

Microeconomics with Ethics

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Chapter 9 Theory of Production

The chapter has two objectives. The first section tells the story of a simple startup food truck business and uses this story to introduce many different common economic and business terms used when talking about firm behavior. It will also describe many of the problems that must be considered by a business and what it must do to operate successfully as a private entity in a capitalist system. It also highlights some of the misconceptions about businesses and why this inspires some to seek alternatives in system like socialism. Take careful note of the italicized terms in this section. They will be defined narrowly in the context of the story told here, but most deserve greater explanation which is not provided. Please look to other sources to learn more about any of special interest.

The second section of the chapter introduces a simple economic model describing the production and cost relationships expected to prevail for most businesses. It is this model that will ultimately be used to derive the supply curve relationship for a product in a market. This section also introduces important economic terms that will be repeatedly used in the rest of the textbook. Pay attention to the definitions of the italicized words and phrases.

9.1 Running a Business

Learning Objectives

1. Learn the terminology related to business startups and operations.
2. Identify the different types of business ownership structures
3. Learn methods businesses use to finance the purchase of physical capital.
4. Learn general methods to raise profit by increasing revenue and reducing costs
5. Learn the fundamental differences between capitalist and socialist business structures.

The simplest business, or firm (I'll use these two terms synonymously), has an individual owner and is called a *sole proprietorship*. For example, suppose Gina has an idea to open up a food truck selling hamburgers and other assorted food items and beverages using recipes that she independently developed while in culinary school. Her business may be successful and she will make a lot of money, or she may be unsuccessful and be forced to close eventually. The fact that she is willing to take this risk makes her an *entrepreneur*.

However, before selling one hamburger, Gina would first have to acquire the equipment, a large truck, a grill, a refrigerator, a sink for clean up, and install all of them. She would need to decorate the truck with attractive colors, create a menu and display. All of these inputs are called capital equipment, or just capital, for short.

Where would she get the money to buy all of this equipment? One source is her own savings, in which case we would say that she is *investing* her own money (or capital) to open the business. Note that the term capital is now being used in two ways. Capital can refer to the equipment itself, also known as (a.k.a.) *physical capital*, or capital can refer to the money used to acquire the equipment, a.k.a. *financial capital*. When used in this course, capital will mostly refer to physical capital.

Oftentimes an entrepreneur with a good business idea doesn't have enough personal savings to start a business. Thus, another source of financial capital is for Gina to borrow the money from a bank and promise to repay it in the future. Such a loan involves a *contract* between Gina and the bank.

A *contract* is a legally enforceable agreement between at least two people involving promises made to each other. In a loan contract, the bank, or lender, agrees to give some amount of money to the borrower, who agrees to repay the money with interest according to the rules specified in the contract; for example, an interest rate of 5% per year paid in monthly installments over five years. *Interest* is a fee the borrower pays for the privilege of using money now to buy the equipment, rather than waiting to accumulate savings to buy the equipment later.

The bank will surely worry about the possibility that Gina may *default* on the loan, meaning, what if she fails to repay? To reduce this risk, the bank may ask Gina for collateral. *Collateral* is something of value, such as real estate property, or a diamond ring, or an automobile, that can be forfeited to the bank as an alternative repayment if the installment payments are not met. The collateral conditions would be specified in the contract and the bank may put a *lien* on the property title so that if Gina tries to sell the property secretly, the bank, as the *lien holder*, must be notified. Alternatively, if Gina has no collateral, then the bank may offer a no-collateral loan but may ask to assess her business plan and would likely charge a higher interest rate if it decides to lend her the money.

Note that a contract is meant to anticipate all sorts of possible outcomes and to stipulate the rules and procedures that will be undertaken when things go well and when they go wrong. The signatures on the contract indicate that the parties promise to abide by the terms of the contract. Being legally enforceable means that if one of the parties fails to abide by the conditions of the contract, the other party can sue them for restitution in a government court. If found guilty of violating a contract, the court could force appropriate repayment, or in serious cases, even imprison the guilty party. The intention of the legal system is that these penalties would be sufficient to induce people to keep their promises and fulfill the contract conditions.

There is another way for Gina to acquire the financial capital for the equipment besides a loan. She could seek an independent investor. Suppose Gina's own savings is only enough to cover half the expense of buying the capital equipment for the food truck. Suppose she has a friend, Jon, who is willing to invest the other half. In this case they could form a business *partnership*. To set up the partnership they should create a contract specifying how profit from the business will be shared between the two and the roles and responsibilities of each investor in operating the business as well as contingencies in case problems arise.

One issue to consider is that some of the inputs for the business consists of Gina's ideas that she developed during her education at culinary school. Economists call this knowledge, embodied in an individual, *human capital*, and often use individuals' level of formal education as a proxy when trying to measure it. If Gina's ideas are especially unique, perhaps including an innovative

production process to maintain the juiciness of the hamburgers, she may have applied for and received a patent from the US Patent and Trademark office. In this case she would have converted her idea into *intellectual property (IP, or, IPR for intellectual property rights)* and would be entitled to prevent others from using this process for a period of 20 years. An alternative strategy for her would be to simply try to keep her production ideas secret from others, in which case they would be called *trade secrets*.

In joining in the partnership with Jon, she may also worry that if the business is very successful, Jon might run off with her recipes and start a competing business on his own. She may therefore ask Jon to sign a *non-disclosure agreement (NDA)* to prevent him from revealing the recipes to others and might also include a *non-compete clause* in the contract preventing him from opening a similar business in the event that the partnership breaks up. Also, if she has an idea for a clever name and moniker for the product she might also apply for a *trademark* from the patent agency to assure that only her product can be legally associated with the name and logo.

Because Gina is contributing her ideas as well as paying for half of the physical capital, the partnership contract might then specify that she should receive 20% of the total profit for her IPR contribution and the two partners would split the remaining 80% of the profit for their physical capital contributions.

There is one other way to acquire the capital equipment needed to run the food truck business; Gina can rent the equipment from another owner, say the Nifty Food Truck Outfitters. This company, noting the food truck craze and with specialty knowledge in constructing specialty vehicles, may have set up their business to outfit trucks that can be used in the food truck industry. This business will make money by renting the trucks to food truck vendors like Gina on a monthly basis. *Rent* is the payment Gina makes for the monthly use of the capital equipment.

The next issue Gina and her partner faces is how to operate the business. Perhaps the two will choose to employ themselves to make and sell the hamburgers. If so, their partnership contract might stipulate that they will pay themselves a salary, such as an hourly wage based on hours worked. Alternatively, they could stipulate a fixed monthly salary that is not based on hours worked. They might also choose to cover expenses for their health insurance costs and decide how to handle vacations and sick time, etc. It is best to arrange the business this way even for themselves since then they will be ready later if they decide to hire other workers, or *employees*.

Note that the salary they receive for hours worked would be different from the profit they earn on their capital investment, these are two separate sources of income from the business. Generally the wage payment takes priority and must be paid regardless of the profitability of the business. For example, if later they hired employees to operate the food truck, and if the business doesn't sell any hamburgers one day, they would still have to pay the worker, drawing on their financial capital to finance these expenditures. This is a risk that the investors are subject to, because they might not be able to cover their costs in some months, they may wish to establish a reserve fund to assure they can pay their day-to-day expenses. Thus they should plan to hold onto some additional financial capital to cover this contingency.

Finally, there are additional costs that must be incurred because they must also pay for the production inputs. They must purchase the ground beef and hamburger buns, the spices and other ingredients, the oil for the French fries, the soft drinks, the napkins and plates, etc., etc. These are usually called *intermediate goods* and are produced by other businesses.

Many of the things the food truck provides to its customers are not produced by the food truck business itself. Instead the food truck adds value (a.k.a. *value added*) by assembling the necessary ingredients, cooking the food, and delivering a meal to its customers. The food truck product itself could be classified in part as a *good*, referring to the physical hamburger and other foods that are sold, and also a *service*, referring to the assembly and delivery of the goods in a particular way. In general, accountants classify restaurants as a service industry because much of its value added consists of the service aspect of cooking and delivering the meal rather than producing the goods themselves. In contrast, a farm that grows the potatoes for the French fries would be classified as an agricultural goods business.

Gina and Jon might also decide to *out-source* some of the other labor services needed to operate the business. For example, if the business were large enough, they might hire an accountant to keep track of the revenues and expenses, make the regular wage payments to workers, and submit the necessary taxes to government agencies. At the early stages, they may have hired a lawyer to put together the original partnership contract since the lawyer would have the knowledge about many of the problems that could arise between business partners and include these issues in the contract. Many small businesses often try to accomplish many of these tasks themselves which is why operating a small business is often very time-consuming and why unexpected problems can sometimes lead to business failures. It is better to have experts, well-versed in their particular specialties, advise a business and prepare for the many contingencies that may arise, even though that adds explicitly to the costs of running the business.

Some other potential problems should also be considered. Suppose Jon is willing to invest, say \$50,000, but he also owns a house worth \$500,000 and is worried that if the business suffers extended losses and incurs *debt* (through loans) to keep the business going and if those loans cannot be repaid, the bank make force him to sell his house to repay the business debt. To solve this problem Gina and Jon may organize their business as a *limited liability company (LLC)*. An LLC is a legal system that allows the investors to separate the money they invest in the business from their own personal assets in order to minimize their *exposure to losses*. In essence the money they invest in the business is put into one pool and is separate from their other personal assets. These simple forms of business organization are called *private firms* because they are owed only by the individuals in the partnership. This contrasts with *public firms* described next.

If the business becomes extremely large they could go one step further and create a public *corporation*. A corporation is a business that issues *shares of stock* and sells these shares to many different investors in order to raise a substantial amount of financial capital to run the business. Each share represents an ownership stake in the corporation and entitles the holder to a stream of *dividends* (usually a quarterly payment based on a percentage of the share price), as well as a voice in the decisions of the company. This is called a *public company* because ownership shares are available for purchase by the general public and the shares are traded daily on a public *stock exchange*, like the New York Stock Exchange or NASDAQ. When a new corporation sells shares of stock for the first time, it is called an *initial public offering (IPO)*. It is a way to raise a large amount of financial capital to expand a business and will often make the original business owners very wealthy.

Note that many stock shares are purchased by *mutual fund* companies and *pension plans*. These companies collect money from many workers and others and pool the funds to invest in stocks, bonds, and other types of assets. Thus, if a worker has a retirement plan that invests money in corporate stocks, then that worker is also a partial owner of the companies in which the plan invests.

Now back to Gina and Jon's simple food truck business. Once all of these details are worked out, they are ready to begin operations and sell hamburgers. But how will they determine the price to charge for each of their items? And how many meals can they expect to sell each day? These two variables will affect the total revenue they earn. Let's let TR represent total revenue earned per month. In this case $TR = PQ$, where Q is the quantity of meals sold per month and P is the price of each meal (or the weighted average price if different meals have different prices). Being smart entrepreneurs, they will know their products are subject to the "law of demand;" charge a high price and demand will be low, charge a low price and demand will be higher. They also know that to make a profit and earn a return on their investment, they must earn enough revenue to cover their production costs.

The simple profit function for their business can be written as

$$\Pi = TR - TC$$

where Π , the greek symbol pi, represents total profit in \$ per month, TR is total revenue in \$ per month and TC is total costs in \$ per month. (Note: to keep the discussions simpler, I'll stop using "per month," in these expressions, but always remember that quantities, revenues and profits, must be measured over some time period; BTW, price is not measured over time).

Total Costs, TC, represents the money payments Gina and Jon must make each month to run the business, including salaries to workers, health insurance contributions, intermediate input costs, and rental costs for their equipment (if they use the Nifty Food Truck Outfitters for their equipment). If they don't use the truck outfitters, then they will not have an explicit rental charge, and they will have greater measured, or, what is sometimes called, accounting profit. In this case, that profit will represent the return on their capital investment, that is, a return on the money they contributed to buy the truck and equipment and to have enough cash to pay expenses. The extra cash for expenses will likely be needed whether they rent the equipment or not, because it is typical for new businesses to suffer negative profit in the early stages when they are trying to establish themselves and attract customers. How long the period of negative profit lasts for a startup business can vary from weeks to years, but its length will depend on the willingness of investors to add capital to pay monthly costs, which will in turn depend on investor expectations about the future viability of the business and the likelihood that the positive returns in the future will offset the early losses.

The average time to profitability for a startup firm in the US is somewhere between 2 and 4 years. As many as 90% of startups eventually fail and about 10% fail in the first year. It is estimated that Google took at least 3 years to become profitable, Facebook took 5 years, and Uber has, by some measures, still had not reached positive profit in 2022 after more than 12 years in operation.

How to Succeed in Business

The objective of owners in a business is to maximize their profit. Put more crudely, they want to make as much money for themselves as possible. Success in business is based on a few basic principles that are easy to state but very difficult to implement; namely, minimize the costs of production and maximize revenue. That's all there is to it!! Let's consider each of these in turn.

To reduce costs, businesses may have an incentive to pay their employees as little as possible. Many people, recognizing this tendency, believe that businesses by their nature try to exploit

their employees. However, lowering wages by too much has a secondary effect based on the law of demand; the lower the wage, the lower the workers' desire to work for that business. It is also important to recognize that all workers are not the same. After working in several companies you may come to learn that some people are hard-working, enthusiastic, and fun to work with. Others are lazy, have difficulty following simple instructions, and don't show up to work at their scheduled time. Most everyone else is somewhere between these extremes.

If a company reduces its wage too much, the best workers will look for better opportunities elsewhere and the only workers remaining to hire will be those who were fired from other companies because they were unproductive. A successful business can't easily exploit workers when there is freedom to quit and look for other jobs. This is not to say that business exploitation never happens, only that there are forces in a market that work against it.

Another way firms can reduce costs is to lower their expenditures on intermediate goods. They could use low quality meat in their hamburgers, and only sell the least expensive soft drinks. However, if they did this, their customers will respond by lowering demand for their meals unless the meal is priced much lower to compensate for the lower quality, and this could reduce their revenue. It is difficult to trick consumers into buying bad products at high prices for very long. The business might also look to reduce their energy costs. Installing solar panels on the truck might reduce the monthly expenditure on refrigeration, but it also entails an up-front capital expenditure to buy the solar panels and if the payback period on this investment is too long, there is a chance the business might fail before then.

There are two ways to think about the cost-cutting tendency of firms. The first way is to view it as harm caused to the suppliers of the inputs. The more firms cut costs, the fewer jobs are available, the less hamburger supply companies will make, the lower wages will be for employees, etc. However, if we take this point-of-view too far, to avoid harm means raising business costs, and if costs rise too much then the business will fail and all the input suppliers will lose. The second way to think of the cost-cutting tendency is as a method to reduce resource usage and leave more available for others to use in alternative ways. Thus, if a firm can supply its product with fewer workers, then the workers they don't hire are free to pursue other opportunities. If energy usage is reduced, then that may leave more for others to use, or, if it's a reduction in fossil fuels, may have the positive effect of reducing environmental damage.

Let's turn to ways to increase revenue. The naïve way to think of this is that firms trying to earn more profit will raise their prices and take advantage of their customers. Sometimes this is referred to as price gouging. However, this strategy may fail to generate an increase in business profit because of the "law" of demand. The higher the price, the lower will be consumer demand. In fact, as shown in section 8.1, if demand is elastic, then an increase in price will cause a reduction in revenue because demand will fall faster than the price rises. Also, demand will tend to be more elastic when there is more competition in the industry. If customers have many substitute products to choose from, then a very small price increase could reduce demand substantially and eventually cause the business to fail.

There is one more important method to increase revenue, that is to stimulate an increase in demand for the product. If Gina and Jon want to sell more food truck meals, then they need to make a superior product that people will want to consume frequently. Gina will hope that her culinary school training and the recipes she created will make their products unique and desirable. Ideally, the food will be so good that customers are inclined to tell their friends about it and Gina and Jon can get free word-of-mouth advertising. In addition they might advertise their product in appropriate venues. Of course, *advertising* is another expense adding to costs,

but if it generates a sufficient increase in demand, it will raise profits. Sometimes it is said that firms must increase the quality of their product to enhance demand, but this isn't always the case. Sometimes consumers want a low quality product that is also very inexpensive. Note, as an example, the success of Dollar stores around the US.

The key to business success, then, is to sell a product that consumers desire, at a price they are willing to pay, while covering the costs necessary to produce the product, and leaving enough profit afterwards to make it worth the time, effort and risk for the business owner to continue operating. The principles are easy. Putting them into practice is much more difficult. Clearly it is not too difficult though, as one can witness in all of the businesses that are currently in operation around the world.

Accounting vs Economic Profit

Economists make one additional distinction about profit that serves to highlight the role of profit seeking in a market economy. They suggest that individuals should work to maximize economic profit rather than accounting profit. The difference between accounting profit and economic profit is described next.

Accounting profit (Π_A) was defined above but can be extended as follows:

$$\Pi_A = TR - \text{worker wages} - \text{intermediate goods cost} - \text{rental truck cost} - \text{installment loan cost} - \text{other miscellaneous costs}$$

where again TR is total revenue earned per month, and total costs, TC, are separated into distinct categories. This is the profit that an accountant would keep track of in determining the profit earned each month which would be distributed to the owners of the business (i.e., to all who contributed financial capital), or, would be reinvested into the business, in which case it is called *retained earnings*.

In contrast *economic profit* (Π_E) is defined as :

$$\Pi_E = \Pi_A - \text{opportunity costs of the owners}$$

where the opportunity cost of owners is measured as the value of the next best opportunity to which they could apply their capital if they were involved in another business or endeavor.

This profit distinction allows us to highlight a key characteristic of a market economy, namely that investors should be constantly scanning the economy and looking, not just for profitable investments, but for the investments that will make them the most money possible.

For example, suppose Akiko, an investor in Gina and Jon's food truck business expects to earn \$2500 per year on her share of the profit from a \$10,000 investment in their business. Suppose Akiko's other options for using the money is to deposit the money in a bank for a year and earn \$500, or to invest in an established business and earn \$1500 per year. Clearly, her best opportunity is to invest in Gina and Jon's business because she will make the most money.

Side Note: In real life, Akiko's decision is more complicated than the simple example above, which assumes perfect information about her investment returns. In reality, she is unlikely to know precisely how much money she will make on her investments. Depositing the money in

the bank is the least risky option, since the return is “almost” certain, but it also yields the lowest return. Her investments in a startup business, like Gina and Jon’s, will be much riskier because she will have to estimate, or guess, how much she will eventually make. The food truck business might have losses, or negative profit, for a few months or years, as many small businesses do, and she’ll have to decide how long she’s willing to wait to receive a positive return and whether that future return will cover her early losses. If she invests her money in an established firm that is already making regular profit, then she may earn less each year, but will also face less risk. How to best make these decisions about the tradeoffs between risk and return is the subject of many business investment courses and will not be considered further here.

If businesses achieve the maximization of economic profit, it will have an important economic effect: namely it will organize production on the basis of comparative advantage and achieve maximum economic efficiency. This means the business endeavors will satisfy the freely chosen desires of consumers in the economy using methods that minimize the resource usage to achieve that objective. Achieving efficiency means generating the greatest amount of human happiness at the lowest possible human and resource cost. That this outcome could be achieved as a result of individuals only pursuing their own self-interest, or trying to make as much money for themselves as possible, is a marvel that has inspired the widespread belief in the free market system for many people ever since the time of Adam Smith.

However, not everyone views business activity positively. Many people contend that the self-interested behavior of business is akin to promoting greed and will result in exploitations and unappealing outcomes. However, as explained in Chapter 4, these outcomes will arise only when businesses do not follow the ethical “rules of the game,” which are avoiding force and fraud and allowing free and open competition.

To illustrate, suppose Akiko in the previous example, had one other investment opportunity to consider. She could invest with her shifty brother-in-law in a business that hires a group of telemarketers to randomly call people and offer a chance to contribute money to victims of the latest natural disaster in the world. Suppose with this investment she could make a return of \$10,000 per year on her \$10,000 investment. The reason the return is so high, is because the business doesn’t actually use the funds to help support victims, instead they just pocket the contributions for themselves. Clearly, from a self-interested and unconstrained point of view, this is her next best opportunity and it would turn the economic profit of Gina and Jon’s business negative. However, this outcome does not achieve higher economic efficiency because her brother in law’s business is engaging in fraud and theft.

Of course, many businesses do engage in unethical behavior to varying degrees. It is a partly the way some businesses operate in the real world. For those who have suffered losses at the hands of swindlers, fraudsters, and thieves or for those who live in highly corrupt communities, it is natural to seek alternatives to the capitalistic market system.

Capitalist vs Socialist Businesses

The most viable contender to market capitalism in the past two centuries has been some version of what can be classified broadly as socialism. Without getting too deeply in the weeds on this, let’s take a few moments to compare the incentive structure of these two system.

The key characteristic of capitalism is that capital, a.k.a. the means of production, is privately owned. When Gina and Jon decide to open a business, they risk their own time and money to purchase the equipment that is used to operate it. Their objective, we said, is to maximize their

profit. Why? Because profit from the business enables them to provide for the wants and needs of themselves and their families. They don't run the business for the sake of others. However, in order to maximize profit, they will have to sell a product or service that satisfies their customers' needs or desires. As long as they follow the ethical rules of the game, their own desires can be fulfilled via sales and profits only when their customers' desires are fulfilled through purchases of their product.

Even if the business is a large public corporation, the means of production are still owned by the private contribution of the many shareholders. The organizing principles are much more complicated, but for a corporation to be profitable, it will have to satisfy the desire of its customers and do so at least equally, or better, than its close competitors.

The alternative is socialism. In a socialist economy, capital, or the means of production is owed by the State, or government. The objective is not to maximize profit, but to maximize the social welfare or social good. This sounds laudable because it is based on the principle of altruism rather than self-interest. But such a system needs to resolve several problems.

First, who is it that gets to decide what to produce for the social good? In democratic socialism the citizens would elect the leaders, who in consultation with the voters would make the decisions about what to produce and who to distribute it to. Second, if the citizens are unhappy with the decisions of the government, there is no alternative available. Presumably in a socialist economy there are no competing firms to go to if a consumer is dissatisfied with what the government provides. The only recourse will be to vote the decision makers out of office in the next election cycle. Finally, proponents of socialism generally assume that the decision makers will always act in a purely selfless manner, only thinking about what's best for others. But what if they don't? What if the leaders realize that once a small group controls most of the means of production in an economy, they could turn that system to satisfy their own self-interests instead? This may be why many centrally planned socialist economies in the 20th century quickly devolved into dictatorships which served the interests of the rulers while providing miserably for the social good.

The alternative to these pure economic systems is to consider a hybrid model, where private ownership prevails for a major share of economic output, while government provides for a, usually, smaller share of economic output. This is the type of system that characterizes virtually all national economies today and will be investigated in more detail later when we discuss the role of government in an economy.

Key Takeaways

1. The primary types of business ownership structures include sole proprietorships, partnerships and corporations.
2. Financial capital is money used to purchase physical capital and to cover operating costs when losses are incurred.
3. Financial capital can come from personal savings of the business owners, from loans, or from investors who take a stake in the business.
4. In principle a firm raises profit simply by increasing revenues and decreasing production costs. In practice, it is much more difficult to accomplish.
5. Capitalist firms are privately owned and operated for profit. Socialist firms are owned by the state and often pursue social objectives rather than seeking profit.

9.2 A Simple Model of Production and Cost Relationships

Learning Objectives

1. Learn to describe a production process using a simple one factor, one output production schedule.
2. Learn how to derive and graph the important cost relationships, especially average total cost and marginal cost.

A theory of production, or supply, seeks to explain what influences the quantity of a product that firms produce and supply to a particular market. Production is a process that takes *inputs*, such as workers, machinery, factory and office space, and converts them into products that can be sold either to other businesses (*intermediate goods*), or to households (*final consumer goods*). To be clear on terminology, inputs used in production are also called *factors of production* and in economics these are often put into three categories; *labor* (meaning workers), *capital* (meaning equipment) and *land or natural resources* (meaning the place where production occurs, or where natural resources such as coal, or lumber, are acquired). To further simplify, many economic models reduce this to only two inputs, labor and capital, in which case land is reclassified as another type of capital. Even simpler models, like the one below, reduce the inputs to only one, namely labor.

Below we construct a simple example of a production relationship for a good that enables us to describe production and cost relationships that economists expect will prevail for virtually all production processes. We will simplify the production model considerably, but the relationships can be expected to hold for much more complicated production structures, as for example, when there are multiple factors of production. Pay close attention to the terminology introduced here because it will be referred to many times later in this course and in other economics courses.

The Production Function

Consider a hypothetical small firm named the Bewitched Broom company that uses workers, or labor, as the only input in the production of brooms. In general, we could write this relationship as a production function $Q = f(L)$ where Q measures the quantity of brooms produced and L measures the number of workers used as inputs in the production process. $f(\cdot)$ refers to some unspecified functional form. Since this is a production function, output is also sometimes called “total product.”

In this example, we’ll measure the units as numbers (number of workers and number of brooms), but in other contexts, labor inputs could be specified in units such as hours per day or hours per week, and output could be measured, especially for other types of products, in units such as kilograms (kg) or pounds (lb). The time period over which the production occurs is typically dropped in presentations for simplicity, but don’t forget that it’s in there. Thus, the number of workers and number of brooms are both measured per day, or per month.

In Table 9.1 we display a production schedule for brooms in the first two columns that shows the number of brooms producible given incremental numbers of workers in the production process.

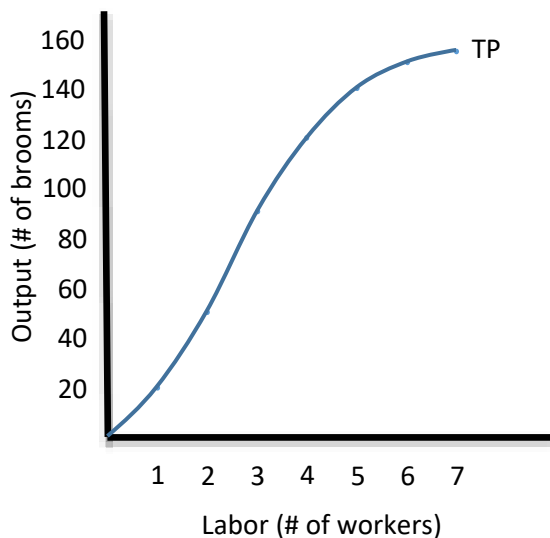
Thus if 1 worker is used then 20 brooms can be produced (per day). If 2 workers are employed, then 50 brooms can be produced, etc.

A graph of the schedule is shown in Figure 9.1. The curve is labeled the total product curve, which in this case is synonymous with the total output of brooms, graphed on the vertical axis, given labor inputs graphed on the horizontal axis.

Table 9.1 The Bewitched Broom Production Schedule

Workers (L) (# of workers)	Output (Q) (# of brooms)	Marginal Product of Labor (MPL) ($\Delta Q/\Delta L$) (brooms per worker)
0	0	--
1	20	20
2	50	30
3	90	40
4	120	30
5	140	20
6	150	10
7	155	5

Figure 9.1 The Total Product Curve (Production Function)



Notice that the quantity of brooms does not rise by the same amount each time one more worker is added. That feature is purposeful and is described next.

The *Marginal Product of Labor (MPL)* is defined as the amount by which output changes when there is an increase in the labor input. The measurement is written as a ratio and abbreviated $\Delta Q/\Delta L$, where Δ means “change in,” and has units of brooms per worker. MPL is generally

written as a function of output and written as $MPL(Q)$. Thus, if you were asked, what is the marginal product at 90 brooms, the answer is 40 brooms per worker.

Side Note: Technically, because the MPL changes as the labor input increases, each MPL should be written in between the labor increments. In other words, they should be shifted up a half-row with the first MPL of 20 situated at labor input level $1/2$. For simplicity, the MPLs are shifted to the end of each increment. However, if we had used a continuous production function, rather than a production schedule, to describe the production relationship, then we could use calculus to specify a unique marginal product at every possible output level and this shifting issue disappears.

Notice in the schedule that the marginal product is low at first, rises to a peak of 40 at output level 90 and then decreases as output rises further. When the marginal product is rising over a production range, as it is between 0 and 90 brooms, we say that production exhibits *increasing returns to scale (IRS)*. IRS occurs in early stages of production largely because of advantages gained in the division of labor. In Adam Smith's pin factory story in Chapter 1, one pin-maker working alone could make at most 20 pins in a day. But if a factory were to employ 10 pin-makers and divide tasks along an assembly line process, they could together make 4,800 pins in a day. Economists expect that most production processes will exhibit economies of scale at low levels of production.

When the marginal product is falling over a production range, as it is between 90 and 155 brooms, we say that production exhibits *decreasing returns to scale (DRS)*. DRS occurs at high levels of production largely because of disadvantages caused by trying to manage a large diverse workforce and because of congestion effects. For example, if a pin factory tries to hire thousands of workers in order to produce millions of pins each day, they will have to employ numerous managers to oversee the many crews working. There would be many coordination problems to solve and if too many workers work in too tight a space, they may begin to impede each other and output gains may suffer. Economists expect that most production processes will exhibit diseconomies of scale at very high levels of production.

In Figure 9.1, the marginal product corresponds to the slope of the total product curve (TP). Note that the slope is positive everywhere along the curve, meaning the more labor always adds more broom output, but the slope increases from 0 to 3 workers (IRS), and the slope decreases above 3 workers (DRS).

Side Note: The reference to *low* and *high* levels of production are kept purposefully vague because they will presumably vary from industry to industry. For some production processes IRS might cease after 10 workers are employed on a crew. For other processes, IRS might still prevail with thousands of workers. Thus, what's considered low or high will depend on the industry being studied.

There is one other situation that can arise. When the marginal product is constant over a production range, we say that production exhibits *constant returns to scale (CRS)*. A range for CRS does not occur in the production schedule in Table 1.1. When CRS prevails, the increase in output is proportional to the increase in labor inputs. Economists expect that CRS may occur at intermediate levels of production for many production processes. Wholly-CRS production functions are also widely used in economics models because they can be specified using simple functional forms. This makes it easier to work with the models and to find solutions or equilibrium values, or, in other words, they make the models more tractable. Later we will

sometimes introduce examples where production exhibits CRS for all output levels when it doesn't greatly affect the principle being evaluated.

Production Costs

Economists generally distinguish between two types of production costs: fixed costs and variable costs.

Fixed Costs, FC, are costs that must be paid each month even in the event that no production takes place. Consider Gina and Jon's food truck business again. Suppose after operating for several months they are making a small profit. Next suppose an emergency happens, like the global Covid 19 pandemic of 2020, which forces them to cease operations for several months. During the closure, sales and revenues are zero. And yet, they will still have obligations that incur costs even while they are closed. For example, suppose they signed a contract with the Nifty Food Truck Outfitters to rent their truck for 2 years. Gina and Jon must still pay the monthly rental even though the business has been shut down. This is a fixed cost. The same would be true if Gina and Jon borrowed money from a bank to raise some financial capital for their business. This too is a fixed cost that must be paid each month regardless of the emergency situation.

The money to pay these fixed costs must come from their holdings of financial capital. Businesses should plan to have some savings, a kind of rainy-day fund, that can be drawn upon in an emergency. If not, Gina and Jon will have to contribute more of their own money to keep up with these expenses, or they will have to borrow more from a bank, thereby using a new loan to maintain payments on another loan and the rental contract.

Note that fixed costs, such as these, are not permanent. If the pandemic struck with, say, three months left in the food truck rental contract, then they might choose not to extend that contract for another term and thus their obligation to pay will end in three months. These fixed costs expire eventually. The same is true for a loan, once the loan has been paid off, the fixed costs disappear.

In the Bewitched Broom production schedule in Table 9.2, we introduce fixed costs into the broom factory by assuming, simply, that all of their fixed costs amount to \$200 per day. Essentially, this means we are assuming they have some daily background costs, such as factory space rents that must be paid, but which are not made explicit in the model. Note, in the third column, that the same \$200 of fixed costs must be paid regardless of how much output is produced. We could say that fixed costs are a function of the quantity Q , but it becomes a constant function, namely $FC(Q) = 200$.

In the fourth column of Table 9.2, average fixed costs are shown for each level of output displayed in the schedule. *Average fixed costs*, AFC or $AFC(Q)$, are fixed costs per unit of output and is found by dividing $FC(Q)$ by Q , at each level of output that is $AFC(Q) = FC(Q)/Q$. Because fixed costs do not change as output rises, average fixed costs always fall as output increases.

The second type of costs classified by economists are variable costs. *Variable costs*, VC or $VC(Q)$, as its name suggests, are those costs that vary based on the quantity produced. In the case of Gina and Jon's food truck business, the variable costs are the hourly wages to the workers and the payments for the intermediate goods such as hamburger and sodas. These do not have to be paid if output drops to zero, and they will naturally increase as the quantity of food truck meals produced increases.

For the Bewitched Broom company there is only one factor of production, labor, and so we introduce a simple assumption. Suppose each worker is paid a wage of \$100 per day. Thus, if

one worker is hired, the variable costs are \$100. If two workers are hired, variable costs are \$200, and so forth, as shown in column 5. Note that we write variable costs as a function of output rather than of labor input, which is used to calculate it. This is so we can directly relate costs to the quantity of the good supplied and match it later with the quantity demanded.

The final column shows the schedule for *Average Variable Costs*, AVC or $AVC(Q)$, which is found by dividing variable costs at each quantity of output by the quantity, $AVC(Q) = VC(Q)/Q$. Notice from the Table that AVC is U-shaped as output rises, meaning it's value is high at low levels of output, then falls to a minimum somewhere between 90 and 120 brooms, and finally rises thereafter.

Table 9.2 The Bewitched Broom Production Costs 1

Workers (L) (#)	Output (Q) (#)	Fixed Cost (FC) (\$)	Average Fixed Cost (AFC) (= FC/Q) (\$/broom)	Variable Cost (VC) (\$)	Average Variable Cost (AVC= VC/Q) (\$/broom)
0	0	\$200	~	\$0	--
1	20	200	\$10	100	\$5.00
2	50	200	4.00	200	4.00
3	90	200	2.22	300	3.33
4	120	200	1.67	400	3.33
5	140	200	1.43	500	3.57
6	150	200	1.33	600	4.00
7	155	200	1.29	700	4.52

Table 9.3 finishes our discussion of production cost by introducing the three most important costs going forward, namely, Total Cost, Average Total Cost and Marginal Cost.

Total Cost, TC or $TC(Q)$, is simply the summation of fixed costs and variable costs measured at each level of output. For example, drawing from Table 9.2, $TC(90) = FC(90) + VC(90) = \$200 + \$300 = \500 . This is the amount of expenditures the Bewitched Broom company will have if it produces 90 brooms each day. Note that Total Cost rises as output increases, as is expected since fixed cost remain the same while variable costs rise with rising output.

Average Total Cost, ATC or $ATC(Q)$, is shown in the third column and is calculated as Total Cost divided by output at each output level, or $ATC(Q) = TC(Q)/Q$. This is also sometimes called the unit-cost of brooms because it shows how much it costs to produce one broom, when total production is at a particular level. Notice that ATC follows the same U-shaped pattern as AVC, namely being higher at low levels of output, falling to a minimum at an intermediate level of output, and rising at higher levels of output.

Economists define the range of output along which average cost is falling as exhibiting *economies of scale*. In other words, **production exhibits economies of scale when average total cost is falling as output increases**. Note that the word “scale” is synonymous with level of production. The term economies relates to savings. Thus economies of scale means that a business saves costs as the level of production increases. Economists define the range of output along which average cost is rising as exhibiting *diseconomies of scale*. In other

words, **production exhibits diseconomies of scale when average total cost is rising as output increases.**

It is expected that the cost to produce each broom will be at a minimum at some intermediate level of output. What an intermediate level is, is intentionally left vague, because it will surely vary across different production processes. That minimum average cost will be important later when we see how competition in an industry induces firms to shift their output level such that per unit cost is lowest.

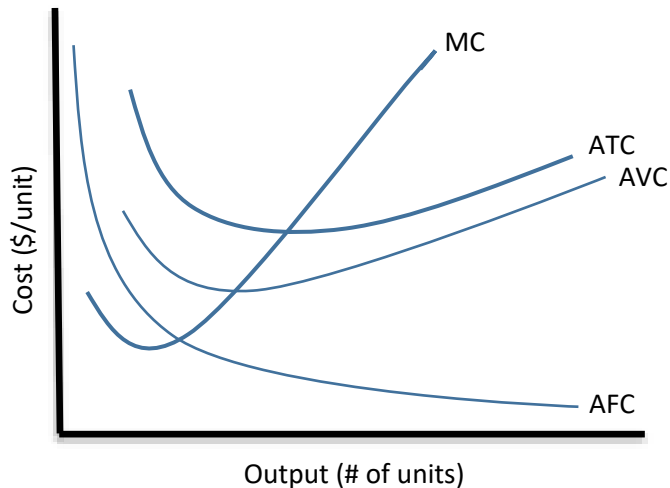
Table 9.3 The Bewitched Broom Production Costs

Output (Q) (#)	Total Cost $TC=FC+VC$ (\$)	Average Total Cost (ATC) $ATC=TC/Q$ (\$/broom)	Marginal Cost (MC) $MC=\Delta TC/\Delta Q$ (\$/broom)
0	\$200
20	300	\$15.00	\$5.00
50	400	8.00	3.33
90	500	5.56	2.50
120	600	5.00	3.33
140	700	5.00	5.00
150	800	5.33	10.00
155	900	5.81	20.00

In Figure 9.2 we graph the most important cost curves in a typical production process with quantity measured along the horizontal axis and cost per unit measured along the vertical axis. Note that the cost values from the Tables above have not been explicitly included. This is because the values used in the Bewitched broom production process were used merely to illustrate the patterns, or shapes, that the individual curves will take. Analysis using more general mathematical relationships (not to be derived here) have indicated that these patterns

will also prevail in general for any production function that exhibits increasing returns to scale for low levels of production and decreasing returns to scale at higher levels.

Figure 9.2 General Production Cost Curves



The cost curves that are most useful going forward are the average and marginal cost curves, rather than the total cost curves. This is because we will regularly need to compare the price of a good, measured in \$/unit with something comparable, such as average and marginal costs, also measured in \$/unit.

The average fixed cost curve, AFC, is shown to be hyperbolic in shape reflecting the rapid reduction in fixed costs per unit as the number of units grows larger. We will rarely have need to refer to the AFC curve later. The average variable cost curve, AVC, is U-shaped and has a minimum at some intermediate level of output. The average total cost curve (ATC), also called average cost (AC), is also U-shaped and has a minimum at some intermediate level of output, at a level that is always higher than minimum variable cost. Finally, marginal cost curve, MC, is also U-shaped and has a minimum value that is always lower than minimum AVC. Marginal Cost also intersects both AVC and ATC at their respective minimums.

The most important of these curves are the average total cost curve, which we will use to derive a firm's total cost, and the marginal cost curve which we will use to define the optimal level of production under different assumptions.

Reality Check

It is worth mentioning that the cost concepts described in this chapter are akin to a bird-eye view of the workings of a real business. Rarely will the costs of production be fully known for all possible levels of production. Most businesses will be unlikely to classify costs into fixed or variable and will not be able to pull up on their company computer the firm's average and marginal cost curves. They won't have a team of economists trying to define the precise output that will maximize profit, or minimize costs. Many firms will also produce and sell multiple products and will have some costs that must be distributed across these products. A good accountant will help determine, usually after the fact, how much it cost to produce each unit of their many products. From some production starting point firms are likely to experiment with different output levels and different production techniques always with a mind to reduce their costs of production so their profit may rise. This is mostly because real-world production

techniques are much more complicated, and also because real firms do not have perfect information about what their costs would be at every output level they might produce.

The model remains useful as guide to what a firm should do to achieve its desired outcome and we imagine that after much trial and error profitable firms will achieve something close to the prediction of this model.

Key Takeaways

1. A production function, or schedule, relates how different physical inputs in production, such as labor, generates different levels of output.
2. Most production processes are expected to exhibit increasing returns to scale at low levels of output and decreasing returns to scale at higher levels of output.
3. Production cost can be separated into two types: fixed costs and variable costs.
4. Fixed costs are those that must be paid even when production drops to zero
5. Variable costs are zero at zero output and rise with increases in output.
6. Total costs are the sum of fixed costs and variable costs at a particular level of output.
7. Average fixed costs (AFC) are always high at low levels of output and fall continuously as output is increased
8. The average variable cost (AVC) and average total cost (ATC) curves are generally U-shaped with increasing output.
9. Marginal costs (MC) measure the change in total costs given a change in output
10. The marginal cost curve is u-shaped with increasing output and crosses AVC and ATC at their respective minimums

