CHAPTER 9

Supply and Demand

Since supply and demand are the most important rules of market grammar, it is worth saying more about them—how they are used as tools of analysis, and something about the theories of production and consumption that underlie them. Supply and demand are so important that some wags have said you could turn a parrot into an economist just by training it to repeatedly squawk "supply and demand"—no need to worry about grammar. However, as you will see in this chapter, there is a good deal more to supply and demand than even a genius parrot could master. But fortunately, it is not too difficult for human beings.

A Shift in the Curve Versus Movement Along the Curve

The amount demanded of a good can change for many reasons, and economists classify these causes into two categories: a change in the price of the good, and everything else. The effect of a change in price on the quantity demanded is shown by a movement along the demand curve. The effect of all other causes of a change in amount demanded is shown by a shift in the entire curve. What are these other causes? The most important are the consumer's income, his tastes, and the prices of related goods.

If the consumer's income rises, he will likely purchase more of every good including *x*, at every price. His demand curve for *x* shifts to the right. For a fall in income, it would shift to the left.

Goods are related as substitutes (ham and bacon) or as complements (bacon and eggs). If the price of bacon goes up, people will substitute ham and buy more ham at every price. The demand curve for ham will shift up. If the price of eggs goes up, the demand curves for both ham and

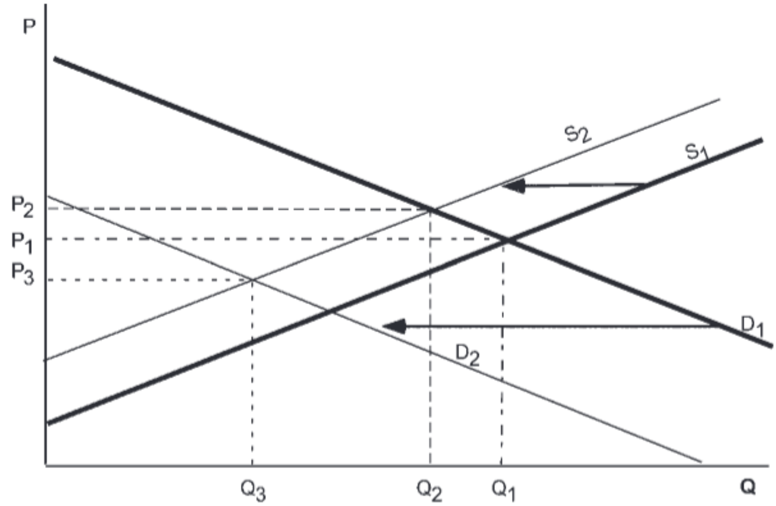

Figure 9.1 • Shifting demand and supply curves.

bacon are likely to shift down as people buy fewer eggs and eat bacon and eggs less often.

A change in tastes or information can shift the demand curve. If people worry more about cholesterol, they will buy fewer eggs at all prices (a shift downward in the demand curve).

To summarize: The demand curve is a relationship between P and Q. Within that given relationship, a change in P causes a change in Q, or vice versa, along the demand curve. But the whole relationship between P and Q can also change. That is a shift in the entire curve. The curve may change its shape and position, but it will always be downward sloping.

Similar things can be said about a movement along the supply curve and a shift in supply. The discovery of a more efficient technology, or a new deposit of resources would, for example, shift the supply curve outward so that more would be offered at each price.

The impact of shifting supply and demand curves on equilibrium price and output are shown in Figure 9.1. A massive recall of *E. coli*-tainted beef and a closing of the guilty processing plant might shift the supply curve for beef from S_1 to S_2. In response to the shift, prices would rise along the D_1 curve, from P_1 to P_2, and supply would drop from Q_1 to Q_2. The recall leads to a series of investigative reports on conditions within meatpacking plants, showing that crowded conditions, rapid processing, and poor inspections make bacterial infection a regular and recurring problem. In response, the demand for beef might shift from D_1 to D_2. As a response to this shift, the amount suppliers would be willing to provide falls along the S_2 curve from Q_2 to Q_3, and price falls from P_2 to P_3.

A mild winter would cause the demand for natural gas to shift down.

An increase in the price of electricity would cause it to shift up. Supply and demand analysis is not just finding the intersection, but knowing where the curves are!

Equilibrium P and Q, Shortage and Surplus

The intersection of supply and demand is important because it defines the equilibrium in which both buyers and sellers are satisfied, and, as we saw in the basic market equation, resources are optimally allocated.

In Figure 9.2, P*Q* is the equilibrium price at which both buyers and sellers are satisfied (maximizing utility and profits, respectively). It is called an "equilibrium" because once at it, there is no tendency to change, because everyone is satisfied.

Any movement away from equilibrium sets in motion forces pushing us back toward equilibrium (the equilibrium is stable). Suppose the price were P_1. Then at P_1 quantity supplied would be P_1B and quantity demanded would be P_1A. The excess of quantity supplied over quantity demanded (AB) is called a *surplus*, and if there is a surplus, the market is not in equilibrium. There are many eager sellers and few eager buyers. The many unsatisfied sellers will begin to compete with each other to sell to the few buyers. How? By offering a lower price. The price will be bid downward until the surplus disappears.

At a price of P_2 we have a quantity supplied of P_2C and a quantity demanded of P_2E. The distance CE represents a *shortage*. It, too, is a disequilibrium situation. We have many willing buyers facing few willing

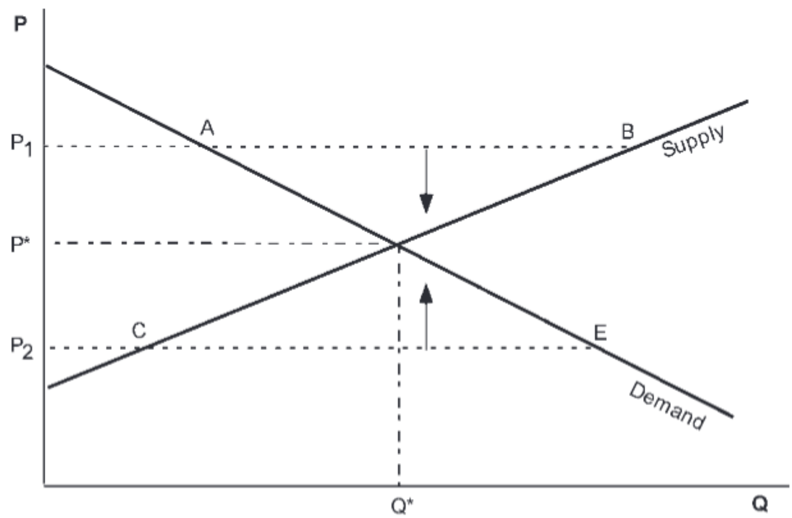

Figure 9.2 • Shortage, surplus, and equilibrium.

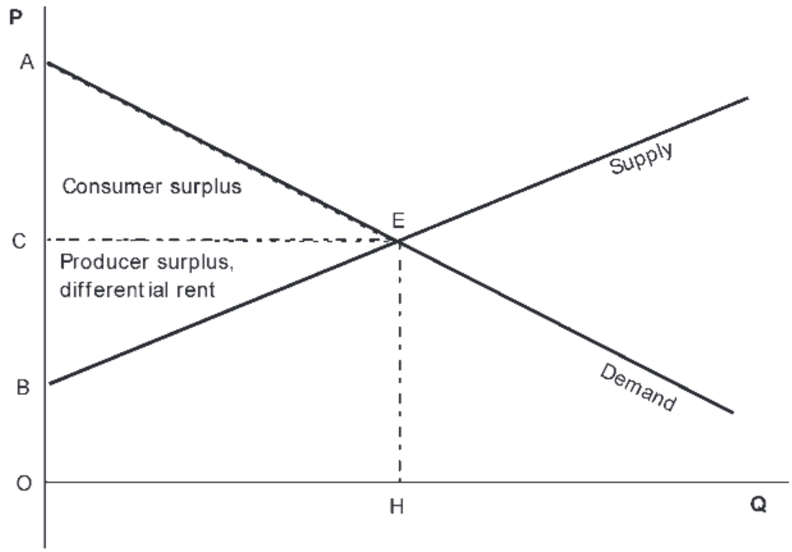

Figure 9.3 • Consumer surplus, differential rent.

sellers. Unsatisfied buyers will begin to compete with each other for the limited sellers. How? By offering a higher price. The price will rise, and as prices rise, producers will produce more, until the shortage disappears.

Note that shortage and surplus are defined with reference to a given price. When people complain about a shortage of petroleum or of labor, what they mean is a shortage of *cheap* petroleum or *cheap* labor. This has led some to claim that the free market can solve all problems. There can be no shortage of resources in a free market, nor any surplus of labor either. All we need to do is to let the price be free to find its equilibrium, and *violà*, no shortage, no surplus—and some would go on to say no resource scarcity, no involuntary unemployment! Hardly comforting if the shortage of a key resource only disappears at a near infinite price, or if the surplus of labor only disappears at a wage below the level of subsistence. The market is a wonderful institution, but not a magic charm.

In Figure 9.3, the equilibrium price is OC, and the equilibrium quantity supplied and demanded is CE. Notice that buyers pay the amount OC for *every* unit of *x* they buy, not just the last or marginal unit. Buyers would have been willing to pay a price of OA for the first unit of *x* rather than do without it. And for the second unit they would have been willing to pay almost as much, and similarly for the third, and so on. But for the last unit at CE, they were only willing to pay OC. The maximum the consumers would have been willing to pay rather than do without is AEHO. What they actually pay is OCEH. The difference, the triangular area ACE, is consumer surplus. It results from the law of diminishing marginal utility. The consumer enjoys the higher marginal utility on all infra-marginal units purchased, but has to pay a price equal to the lowest marginal utility, that of the last unit purchased.

For necessities, consumer surplus is enormous. For example, I buy water at a price that equals my marginal utility of water—say, washing my car. But I get the benefits of the higher marginal utility uses on the infra-marginal units of water used to keep me from dying of thirst, from just being thirsty, from going without a bath, and so on. Many environmental goods and services are necessities that have a large or even infinite consumer surplus.

The producer is also getting a producer surplus, sometimes called **rent**, or differential rent. The producer sells all CE units at his marginal cost for making the last unit, or OC. But for the first unit he would have been willing to accept only OB rather than not sell it. And he would have been willing to accept just a bit more for the next unit, and so on. So thanks to the law of diminishing marginal physical product (law of increasing marginal costs) the producer can sell all his low-cost infra-marginal production for the same price as his highest marginal cost final unit. For example, the price of coal will be equal to the marginal cost of the most expensive coal that can be sold. That marginal coal will come from the worst, leanest, most inaccessible coal mine. But the coal from the rich easy to dig coal mines will sell at the same high price (equal to marginal cost at the worst mine), so the good mines earn a surplus or rent. This is over and above the normal profits of the operation. Normal profit is reflected in the costs underlying the supply curve. **Normal profit** is defined as the opportunity cost of the time and money the entrepreneur has put into the enterprise—that is, what he could have earned from his time and money in his next best alternative. Rents are especially important in extractive industries.

Rent (also known as differential rent or, in the case of natural resources, scarcity rent) is equivalent to producer surplus and is defined as payment over and above the minimum necessary supply price.

The usual definition of rent in economics is payment over and above minimum necessary supply price. The term is usually associated with land because any payment for the use of land is over and above its minimum supply price in the sense of its cost of production. The cost of production of land is zero. That doesn't mean that land is not scarce, and that no charge should be levied on its use. But it does mean that such rent is unearned income, as the tax accountants so frankly call it. It is better to tax unearned income than earned income from the point of view of both fairness and economic efficiency, as Henry George argued over a century ago. Ecological economists have followed Henry George, generalizing his insight a bit to advocate Ecological Tax Reform—shifting the tax base from value added, and on to that to which value is added, namely the throughput flow. In bumper sticker form: "Tax bads, not goods!" The bads are depletion and pollution (throughput), and the goods are value added by labor and capital, that is, earned income. More about that later.

ELASTICITY OF DEMAND AND SUPPLY

How sensitive is a change in quantity demanded to a change in price? Does it take a big change in price to get even a small change in quantity demanded? Or does even a tiny change in price cause a big change in quantity demanded? Clearly it could be either, or anywhere in between. **Elasticity** is a measure of the responsiveness of a change in quantity demanded to a change in price.

The numerical measure of elasticity is defined as follows: Price elasticity of demand = percentage change in quantity demanded, divided by the percentage change in price. Or,

$$ED = (\Delta q/q) \div (\Delta p/p)$$

An exactly analogous definition holds for the price elasticity of supply.

Figure 9.4 shows the extreme values of elasticity of demand and helps give you a feel for the concept. In the case on the left, elasticity is infinite because even the smallest percentage change in price would cause an infinite percentage change in quantity demanded. This is the way the demand curve looks to a pure competitor, a pure price-taker (i.e., one whose production is too small relative to the market supply to have any noticeable effect on price). In the case on the right, even an infinite percentage change in price would cause no change in quantity demanded, which might approximate the demand for essential goods (e.g., water, food, vital ecological fund-services) when in short supply. Most demand curves are neither horizontal nor vertical, but are negatively sloped somewhere in between. For these in-between curves, elasticity varies along the curve in most cases. Demand is said to be elastic when a 1% change in price gives rise to a more than a 1% change in quantity demanded. If a 1% change in price causes a 1% change in quantity then the formula gives an elasticity of 1, and consequently this case is called unitary elasticity.

A classic case of the importance of elasticity is the demand for agricultural crops in general. People need to eat no matter how high the price,

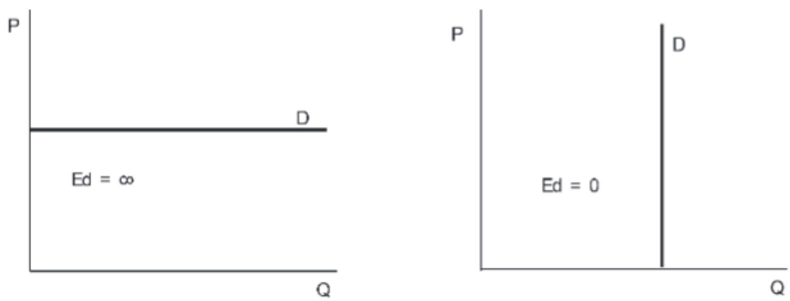

Figure 9.4 • Price elasticity of demand.

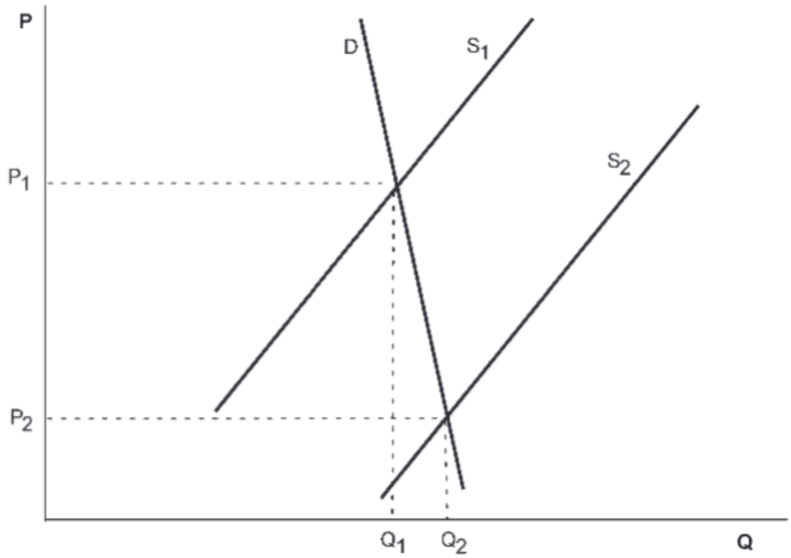

Figure 9.5 • Inelasticity of demand in agriculture. A small shift in quantity supplied leads to a large change in price.

and they will not eat much more than their fill no matter how low the price. The demand for food in general is rather inelastic, as shown in Figure 9.5. This means that the price (and total revenue) change drastically with small changes in quantity, putting the farmer in a risky position. This is one reason why governments frequently subsidize agriculture.

Figure 9.5 shows the impact of a shift in supply on the equilibrium price and quantity of a good with inelastic demand, using food as an example. At a harvest of Q_1 the price is P_1 and the total revenue to the farmers is the area of the rectangle $P_1(Q_1)$. Next year comes a bumper crop due to good weather, and the supply shifts out to S_2 with demand staying the same. The farmers' total revenue has fallen to $P_2(Q_2)$, a much smaller amount even though the harvest has increased from Q_1 to Q_2. The reason is that with inelastic demand, a small increase in quantity caused a large decrease in price. (Elasticity works in reverse, too!) When demand is elastic, price and total revenue move in the opposite directions; when demand is inelastic, they move in the same direction.[1]

THINK ABOUT IT!

What do you think would happen if the World Bank loaned money to lots of developing countries to produce and export food crops?

[1]Note the implications of this for GNP (to be discussed at length in Chapter 13). If agricultural production goes down, GNP could go up as a result, and if water becomes sufficiently scarce, GNP could skyrocket!

What determines whether demand is elastic or inelastic? Mainly the necessity of the good for human well-being, and the number of good substitutes available. If ham is easily available, the demand for bacon is likely to be elastic. Since there is no good substitute for food in general, the demand for agricultural goods in general is going to be inelastic.

The longer the time period of the analysis (Q on the X-axis is really a flow, Q/t), then the more time consumers have to adjust their habits, and the more elastic demand will be.[2] The time period also greatly affects the elasticity of supply. In the very short run, say daily, the fish supply is totally inelastic once the fishing boats have returned with the day's catch. Weekly supply is more elastic because fishermen can respond to a higher price by staying out longer, or taking more crew. Over a year, elasticity is still greater because new fishing boats can be built. But then the supply could become totally inelastic as the limits of the fishery are reached. There is a tendency to neglect the last case in most microeconomics texts, but it is critical in ecological economics.

THE PRODUCTION FUNCTION

The **production function** is a relation that shows how factor inputs are converted into product outputs. It is basically a technical recipe for producing a good or service, or rather for *transforming* labor, capital, and resources into a good or service.

$$Q = F(a,b,c\ldots)$$

In plain English, the quantity produced is a function of the inputs (factors of production) *a, b,* and *c*. We earlier spoke of the marginal physical product of factor *a*. In terms of the production function, it is the increase in Q resulting from adding one more unit of factor *a* to the production process, holding factors *b, c,* and everything else constant. The main thing we know about production functions is that they follow the law of diminishing marginal physical product, as depicted in Figure 9.6. In the graph, the marginal physical product of *a* is the change in Q resulting from a change in *a* ($\Delta Q/\Delta a$), which is also the slope of the Q curve, when Δa is one unit. In Figure 9.6, Δa is the same in both cases, but the corresponding ΔQ is much smaller when *a* is larger. The slope diminishes as we increase *a*, and it finally becomes zero. A similar curve could be drawn for factors *b* and *c*. From the basic market equation we already know the significance of the law of diminishing marginal product, as well as the basic argument for why it is true. Another way of stating the relationship is to say that for each equal increment of Q we need to employ increasing

[2]Of course, it can be very difficult to adjust demand for food, water, and other things essential to life.

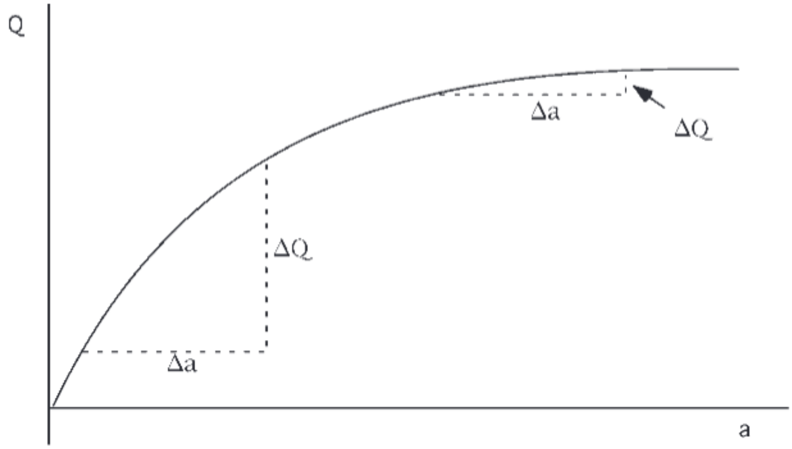

Figure 9.6 • Diminishing marginal physical product.

amounts of *a*. Stated this way, the relation is the law of increasing marginal cost.

The assumption behind the curve is that *a* is a substitute for *b, c*, etc.—all the other factors held constant, but that it is an imperfect substitute. Therefore, the more we try to substitute *a* in the recipe, the less successful the substitution becomes in terms of producing more Q. The poorer a substitute factor *a* is for the other factors held constant, the sooner MPP*a* falls to zero. And if *a* is really a complement to the other factors held constant, then MPPa is zero from the start.[3] Production functions exhibit both **substitutability** and **complementarity** between factors. But standard economists tend to see mostly substitution, whereas ecological economists emphasize complementarity. Why is this so?

Probably it is because ecological economists put different things in the production function and assign different qualitative roles to the different factors in the production process. For instance, neoclassical economists treat all inputs the same—labor, capital, and resources. Ecological economists insist on a qualitative difference. Labor and capital are transforming agents, funds that transform the flow of resources into a flow of product, but which are not themselves embodied physically in the product. Labor and capital are agents of transformation (efficient causes), while resources are that which is being transformed (material causes). The neoclassical production function abstracts from the difference between material and efficient cause of production, and considers both to be equivalent. Ecological economists insist on the distinction. It is clear that while one **material cause** (resource) can often be substituted for another, and one

[3]Note that the relations of complementarity and substitutability apply to factors of production as well as to goods used by consumers.

efficient cause (labor, capital) can often be substituted for another, the relation of efficient cause to material cause, of agent of transformation to material undergoing transformation, is mainly one of complementarity. Ecological economists emphasize this latter relation; neoclassical economics misses it entirely.

The ecological economics production function embodies the fund-flow distinction:

$$Q = F(N, K, L; r)$$

K and L are funds of labor and capital, and r represents flows of natural resources. Funds and flows are basically complements. Substitution takes place within each category, but usually not between them. N stands for natural capital, which exists both as a stock that yields a flow of resources (a forest yielding cut timber) and as a fund (a forest yielding the service of watershed protection or wildlife habitat). The stock function of yielding a flow of resources is already captured in r, so N then should be taken here as representing the fund function of providing an indirect service that contributes to the transformation of r into Q, much as K and L provide direct services. For example, forest cover providing the service of water catchment to recharge aquifers used in irrigated agriculture is as much a capital fund-service to agriculture as is the fund of pipes and sprinklers used in irrigation.

In most neoclassical economics textbooks, the production function is written as

$$Q = F(K, L)$$

In other words, resources are neglected entirely! A flow of output is seen as a function of two funds, or two stocks that are not decumulated, or drawn down.

Is it possible for stocks (or funds) that do not decumulate, by themselves, to yield a flow? An economist's first reaction is to say of course a stock by itself can yield a flow; consider the stock of money in the bank yielding by itself a flow of interest (the principal is not decumulated yet the interest flow continues, perhaps even in perpetuity). True, but that is a convention of finance, not a physical process of production. How about a stock of cattle yielding a flow of new cattle in a sustained-yield fashion. Isn't that a physical stock yielding a physical flow? Not really. It is a stock (livestock) converting a *flow* of inputs (grass, grain) into a *flow* of outputs (new cattle, and waste products). The resource inflow of grass and grains, and so on is *transformed* into a product outflow of new cattle (and replacement to the livestock herd for natural mortality or "depreciation"), plus waste. The correct description of "production" is transformation of a resource inflow into product outflows, with stocks (funds) of capital and labor functioning as the transforming agents. This is true not only for the living transformers in agriculture (plants and animals), but even more obviously for industrial processes of production where the transformation is visible within the factory at every stage.

Why are such basic facts excluded from neoclassical economics? Why does it choose to ignore them, to exclude natural resources from theoretical analysis right from the start? Perhaps it is a case of "money fetishism"—assuming that what is true for money in the bank, the symbol and measure of wealth, "must" be true for the wealth that it symbolizes.[4]

Recall that the production function is a recipe. Real recipes in real cookbooks always begin with a list of ingredients. They do not just say "take the labor of a cook and the capital equipment in a standard kitchen and make cherries jubilee." Real cookbooks give us a list of ingredients, followed by instructions about how to combine and transform the ingredients into the product. The cook and her kitchen are not physically transformed into an edible dish! They are the transformers, not the transformed.

Perhaps this latter consideration has led some neoclassical economists to include r in their production function. But they have done it in such a way as not to solve the problem. Most production functions are multiplicative forms—that is, the relationship F among the factors is one of multiplication (e.g., the Cobb-Douglass production function[5]). After all, what could be more natural than "multiplying" together things that we call "factors" to produce something that we call a "product"! Unfortunately there is nothing in the real-world process of production that corresponds at all to multiplication. There is only transformation. This means that substitutability is built into these production functions from the beginning as a mathematical artifact, including substitutability between r and K, and r and L (between funds and flows). In these multiplicative production functions, we can make one factor as small as we wish, while keeping the product constant, if we increase the other factor sufficiently. The only restriction is that no factor can be reduced to zero, but it can approach zero. But according to this logic, if our cook is making a 5-pound cake, he can increase it to a 1000-pound cake with no extra ingredients—just by stirring harder and baking longer in a bigger oven! The First Law of Thermodynamics (conservation of matter and energy) has been totally ignored.

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[4]One current text includes resources among its factors of production in discussion, but on the next page wrote the production function as above with only K and L as variables, and from then on forgot about resources. J. M. Perloff, *Microeconomics*, 2nd ed., Reading, MA: Addison Wesley, 2000.

[5]The Cobb-Douglass production function (in its simplest form, $Q = K^{\alpha}L^{\beta}$) states that production equals capital (raised to an exponent) times labor (raised to an exponent), and the sum of the exponents ($\alpha + \beta$) equals one. The important point for us is simply that capital and labor are multiplied, and if R (resources) is added as a third factor, it too is multiplied in like manner.

Ignoring the necessary role of natural resources in production is part of a pattern in neoclassical economics that has the effect of denying that nature has any role in economic life. Value in their view is only value added—added by labor and capital. But added to what? In the neoclassical view, that to which value is added is thought to be merely inert stuff having no independent value of its own. Ecological economics recognizes the contribution of nature in supplying that to which value can be added. It is by no means inert stuff. It is scarce low-entropy matter and energy, as we discussed in Chapter 4.

Moreover, since resource flows are complementary with manmade funds, they can become the limiting factor on production when they become more scarce than the manmade fund factors. This is exactly what is happening in the real world. Economic logic tells us to maximize the productivity of the limiting factor in the short run, and to invest in its increase in the long run. Economic logic has not changed, but the pattern of scarcity has. As we move from the empty to the full world economy, natural resource flows and services generated by natural capital stocks and funds become the limiting factor. Fish catches are no longer limited by the manmade capital of fishing boats, but by remaining natural capital of stocks of fish in the sea and the natural funds that support their existence. We need to economize on and invest in the limiting factor. Economic logic has not changed, but the identity of the limiting factor has.

Because our basic neoclassical theory of production, when it considers natural resources at all, cannot distinguish funds from flows or recognize complementarity between them, we have been slow to recognize this change.

THE UTILITY FUNCTION

The **utility function** relates utility or want satisfaction to the flow commodities (goods and services) consumed by the individual:

$$U = F(x, y, z, \ldots)$$

In plain English, our happiness depends on what we consume (and not on our freedom, creativity, social relationships, etc.). The main thing we know about the utility function is the law of diminishing marginal utility—that as we consume increasing amounts of a single good, other things being equal, our additional satisfaction from each additional unit of the good in question declines—that is, total utility increases but at a decreasing rate.

THINK ABOUT IT!
Do you remember the argument demonstrating why it is reasonable to believe that this law is true?

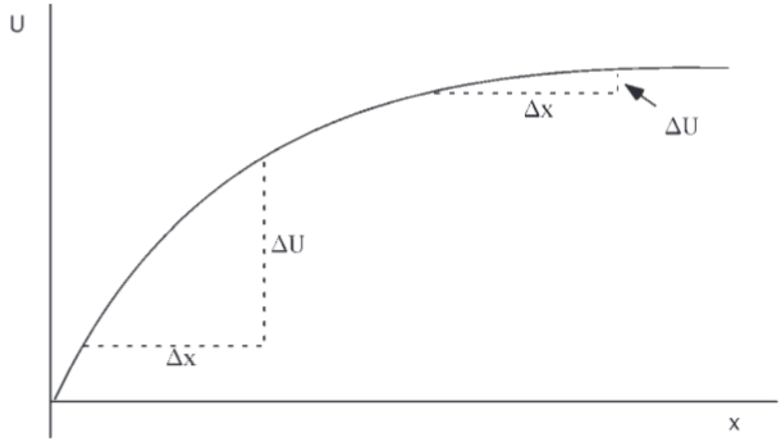

Figure 9.7 • The law of diminishing marginal utility.

The graph in Figure 9.7 simply shows that marginal utility declines with more units of *x* consumed in a given period, even though total utility increases (but ever more slowly). The first ice cream cone on a hot day is a delight, the third is not. To the extent that *x* is complementary with other goods that are being held constant, the marginal utility of *x* will decline faster, or may even be zero from the start. For example, a third ice cream cone without a complementary glass of water is not so enjoyable. And a right shoe without a left shoe has zero marginal utility to most people.

The neoclassical production function only contains flows of goods or services as variables. A more complete picture of consumer satisfaction would include the services of directly enjoyed natural capital funds—the provision of breathable air by a well-functioning atmosphere, drinkable water by a well-functioning hydrologic cycle, and so on. As we did previously, let's refer to these natural funds as N and include them in the utility function in a way analogous to our inclusion of the transforming funds L and K in the production function. Direct service from N is not just the pleasure of a beautiful landscape, although that is included. It also and primarily refers to the basic fitness of our environment to our organism that supports our life, and consequently supports our consumption and want satisfaction from commodities. We have evolved over millions of years into a relation of fitness to our environment. But fitness is a reciprocal relation. If we are fit for our environment, then our environment is fit for us. The relation of fitness can be destroyed by either a change in us or a change in our environment.[6] This fitness of the environment implies

[6]Fitness-destroying changes in the environment can be induced by humans (e.g., global warming) or autonomously caused by nature (e.g., a volcanic eruption or earthquake). H. J. Henderson, *The Fitness of the Environment*, Gloucester, MA: Smith, 1913.

a relation of complementarity between N and ourselves, including most of our artifacts, which are extensions of ourselves.[7]

Let's rewrite the utility function as:

$$U = F(N; x, y, z, \ldots)$$

If *x* is a pair of hiking boots, then its utility depends on places worth hiking in (N). If *y* is a snorkeling mask, its utility depends on reefs and clean water (N)—not to mention prior dependence on breathable air, drinkable water, sunlight filtered of enough of its UV rays so we won't get melanoma if we go snorkeling, and so on. N provides a complementary service without which the utilities of most consumer goods are not very great.

Consumers may be able to maintain the same level of satisfaction in the face of a reduction in *x* by simply consuming more *y* and *z*, which to some degree are substitutes. But N is a complement to *x, y*, and *z*, and their increase will usually not compensate for a decline in N. In fact, their utility will fall with a decline in N. For example, you won't enjoy your new hiking boots very much if there are no pleasant hiking trails.

The production of more *x, y,* and *z* may not make us any better off if accompanied by a decline in N. Indeed, it may make us worse off. The usual assumption is that N is superabundant and *x, y,* and *z* are scarce. But that was back in the empty world. We are now in a full world. The use of N as a stock that yields r is likely being pushed beyond sustainable limits. Consequently we may lose not only N in the stock sense, but also the services of N in the fund sense. And those services are complementary with most consumer goods, so reduced N will mean reduced utility from *x, y,* and *z*.

We may argue that for rich people with a low MU for goods in general, the relative importance of N is high, but that for the poor, the MU of goods still outweighs the MU of N. That may be the case in certain instances, and it is certainly what institutions like the World Bank consider realistic. But it need not be. Even food bought by the poor has low marginal utility if the poor are being choked by poisonous air and fried by UV radiation.

Microeconomics is a big subject, and this section could turn into a book by itself. We have not tried to cover the whole topic, but rather to explain the basic grammar of markets, why markets are efficient, what conditions have to hold for markets to be efficient (and by implication what might possibly go wrong), and to give the rudiments of supply-and-demand analysis. We have also tried to point out those places where we think the ecological economics perspective improves microeconomics. We

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[7]Cars and bicycles are extensions of our legs, clothes are extensions of our skin, telephones extend our ears, computers extend our brains, etc.

will now focus our attention more directly on N, the goods and services provided by nature, to determine how well they meet the criteria for efficient allocation by market forces.

BIG IDEAS to remember

- Shift in the supply or demand curve versus movement along the curve
- Shortage, surplus, equilibrium
- Consumer surplus
- Producer surplus, rent
- Elasticity
- Complementarity and substitutability
- Production function
- Utility function
- Diminishing marginal utility
- Diminishing marginal physical product
- Production as transformation
- Fitness of the environment
- Natural capital's role in both utility and production functions