = MC \) can be stated as choose output where \( P = MC \) in order to maximize profit. Thus, at \( Y^* \), \( P = MC \), i.e., price is equal to marginal cost at a profit maximizing output level. We will discuss this further in chapter 9 and apply it to different market structures.

**Example:** Consider a firm that has a production division, a sales and marketing division, but outsources its accounting to a local accounting firm. If it can become more organizationally efficient by outsourcing some of its marketing, this will lower its cost. Suppose it has done this. It might still be producing in a technologically inefficient manner if its production lines break down too easily, workers take long coffee breaks, and so on. Cracking down on this will improve its technological efficiency. Finally, suppose labor has become much more expensive all of a sudden. Then the firm may try to become more economically efficient by switching from unionized labor to non-unionized labor, or by switching from labor intensive methods of production toward more capital intensive methods of production. Alternatively, it may shift some of its production to Mexico where labor is cheaper. All three kinds of efficiency affect the cost function.

**Example:** Dunder Mifflin. Mid-sized paper supply company. The company is organized in geographic branches. In the Scranton branch it is organized in the following manner: sales group (Jim, Dwight, Stanley, Phyllis), several accountants (Oscar, Kevin, Angela), some HR people (Toby, Kelly), and a warehouse (run by Darryl). Michael Scott is in charge of the branch as regional manager, and Dwight Schrute is assistant to the regional manager. The company’s strategy is to provide personalized service Office Depot and Staples cannot. If it can lower cost by outsourcing its accounting this improves its organizational efficiency. If its workers take long coffee breaks, or the boss forces everyone to watch his favorite movie, this reduces its technological efficiency. Suppose health costs increase. Switching from labor to capital intensive production (cutting the sales staff and developing a web site) may increase its economic efficiency.

### 7.3 The Principal-Agent Problem

The cost curve is drawn on the assumption that the firm is organizationally, technologically, and economically efficient. The real question then becomes: When can we expect firms to be efficient? For managers in the business world this usually boils down to what variables can be observed and what do you do once you have observed your data. The main problem in obtaining the data is in what you can observe. This leads to the famous problem of incentives.

The principal - agent problem involves a situation where the principal wants the agent to take an action that benefits the principle but is costly for the agent to take.

**Examples** include:

- the parent wants the child to behave;
- the teacher wants the student to study hard and learn;
- the police officer wants drivers to obey the speed limit;
- the voter/taxpayer wants her senator to pass laws that improve her quality of life;
- the patient wants the physician to diagnose her problem correctly.

And more to the point for those in business:

- managers want workers to work hard;
- shareholders want managers to increase share prices.
Consider the situation that occurs frequently on the shop floor. The supervisor wants the workers to work hard but it is difficult to observe each worker all day long. Workers do not like to work and would prefer shirking, e.g., taking long coffee breaks. One possible solution to the problem is for the supervisor to find some variable, called a "signal," that is easy to observe and is also closely connected to the worker's productivity. If the observed "signal" is high, the worker must be working hard. If the "signal" is low, the worker must be shirking.

There are two problems with this. First, a worker's output might be low due to reasons beyond the worker's control, and not necessarily due to shirking behavior. For example, a machine could break down unexpectedly. Second, workers may work together in teams. The output of the team might be high despite one or two workers who are shirking. Or the output of the team might be low despite tremendous effort by one of the members of the team because others are shirking. In any case, the solution involved in observing a signal may not work.

Another potential solution is to set up an incentive scheme that gives the worker an incentive to perform. A "piece rate" system where a worker is paid on the basis of how much she produces is often used. An end of the year bonus system is also used to provide the appropriate incentive. Workers then have an incentive to work hard to get the extra bonus.

A major problem in large publicly held corporations is the relationship between the management team running the company and the shareholders that own the company. Shareholders, unfortunately, have great difficulty observing the managers in their everyday activity. Sometimes managers can take advantage of this. In fact, this can lead to managers running the company in a very inefficient manner leading to low profits and a low share price for the shareholders. (Managers might pay themselves big bonuses, have "conferences" in terrific locations like Tahiti, work in plush offices, and so on.) There have been a large number of corporate scandals in the early 2000s where top management took advantage of the asymmetry in information. Tyco, Adelphia, WorldCom, Arthur Anderson, and Enron, to mention a few, provide examples of this.

What can shareholders do? Not much. However, there is a potential solution. This involves takeovers by corporate raiders. A corporate raider can study the books of the company and if the company is being run badly, the raider can take over the company. It is this potential threat, that keeps managers attempting to run the company efficiently.

Another potential solution comes from the marketplace itself. It is entirely possible that if the managers are really doing a bad job, competitors will take some of the firm's market share away forcing a shake up in the managers running the company. This can also force managers to behave in the best interest of the shareholders.

Example: Loan officers approve loans to borrowers. Traditionally, they required applicants for a loan to prove their income before the loan could be approved. The bank wants to know if it is going to get its money back. However, after deregulation some companies wanted to increase their loan volume (in order to sell a package of mortgages to investment banks). Loan officers at Countrywide, a large finance company specializing in mortgages, were paid bonuses based on how many loans they made, not on the quality of the loans. So when house prices started falling, default rates went up and Countrywide went under adding to the financial crisis of 2007–2009. Other lenders engaged in the same practice creating too much risk for the entire system.

7.4 A General Principle.
Keep in mind the following general principle: **high productivity leads to low cost on average and low productivity leads to high cost on average.** One of the key concepts in measuring productivity is the extra production the firm gets when hiring more of an input and one of the most important inputs is labor. The marginal product of labor is defined as
**ΔY/ΔL = MPL.**

This is the extra output the firm obtains by hiring more labor. There are several interpretations possible. For example, suppose your boss asks you to work one more hour after your normal shift is over. The MPL of that one-hour is the output you can produce in the hour. As another example, suppose the firm hires one more worker. Then the interpretation is how much extra output that one worker can produce. Finally, suppose you want to add an extra shift, the graveyard shift (I wonder if they use that terminology in hospitals?), and run three shifts instead of two. Then it is the extra output the last shift can produce for you.

**Example:** How is productivity linked to cost? Suppose there are two firms A and B. Suppose that if firm A (Burger King?) adds 5 more workers output will increase by 50, i.e., ΔY = 50 when ΔL = 5. Let w be the wage and assume it is w = $10 per hour. Then the cost of hiring the extra workers is $50 per hour. What is the benefit? The revenue the firm gets by selling the extra output. Suppose P = price = $2 per unit, e.g. hamburger. Then the benefit of the extra workers is 50 x $2 = $100. However, suppose at firm B (McDonald's?) that when they hire 5 workers they only get 25 extra units per hour, i.e., ΔL = 5 leads to ΔY = 25. The cost is the same (5 x 10 = $50) but the increase in output is smaller. So we have the following data:

- **Firm A:** ΔL = 5 leads to ΔY = 50 units and ΔC = $50.
- **Firm B:** ΔL = 5 leads to ΔY = 25 units and ΔC = $50.

where ΔC = change in cost.

For A: MP_L = 50/5 = 10 and MC = 50/50 = 1.
For B: MP_L = 25/5 = 5 and MC = 50/25 = 2.

Thus firm A is more productive, i.e., ΔY/ΔL is higher and ΔC/ΔY is lower.\(^3\)

A crude measure of productivity is real GDP per worker. From OCED data we have the following ratio RGDP/L for 2005 in USD, where L is total civilian employment over the age of 16:

- US - $82,000
- Japan - $58,000
- Germany - $61,000
- France - $73,000

The low number for Japan may reflect their "lost decade" of the 1990s. They experienced a land market boom in the 1980s which also led to a dramatic rise in stock prices. The land market bubble burst in 1989 bringing the Nikkei down with it to less than half what it was in 1989. It remains below half even today. The seemingly low number for Germany may reflect the huge costs of reuniting eastern Germany with the west after the Wall came down.

In terms of growth rate of marginal productivity of labor, ΔMP_L/MP_L, the following is from OECD data in 2009:

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<th>US</th>
<th>Japan</th>
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<th>France</th>
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<tr>
<td>'82 - 90</td>
<td>1.48</td>
<td>2.78</td>
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<td>'91 - 00</td>
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<tr>
<td>'01 - 05</td>
<td>1.82</td>
<td>1.78</td>
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There are several points to notice. The US has had the fastest growth of productivity in the 1990s and 2000s. Second, the slow growth in the 1990s in Japan reflects their "lost decade." They have made a comeback since then. The growth rate has been falling in Europe in the 1990s and 2000s. Growth in Germany and France has been anemic in the 2000s. Wages reflect this

\(^3\) Note: Recall we define the marginal cost as MC = ΔC/ΔY. So the **MC is lower when the MPL is higher.** This is a general rule.
since the wage is tied to marginal productivity. Growth in marginal productivity leads to growth in the wage and hence the standard of living.

**Example:** Many technological innovations shift from labor to capital. Traffic lights reduce the need for police to direct traffic; Infrared scanners in grocery stores reduce the number of cashiers; ATMs eliminate jobs for tellers; Redesigning a product so it can be assembled by the customer reduces labor cost; Drones reduce the need for soldiers; Video conferencing means less time spent traveling;

When there are a lot of innovations, or when innovation comes quickly, the labor market may become “dislocated.” Some workers will lose their job and they may have trouble finding work in the transition as they move from one occupation to another. This can cause a period of adjustment where some are out of a job and have difficulty finding a new job, or acquiring the skills required to get a new job.

### 7.5 Production

We will assume that the output of the firm is produced using inputs of capital and labor. To be sure, other inputs are also important. For example, in the 1970's we discovered how important energy is to the economy. And Lays Potato Chips cannot be made without potatoes. However, much of our analysis will be conducted using graphs and we have to keep things to two dimensions in order to make sense of them. So we will assume that there are only two inputs, capital and labor.

Let $Y = \text{output}$, $L = \text{labor}$, $K = \text{capital}$. Output is produced according to the production function $Y = F(L, K)$. We have seen several examples of this in chapter two. In the theory of the firm, the time dimension matters a lot and there is an important distinction between the short run and the long run. In the short run, some decisions are fixed and cannot be changed, literally. In the long run, however, everything is variable mainly because the firm can decide whether or not to go out of business in the long run.

We will assume that the firm's capital decision is fixed in the short run. Only labor is variable in the short run. One useful way to think about this is to imagine the firm's capital as an investment in factories and equipment. So in the past, the firm made a decision about its technology, the number of factories it would build, and the kind of equipment it needs to run its production facilities. But the firm had to finance this investment. So assume the firm borrowed the money to do it. In that case, the firm must repay its loan plus interest. In fact, it must repay its loan plus interest regardless of whether it produces or not. This constitutes the firm's fixed cost. Let $r =$ interest rate or "cost of a unit of capital." Then the firm's fixed cost in the short run is

$$\text{Fixed cost} = FC = rK.$$  
In the short run the firm's labor input, its work force, is variable and this constitutes the firm's variable cost. Let $w =$ wage. Then,

$$\text{Variable cost} = VC = wL.$$  
The firm's total cost in the short run is given by

$$\text{Total cost} = C = VC + FC = wL + rK.$$  
In the long run all costs are variable; there are no fixed costs since the firm can decide to go out of business. A diagram of a long run total cost curve appears in the far-left diagram above. We will discuss cost in greater detail in the next chapter.
7.6 Short run productivity

In the short run, \( K = K^* \) is fixed but the firm can vary its work force through hiring, firing, and layoffs. During a time of peak demand the firm must hire extra workers, and during slack times it lays people off. It is critically important for the firm to understand exactly how this will affect its output. If it doesn't understand the connection between its inputs and its output, the firm will not survive the competitive process. Keep in mind, a lot of firms don't; anywhere from 30,000 to 50 or 60,000 firms go bankrupt in the United States every year.

Consider McDonald's, the largest food service company in the world. They have an interesting short run dilemma. During peak business times, they experience an extraordinary increase in demand. This lasts from 6:30 - 9:00am, 11:30am - 1:30pm, and 5:00pm - 6:30pm. At other times, business drops way off. McDonald's must be sure to have enough workers on staff during their peak service times. McDonald's hires a lot of part time workers as a result. If McDonald's cannot figure out the relationship between \( L \) and \( Y \), it might very well have too many workers working during slack times and not being very productive, and too few workers working during peak times. If customers have to wait too long in line for their food, they might very well take their business elsewhere to another fast food chain, e.g., Wendy's or Burger King.

Output is given by \( Y = F(L, K^*) \) in the short run because \( K = K^* \) is fixed. When the firm varies labor by adding one more worker, \( \Delta L = 1 \), it must be able to figure out how much output varies by, namely, \( \Delta Y \). In the diagram, the relationship between \( Y \) and \( L \) has been graphed, holding \( K = K^* \), where "TP" in the graph stands for total product. When labor changes, so, too, does output. The ratio \( \Delta Y / \Delta L = MP_L \) is the marginal product of labor. It instructs the firm as to how much more output an extra worker can produce. So if \( \Delta L = 1 \), the firm is asking one of its workers to work one more hour (overtime?), it is hiring one more worker, or it is possibly hiring one extra shift of workers, depending on how labor is defined. The firm is interested in knowing how much extra output this labor will produce.

Clearly, when the firm increases its labor input, it will produce more output. However, the amount of labor the firm is already using will affect how much more output it can get when it adds more labor. At point A, the firm obtains a large increase in output when it adds more labor. However, if it's already using a lot of labor, as at point B, and then hires more workers, it will not get as much extra output from those workers as it did at A. This captures the notion of diminishing marginal returns or diminishing marginal product. We studied this concept earlier in chapter two. It is similar in spirit to diminishing marginal utility.

Consider McDonald's. When it has only two workers working a shift and adds another worker (point A), the extra worker is very productive in producing hamburger sales. However, if it already has twenty workers working a shift (point B) and adds another worker, that extra worker is not nearly as productive as when there were only two workers to begin with, i.e., \( \Delta Y = 2 \) is smaller at B than at A for a given increase in labor. Eventually, if McDonald's keeps adding workers, they will start running into one another, and output might actually fall!
The slope of the total product curve in the diagram is the marginal product of labor, i.e., the \( MP_L \) is the slope of the TP curve. We can also graph the \( MP_L \) curve as below. It is downward sloping, reflecting diminishing marginal returns. As we will see later, the marginal cost, \( \Delta C/\Delta y = MC \) will slope upward because the \( MP_L \) curve slopes downward, i.e., diminishing marginal returns to labor leads to increasing marginal cost in the short run and increasing marginal returns to labor lead to falling marginal cost in the short run.

Note that the total product curve was drawn holding capital fixed. If the firm changes its capital investment, the total product curve will swivel upward. This will cause the marginal product curve to shift. Suppose the firm expands its factory, i.e., increases its capital input. The total product curve will swivel upward and the marginal product curve will shift up, as depicted below. To see this, pick a level of labor input. Note how much output the firm can produce from the total product curve. Now, for the same amount of labor, figure out how much can be produced if there is more capital.

We also tend to notice a certain pattern in the total product curve across different industries. First, output increases dramatically as the labor input increases for a fixed amount of capital, i.e., the firm initially experiences increasing marginal returns to hiring labor. However, eventually, decreasing marginal returns set in and the total product curve has a concave shape.
In the diagram above, there are increasing marginal returns between 0 and A. This is depicted as an increasing slope of the TP curve. The marginal product curve, which is the slope of the TP curve, is depicted with a positive slope up to point A in the right-hand diagram to capture this. Between A and B the concavity of the slope of the TP curve changes; it goes from being concave from above to being concave from below. This is where diminishing marginal returns set in; the marginal product curve slopes downward after point B to capture this. Finally, the slope of the TP curve can become zero and even turn negative if workers are running into one another, for example. At such a point the firm has clearly hired too many workers and they are actually getting in one another's way. The marginal product turns negative at such a point (to the right of C).

For example, imagine Burger King hiring workers for its lunch shift. As it increases its workforce in the kitchen from zero to three, the increase in output is huge. If it adds a fourth worker, output will increase. If it adds a fifth worker, output may increase more than it did when it added the fourth worker, i.e., there is increasing marginal returns to the fifth worker. However, eventually, the extra worker's addition to output will not be as large because diminishing returns will set in. It is certainly possible for Burger King to hire too many workers and its output might actually fall because workers are literally running into one another. However, no firm would ever hire that many workers since it can increase its profit by laying people off. No firm would miss taking such an action!

We have also depicted the average product of labor, which is defined as $\text{AP}_L = Y/L$, or $\text{AP}_L = \text{TP}/L$. This is typically very easy for the firm to measure; divide total output by some measure of the labor force, e.g., the number of workers. The shape of the AP curve is also easy to determine. Take a ray from the origin to the TP curve and its slope is the AP at the point it touches the TP curve. For example, the AP at point A in the first diagram on the left is given by the slope of the ray connecting the origin with point A. At point A, the equation for a line going through the origin and point A is: $TP_A = m_AL_A$, where the slope of this ray is $m_A$. Notice from the last equation: $m_A = TP_A/L_A$, where $TP_A/L_A$ is the average product at point A. The equation of the ray through point B and the origin is $TP_B = m.BL_B$, so the slope of the ray through point B is $m_B = TP_B/L_B$, which is the average product at point B on the TP curve. The slope of the rays, and hence the AP curve, increases as we go from A to B, i.e., $m_A > m_B$. Notice that at point B the slope of the TP curve (the MP) is equal to the slope of the ray from the origin (AP). So at point B, the marginal product equals the average product, $\text{MP} = \text{AP}$, as depicted in the right hand diagram. (You don't have to worry about the derivation of the MP and AP curves. Just recall their relative shapes and why they have that particular shape.)
Application: The 1980s was a difficult time for the US auto industry. Before its recent difficulties involving recalls, Toyota was considered the best managed car company in the world. They were the gold standard to which everyone else was compared. For example, they had the lowest worker/car ratio and the highest average product in the industry as depicted in the chart.

<table>
<thead>
<tr>
<th>Auto Industry (1990)</th>
<th>Toyota</th>
<th>Ford</th>
<th>Chrysler</th>
<th>GM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workers per car</td>
<td>2.9</td>
<td>3.4</td>
<td>4.4</td>
<td>5</td>
</tr>
<tr>
<td>Average Product</td>
<td>0.345</td>
<td>0.294</td>
<td>0.227</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Since 1990, there have been major cutbacks at GM and Ford that have raised their productivity dramatically so they are only slightly behind Toyota. GM, for example, eliminated 40,000 clerical and middle level management positions and 79,000 factory jobs in the US. They also closed 21 assembly plants. This adjustment was due to competition from Toyota and Honda, etc. Interestingly enough, while GM was downsizing in the US they were also expanding in Europe. GM and Ford became more technologically and economically efficient in the 1990s and were able to get their unit cost to about the same level as Toyota's by 1998. However, a ranking in 2005 showed that both companies were slipping again as their unit costs rose. Standard and Poor's rating service downgraded both GM and Ford's bonds to junk status. Eventually, they had to declare bankruptcy and be bailed out by the Federal government under both the Bush and Obama Administrations in 2008 – 09.

Of course, it is anyone’s guess as to how customers will feel about Toyota as they handle, or mishandle, the brake and sudden acceleration problems that cropped up in 2009 and 2010. Newspaper articles in the Times and the WSJ indicate that Toyota ignored customer complaints about these issues that surfaced in Japan in 2008. Customer complaints in Japan are routinely ignored. And GM has had its own difficulties in 2012 – 15 with massive recalls due to a faulty ignition switch.

7.7 Long run productivity: Returns to scale.
In the long run all inputs are variable. Indeed, the firm can decide to go bankrupt if that is the optimal choice. Therefore, there are no fixed costs in the long run, only variable costs. In the long run, the firm can decide on its scale of operations by building and equipping new factories, i.e., by its choice of capital investment.

When the firm alters its scale of operations it must change all of its inputs. The concept of returns to scale becomes relevant. Returns to scale refers to the increase in output when the firm increases or decreases all of its inputs by the same percentage. The best way to think of

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5 GM produced Opels and Vauxhais in Europe and is the number two producer of cars in Europe right behind Volkswagen, circa 2008.
6 “Recall of 8 Million Toyotas, but None in Japan,” NYTImes, 3/5/10.
7 For example, Mrs. Sakai, 64, had her Toyota station wagon shoot forward over 3000 feet before hitting two other cars injuring both drivers and breaking her collarbone. Braking and downshifting did not work. She complained to the Toyota dealer who forwarded her complaint. Toyota never responded and the Tokyo Metropolitan Police tried to get her to sign a statement saying she accidentally hit the accelerator instead of the brake. They told her she could have her car back after signing the statement. She refused. The police responded by saying it was a misunderstanding. To quote the article, “….. But veterans of Japan’s moribund consumer rights movement say that Mrs. Sakai, like many Japanese, is the victim of a Japanese establishment that values Japanese business over Japanese consumers, and the lack of consumer protections here.” It will be interesting to see how this plays out and if Toyota really cares about customers or not.
this is to imagine a firm that will alter the number of factories it operates. Suppose it wants to increase its scale of operation by building new factories. When it builds a second factory it must equip it fully with the appropriate machinery and tools. It must also hire a work force to operate the factory. So all of its inputs are increasing in the same percentage; they are doubling. Another interpretation is that the firm wants to expand its existing operations. Suppose it is currently running ten production lines and wants to add a line. This requires a ten percent increase in capital (another production line), labor, raw materials, and so on, so all inputs are increasing by 10%.

Given the "production function," \( Y = F(L, K) \), we can imagine fixing output and varying the two inputs since there are usually different ways of producing something. Suppose the firm wants to produce \( Y = 12,000 \) units per day. Then \( 12,000 = F(L, K) \). For example, the firm could be operating a theme park, e.g., Disneyland, and wants to bring in 12,000 tourists each day. There are different combinations of labor and capital that can produce that outcome and they are depicted in the diagram below in the "Isoquant Map." If the firm wants to produce more output, it must hire more of one or both inputs. The curve labeled \( Y = 12,000 \) in the diagram is called an "Isoquant" meaning "same quantity." It plays the same role in the theory of the firm that the indifference curve plays in the theory of the consumer. The only difference is that isoquants are actually observable if the firm can collect enough data. Indifference curves are not objectively observable. (Indeed, the production function in the theory of the firm is very similar to the utility function in the theory of the consumer.)

When the firm can increase all of its inputs there are three cases to consider: constant returns to scale (CRS), increasing returns to scale (IRS), and decreasing returns to scale (DRS). First, consider constant returns to scale. Under CRS all inputs increase by the same percentage and output increases by the same percentage. So if all inputs double when the company builds a new factory, equips it fully, and hires a work force to operate the new factory, then under CRS, output will double as in the diagram above. Under IRS, when the firm doubles all of its inputs,
output increases by more, e.g., output triples, as in the diagram below. Finally, under DRS, output does not increase by as much as the inputs do. So, for example, if all inputs double, output increases by only 1.5 times under DRS. So we have:

CRS: Increase K, L by 10%, then Y increases by 10%.
IRS: Increase K, L by 10%, then Y increases by more than 10%.
DRS: Increase K, L by 10%, then Y increases by less than 10%.

This also works in reverse. If a firm cuts its capital and labor by 10%, output falls by more than that under IRS, and similarly for DRS, i.e., output would fall by less than 10%.

Under constant returns to scale the isoquants are evenly spaced. Under IRS they tend to bunch up and under DRS (decreasing returns to scale) they tend to spread out, as in the figure below. The strongest case can be made for CRS because of the replication argument. After all, if the firm literally builds a new factory identical to the first factory, equips it in the same way, and hires and trains a similar work force, why shouldn't it get the same output from the new factory?

Another way to see the difference between the three cases is to consider points A and B in the diagrams above and compare the distance between A and B in each diagram. In each, output doubles as we go from A to B. When there is constant returns to scale, as in the diagram on the
left above, if we double the inputs we will double the output. Geometrically, point B is twice the
distance from the origin as point A. Now compare that to the middle diagram. When there is
increasing returns to scale instead, the isoquants tend to bunch up so that the $Y = 24$ isoquant is
closer to the $Y = 12$ isoquant than in the constant returns to scale case. In other words, point B is
less than twice the distance from the origin as point A. Finally, with decreasing returns to scale,
the isoquants tend to spread out so point B is now more than twice the distance from the origin as
point A. With IRS fewer inputs are needed to double output than CRS. With DRS, more inputs
are required to double output than under CRS.

**Application**: Oil pipelines. $Y =$ "throughput," the amount of oil flowing through the pipe.
Inputs: pumping power, pipe size. We can interpret the pipe size as the fixed input and the
pumping power as the variable input. The Alaska pipeline appears to exhibit increasing returns to
scale. Doubling the horsepower of the pumps used to pump the oil and doubling the diameter of
the pipe led to a much larger increase in output; an increase of about eight times rather than two.
With increasing returns to scale it is more productive to build one large pipeline than two smaller
pipelines half the size. If there were constant returns instead, two small pipelines would be
equivalent to one large pipeline twice the size in diameter. This turned out not to be the case.

**Application**: Higher education. The so-called baby boomer generation was born in the late
1940's through the early 1960's. There are approximately 75 million people in this generation and
it is large relative to the generations coming immediately before and after. As the baby boomers
grew up, our country built more elementary, middle, and high schools to serve their education
needs. As they started to hit the colleges and universities we did the same. From 1965 to 1975 we
approximately doubled spending on higher education. In that period we also approximately
doubled the number of baccalaureate degrees that were granted. In a broad sense this might be
taken as an example of "constant returns to scale." However, in the short run there are probably
diminishing returns to labor in higher education. Teaching is a very labor intensive activity and
there are usually diminishing returns to labor.

Let $Y =$ trained students who graduate with a degree, $L_1 =$ untrained student labor (number
of students taking notes in class, studying, reading, doing homework sets), $L_2 =$ the input of
professors, e.g., lectures, $K =$ libraries, classroom buildings, and computer labs. Then $Y = F(L_1,
L_2, K)$. If $L_2$ and $K$ are fixed and we increase $L_1$, eventually diminishing returns to adding more
students to a given class, for example, will lead to diminishing returns in the quality of the
outcome. This will cause the short run costs described in the next chapter to increase.

7.8 **Heavy Manufacturing**
In many plants involved in manufacturing there is a fixed number of workers associated with
each machine used to produce output. For example, there might be three workers needed to run a
production line to produce coke cans. Adding workers doesn't add any extra output because the
pace of the production line is set automatically. Adding another production line without adding
any workers to run and operate the line will not add any additional output. Adding output requires adding a new production line fully manned with the right number of workers. We can depict this using "L-shaped" isoquants. This is the Leontief technology we looked at in chapter two. The inputs are considered perfect complements to one another.

At point a, output of $y = 11,000$ can be produced each year using one production line and three workers. If the firm adds workers but no new machines by moving to point b, no extra output will be produced. If the firm wants to increase its output it must hire a new work force of three workers and build a new production line.

We can write this production function as $Y = \min(AL, BK)$, where A and B are constants. If $AL < BK$, then $Y = AL$ (because that is the minimum of AL and BK). If $AL > BK$, then $Y = BK$ (because that is the minimum of AL and BK). If $AL = BK$, they are both the minimum and $Y = AL = BK$. This occurs at a corner point like point a or c. At a point like b, $AL > BK$ so $Y = BK$ and some of the labor is redundant and doesn't produce anything, in this case, three workers are not needed. If $BK > AL$, then $Y = AL$ and some of the capital is redundant. This would be a point vertically above point a. In this example, $A/B = 1/3$.

In this case, we can calculate the marginal product of "capital" as $MP_K = \Delta Y/\Delta K = 0$ since extra "capital" doesn't produce any additional output, holding labor constant. The marginal product of labor is also given by $MP_L = 0$, for the same reason. Finally, if we double the number of production lines and workers, we double output. Thus, constant returns to scale prevails.

### 7.9 Corporate Raiders

A corporate raider collects tremendous amounts of data on firms and attempts to find firms that are undervalued by the stock market. A firm may be undervalued for a variety of reasons. For example, the raider may believe that a firm is being run inefficiently.

If the raider can convince the shareholders of the company that the current management group running the company is doing a bad job of managing the company, the raider may be able to buy the company. Suppose the company is currently worth $29 per share and the raider privately thinks he can reorganize the company and get the share price up to $45 per share. The raider can offer the current shareholders an intermediate price, say, $35 per share and try to buy the company. Of course, the current management group will not appreciate this and may try to make a counteroffer. This will involve a plan to increase efficiency at the company. Many times in the 1980's this meant getting employees to give back concessions in health benefits, time off, sick leave, over time pay, and other fringe benefits. Sometimes it also meant selling off part of the company.

One argument in favor of corporate raiders is that they force the current management group to behave more efficiently. A counter argument to the value of corporate raiders is that they force elimination of fringe benefits that workers place great value on but management may not.

Consider the production function $Y = F(K, L, M)$, where $K = \text{capital}$, $L = \text{labor}$, and $M = \text{management}$. As the firm expands, $K$ and $L$ are increasing. However, an increase in the
company's operations may require more managers and more levels of management. This may cause the company to become somewhat inefficient and decreasing returns to scale may be the result. Recall, with decreasing returns to scale, a doubling of all inputs, in this case including management, leads to an increase in output that is less than twice the original amount. The reason for this may be that it becomes harder for the top management level to keep track of all of the different operations owned by the company and coordinate their efforts.

Suppose this is true, i.e., suppose a large firm is subject to decreasing returns to scale in this sense. Then it is possible for a corporate raider to come in and reduce the size of the firm, fire some of the middle and upper level managers, increase efficiency, and reduce the unit cost of production. The stock market might see this as a good sign and investors may increase their demand for the company's stock. This is how the corporate raider makes money and improves the efficiency of the company. At least that's the theory anyway. Unfortunately, there may be some managers who lose their jobs in the downsizing of the company. Employees can also fare very badly as well losing jobs, pensions, and health benefits. There may also be problems with the methods used by the firm taking over the company and how it finances the takeover.

So-called private equity firms have found ways of minimizing their own risk by leveraging buyout deals. The idea is quite simple. Borrow the money to be used in a takeover and sell off parts of the company to pay back some of the borrowed funds. It gets even better by having the bought out company borrow to pay back the rest of the original loans as well as pay the equity firm hefty "management" fees. Eventually, the equity firm can sell the company and make a profit in an up market. This is very similar to flipping houses and making money as house prices increase.

Application: The Simmons Bedding Company is a good example of a takeover that worked well for the financiers backing the deal but not the company or workers. The company was started in the 1870s and quickly developed into one of the largest producers of mattresses in the nation. It did reasonably well for itself earning a solid profit until the 1970s when it was taken over by one conglomerate and then another. The company was then bought in 1986 by an equity firm run by William Simon, Secretary of the Treasury under President Nixon for $120 million borrowing most of the funds. The strategy is essentially the same as the one used now, buy undervalued companies, redesign them, and sell them at a profit. Simon sold Simmons to its own employee stock ownership plan for $241 million in 1989, double what it paid. Since the employee stock was used in the buyout the company stopped making contributions to its pension. When the real estate boom ended in the late 1980s and stock prices plummeted, the employees were hard hit, losing jobs and pensions. A series of other equity firms have bought the firm, rearranged it, and then sold it using borrowed money that put Simmons more deeply in debt, going from $164 million in debt in 1991 to $1.3 billion in 2009. It has been bought seven times in the last twenty years and now has to declare bankruptcy since business has dropped off and credit markets are frozen because of the recession in 2009. Investors and bondholders will lose over $500 million, and 1000 employees will be laid off, 25% of the workforce.

According to the article, "Buyout Firms Profited as a Company's Debt Soared," Simmons is just one of several hundred companies caught up in a merger-buying frenzy of the 2000s. More than half of the companies going bankrupt in 2009 were owned by private equity firms and most of them took on enormous amounts of debt including companies like Harrah's Entertainment and Six Flags. It is hard to argue that this activity somehow makes the firm more efficient at its core business.

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8 NYTimes, 10/5/09.
7.10 Does the Best Technology Always Win in the Market Place?

In 1975 Sony introduced the Betamax video recorder. A year later JVC came up with an alternative technology, VHS, which was incompatible with the Betamax. You could not record a program on one machine and play it on the other. By all accounts the Betamax technology was far superior to the VHS technology. The picture was clearer, the image was stored more compactly and efficiently, and replay provided more options. For example, the clarity of the picture in "fast forward" mode was much better with the Betamax technology.

JVC licensed their VHS technology to several large companies in Japan, e.g., Matsushita. Within two years Toshiba and other companies were producing less expensive VCR machines using the VHS technology. Sony began losing market share almost immediately. By 1987 Sony only had a market share of 5% and finally gave up. Sony started producing VHS machines in 1988 in an attempt to compete with JVC, Toshiba, and other companies. So the better technology did not win out in the market place.

The Macintosh personal computer provides another example. Many believe that the Mac technology is superior to the Microsoft based PC and that Apple is a more innovative company. Need convincing? One word will suffice: Vista. A 2008 New York Times article discussed email traffic among Microsoft executives who were unhappy with the new operating system that was being shipped, some of whom refused to use it. The Mac was first to apply the mouse, the pull down menus, the drag and drop method of moving files and folders, and the straightforward, easy-to-organize file folder system. The PC clones of IBM's original PC, e.g., Gateway, Dell, Compaq, and so on, were latecomers to these techniques and only adopted them because Apple showed their utility and versatility. Indeed, in the mid 1990s Microsoft and IBM admitted that the entire Macintosh interface was better than the original IBM interface by mimicking it in Windows '95. Also, the Mac operating system is more stable than the PC; it doesn't crash as much as the PC does. Remember Bill "Pie-in-the-face" Gates attempting to show people a new version of Windows, Windows '98, and having the "blue crash screen" come up when his assistant tried to scan a document in front of shareholders? And, Macs do not come under attack from hackers sending viruses, Trojan horses, worms, destructive bots, and rabbits, trying to steal your personal information, crash your machine, or use it to send millions of emails to jam up corporate computer systems.

Unfortunately, for Mac fans, Apple lost market share from 1993 to 1998 when they tried to compete with the PC head-to-head. In 1993 they had 11.8% market share according to an article in the New York Times (April 2, 1998). By 1997, their market share was only 4.2%!!!! However, with the introduction of its iMac, the iPod, iPad, iPhone, online music, a low cost version of the e-Mac, the G5 power Macintosh line of desktop computers with its dual processors and the new operating system. Apple has regained market share and is one of the biggest companies in the US. The G5 makes as many calculations as a supercomputer of the early 1990's and cannot be exported to certain countries, e.g., North Korea, China, because of this.

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9 As an interesting footnote, Sony still produced the Betamax machine for "high-end" users like television production companies, e.g., major networks, CBS, NBC, and ABC. So the technology did not completely disappear. It found a niche for it until it was supplanted by digital technology.
10 As an aside, the basic interface of the PC/Mac with the mouse and pull down menus, and so on, was initially designed by some researchers at Xerox's Palo Alto research labs. See their web page: http://www.parc.xerox.com/history.html. So IBM, Gates, and Apple all "borrowed" the interface from Xerox.
11 Anecdotally, thieves began targeting users of iPhones when the new iPhone 5 came out in 2012 because they have high resale value. There have even been cases in NYC of a thief taking a phone from the owner, looking at it, and realizing it was an older model, and giving it back to the customer!
7.11 Microsoft’s Biggest Blunders

Firms that succeed do not always make wise decisions. Microsoft has had a number of blunders over the years.

1. Windows 98 was designed to be "plug and play", users could plug devices like printers and scanners into their computers and use them right away, without installing any software. But Microsoft's demonstration of that function at the Computer Dealers Exposition in Las Vegas on April 20, 1998, didn't go so smoothly. When Bill Gates and his assistant plugged a scanner into the computer, instead of loading the scanner's software, the computer encountered a fatal error and displayed the "blue screen of death." The audience roared with laughter and applause. Even Gates began to laugh, eventually chiming in with, "That must be why we're not shipping Windows 98 yet." CNN carried the event live, and the YouTube clip of the crash has been viewed 1.4 million times.

2. Clippy. The despised talking paper clip is best known for interrupting virtually every task in Microsoft Office, but Clippy actually got his start in a much-forgotten version of Windows, Microsoft Bob. In Office 97 and 2000, if a user typed, "Dear" at the beginning of a document, Clippy would appear in the bottom right corner with a text bubble that read, "It looks like you're writing a letter. Would you like help?" Clippy would also interrupt countless other tasks, making the Office Assistant one of the most reviled Microsoft features ever.

3. Windows Millennium Edition was Microsoft's flagship operating system for just 13 months. The operating system debuted in September 2000. Users reported problems upgrading their computers to Windows Me and when they were able to, Me frequently froze and crashed. There were numerous compatibility issues with hardware and software, and Me didn't always like to wake up from sleep mode. PC World in 2006 named the 25 worst tech products of all time -- Windows Me was fourth. That list came out one year before Vista was released.

4. Windows Media Center works ... trust me. Gates unveiled the new Windows Media Center at the 2005 Consumer Electronics Show in Las Vegas. It was supposed to have the ability to play your computer's media files on your home television. Conan O'Brian took some photos of Gates, which would be put on the TV through the computer. Gates then clicked the button on the remote and got ... Nothing! Later, the TV's program guide wouldn't open, and Microsoft program manager Garrett Young's demonstration of a racing car video game caused a system failure. "I'm out of system memory apparently," said Young. "Yeah, so just imagine, if you will, that I was customizing my car and doing some really cool stuff."

5. Windows Vista. For all of the Windows-related debacles, Vista was by far the worst for Microsoft. Vista was released in 2007 to much fanfare, since it was the first new operating system that Microsoft had unveiled since XP in 2001. Vista was plagued by bugs, software and hardware incompatibilities, sluggishness and annoying security alerts. It was so badly received that a majority of businesses opted to stick with the eight-year-old Windows XP. Rival Apple cashed in on Vista's annoyances with its popular "Mac vs. PC" ad campaign. Since Vista's release, Macintosh's market share nearly doubled.

7.12 Conclusion

In this chapter we studied the productivity of an individual firm. The firm combines inputs with a production technology in order to produce an output. In the short run many decisions are fixed, e.g., investment. However, in the long run everything is variable since the firm can decide to go out of business. The law of diminishing returns in the short run is almost universal. Increasing

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12 Source: CNN Money 10/21/09
the use of an input like labor may lead to increasing returns early on. Eventually, however, diminishing returns will set in. It is even possible for returns to be zero or negative at the margin if the firm has hired too many workers.

We also studied the firm's productivity in the long run. The firm in the long run can decide to replicate itself by building new factories and equipping them in the same way as its old factories. The concept of returns to scale relates to this process. If the firm can exactly replicate it's production process, doubling up in size and output, then returns to scale are constant.

We applied the theory to a number of examples, notably corporate raiders. Raiders can make the system more efficient by weeding out inefficient managers. If the raider can buy the company and reorganize it, efficiency may improve. If the threat of a takeover is strong enough, the current management team has an incentive to run the company as efficiently as it can.

**Important Concepts**

Transactions costs
outsourcing
Efficiency: organizational, technological, economic
Marginal revenue
Marginal cost
General optimizing rule: choose output where MR = MC.
Principal Agent problem
Production function
Marginal product
Returns to scale

**Review Questions**

1. How does a firm configure itself? What are transactions costs? Why would a firm outsource some of its operations? Wouldn't it be better for the firm to do it instead?
2. Define technological efficiency and economic efficiency. How do they differ?
3. Define marginal revenue. Define marginal cost. Why is MR = MC the general optimizing rule for a firm. What happens to the rule if the firm takes price as given?
4. What is the principal agent problem? Give an example.
5. Why is corr(productivity, cost) < 0?
6. What is a production function? Draw an example of a total product curve. What is being held constant when you draw the curve?
7. What is the difference between the short run and the long run?
8. What is the relationship between the total product curve and the marginal product curve? What is diminishing marginal returns?
9. What happens to the total product curve and the marginal product curve when the firm increases its capital stock?
10. What are the different cases of returns to scale? How do they differ?
11. How does the production function for "heavy manufacturing" differ from the more general case?

**Practice Questions**

1. What is the difference between diminishing marginal returns and decreasing returns to scale?
   a. There isn't any difference.
b. Under diminishing marginal returns some inputs are held fixed while all inputs are held fixed under decreasing returns to scale.

c. Under diminishing marginal returns all inputs are held fixed while only some inputs are held fixed under decreasing returns to scale.

d. Under diminishing marginal returns all inputs but one are held fixed while all inputs are allowed to vary under decreasing returns to scale.

2. Toyota is twice as efficient as GM and Ford.
a. True b. False.

3. Let \( Y = \) number of college degrees granted, \( L = \) faculty, \( K = \) classroom space, \( N = \) number of incoming freshpeople, and assume that \( Y = F(L, K, N) \). In the short run what would happen if WSU tried to dramatically increase the number of students attending WSU without hiring new faculty or providing any new classroom space?
a. Diminishing marginal returns would probably set in and the number of degrees granted would only increase by a small amount.
b. Increasing marginal returns would probably set in and the number of degrees granted would only increase by a small amount.
c. Constant marginal returns would probably set in and the number of degrees granted would only increase by a small amount.
d. Increasing returns to scale would probably set in and the number of degrees granted would only increase by a small amount.
e. Decreasing returns to scale would probably set in and the number of degrees granted would only increase by a small amount.

4. From the previous question, if we double the usage of classroom space, double the number of faculty at WSU, and double the size of the incoming class of students, but only increase the number of degrees granted by 25%, what must be true?
a. The production of "college degrees" experiences diminishing marginal returns.
b. The production of "college degrees" experiences increasing marginal returns.
c. The production of "college degrees" experiences decreasing returns to scale.
d. The production of "college degrees" experiences increasing returns to scale.

5. Does competition always mean that the best technology wins in the market place?
a. Yes, and the steam technology applied to railroads is an example.
b. Yes, and the VHS technology is an example of the best technology that did succeed.
c. No, and the VHS technology is an example of a technology that succeeded but was dominated by another technology, BluRay.
d. No, and the Betamax technology is an example of a technology that was better but did not succeed.

6. Hilton has a choice. It can include a laundry service as part of the company, or it can outsource this service. Under what condition will it outsource it?
Answers
1. d.
2. b.
3. a.
4. c.
5. d.
6. It will outsource if the benefit from doing so outweighs the cost. Each hotel in the chain would have to outsource separately in the local economy. Since this would be too costly to do it should maintain its own laundry service within each hotel.