CHAPTER

8

The Basic Market Equation

The purpose of microeconomics is to understand how decentralized decisions by thousands of independent firms and households are communicated, coordinated, and made consistent through prices determined by supply and demand in markets. In the absence of central planning, markets make it possible to have spontaneous order. This seems a bit miraculous, but an analogy will clarify. Even though no one designed a language, nevertheless a language is logically structured and ordered. Although the capacity for language is no doubt part of our genetic inheritance, an actual language is an ordered structure that evolved spontaneously through use. We can, after the fact, analyze the logical structure and grammar of a language, but that is description, not design. Even Esperanto, which is a designed language, was largely copied from Spanish, a natural spontaneously evolved language. Few people speak Esperanto. Like language, the market is also a communications system, though much more limited in what it can communicate. But the market, too, has a "grammar," a logic that can be analyzed even though it arose in a spontaneous, unplanned way. And the market does more than communicate—it allocates.

What are the grammar rules of markets? What is being communicated? In what sense is the market allocation efficient, and why? Is the outcome fair, or sustainable? These are microeconomic questions. Our approach here is to develop the basic answers, the big ideas and conclusions, without getting lost in details, and without resorting to calculus or indeed to any mathematics beyond ratios and simple equations. To do this we need five definitions and three principles. On the basis of these definitions and principles, we will derive a "basic market equation" and then interpret its meaning concretely. So a little patience will be required for several pages before we see just how all the concepts and principles cohere into the main conclusion of price theory. Once we have the main conclusion and big picture, we'll show how basic supply and demand derive from that picture and will present the most basic "grammar rules" that govern supply and demand in individual markets. Then we will look behind supply and demand, first at the production function that underlies supply, then at the utility function that underlies demand. Finally, we will see the implications of ecological economic analysis with respect to the production and utility functions.

Components of the Equation

Let's begin with the five definitions of concepts we'll need:

1. MU*xn* = marginal utility of good *x* to consumer *n*. The marginal utility is the extra satisfaction one gets from consuming one more unit of the good, other things being equal. If *x* is pizza and you are the consumer, MU*xn* is the amount of utility you get from consuming another piece of pizza.
2. *Px* = the market price of good *x* (goods are *x, y*). What's the market price of a slice of pizza, $2.50?
3. *Pa* = the market price of factor *a* (factors are *a, b*). What factors of production go into making a pizza? The kitchen and stove are the capital (fund-service), the cook is the labor (fund-service), and the flour, tomatoes, and cheese are raw material stock-flows yielded by natural capital, with the assistance of cultivation. The cook and oven transform the raw ingredients into pizza.
4. MPP*ax* = the marginal physical product of factor *a* when used to make good *x*. The marginal physical product is the extra output produced as a result of using one more unit of a factor as an input, all other inputs remaining constant. For example, if adding one more cook increases the pizza output of a pizzeria by 20 pizzas per night, then the marginal physical product of 8 hours of labor in terms of pizza is 20 pies.
5. Competitive market. A **competitive market** is a market in which there are many small buyers and sellers of an identical product. "Many" means "enough that no single buyer or seller is sufficiently large to affect the market price." Put another way: Everyone is a price-taker; no one is a price-maker. Everyone adjusts his or her plans to prices; no one has the power to adjust prices to plans. Since everyone treats price as a parameter (a given condition) rather than a variable (something one can change), this condition is sometimes called the parametric function of prices.[1]

[1]See O. Lange, "On the Economic Theory of Socialism," Review of Economic Studies, for an excellent exposition of markets prices and parametric function.

Here are the three principles:

Law of diminishing marginal utility. As one consumes successive units of a good, the additional satisfaction decreases, that is, total satisfaction increases, but at a decreasing rate. The marginal utility of one's first slice of pizza on an empty stomach is great. The marginal utility of the fifth slice is much less. How do we know that this principle is generally true? One way to make an argument is to assume the contrary and show that it leads to absurdity. Suppose that there were a law of increasing or even constant marginal utility—the utility of the fifth slice of pizza were equal or greater than the first. Then what would we observe? A consumer would first purchase the good that gave him the highest marginal utility per dollar. But then the second unit of that good would, under constant or increasing marginal utility, give him the same or even more satisfaction per dollar than the first, and so on. With a law of constant or increasing marginal utility, consumers would spend all their income on only one good. Since the contrary of diminishing marginal utility leads to absurdity, we have indirectly established the reasonableness of diminishing marginal utility.

Law of diminishing marginal physical product = as a producer adds successive units of a variable factor to a production process, other factors constant, the extra output per unit of the variable factor diminishes with each addition, that is, total output increases at a decreasing rate. This is sometimes called the law of diminishing returns. Again we can convince ourselves of its reasonableness by assuming the contrary and showing that it leads to absurdity. Assume a law of increasing marginal physical product. We have a 10-acre wheat farm. We add one more laborer, and his marginal product is greater than that of the previous laborer. So we add another, and so on. The result is that all agricultural labor will be employed on a single farm. Indeed, we could grow the whole world's wheat crop in a single flowerpot. This is absurd, and thus we have indirectly established the reasonableness of the law of diminishing marginal physical product.[2]

The **equimarginal principle of maximization** has been referred to

[2]The law of diminishing marginal product should not be confused with economies or diseconomies of scale. An economy of scale occurs when a 1% increase in *all* the factors of production together leads to more than a 1% increase in output. This does not contradict the law of diminishing marginal physical product. With an economy of scale, we couldn't necessarily produce the world's wheat supply in one flowerpot, but we would want to grow it all on one very large farm. In reality, economies are likely to occur over a limited range of production, usually followed by diseconomies of scale. Over very limited ranges of production, an additional unit of a factor of production may have a higher marginal physical output than the first. For example, four carpenters building a house may finish a house more than four times faster than a single carpenter, as a single person simply cannot lift a large wall or maneuver a truss, but 16 carpenters on the same house are unlikely to get it built four times faster than four.

earlier as the "when to stop" rule.[3] When does a consumer stop reallocating her income among different goods? When she has found an allocation that maximizes her total satisfaction or total utility. That point occurs when the marginal utility per dollar spent on each good is equal. Again, suppose the contrary—the marginal utility of good *a* per dollar spent were greater than that for good *b*. Then our consumer could increase her total utility by reallocating a dollar from *b* to *a*. Only when utilities were equal at the margin would it no longer be possible to increase total utility by reallocation of expenditure. Furthermore, the law of diminishing marginal utility guarantees that each reallocated dollar brings us closer to the optimum—buying more *a* reduces the marginal utility of *a*, buying less *b* raises the marginal utility of *b*, moving us toward equality at the margin.[4]

In a simple economy of shoes and pizzas, how would you spend your money? You buy pizza if a dollar spent on pizza provides more pleasure than a dollar spent on shoes, and you buy shoes if a dollar spent on shoes provides more pleasure than a dollar spent on pizza. To maximize pleasure, the last dollar spent on pizza must supply the same pleasure as the last dollar spent on shoes.

Similar logic applies to the producer who is maximizing her output by choosing a combination of factors such that the marginal product per dollar spent on each factor is equal. If the MPP of each factor were not equal, the same total output could be produced with fewer inputs, hence at lower total cost, thus yielding higher profit.

Think in terms of a pizza parlor. The owner can hire another cook for $1600/month who can produce an additional 20 pizzas per day, generating $1700 in additional net monthly revenue. Alternatively, if the owner sends $1600/month on payments for a better kitchen, she would only be able to produce 18 more pizzas per day. The owner will keep hiring cooks as long as the additional pizzas they produce generate net profits, and

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[3]This basic rule in economics does have an important limitation. The rule says that the way to get to the top of the mountain is to take any step that leads upward. When you can no longer do that, when any step you take will move you downward, you know you are at the top of the hill, the maximum point. Or do you? If there is a temporary dip on the hillside, you might mistake a local maximum for the global maximum. The laws of diminishing marginal utility and diminishing returns are thought to guarantee hillsides with no dips, but the caveat is important to keep in mind.

[4]The "when to stop" rule assumes people are only concerned with maximizing their own utility and do not allocate resources for the sole purpose of making others happy. It also assumes people always make the utility-maximizing choice. Mainstream economic theory assumes that rational self-interest guides all allocation decisions, and someone who acts in this way is known as *Homo economicus*. Empirical studies and common observations show that in reality, people are not always "rational," as economists define the term, and sometimes act selflessly (helping others with no gain to themselves), vengefully (harming others even when it harms themselves as well), or in other "irrational" ways. Though the individual might maximize his or her own utility by harming or helping someone, applying the equi-marginal principle of maximization to such actions will not lead optimal outcomes for society.

those profits are greater than the profits from spending an equivalent sum on the kitchen. However, as she hires more cooks, the cooks get in each other's way, there are insufficient ovens, and their marginal productivity goes down. In contrast, with more cooks available, the marginal productivity of a better kitchen might increase. If the productivity of a bigger kitchen per dollar invested becomes greater than the productivity of another cook (and produces enough extra pizza so their sales will cover the costs of improvement), the owner will invest in the kitchen. The point is that to maximize profits in the pizzeria, the last dollar spent on hiring cooks should generate the same profit as the last dollar spent on expanding the kitchen.[5]

Now let's imagine a shoe store moves in next door to the pizzeria. Business grows, and the owner estimates that an assistant would generate an additional $1800 in net monthly revenue. The town is small, and the only available workers are employed by the pizza parlor. Because the shoe store owner profits more from an extra worker than the pizzeria, he can afford to pay more. One of the pizza cooks comes to work for him (assuming the skills are transferable). As the shoe store owner hires away more pizza cooks, his store gets crowded and production per laborer goes down, while the pizzeria gets less crowded and production per laborer goes up. The pizzeria owner can therefore raise wages to retain her employees. As long as the shoe store owner can make more profit from another laborer than the pizzeria owner, he can hire laborers away from her, but the decreasing productivity of more workers for him and the increasing productivity of fewer workers for her means that this cannot go on forever. Eventually, the marginal product valued in dollars of profit from a pizza cook and a shoe store assistant become equal, and neither store owner can outbid the other in hiring extra labor. Hence, the marginal physical product of labor for shoes and pizzas, as valued in dollars, will be equal. The same holds true for all factors of production across all industries.

Now we are in a position to state the basic market equation, then show why it must hold, and then interpret just what it means. The basic market equation can be written as:

$$\mathrm{MU}x n/\mathrm{MU}y n = \mathrm{P}x/\mathrm{P}y = \mathrm{MPP}ay/\mathrm{MPP}ax$$

First, notice the central position of relative prices. On the left are conditions of relative desirability, reflecting the upper or ends part of the ends-means spectrum (see Figure 3.1). On the right are conditions of

[5]Of course, there are real differences between hiring cooks and improving a kitchen. Cooks can be hired or fired, can work longer or shorter hours, and in general may allow greater flexibility than kitchen construction. Improving a kitchen is a lumpier investment, harder to do in discrete units. The arguments presented here would make more sense if the restaurant owner could invest in cooks and kitchens in very small units.

relative possibility, reflecting the lower or means part of the ends-means spectrum. The intermediary role of prices is to bring about a balance between ends and means, an efficient allocation of means in the service of ends.

But how do we know that the basic market equation holds? We know the left-hand equality holds because it is just a restatement of the consumer's allocation rule of equal marginal utility per dollar, usually written as:

$$\mathrm{MU}xn/\mathrm{P}x = \mathrm{MU}yn/\mathrm{P}y$$

The marginal utility per dollar spent on pizza should equal the marginal utility per dollar spent on shoes for consumer *n*. If you think about it and review the section on the equimarginal principle of maximiation, you'll see that if the first ratio is larger than the second, *n* will increase her total utility by buying more pizza and fewer shoes.

Similarly, the right-hand equality must hold because it is the producer's equimarginal principle of maximization—all factors are employed in quantities such that the price of each factor equals the value of its marginal product. For all firms using *a* to produce *x*, we have

$$\mathrm{P}a = \mathrm{P}x\ (\mathrm{MPP}ax)$$

The price of labor equals the price of pizza times the number of pizzas an additional unit of labor can produce with all other factors of production held equal.

THINK ABOUT IT!
In real life, can more labor produce more pizza without additional pizza ingredients? We will return to this question.

If the marginal unit of labor costs more than the value of the pizzas it can produce, the pizzeria owner would earn higher profits by employing less labor.

Likewise, for all firms using factor *a* (e.g., labor) to produce good *y* (e.g., shoes) we have

$$\mathrm{P}a = \mathrm{P}y\ (\mathrm{MPP}ay)$$

Since P*a* is the same for all firms, and things equal to the same thing are equal to each other, it follows that

$$\mathrm{P}x\ (\mathrm{MPP}ax) = \mathrm{P}y\ (\mathrm{MPP}ay)$$

The value of the additional pizzas a worker could produce in a pizzeria will equal the value of the additional shoes a worker can produce in a shoe store.

Reorganizing terms, we get

$$Px/Py = MPPay/MPPax$$

This is the right-hand equality in the basic market equation.

What Does the Market Equation Mean?

Now that we have derived the basic market equation, what does it mean? So what?

First, note that *x* and *y* are any pair of goods, *a* is any factor of production used by any firm, and *n* is any individual. The equation holds for all pairs of goods, all factors, all firms, and all individuals. We could string out marginal utility ratios to the left, one for each individual in the economy, not just *n*. For each individual, the ratio of his marginal utilities between *x* and *y* would equal the price ratio. Does this mean that all individuals consume the same amounts of *x* and *y*? Certainly not! People have different tastes, and in order to get equality at the margin, different consumers have to consume different total amounts of *x* and *y*. Unless each consumer is consuming amounts such that the ratio of marginal utilities is equal to the price ratio, that consumer is not maximizing his utility.

The basic market equation is:

$$MUxn/MUyn = Px/Py = MPPay/MPPax$$

MU is the marginal utility of good x or good y to person n, and MPP is the marginal physical product of factor a used to produce good x or good y.

Likewise, we could string out marginal physical product ratios to the right, one for each factor of production (*a, b, c,* etc.) used by any firm in making *x* and *y*. Does the equality of each marginal ratio imply that all firms use the same total amounts of factor *a* or *b* in producing *x* and *y*? No, because different firms have different production processes. But unless the ratio of MPP equals the price ratio, the firm in question is not maximizing profits.

We could write a similar basic market equation for every other pair of goods—one for *x* and *z*, one for *y* and *z*, and so on. So the equation holds for all relative prices.

The central role of P*x*/P*y* is worth emphasizing. It brings about an equality of the marginal utility ratios with the marginal productivity ratios. Things equal to the same thing are equal to each other—prices serve as a kind of sliding fulcrum on a seesaw that balances the weight of relative possibility with the weight of relative desirability, of means with ends (Figure 8.1). The rate at which consumers are *willing* to substitute one good for another (psychological rate of substitution) is equal to the rate at which they are *able* to substitute goods by exchange (market rate of substitution), and also equal to the rate at which producers are able to produce one good rather than another (essentially "transform" one good into another) by reallocating resources between them (technical rate of substitution or transformation).

Relative prices serve as a sliding fulcrum to bring about balance or equality between the utility and productivity ratios. But once that equality is achieved, what does it mean? To understand better, leave out the

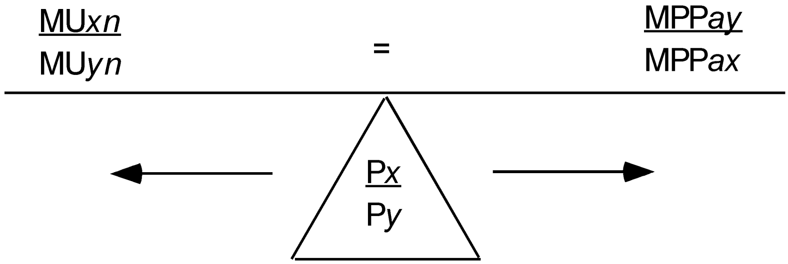

Figure 8.1 • The parametric or fulcrum function of relative prices.

intermediate price ratio and consider only the resulting equality of the marginal utility ratio and the marginal productivity ratio:

$$\mathrm{MUxn}/\mathrm{MUyn} = \mathrm{MPPay}/\mathrm{MPPax}$$

Rewrite this equation as:

$$\mathrm{MUxn} \times \mathrm{MPPax} = \mathrm{MUyn} \times \mathrm{MPPay}$$

This states that the marginal utility derived from factor *a* when allocated to good *x* is just equal to the marginal utility derived from factor *a* when allocated to the production of good when allocated to the production of good *y*, as judged by consumer *n*,[6] or in more concrete terms, the amount of pizza a worker producers in an hour provides the same utility to consumer *n* as the amount of shoes the worker could produce in an hour (assuming the same wage). Because *n* is any consumer, *x* and *y* are any goods, and *a* any factor, it follows that no consumer would want to reallocate any factor between any pair of goods. In other words, the **basic market equation** defines an optimal allocation of resources, one in which no one would want to reallocate any factor to any alternative use because doing so would only decrease that person's total satisfaction. No firm would want to reallocate any factor to any other use because doing so would lower profit.

Perhaps this seems a very big rabbit to pull out of a very small hat! We will come back to that, but for now, let's appreciate the result. Prices in competitive markets lead to an efficient allocation of resources in the sense that no one can be made better off in his own judgment by reallocating resources to produce a different mix of goods. Of course, individual *n* could be made better off if income or wealth were redistributed from individual *m* to himself. We all could be better off if we had a larger resource endowment. But this analysis assumes a given distribution of income and

[6]A review of the units: MU*xn* is utility per unit of good *x*, or U/*x*. MPP*ax* is units of good *x* per unit of factor *a*, or *x*/*a*. The units of the product are U/*x* × *x*/*a* = U/*a*. The units are utility per unit of factor *a* when it is used to make *x* (utility as experienced by individual *n*). In other words the utility yielded by factor *a* in its *x*-use is equal to that yielded in its *y*-use.

wealth among people, and a given total resource endowment. The optimal allocation of resources is what economists call a **Pareto optimum**: Everyone is as well off as they can be without making someone else worse off.

A Pareto optimum occurs when no other allocation could make at least one person better off without making anyone else worse off. This is also known as a Pareto efficient allocation (see Chapter 1), Pareto efficiency, or simply efficiency.

These qualifications shrink the rabbit back down to the dimensions of the hat, but it is still a nice trick to bring about a balanced adjustment of relative possibilities with relative desirabilities, to communicate and mutually adjust means to ends in an efficient way without central coordination. The technical possibilities of transforming one good into another by reallocating resources are balanced with the psychic desirabilities of such transformations as judged by individuals.

The key thing about this result is that it is attained by an unplanned, decentralized process. The problem solved by the price system is in the words of F.A. Hayek, "the utilization of knowledge not given to anyone in its totality."[7] The psychological rates of substitution, the terms on which consumers are willing to substitute commodities, are known to the different individual consumes only. The technical terms on which producers are able to substitute or transform commodities are known only to various production engineers and managers. Yet all this piecemeal, scattered knowledge is sounded out and communicated, and used by the price system in the allocation of resources. No single mind or agency has to have all of this information, yet it all gets used.

Monopoly and the Basic Market Equation

The parametric or fulcrum function of prices depends on pure competition. It fails if there is a monopoly. Suppose the producer of good *x* is a monopolist while *y* is still produced in a competitive market. The equimarginal rule of maximization tells both monopolist and competitive firms to produce up to where **marginal cost**—the additional expenditures required to produce one more unit—equals **marginal revenue**—the additional income from selling one more unit.[8] For the competitive firm, **marginal revenue** is equal to price (price is constant and the extra revenue from selling one more unit of *x* is P*x*). But the monopolist is the only supplier and is definitely not too small to influence price by the amount he can produce. When the monopolist supplies more, it causes the price to fall. But the monopolist's marginal revenue is not equal to the price times the extra unit. Instead it is equal to the new lower price times the

[7] F. Hayek, "The Use of Knowledge in Society." *The American Economic Review* Volume 35(4), p. 520 (1945).

[8] The pizzeria owner will keep hiring cooks as long as their marginal cost (their wage, plus the cost of the additional ingredients they use) is less than the marginal revenue they generate (the price of the pizzas they produce).

extra unit *minus* the fall in price times all previously sold units. For the monopolist, marginal revenue is less than price, that is, $MRx < Px$. If we substitute MRx for Px in the basic market equation on the right-hand side, we have:

$$MUxn/MUyn = Px/Py > MRx/Py = MPPay/MPPax$$

Therefore,

$$MUxn/MUyn > MPPay/MPPax$$

And further

$$MUxn \times MPPax > MUyn \times MPPay.$$

This means that the marginal utility yielded by factor *a* in its *x*-use is greater than that yielded in its *y*-use. Consumer *n* would like to see some of factor *a* reallocated from *y* to *x*. But this is not profitable for the monopolist. The monopolist finds it profitable to restrict supply below what consumers would most desire. He does this to avoid losing too much revenue on previously sold units of *x* as a result of lowering the price a bit in order to sell another unit of *x*. The fulcrum is split, the balance between ends and means is broken, the invisible hand fails.

Neoclassical economics deserves a hearty round of applause for the interesting and important demonstration that competitive markets result in an optimal allocation of resources. If we do not rise to our feet in a standing ovation, it is only because conventional economists sometimes forget the assumptions and limitations of the analysis that led to the conclusion. A short list that we will address later includes the limiting assumptions that the analysis is independent of the distribution of income and wealth, that all goods are market goods (i.e., rival and excludable), that factors of production are substitutes for each other, that external costs and benefits are negligible, that information is perfect,[9] and that all markets are competitive.

Non-Price Adjustments

We need to consider two more results from the basic market equation: First, what it tells us about making adjustment by means other than price, as well as price adjustment; and second, how it relates to supply and demand, the most basic rules of market grammar.

In the seesaw diagram (Figure 8.1), the desirability conditions (MU ratios) can be altered only by substitution, by reallocation of consumers' ex-

[9]Perfect information requires that buyers and sellers can acquire information about a product at negligible cost, and that one side in a negotiation does not have more information than the other (i.e., information is cheap and symmetrical).

penditure (not by a fundamental change in preferences); likewise, the possibility conditions (ratios of MPP) are alterable only by substituting factors (not by a fundamental change in technology). Prices, the sliding fulcrum, coordinate the substitutions and reallocations necessary to attain balance between the first and last terms of the equation. But what really defines the optimum is the equality of the first and last terms. Prices play only an adjusting and accommodating role.

Suppose that relative prices were fixed. Could we ever attain balance? Suppose the fulcrum position on a seesaw were fixed. How would we attain balance? By directly adjusting the weights on both sides. We could directly change the conditions of relative desirability by altering peoples' preferences through advertising. We could also directly alter the conditions of relative possibility by technological innovation. Vast sums of money are spent on advertising and on technological research. These efforts may be thought of as **non-price adjustments**. But regardless of whether adjustments to equality are by price or non-price mechanisms, the resulting equality of the end terms defines a Pareto optimum.

There are many Pareto optima, one for each distribution of income, set of technologies, and set of wants or preferences. However, if wants are created and preferences altered through advertising, and if advertising is a cost of production of the product, then production begins to look like a treadmill. If we produce the need along with the product to satisfy it, then we are not really making any forward motion toward the satisfaction of pre-existing needs. The producer replaces the consumer as the sovereign. Then, the moral earnestness of production, as well as the concept of Pareto optimal allocation of resources in the service of such production, suffers a loss.

Indeed, even under price adjustment we have the parametric function of prices—each individual takes prices as given and adjusts his plans to prices, rather than adjusting prices to his convenience. Yet the market price does change as a result of the market supply and demand conditions that result from each individual treating price as given. Yet, if no individual can change the price, then how do prices ever change in the real world? Someone, somewhere has to be a price-maker rather than a pure price-taker if prices are ever to change. This puzzle has been met in two ways by economic theorists. One is to assume an auctioneer who takes bids and changes the price. This is fine for auction markets, but most markets are not auctions. The other solution is to say that markets really cannot be 100% competitive in the sense of total compliance with the parametric function of prices, or they would never be able to adjust prices. Someone has to have a bit of market power if prices are ever to change. So some real resources have to be dedicated to price adjustment, whether it be the salary of an auctioneer or the temporary monopoly profits of a price leader. But the point to remember is that there is non-price market adjustment as well as adjustment by prices, and the basic market equation helps to analyze all three types of adjustment: price adjustment, psychological adjustment, and technological adjustment. All will get us to Pareto optima, albeit different ones. There are many, many different Pareto optima. While it is good to know that the market will get us to some Pareto optimum, it is vital to remember that that is not enough. Some Pareto optima are heavenly, others are hellish. There is more to welfare than efficient allocation—there are distribution and scale, for example.

Supply and Demand

How do supply and demand relate to the basic market equation? This is important because supply and demand are the most useful tools of market analysis. Let's begin with demand. Take the left-hand side of the basic market equation, rewritten as:

$$\mathrm{Mu}xn/\mathrm{P}x = \mathrm{MU}yn/\mathrm{P}y$$

Let commodity y be money. Then MUyn becomes Mumn the marginal utility of money, and Py becomes Pm the price of money, which is unity—that is, the price of a dollar is another dollar. Then we have:

$$\mathrm{Mu}xn/\mathrm{P}x = \mathrm{Mu}mn/\mathrm{P}m$$

or,

$$\mathrm{MU}xn/\mathrm{P}x = \mathrm{Mu}mn$$

or

$$\mathrm{P}x = \mathrm{MU}xn/\mathrm{MU}mn.$$

This is the condition for the consumer to be on his demand curve. To be on the demand curve is to be maximizing utility by substituting good x for money to the point where utility is a maximum—where the marginal utility of a dollar is just equal to the marginal utility of a dollar's worth of good x.

From the relation Px = MUxn/MUmn, and the law of diminishing marginal utility, we can see that the quantity of x demanded by the consumer will be inversely related to price.

If the consumer is always maximizing utility according to the relation Px = MUxn/Mumn, and if diminishing marginal utility rules, then we can see that the relation between Px and the amount of x demanded (Qx) will be inverse, as depicted in Figure 8.2. Suppose the left-hand side of the equation, Px, falls. Then to reestablish equality the right hand side will have to fall. The consumer makes the right-hand side fall by buying more

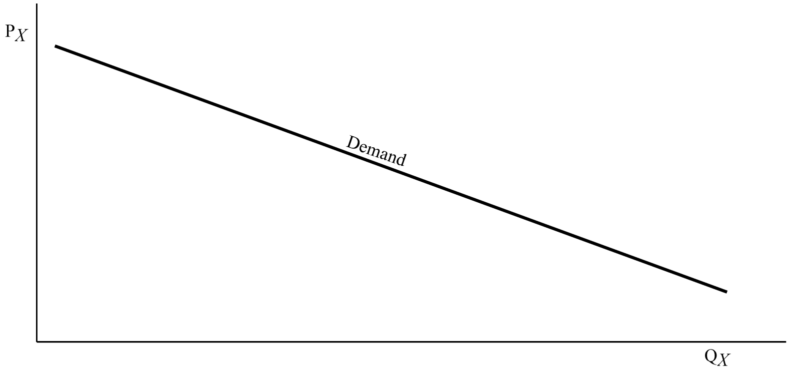

Figure 8.2 • The demand curve.

x. More x means the numerator, Muxn, will decline thanks to the law of diminishing marginal utility. That reduces the ratio. Also, as the consumer buys more x she has less money, so the marginal utility of money rises, increasing the denominator and again reducing the right-hand ratio.

To go from the demand curve of the individual consumer to the demand curve of the whole market, we just add up all the individual demand curves; that is, for each price we add up all the q's demanded at that price by each consumer. Thus the market demand curve will be downward sloping, just like that for each individual. Only the units on the horizontal axis have changed, now Q instead of q.

Turning to supply, we know that at all points on the producer's supply curve he must be offering an amount at each price that would maximize profits. That would be when Px = MCx, where MCx is the marginal cost of producing x.[10] By definition, MCx is the cost of producing an additional unit of x. We can produce an additional unit if x by using an additional amount of factor a or b or some other factor. The marginal cost of producing x by using more factor a is Pa/MPPax—that is, the dollars spent to get one more unit of a (which is Pa) divided by the extra x that was produced by the extra unit of a gives the extra cost of a unit of x, or the marginal cost of x. We could do the same in terms of factor b, and so on. Whichever turns out to be the cheapest way to produce another unit of x (using more a or more b) is the marginal cost of x.

THINK ABOUT IT!
As you might guess, the marginal cost of x *in terms of each factor would tend to equality. Can you explain why?*

[10]Remember, we're assuming here that the marginal cost of producing x is increasing. As long as the marginal cost of production is less than the price, then it pays to produce more. Therefore, the producer stops producing when the marginal cost of production equals the price.

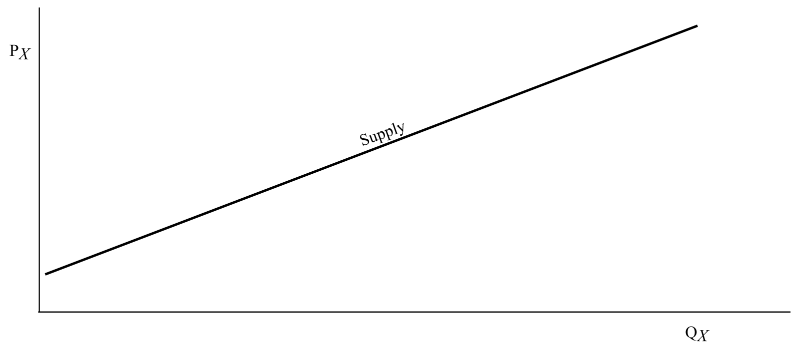

Figure 8.3 • The supply curve.

So for the profit maximizing producer to be on her supply curve the condition that must hold is

$$Px = MCx = Pa/MPPax.... = Pb/MPPbx \ldots$$

Let's consider only P*x* = P*a*/MPP*ax* as the condition. From it we see that the relation between P*x* and Q*x* supplied must be positive, as shown in Figure 8.3. Suppose P*x* rises; then P*a*/MPP*ax* will also have to rise to maintain equality. To bring this about, the producer makes more of *x*. By the law of diminishing marginal physical product, MPP*ax* declines. Since it is the denominator of the right-hand ratio, that ratio rises to restore equality with the increased P*x*.

Once again we move from the individual's supply curve to that of the market simply by adding up the amounts supplied by each individual at each P*x*. The upward slope of the curve remains, and we simply have larger units on the horizontal axis, Q instead of q.

If we put the supply and demand curves together, their intersection will give the combination of P*x* and Q*x* such that buyers and sellers are both happy (Figure 8.4). Sellers are maximizing profits and buyers are

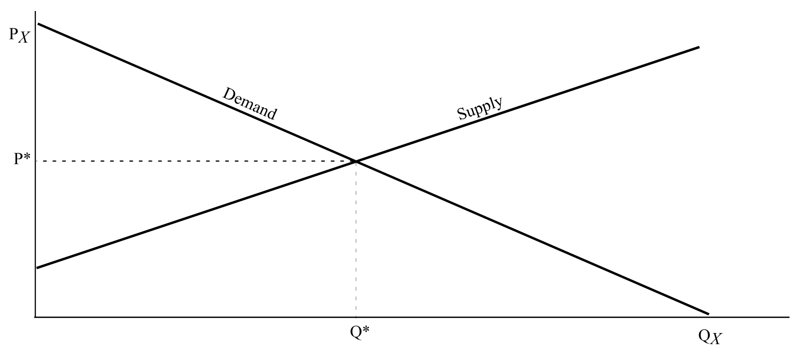

Figure 8.4 • Supply and demand determine P* and Q*.

maximizing utility. It is as if the market were solving two simultaneous equations in two unknowns by a process of trial-and-error approximation.

At the equilibrium point we have the following:

$$MUxn/MUmn = Px = Pa/MPPax$$

The left-hand equality assures that the buyer is on his demand curve. The right-hand equality guarantees that the seller is on his supply curve. The point of intersection satisfies both buyer and seller, so the market equilibrium is at P* and Q*.

We could do exactly the same analysis with the market for good *y*, and we would end up with similar supply and demand curves, and a similar equation:

$$MUyn/Mumn = Py = Pa/MPPay$$

If we divide each term in the *x*-market equation by each term in the *y*-market equation, we again arrive at the basic market equation previously derived. The terms for the marginal utility of money and the price of factor *a* cancel out, and we have again the basic market equation:

$$Muxn/Muyn = Px/Py = MPPay/MPPax$$

Finally, it is worth commenting on the fact that the basic market equation states that the ratio of marginal utilities of good *x* and *y* are *inversely* proportional to the ratio of marginal physical products of factor *a* when used to make *x* or *y*. Why this inversion? What does it mean in terms of economics? Why not a direct proportionality instead of an inverse one? Actually there is a direct proportionality between the ratio of marginal utilities of *x* and *y* and the marginal costs of *x* and *y*. Prices, in effect, measure both the ratio of marginal utilities and the ratio of marginal costs. But we have to realize that the true marginal cost of *x*, the *opportunity cost* of a unit of *x*, is in fact the amount of *y* that has to be sacrificed to get the extra *x*. Thus MPPay is the amount of *y* given up when we use *a* to produce *x* instead of *y*. The amount of *y* sacrificed (MPP*ay*) *is*, in real terms, the marginal opportunity cost of *x*. The best alternative sacrificed (in this case the only alternative) is by definition the opportunity cost. Therefore, the direct proportionality between prices and marginal opportunity costs is at the same time an inverse proportionality between prices and marginal physical products. The true marginal cost of *x* is *precisely* the amount of *y* you have to sacrifice to get it.

To summarize: We have derived a basic market equation; shown why it defines and how it brings about an optimal allocation of resources in the sense of Pareto (everyone as well off as they can be without making someone else worse off, i.e. without redistributing income or wealth); and shown how supply and demand derive from the equation. Since *x* and *y* represent any pair of goods, *a* and *b* any pair of factors, and *n* any consumer, our conclusions hold for all pairs of goods, all pairs of factors, and all consumers. In other words, we get a good insight into the meaning of general equilibrium, yet without having to confront all the complexities of a general equilibrium model.

We have also repeatedly applied the equimarginal principle of maximization in determining how far consumers should substitute one good for another in their shopping basket, and how far producers should substitute one factor for another in their production processes. We have taken it for granted that goods can be substitutes in the minds of consumers, and that factors can be substitutes in the production processes of firms. This is sometimes referred to as the **principle of substitution**. Goods (and factors) are not always related as substitutes. Sometimes they are complements, meaning that one makes the other desirable (useful) rather than less. These relations of substitution and complementarily will play an important role in later chapters.

BIG IDEAS to remember

- Basic market equation
- Competitive market
- Law of diminishing marginal utility
- Law of diminishing marginal product
- Equimarginal principle of maximization
- Pareto optimal allocation
- Sliding fulcrum function of prices
- Monopoly and misallocation
- Marginal cost and marginal revenue
- Non-price adjustments
- Supply and demand