CHAPTER 2

The Basics of Supply and Demand

mental and powerful tool that can be applied to a wide variety of interesting and important problems. To name a few: understanding and predicting how changing world economic conditions affect market price and production; evaluating the impact of government price controls, minimum wages, price supports, and production incentives; and determining how taxes, subsidies, tariffs, and import quotas affect consumers and producers.

We begin with a review of how supply and demand curves are used to describe the market mechanism. Without government intervention (e.g., through the imposition of price controls or some other regulatory policy), supply and demand will come into equilibrium to determine the market price of a good and the total quantity produced. What that price and quantity will be depends on the particular characteristics of supply and demand. And how price and quantity vary over time depends on how supply and demand respond to other economic variables, such as aggregate economic activity and labor costs, which are themselves changing.

We will therefore discuss the characteristics of supply and demand and how those characteristics may differ from one market to another. Then we can begin to use supply and demand curves to understand a variety of phenomena-why the prices of some basic commodities have fallen steadily over a long period, while the prices of others have experienced sharp gyrations; why shortages occur in certain markets; and why announcements about plans for future government policies or predictions about future economic conditions can affect markets well before those policies or conditions become reality.

Besides understanding *qualitatively* how market price and quantity are determined and how they can vary over time, it is also important to learn how they can be analyzed *quantitatively.* We will see how simple "back of the envelope" calculations can be used to analyze and predict evolving market conditions, and how markets respond both to domestic and international macroeconomic fluctuations and to the effects of government interventions. We will try to convey this understanding through simple examples and by urging you to work through some exercises at the end of the chapter.

2.1 *The Market Mechanism*

Let us begin with a brief review of the basic supply-demand diagram as shown in Figure 2.1. The vertical axis shows the price of a good, P, measured in dollars per unit. This is the price that sellers receive for a given quantity supplied and that buyers will pay for a given quantity demanded. The horizontal axis shows the total quantity demanded and supplied, Q, measured in number of units per period.

The *supply curve S* tells us how much producers are willing to sell for each price that they receive in the market. The curve slopes upward because the higher the price, the more firms are usually able and willing to produce and sell. For example, a higher price may enable existing firms to expand production in the short run by hiring extra workers or by having existing workers

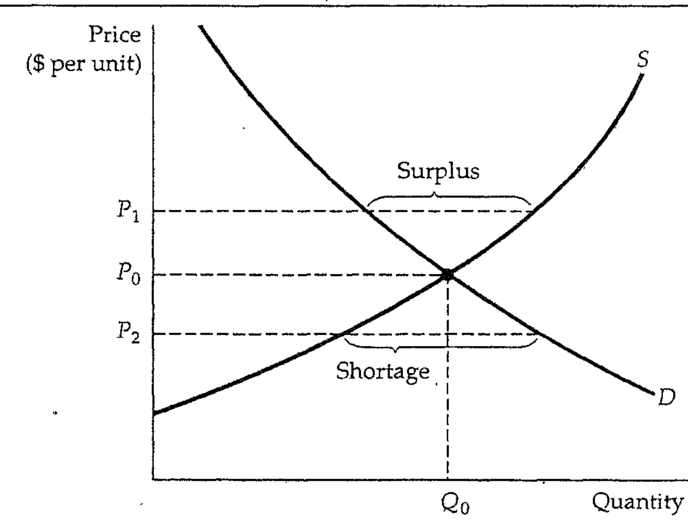


FIGURE 2.1 Supply and Demand. The market dears at price P_0 and quantity Q_0. At the higher price P_1 a surplus develops, so price falls. At the lower price P_2 there is a shortage, so price is bid up.

work overtime (at greater cost to the firm),and in the long run by increasing the size of their plants. A higher price may also attract into the market new firms that face higher costs because of their inexperience and that therefore would have found entry into the market uneconomical at a lower price.

The *demand curve D* tells us how much consumers are willing to buy for each price per unit that they must pay. It slopes downward because consumers are usually ready to buy more if the price is lower. For example, a lower price may encourage consumers who have already been buying the good to consume a larger quantity, and it may enable other consumers who previously might not have been able to afford the good to begin buying it.

The two curves intersect at the *equilibrium,* or *market-clearing,* price and quantity. At this price P_0, the quantity supplied and the quantity demanded are just equal (to Q_o), The *market mechanism* is the tendency in a free market for the price to change until the market clears (i.e., until the quaiitity supplied and the quantity demanded are equal). At this point there is neither shortage nor excess supply, so there is also no pressure for the price to change further. Supply and demand might not *always* be in equilibrium, and some markets might not clear quickly when conditions change suddenly, but the *tendency* is for markets to clear.

To understand why markets tend to clear, suppose the price were initially above the market clearing level, say. P_1 in Figure 2.1. Then producers would try to produce and sell more than consumers were willing to buy. A surplus would accumulate, and to sell this surplus or at least prevent it from growing, producers would begin to lower their prices. Eventually price would fall, quantity demanded would increase, and quantity supplied would decrease until the equilibrium price P_0 was reached.

The opposite would happen if the price were initially below P_0, say, at P_2. A shortage would develop because consumers would be unable to purchase all they would like at this price. This would put upward pressure on price as consumers tried to outbid one another for existing supplies and producers reacted by increasing price and expanding output. Again, the price would eventually reach P_0.

When we draw and use supply and demand curves, we are assuming that at any given price, a given quantity will be produced and sold. This makes sense only if a market is at least roughly *competitive.* By this we mean that both sellers and buyers should have little *market power* (i.e., little ability *individually* to affect the market price). Suppose instead that supply were controlled by a single producer-a monopolist. In this case there would no longer be a simple one-to-one relationship between price and quantity supplied. The reason is that a monopolist's behavior depends on the shape and position of the demand curve. If the demand curve shifted in a particular way, it might be in the monopolist's interest to keep the quantity fixed but change the price, or keep the price fixed and change the quantity. (How this could occur is explained in Chapter 10.) So when we work with supply and demand curves, we implicitly assume that we are referring to a competitive market.

2.2 *Shifts in Supply and Demand*

Supply and demand curves tell us how much competitive producers and consumers are willing to sell and buy as functions of the price they receive and pay. But supply and demand are also determined by other variables besides price. For example, the quantity that producers are willing to sell depends not only on the price they receive, but also on their production costs, including wages, interest charges, and costs of raw materials. And in addition to price, quantity demanded depends on the total disposable income available to consumers, and perhaps on other variables as well. Later we will want to determine how changes in economic conditions or tax or regulatory policy affect marketprices and quantities. To do this, we must understand how supply and demand curves shift in response to changes in such variables as wage rates, capital costs, and income.

Let's begin with the supply curve S in Figure 2.2. This curve shows how much producers are willing to sell as a function of market price. For example, at a price P_1, the quantity produced and sold would be Q_1. Now suppose the cost of raw materials *falls*. How does this affect supply?

Lower raw material costs, indeed lower costs of any kind, make production more profitable, encouraging existing firms to expand production and enabling new firms to enter the market and produce. So if the market price stayed constant at P_1, we would expect to observe a greater supply of output than be-

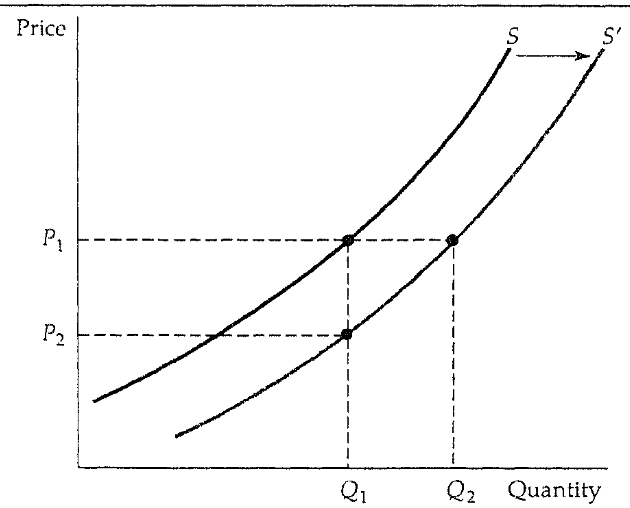


FIGURE 2.2 Shift in Supply. If production costs fall, firms can produce the same quantity at a lower price or a larger quantity at the same price. The supply curve shifts to the right.

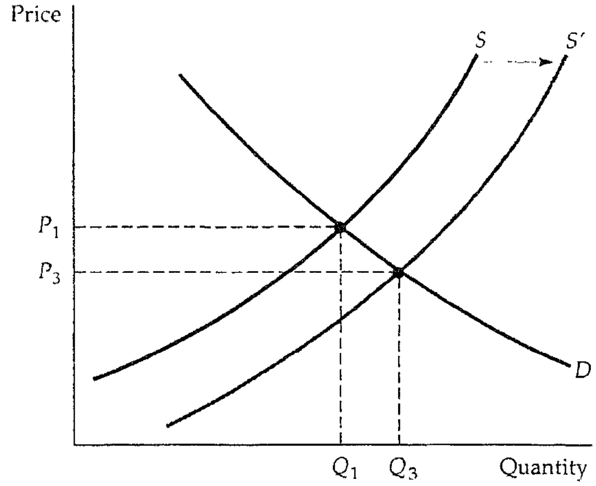


FIGURE 2.3 New Equilibrium Following Shift in Supply. When the supply curve shifts to the right, the market clears at a lower price P_3 and a larger quantity Q_3.

fore. In Figure 2.2 this is shown as an increase from Q_1 to Q_2. Output increases no matter what the market price happens to be, so *the entire supply curve shifts to the right,* which is shown in the figure as a shift from S to S'.

Another way of looking at the effect of lower raw material costs is to imagine that the quantity produced stays fixed at Q_1 and consider what price firms would require to produce this quantity. Because their costs are lower, the price they would require would also be lower-P_2 in Figure 2.2. This will be the case no matter what quantity is produced. Again, we see in the figure that the supply curve must shift to the right.

Of course, neither price nor quantity will always remain fixed when costs fall. Usually both will change as the new supply curve comes into equilibrium with the demand curve. This is illustrated in Figure 2.3, where the supply curve has shifted from S to S' as it did in Figure 2.2. As a result, the market price drops (from P_1 to P_3), and the total quantity produced increases (from Q_1 to Q_3). This is just what we would expect: Lower costs result in lower prices and increased sales. (And indeed, gradual decreases in costs resulting from technological progress and better management are an important driving force behind economic growth.)

Now let's turn to Figure 2.4 and the demand curve labeled *D*. How would an *increase in disposable income* affect demand?

With greater disposable income, consumers can spend more money on any good, and some consumers will do so for most goods. If the market price were held constant at P_1, we would therefore expect to see an increase in quantity demanded, say, from Q_1 to Q_2. This would happen no matter what the market price was, so that the result would be a *shift to the right of the entire demand*

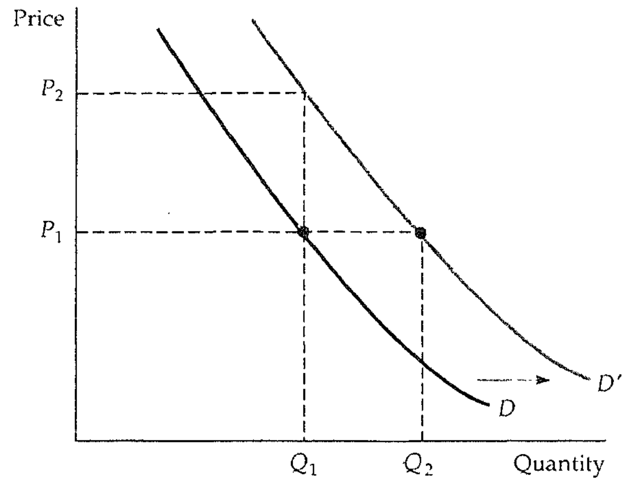


FIGURE 2.4 Shift in Demand. The demand for a product depends on its price but may also depend on other variables, such as income, the weather,and the prices of other goods. For most products, demand increases when income rises. A higher income level shifts the demand curve to the right.

curve. In the figure, this is shown as a shift from D to D'. Alternatively, we can ask what price consumers would pay to purchase a given quantity Q_1. With greater disposable income, they should be willing to pay a higher price, say, P_2 instead of P_1 in Figure 2.4. Again, *the demand curve will shift to the right.*

In general, neither price nor quantity remains constant when disposable income increases. A new price and quantity result after demand comes into equilibrium with supply. As shown in Figure 2.5, we would expect to see consumers pay a higher price P_3 and firms produce a greater quantity Q_3 as a result of an increase in disposable income.

Changes in the prices of related goods also affect demand. For example, copper and aluminum are substitute goods. Because one can often be substituted for the other in industrial use, the demand for copper will increase if the price of aluminum increases. Automobiles and gasoline, on the other hand, are complementary goods (i.e., they tend to be used together). Therefore a decrease in the price of gasoline increases the demand for automobiles. So the shift to the right of the demand curve in Figure 2.5 could also have resulted from an increase in the price of a substitute good or from a decrease in the price of a complementary good.

In most markets both the demand and supply curves shift from time to time. Consumers' disposable incomes change as the economy grows (or contracts, during economic recessions). The demands for some goods shift with the seasons (e.g., fuels, bathing suits, umbrellas), with changes in the prices of related goods (an increase in oil prices increases the demand for natural gas), or sim-

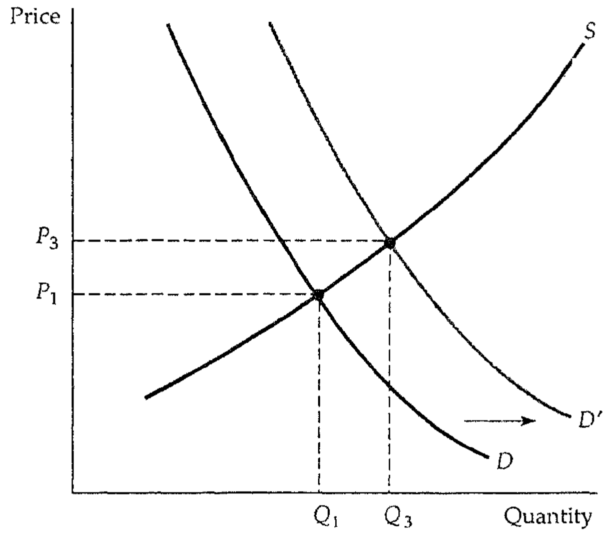


FIGURE 2.5 New Equilibrium Following Shift in Demand. When the demand curve shifts to the right, the market clears at a higher price P_3 and a larger quantity Q_3.

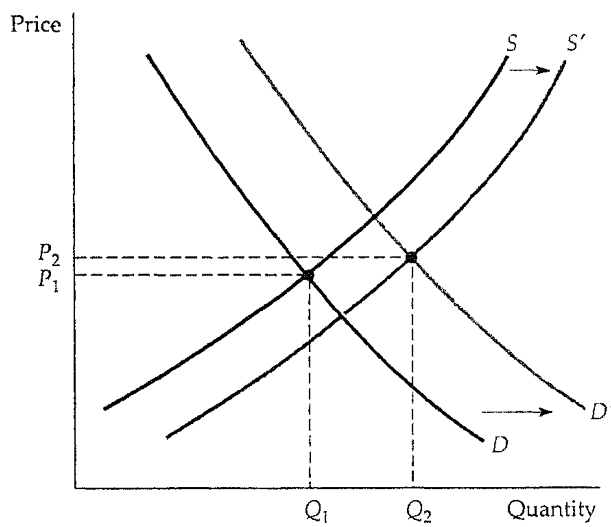


FIGURE 2.6 New Equilibrium Following Shifts in Supply and Demand. Supply and demand curves shift over time as market conditions change. In this example, rightward shifts of the supply and demand curves lead to slightly higher price and a much larger quantity. In general, changes in price and quantity depend on the amount by which each curve shifts and the shape of each curve.

ply with changing tastes. Similarly wage rates, capital costs, and the prices of raw materials also change from time to time, which shifts supply.

Supply and demand curves can be used to trace the effects of these changes. In Figure 2.6, for example, shifts to the right of both supply and demand result in a slightly higher price (from P_1 to P_2) and a much larger quantity (from Q_1 to Q_2). In general, price and quantity will change depending both on how much the supply and demand curves shift and on the shapes of those curves. To predict the sizes and directions of such changes, we must be able to quantitatively characterize the dependence of supply and demand on price and other variables. We will turn to this in the next section.

EXAMPLE 2.1 THE PRICE OF EGGS AND THE PRICE OF A COLLEGE EDUCATION

In Example 1.2 we saw that from 1970 to 1993, the real (constant dollar) price of eggs fell by 56 percent, while the real price of a college education rose by

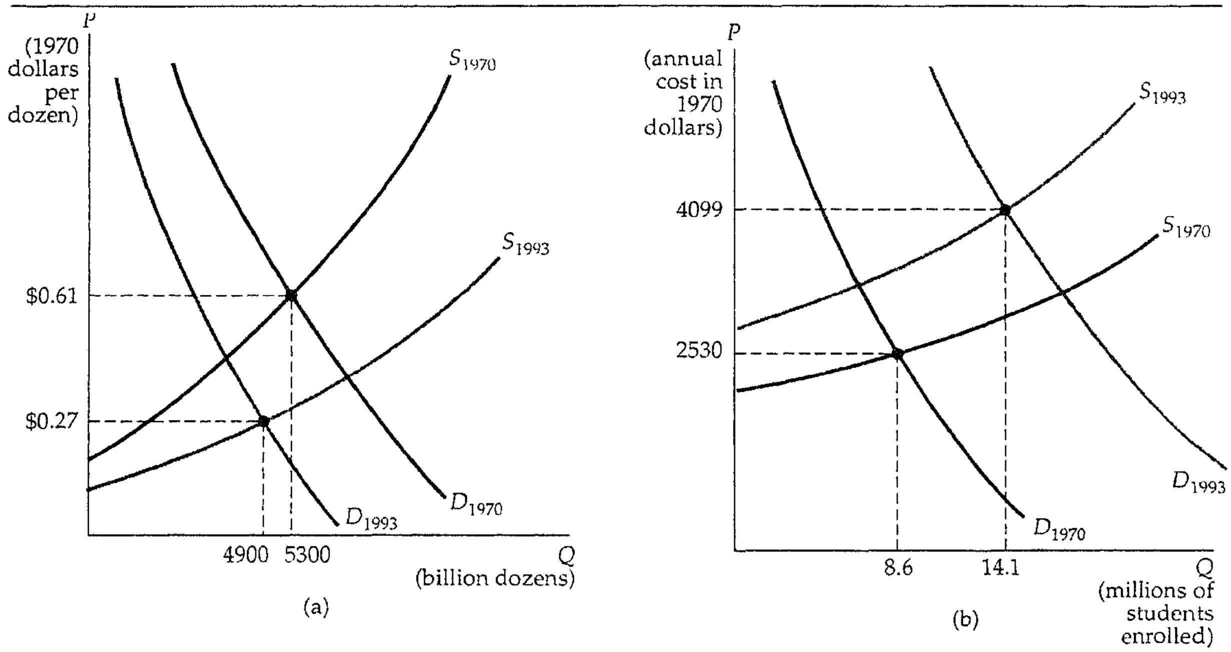


FIGURE 2.7a Market for Eggs. The supply curve for eggs shifted down as production costs fell, and the demand curve shifted to the left as consumer preferences changed. As a result, the real price of eggs fell sharply, and egg consumption fell slightly.

FIGURE 2.7b Market for College Education. The supply curve for a college education shifted up as the costs of equipment, maintenance, and staffing rose. The demand curve shifted to the right as a growing number of high school graduates desired a college education. As a result, both price and enrollments rose sharply.

62 percent. What caused this large decline in egg prices and large increase in the price of college?

We can understand these price changes by examining the behavior of supply and demand for each good, as shown in Figure 2.7. For eggs, the mechanization of poultry farms sharply reduced the cost of producing eggs, shifting the supply curve downward over this period. At the same time, the demand curve for eggs shifted to the left as a more health (and cholesterol) conscious population changed its eating habits, tending to avoid eggs. As a result, not only did the real price of eggs decline sharply, but total annual consumption fell somewhat (from 5300 billion dozen to 4900 billion dozen).

For college, supply and demand shifted in the opposite directions. Increases in the costs of equipping and maintaining modern classrooms, laboratories, and libraries, along with increases in faculty salaries, pushed the supply curve up. At the same time, the demand curve shifted to the right as a larger and larger percentage of a growing number of high school graduates decided that a college education was essential. Thus, despite the increase in price, 1993 found over 14 million students enrolled in college degree programs, compared to 8.6 million in 1970.

EXAMPLE 2.2 THE LONG-RUN BEHAVIOR OF MINERAL PRICES

The early 1970s was a period of public concern about the earth's natural resources. Groups like the Club of Rome predicted that our energy and mineral resources would soon be depleted, so that prices would skyrocket and bring an end to economic growth.[1] But these predictions ignored basic microeconomics. The earth does indeed have only a finite amount of minerals, such as copper, iron, and coal. Yet during the past century, the prices of these and most other minerals have declined or remained roughly constant relative to overall prices. For example. Figure 2.8 shows the price of iron in real terms (adjusted for inflation), together with the quantity of iron consumed from 1880 to 1985. (Both are shown as an index, with 1880 =1.) Despite short-term variations in price, no significant long-term increase has occurred, even though annual consumption is now about 20 times greater than in 1880. Similar patterns hold for other mineral resources, such as copper, oil, and coal.[2]

[1] See, for example, Dennis Meadows et al., *The Limits to Growth* (New York: Potomac Associates, 1972). This book and others like it struck a resonant chord in the public consciousness. Unfortunately these studies ignored such basic economic phenomena as cost reduction resulting from technical progress, experience, and economies of scale, and substitution of alternative resources (including nondepletable ones) in response to higher prices. For a discussion of these issues, see Julian L. Simon, *The Ultimate Resource*(Princeton, N.J.: Princeton University Press, 1981).

[2] The data in Figure 2.8 are from Robert S. Manthy, *Natural Resource Commoditie-A Century of Statistics* (Baltimore: Johns Hopkins University Press, 1978), supplemented after 1973 with data from the U.S. Bureau of Mines.

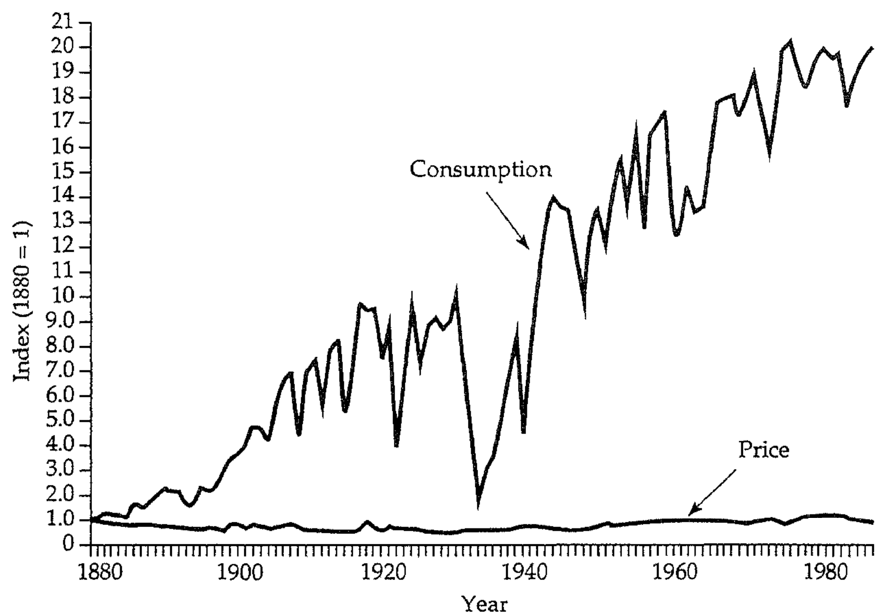


FIGURE 2.8 Consumption and Price of Iron, 1880-1985. Annual consumption has increased about twentyfold, but the real (inflation-adjusted) price has not changed much.

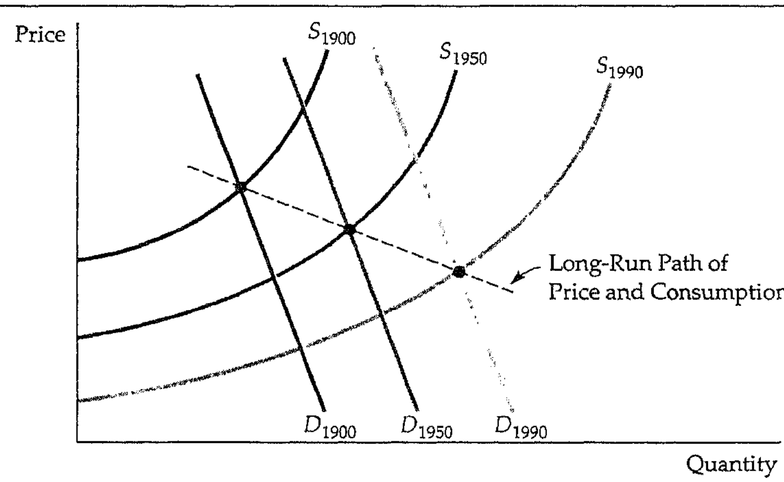


FIGURE 2.9 Long-Run Movements of Supply and Demand for Mineral Resources. Demand for most resources has increased dramatically over the past century, but prices have fallen or risen only slightly in real (inflation-adjusted) terms because cost reductions have shifted the supply curve to the right just as dramatically.

The demands for these resources grew along with the world economy. (These shifts in the demand curve are illustrated in Figure 2.9.) But as demand grew, production costs fell. This was due first to the discovery of new and bigger deposits, which were cheaper to mine, and then to technical progress and the economic advantage of mining and refining on a large scale. As a result, the supply curve shifted to the right over time. Over the long term, these shifts in the supply curve were greater than the shifts in the demand curve, so that price often fell, as shown in Figure 2.9.

This is not to say that the prices of copper, iron, and coal will decline or remain constant forever-these resources are *finite*. But as their prices begin to rise, consumption will likely shift at least in part to substitute materials. For example, copper has already been replaced in many applications by aluminum, and more recently in electronic applications by fiber optics. (See Example 2.6 for a more detailed discussion of copper prices.)

EXAMPLE 2.3 THE MARKET FOR WHEAT

Wheat is an important agricultural commodity, and the market for it has been studied extensively by agricultural economists. During the 1980s, changes in the wheat market had major implications for American farmers and for U.S. agricultural policy. To understand what happened, let us examine the behavior of supply and demand.

From statistical studies, we know that for 1981 the supply curve for wheat was approximately as follows:[3]

$$\textit{Supply: } Q_s = 1800 + 240P$$

where price is measured in dollars per bushel and quantities are in millions of bushels per year. These studies also indicate that in 1981 the demand curve for wheat was

$$\textit{Demand: } Q_D = 3550 - 266P$$

By setting supply equal to demand, we can determine the market-clearing price of wheat for 1981:

$$Q_S = Q_D$$

$$1800 + 240P = 3550 - 266P$$

$$506P = 1750$$

$$P = \$3.46 \text{ per bushel}$$

[3] For a survey of statistical studies of the demand and supply of wheat and an analysis of evolving market conditions, see Larry Salathe and Sudchada Langley, "An Empirical Analysis of Alternative Export Subsidy Programs for U.S. Wheat," *Agricultural Economics Research* 38, No. 1 (Winter 1986). The supply and demand curves in this example are based on the studies they survey.

The demand for wheat has two components-domestic demand (i.e., demand by U.S. consumers) and export demand (i.e., demand by foreign consumers). By the mid-1980s, the domestic demand for wheat had risen only slightly (due to modest increases in population and income), but export demand had fallen sharply. Export demand had dropped for several reasons. First and foremost was the success of the Green Revolution in agriculture-developing countries like India that had been large importers of wheat became increasingly self-sufficient On top of this, the increase in the value of the dollar against other currencies made U.S. wheat more expensive abroad. Finally, European countries adopted protectionist policies that subsidized their own production and imposed tariff barriers against imported wheat. In 1985, for example, the demand curve for wheat was

$$\text{Demand: } Q_D == 2580 - 194P$$

(The supply curve remained more or less the same as in 1981.)

Now we can again equate supply and demand and determine the market-clearing price for 1985:

$$1800 + 240P = 2580 - 194P$$

$$P = \$1.80 \text{ per bushel}$$

We see, then, that the major shift in export demandled to a sharp drop in the market-clearing price of wheat-from $3.46 in 1981 to $1.80 in 1985.

Was the price of wheat actually $3.46 in 1981, and did it actually fall to $1.80 in 1985? No-consumers paid about $3.70 in 1981 and about $3.20 in 1985. Furthermore, in both years American farmers received more than $4 for each bushel they produced. Why? Because the U.S. government props up the price of wheat and pays subsidies to farmers. We discuss exactly how this is done and evaluate the costs and benefits for consumers, farmers, and the federal budget in Chapter 9.

2.3 *Elasticities of Supply and Demand*

We have seen that the demand for a good depends on its price, as well as on consumer income and on the prices of other goods. Similarly, supply depends on price, as well as on variables that affect production cost. For example, if the price of coffee increases, the quantity demanded will fall, and the quantity supplied will rise. Often, however, we want to know *how much* supply or demand will rise or fall. How sensitive is the demand for coffee to its price? If price increases by 10 percent, how much will demand change? How much will demand change if income rises by 5 percent? We use *elasticities* to answer questions like these.

An elasticity is a measure of the sensitivity of one variable to another. Specifically, it is a number that tells us *the percentage change that will occur in one variable in response to a 1 percent change in another variable.* For example, the *price elasticity of demand* measures the sensitivity of quantity demanded to price changes. It tells us what the percentage change in the quantity demanded for a good will be following a 1 percent increase in the price of that good.

Lets look at this in more detail. Denoting quantity and price by Q and P, we write the price elasticity of demand as

$$E_p = (\%\Delta Q)/(\%\Delta P)$$

where $\%\Delta Q$ simply means "percentage change in Q" and $\%\Delta P$ means "percentage change in P."[4] But the percentage change in a variable is just the absolute change in the variable divided by the original level of the variable. (If the Consumer Price Index were 200 at the beginning of the year and increased to 204 by the end of the year, the percentage change-or annual rate of inflation-would be 4/200 = .02, or 2 percent.) So we can also write the price elasticity of demand as[5]

$$E_p = \frac{\Delta Q/Q}{\Delta P/P} = \frac{P}{Q}\frac{\Delta Q}{\Delta P} \tag{2.1}$$

The price elasticity of demand is usually a negative number. When the price of a good increases, the quantity demanded usually falls, so $\Delta Q/\Delta P$ (the change in quantity for a change in price) is negative, and therefore E_p is negative.

When the price elasticity is greater than 1 in magnitude, we say that demand is *price elastic* because the percentage decline in quantity demanded is greater than the percentage increase in price. If the price elasticity is less than 1 in magnitude, demand is said to be *price inelastic.* In general, the elasticity of demand for a good depends on the availability of other goods that can be substituted for it. When there are close substitutes, a price increase will cause the consumer to buy less of the good and more of the substitute. Demand will then be highly price elastic. When there are no close substitutes, demand will tend to be price inelastic.

Equation (2.1) says that the price elasticity of demand is the change in quantity associated with a change in price ($\Delta Q/\Delta P$) times the ratio of price to quantity (P/Q). But as we move down the demand curve, $\Delta Q/\Delta P$ may change, and the price and quantity will always change. Therefore, the price elasticity of demand must be measured *at a particular point on the demand curve* and will generally change as we move along the curve.

This is easiest to see for a *linear* demand curve, that is, a demand curve of the form

$$Q = a - bP$$

[4] The symbol Δ is the Greek capital letter delta; it means "the change in," So ΔX means "the change in the variable X," say, from one year to the next.

[5] In terms of infinitesimal changes (letting the ΔP become very small), $E_p = (P/Q)(dQ/dP)$.

As an example, consider the demand curve

$$Q = 8 - 2P$$

For this curve, $\Delta Q/\Delta P$ is constant and equal to -2 (a ΔP of 1 results in a ΔQ of -2). However, the curve does *not* have a constant elasticity. Observe from Figure 2.10 that as we move down the curve, the ratio *P/Q* falls, and therefore the elasticity decreases in magnitude. Near the intersection of the curve with the price axis, Q is very small, so $E_p = -2(P/Q)$ is large in magnitude. When $P = 2$ and $Q = 4$, $E_p = -1$. And at the intersection with the quantity axis, $P = 0$ so $E_p = 0$.

Because we draw demand (and supply) curves with price on the vertical axis and quantity on the horizontal axis, $\Delta Q/\Delta P$ = (l/slope of curve). As a result, tor any price and quantity combination, the steeper the slope of the curve, the less elastic demand is. Figures 2.1 la and b show two special cases. Figure 2.11a shows a demand curve that is *infinitely elastic.* There is only a single price P* at which consumers will buy the good; for even the smallest increase in price above this level, quantity demanded drops to zero, and for any decrease in price, quantity demanded increases without limit. The demand curve in Figure 2.11b, on the other hand, is *completely inelastic.* Consumers will buy a fixed quantity Q^*, no matter what the price.

We will also be interested in elasticities of demand with respect to other variables besides price. For example, demand for most goods usually rises when

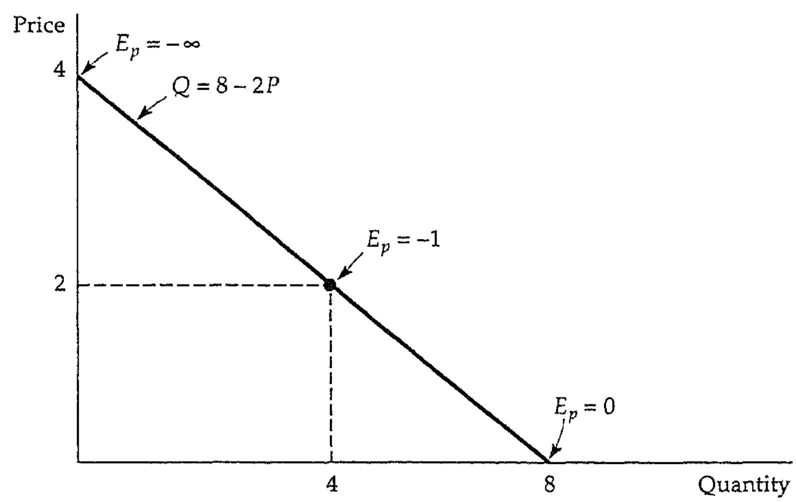


FIGURE 2.10 Linear Demand Curve. The price elasticity of demand depends not only on the slope of the demand curve, but also on the price and quantity. The elasticity therefore varies along the curve as price and quantity change. Slope is constant for this linear demand curve. Near the top, price is high and quantity is small, so the elasticity is large in magnitude. The elasticity becomes smaller as we move down the curve.

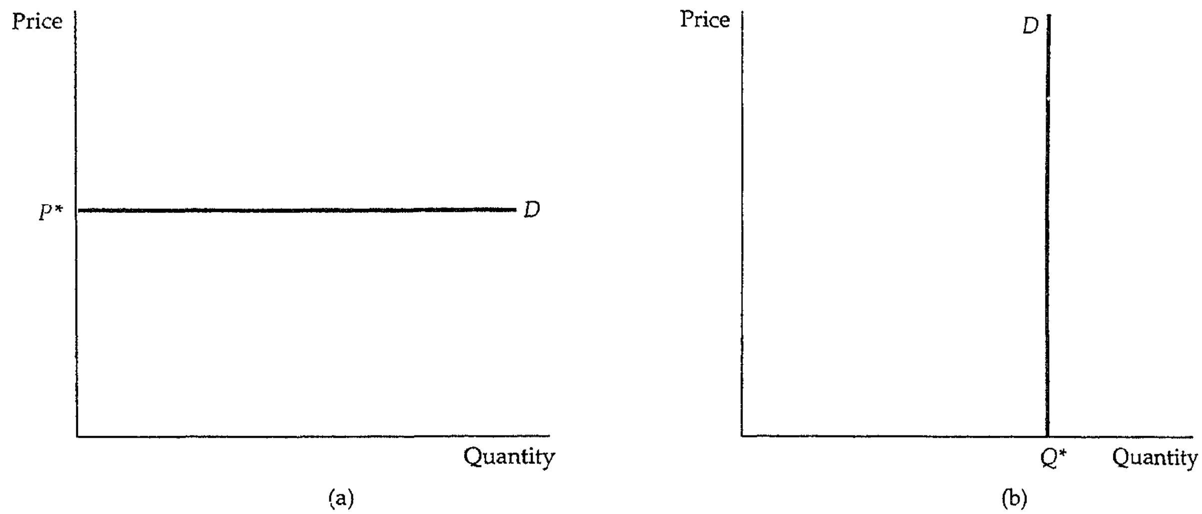


FIGURE 2.11a Infinitely Elastic Demand. For a horizontal demand curve, $\Delta Q/\Delta P$ is infinite. (A tiny change in price leads to an enormous change in demand.) The elasticity of demand is therefore infinite.
FIGURE 2.11b Completely Inelastic Demand. For a vertical demand curve, $\Delta Q/\Delta P$ is zero. The quantity demanded is the same no matter what the price, so the elasticity of demand is zero.

aggregate income rises. The *income elasticity of demand* is the percentage change in the quantity demanded Q resultingfrom a 1 percent increase in income I:

$$E_I = \frac{\Delta Q/Q}{\Delta I/I} = \frac{I}{Q}\frac{\Delta Q}{\Delta I} \qquad (2.2)$$

The demand for some goods is also affected by the prices of other goods. For example, because butter and margarine can easily be substituted for each other, the demand for each depends on the price of the other. A *cross-price elasticity of demand* refers to the percentage change in the quantity demanded for a good that results from a 1 percent increase in the price of another good. So the elasticity of demand for butter with respect to the price of margarine would be written as

$$E_{Q_bP_m} = \frac{\Delta Q_b/Q_b}{\Delta P_m/P_m} = \frac{P_m}{Q_b}\frac{\Delta Q_b}{\Delta P_m} \qquad (2.3)$$

where Q_b is the quantity of butter and P_m is the price of margarine.

In this example of butter and margarine, the cross-price elasticities will be positive because the goods are *substitutes*-they compete in the market, so a rise in the price of margarine, which makes butter cheaper relative to margarine than it was before, leads to an increase in the demand for butter. (The demand curve for butter will shift to the right, so its price will rise.) But this is not always the case. Some goods are *complements;* they tend to be used together, so that an increase in the price of one tends to push down the consumption of the other. Gasoline and motor oil are an example. If the price of gasoline goes up, the quantity of gasoline demanded falls-motorists will drive less. But the demand for motor oil also falls. (The entire demand curve for motor oil shifts to the left.) Thus, the cross-price elasticity of motor oil with respect to gasoline is negative.

Elasticities of supply are defined in a similar manner. The *price elasticity of supply* is the percentage change in the quantity supplied resulting from a 1 percent increase in price. This elasticity is usually positive because a higher price gives producers an incentive to increase output.

We can also refer to elasticities of supply with respect to such variables as interest rates, wage rates, and the prices of raw materials and other intermediate goods used to manufacture the product in question. For example, for most manufactured goods, the elasticities of supply with respect to the prices of raw materials are negative. An increase in the price of a raw material inpu means higher costs for the firm, so other things being equal, the quantity supplied will fall.

2.4 *Short-Run Versus Long-Run Elasticities*

When analyzing demand and supply, it is important to distinguish between the short run and the long run. In other words,if we ask how much demand or supply changes in response to a change in price, we must be clear about *how much time is allowed to pass before measuring the changes in the quantity demanded or supplied.* If we allow only a short time to pass, say, one year or less, then we are dealing with short-run demand or supply. In general, short-run demand and supply curves look very different from their long-run counterparts.

Demand

For many goods, demand is much more price elastic in the long run than in the short run. One reason is that people take time to change their consumption habits. For example, even if the price of coffee rises sharply, the quantity demanded will fall only gradually as consumers slowly begin to drink less of it. Another reason is that the demand for a good might be linked to the stock of another good, which changes only slowly. For example, the demand for gasoline is much more elastic in the long run than in the short run. A sharply higher price of gasoline reduces the quantity demanded in the short run by causing motorists to drive less,but it has its greatest impact on demand by inducing consumers to buy smaller and more fuel-efficient cars. But the stock of cars changes only slowly, so that the quantity of gasoline demanded falls only slowly. Figure 2.12a shows short-run and long-run demand curves for goods such as these.

On the other hand, for some goods just the opposite is true-demand is more elastic in the short run than in the long run. These goods (automobiles, refrigerators, televisions, or the capital equipment purchased by industry) are *durable, so* that the total stock of each good owned by consumers is large relative to the annual production. As a result, a small change in the total stock that consumers want to hold can result in a large percentage change in the level of purchases. Suppose, for example, that price goes up 10 percent, causing the total stock of the good consumers want to hold to drop 5 percent. Initially, this will cause purchases to drop much more than 5 percent. But eventually, as the stock depreciates (and units must be replaced), demand will increase again, so that in the long run the total stock of the good owned by consumers will be about 5 percent less than before the price increase.

Automobiles are an example. (Annual U.S. demand-new car purchases-is about 7 to 10 million, but the stock of cars is around 70 million.) If automo-

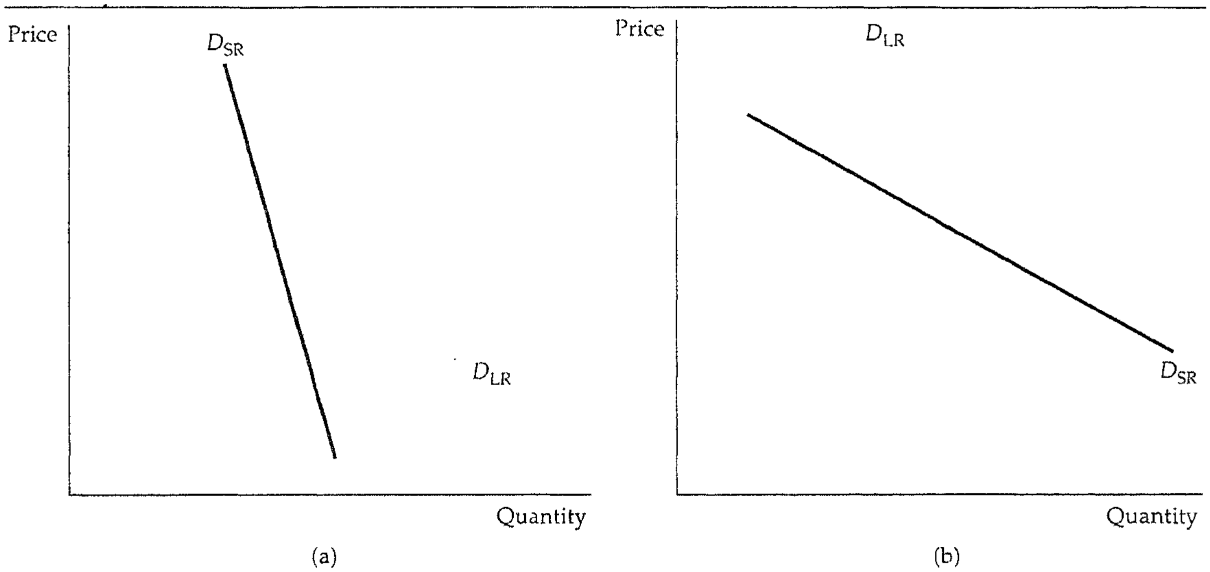


FIGURE 2.12a Gasoline: Short-Run and Long-Run Demand Curves. In the short run, an increase in price has only a small effect on the demand for gasoline. Motorists may drive less, but they will not change the kind of car they are driving overnight. In the longer run, however, they will shift to smaller and more fuel-efficient cars, so the effect of the price increase will be larger. Demand is therefore more elastic in the long run than in the short run.

FIGURE 2.12b Automobiles: Short-Run and Long-Run Demand Curves. The opposite is true for automobile demand. If price increases, consumers initially defer buying a new car, so that annual demand falls sharply. In the longer run, however, old cars wear out and must be replaced, so that annual demand picks up. Demand is therefore less elastic in the long run than in the short run.

bile prices rise, many people will delay buying new cars, and the quantity demanded will fall sharply (even though the total stock of cars that consumers want to hold falls only a small amount). But eventually, old cars wear out and have to be replaced, so demand picks up again. As a result, the long-run change in the quantity demanded is much smaller than the short-run change. Figure 2.12b shows demand curves for a durable good like automobiles.

Income elasticities also differ from the short run to the long run. For most goods and services-foods, beverages, fuel, entertainment, etc.-the income elasticity of demand is larger in the long run than in the short run. For example, consider the behavior of gasoline consumption during a period of strong economic growth when aggregate income rises by 10 percent. Eventually people will increase their gasoline consumption-they can afford to take more trips and perhaps own a larger car. But this change in consumption takes time, and initially demand increases only a small amount. Thus, the long-run elasticity will be larger than the short-run elasticity.

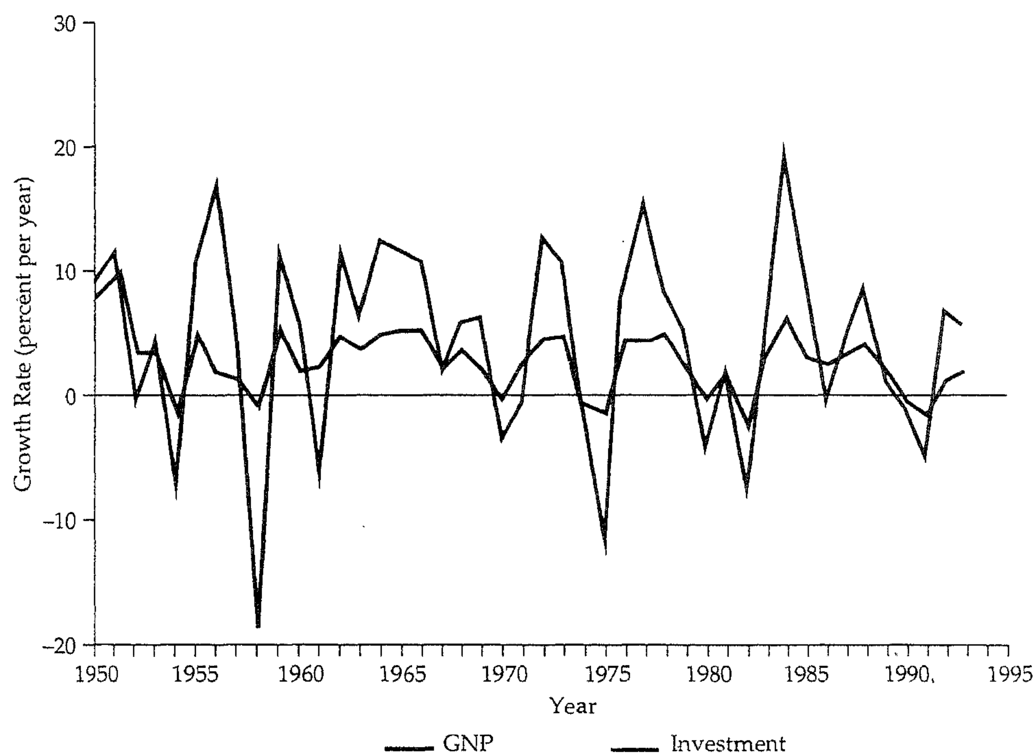


FIGURE 2.13 GNP and Investment in Durable Equipment. Annual growth rates are compared for GNP and investment in durable equipment. The short-run GNP elasticity of demand is larger than the long-run elasticity for long-lived capital equipment, so changes in investment in equipment magnify changes in GNP Hence, capital goods industries are considered "cyclical."

For a durable good, the opposite is true. Again,consider automobiles. If aggregate income rises by 10 percent, the stock of cars that consumers will want to hold will also rise, say, by 5 percent. But this means a much larger increase in *current purchases* of cars. (If the stock is 70 million, a 5 percent increase is 3.5 million, which might be about 50 percent of normal demand in a single year.) Eventually consumers succeed in building up the stock of cars, after which new purchases are largely to replace old cars. (These new purchases will still be greater than before because with a larger stock of cars outstanding, more cars need to be replaced each year.) Clearly, the short-run income elasticity of demand will be much larger than the long-run elasticity.

Because the demands for durable goods fluctuate so sharply in response to short-run changes in income, the industries that produce these goods are very vulnerable to changing macroeconomic conditions, and in particular to the business cycle-recessions and booms. Hence, these industries are often called

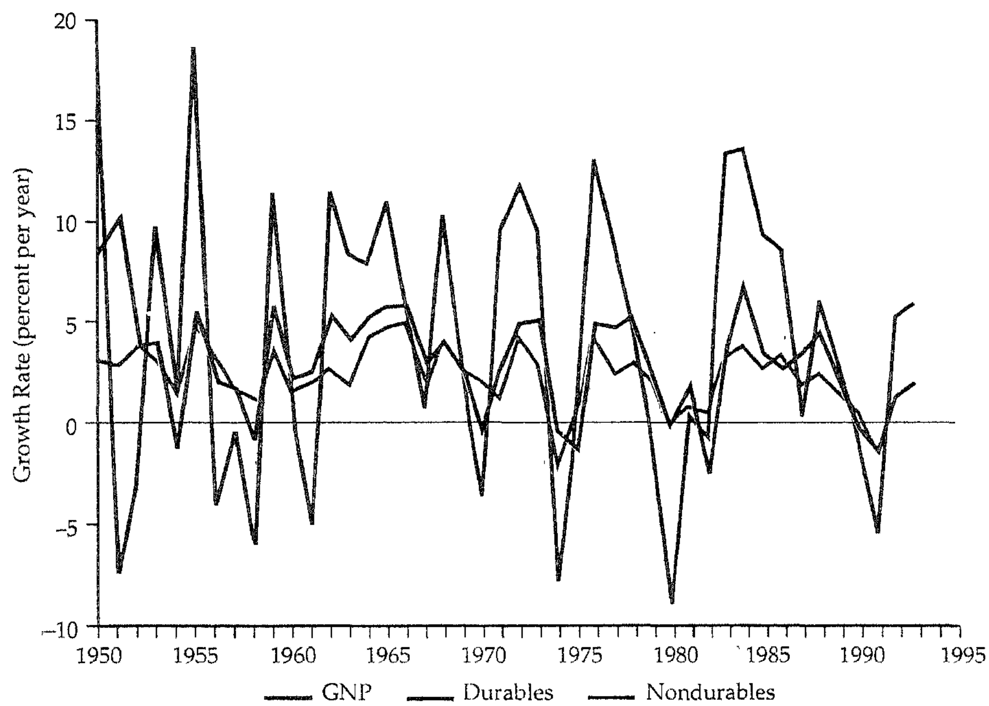


FIGURE 2.14 Consumption of Durables Versus Nondurables. Annual growth rates are compared for GNP, consumer expenditures on durable goods (automobiles, appliances, furniture, etc.), and consumer expenditures on nondurable goods (food, clothing, services, etc.). The stock of durables is large compared with annual demand, so short-run demand elasticities are larger than long-run elasticities. Like capital equipment, industries that produce consumer durables are "cyclical" (i.e., changes in GNP are magnified). This is not true for nondurables.

cyclical industries-their sales tend to magnify cyclical changes in gross national product (GNP) and national income.

Figures 2.13 and 2.14 illustrate this. Figure 2.13 plots two variables over time the annual real (inflation-adjusted) rate of growth of GNP, and the annual real rate of growth of investment in producers' durable equipment (i.e., machinery and other equipment purchased by firms). Note that the durable equipment series follows the same pattern as the GNP series, but the changes in GNP are magnified. For example, in 1961-1966 GNP grew by at least 4 percent each year. Purchases of durable equipment also grew but by much more (over 10 percent in 1963-1966). On the other hand, during the recessions of 1974-1975,1982, and 1991, equipment purchases fell by much more than GNP.

Figure 2.14 also shows the real rate of growth of GNP, and in addition, the annual real rates of growth of spending by consumers on durable goods (automobiles, appliances, etc.), and on nondurable goods (food, fuel, clothing etc.). Note that both consumption series follow GNP but only the durable goods series tends to magnify the changes in GNP Changes in consumption of nondurables are roughly the same as changes in GNP, but changes in consumption of durables are usually several times larger. It should be clear from this why companies such as General Motors and General Electric are considered "cyclical"-sales of cars and of electrical appliances are strongly affected by changing macroeconomic conditions.

EXAMPLE 2.4 THE DEMANDS FOR GASOLINE AND AUTOMOBILES

Gasoline and automobiles exemplify some of the different characteristics of demand discussed above. They are complementary goods-an increase in the price of one tends to reduce the demand for the other. And their respective dynamic behaviors (long-run versus short-run elasticities) are just the opposite from each other-for gasoline the long-run price and income elasticities are larger than the short-run elasticities; for automobiles the reverse is true.

There have been a number of statistical studies of the demands for gasoline and automobiles. Here we report estimates of price and income elasticities from two studies that emphasize the dynamic response of demand.[6] Table 2.1 shows price and income elasticities of demand for gasoline in the United States for the short run, the long run, and just about everything in between.

Note the large differences between the long-run and the short-run elasticities. Following the sharp increases that occurred in the price of gasoline with the rise of the OPEC cartel in 1974, many people (including executives in the automobile and oil industries) claimed that the demand for gasoline would

[6] The study of gasoline demand is in Robert S. Pindyck, *The Structure of World Energy Demand* (Cambridge. Mass.: MIT Press, 1979). The estimates of automobile demand elasticities are based on the artide by Saul H. Hymans, "Consumer Durable Spending: Explanation and Prediction," *Brookings Papers on Economic Activity* 1 (1971): 173-199.

TABLE 2.1 Demand For Gasoline

	Years Following Price or Income Change					
Elasticity	1	2	3	5	10	20
Price	−0.11	−0.22	−0.32	−0.49	−0.82	−1.17
Income	0.07	0.13	0.20	0.32	0.54	0.78

not change much-that demand was not very elastic. Indeed, for the first year after the price rise, they were right-the quantity demanded did not change much. But demand did eventually change. It just took time for people to alter their driving habits and to replace large cars with smaller and more fuel-efficient ones. This response continued after the second sharp increase in oil prices that occurred in 1979-1980. It is partly because of this that OPEC could not maintain oil prices above $30 per barrel, and prices fell.

Table 2.2 shows price and income elasticities of demand for automobiles. Note that the short-run elasticities are much larger than the long-run elasticities. It should be clear from the income elasticities why the automobile industry is so highly cyclical. For example, GNP fell by nearly 3 percent in real (inflation-adjusted) terms during the 1982 recession, but automobile sales fell by about 8 percent in real terms.[7] Auto sales recovered, however, during 1983-1985. Auto sales also fell by about 8 percent during the 1991 recession (when GNP fell 2 percent), but began to recover in 1993.

TABLE 2.2 Demand For Automobiles

	Years Following Price or Income Change					
Elasticity	1	2	3	5	10	20
Price	−1.20	−0.93	−0.75	−0.55	−0.42	−0.40
Income	3.00	2.33	1.88	1.38	1.02	1.00

Supply

Elasticities of supply also differ from the long run to the short run. For most products, long-run supply is much more price elastic than short-run supply

[7] This includes imports, which were capturing a growing share of the U.S. market Domestic auto sales fell by even more.

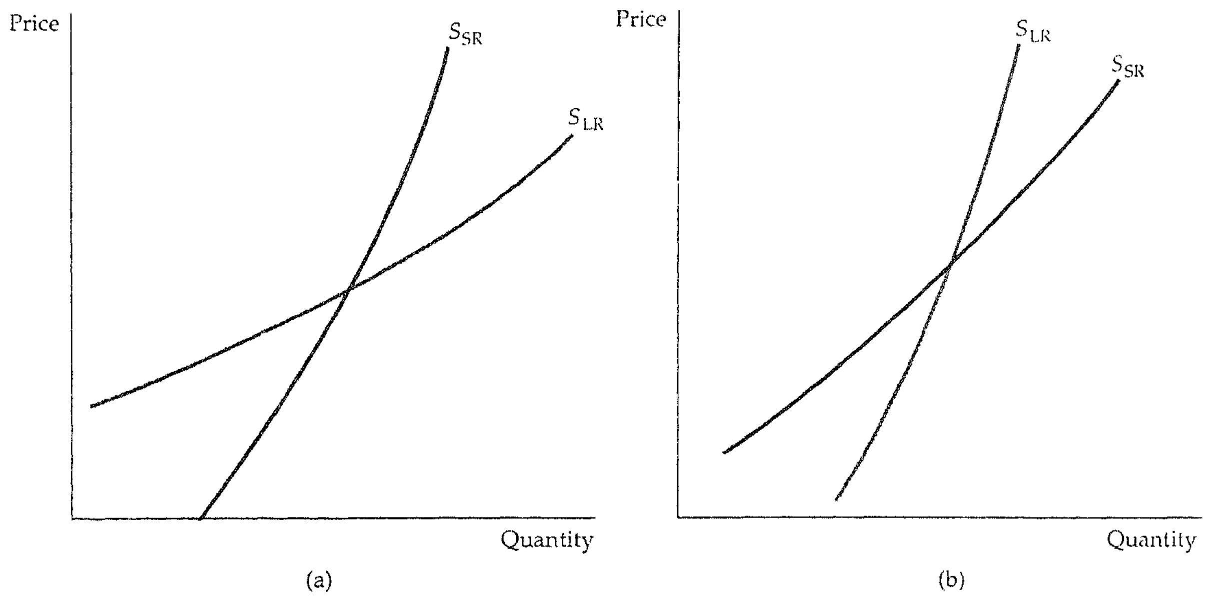


FIGURE 2.15a Primary Copper: Short-Run and Long-Run Supply Curves. Like most goods, supply is more elastic in the long run. If price increases, firms would like to produce more but are limited by capacity constraints in the short run. In the longer run, they can add to capacity and produce more.
FIGURE 2.15b Secondary Copper: Short-Run and Long-Run Supply Curves. If price increases, there is a greater incentive to convert scrap copper into new supply, so initially secondary supply (i.e., supply from scrap) increases sharply. But later, as the stock of scrap falls, secondary supply contracts. Secondary supply is therefore less elastic in the long run than in the short run.

because firms face *capacity constraints in* the short run and need time to expand their capacity by building new production facilities and hiring workers to staff them. This is not to say that supply will not increase in the short run if price goes up sharply. Even in the short run, firms can increase output, by using their existing facilities more hours per week, paying workers to work overtime, and hiring some new workers immediately. But firms will be able to expand output much more given the time to expand their facilities and hire a larger permanent work force.

For some goods and services, short-run supply is completely inelastic. Rental housing in most cities is an example. In the very short run, because there is only a fixed number of rental units, an increase in demand only pushes rents up. In the longer run, and without rent controls, higher rents provide an incentive to renovate existing buildings and construct new ones, so that the quantity supplied increases.

For most goods, however, firms can find ways to increase output even in the short run, if the price incentive is strong enough. The problem is that be-

TABLE 2.3 Supply of Copper

Price Elasticity of:	Short-run	Long-run
Primary supply	0.20	1.60
Secondary supply	0.43	0.31
Total supply	0.25	1.50

cause of the constraints that firms face, it is costly to increase supply rapidly, so that it may require a large price increase to elicit a small short-run increase in supply. We discuss these characteristics of supply in more detail in Chapter 8, but for now it should be clear why for many goods, short-run and long-run supply curves resemble those in Figure 2.15a. (The figure refers to the supply of primary [newly mined] copper, but it could also apply to many other goods.)

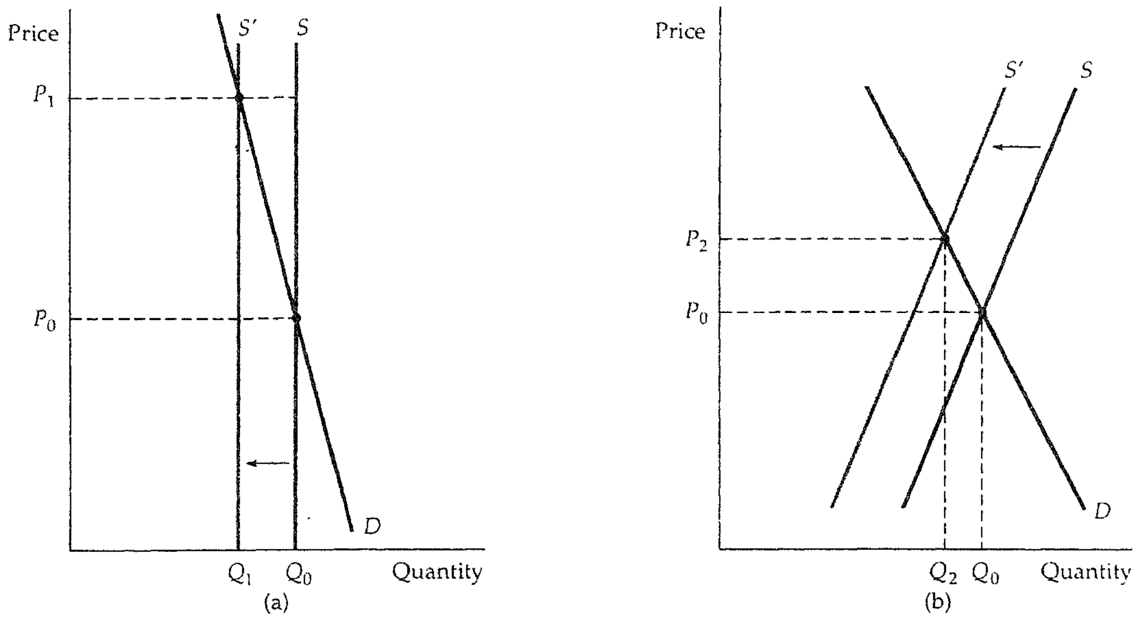
For some goods, supply is more elastic in the short run than in the long run. Such goods are durable and can be recycled as part of supply if price goes up. An example is the *secondary supply* of metals (i.e., the supply from *scrap metal,* which is often melted down and refabricated). When the price of copper goes up, it increases the incentive to convert scrap copper into new supply, so that initially secondary supply increases sharply. But eventually the stock of good-quality scrap will fall, making the melting, purifying, and refabricating more costly, so that secondary supply will contract. Thus the long-run price elasticity of secondary supply is smaller than the short-run elasticity.

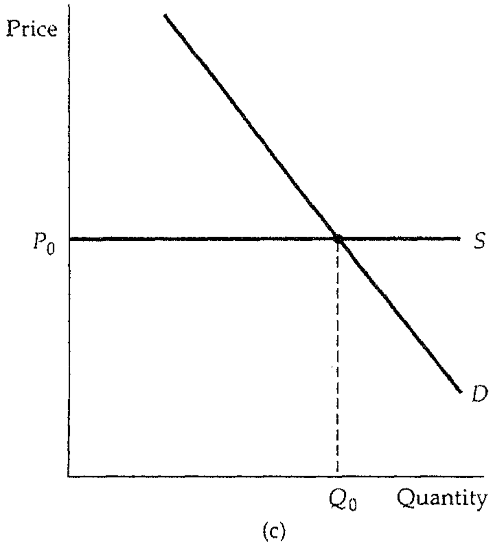
Figures 2.15a and 2.15b show short-run and long-run supply curves for primary (production from the mining and smelting of ore) and secondary copper production. Table 2.3 shows estimates of the elasticities for each component of supply, and then for total supply, based on a weighted average of the component elasticities.[8] Because secondary supply is only about 20 percent of total supply, the price elasticity of total supply is larger in the long run than in the short run.

EXAMPLE 2.5 THE WEATHER IN BRAZIL AND THE PRICE OF COFFEE IN NEW YORK

Subfreezing weather occasionally destroys or damages many of Brazil's coffee trees. Because Brazil produces much of the world's coffee, the result is a decrease, in the supply of coffee and a sharp run-up in its price. A dramatic example of this occurred in July 1975, when a frost destroyed most of

[8] These estimates were obtained by aggregating the regional estimates reported in Franklin M. Fisher, Paul H. Cootner, and Martin N. Baily, "An Econometric Model of the World Copper Industry," *Bell Journal of Economics* 3 (Autumn 1972): 568-609.





FIGURES 2.16a, b, and c Supply *and* Demand for *Coffee.* (a) A freeze in Brazil causes the supply curve to shift to the left. In the short run, supply is completely inelastic; only a fixed number of coffee beans can be harvested. Demand is -*also* relatively inelastic; consumers change their habits only slowly. As a result, the initial effect of the freeze is a sharp increase in price, from P_0 to P_1. (b) In the intermediate run, supply and demand are both more elastic, so price falls part way back,to P_2. (c) In the long run, supply is extremely elastic; new coffee trees will have had time to mature, so the effect of the freeze will have disappeared. Price returns to P_0.

Brazil's 1976-1977 coffee crop. (Remember that it is winter in Brazil when it is summer in the northern hemisphere.) The spot price of a pound of cof fee in New York went from 68 cents in 1975 to $1.23 in 1976, and then to $2.70 in 1977.

The run-up in price following a freeze is usually short-lived, however Within a year price begins to fall, and within three or four years it returns to its prefreeze level. For example, in 1978 the price of coffee in New York fell to

$1.48 per pound, and by 1983 it had fallen in real (inflation-adjusted) terms to within a few cents of its prefreeze 1975 price.[9]

Coffee prices behave this way because both demand and supply (especially supply) are much more elastic in the long run than in the short run. Figures 2.16a, 2.16b, and 2.16c show this. Note that in the very short run (within one or two months after a freeze), supply is completely inelastic; there are simply a fixed number of coffee beans, some of which have been damaged by the frost. Demand is also relatively inelastic. As a result of the frost, the supply curve shifts to the left, and price increases sharply, from P_0 to P_1.

In the intermediate run, say, one year after the freeze, both supply and demand are more elastic, supply because existing trees can be harvested more intensively (with some decrease in quality), and demand because consumers have had time to change their buying habits. The intermediate-run supply curve also shifts to the left, but price has come down from P_1 to P_2 The quantity supplied has also increased somewhat from the short run, from Q_1 to Q_2. In the long run, price returns to its normal level; coffee growers have had time to replace the trees damaged by the freeze. The long-run supply curve, then, simply reflects the cost of producing coffee, including the costs of land, of planting and caring for the trees, and of a competitive rate of profit.

*2.5 *Understanding and Predicting the Effects of Changing Market Conditions*

We have discussed the meaning and characteristics of supply and demand, but our treatment has been largely qualitative. To use supply and demand curves to analyze and predict the effects of changing market conditions, we must begin to attach numbers to them. For example, to see how a 50 percent reduction in the supply of Brazilian coffee may affect the world price of coffee, we need to write down actual supply and demand curves and then calculate how those curves will shift, and how price will then change.

In this section we will see how to do simple "back of the envelope" calculations with linear supply and demand curves. Although they are often an approximation to more complex curves, we use linear curves because they are the easiest to work with. It may come as a surprise, but one can do some in-

[9] During 1980, however, prices temporarily went just above $2.00 per pound as a result of export quotas imposed under the International Coffee Agreement (ICA). The ICA is essentially a cartel agreement implemented by the coffee-producing countries in 1968. It has been largely ineffective and in most years has had little impact on price. We discuss cartel pricing in detail in Chapter 12.

formative economic analyses on the back of a small envelope with a pencil and a pocket calculator.

First, we must learn how to "fit" linear demand and supply curves to market data. (By this we do not mean statistical fitting in the sense of linear regression or other statistical techniques, which we discuss later in the book.) Suppose we have two sets of numbers for a particular market. First are the price and quantity that generally prevail in the market (i.e., the price and quantity that prevail "on average," or when the market is in equilibrium, or when market conditions are "normal"). We call these numbers the equilibrium price and quantity, and we denote them by P^* and Q^*. Second are the price elasticities of supply and demand for the market (at or near the equilibrium), which we denote by E_S and E_D, as before.

These numbers might come from a statistical study done by someone else; they might be numbers that we simply think are reasonable; or they might be numbers that we want to try out on a "what if" basis. What we want to do is *write down the supply and demand curves that fit (i.e., are consistent with) these numbers.* Then we can determine numerically how a change in a variable such as GNP, the price of another good, or some cost of production will cause supply or demand to shift and thereby affect the market price and quantity.

Let's begin with the linear curves shown in Figure 2.17. We can write these curves algebraically as

$$\textit{Demand:} \quad Q = a - bP \tag{2.4a}$$

$$\textit{Supply:} \quad Q = c + dP \tag{2.4b}$$

The problem is to choose numbers for the constants a, b, c, *and d.* This is done, for supply and for demand, in a two-step procedure:

Step One: Recall that each price elasticity, whether of supply or demand, can be written as

$$E = (P/Q)(\Delta Q/\Delta P)$$

where $\Delta Q/\Delta P$ is the change in quantity demanded or supplied resulting from a small change in price. For linear curves, $\Delta Q/\Delta P$ is constant. From equations (2.4a) and (2.4b), we see that ΔQ/AP = d for supply, and $\Delta Q/\Delta P = -b$ for demand. Now, let's substitute these values for $\Delta Q/\Delta P$ into the elasticity formula:

$$\textit{Demand:} \quad E_D = -b(P^*/Q^*) \tag{2.5a}$$

$$\textit{Supply:} \quad E_S = d(P^*/Q^*) \tag{2.5b}$$

where P^* and Q^* are the equilibrium price and quantity for which we have data and to which the curves will be fit. Because we have numbers for E_S, E_D, P^*, and Q^*, we can substitute these numbers in equations (2.5a) and (2.5b) and solve for b and d.

Step Two: Since we now know b and d, we can substitute these numbers, as well as P^* and Q^*, into equations (2.4a) and (2.4b) and solve for the remaining constants a and c. For example, we can rewrite equation (2.4a) as

$$a = Q^* + bP^*$$

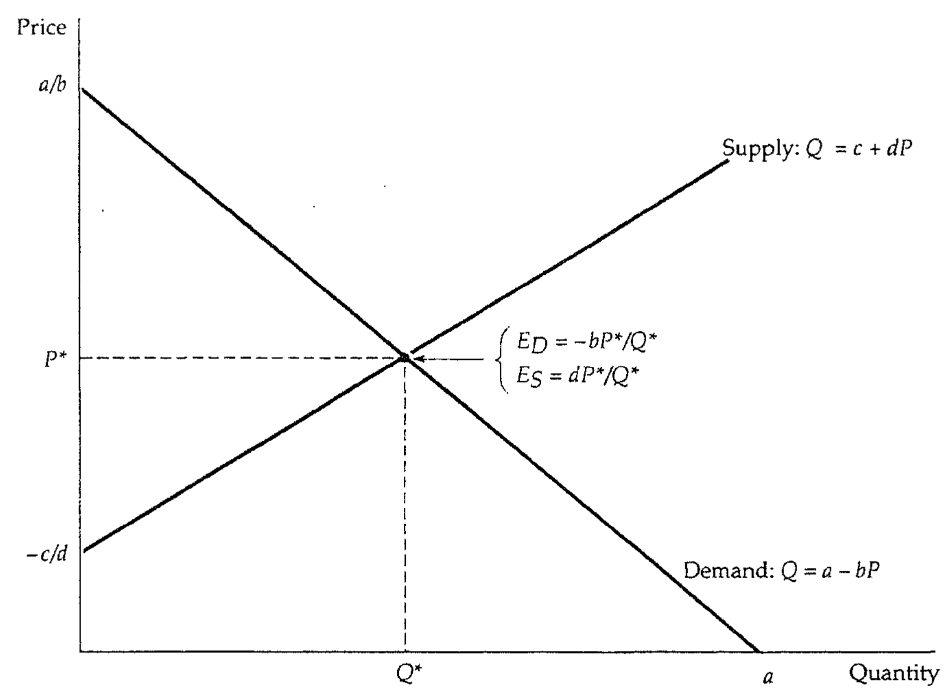


FIGURE 2.17 Fitting Linear Supply and Demand Curves to Data. Linear supply and demand curves provide a convenient tool for analysis. Given data for the equilibrium price and quantity P^* and Q^*, and estimates of the elasticities of demand and supply ED and E_S, we can calculate the parameters c and d for the supply curve, and a and b for the demand curve. (In the case drawn here, $c < 0$.) The curves can then be used to analyze the behavior of the market quantitatively.

and then use our data for Q^* and P^*, together with the number we calculated in Step One for b, to obtain a.

Let's do this for a specific example-long-run supply and demand for the world copper market. The relevant numbers for this market are as follows:[10] quantity $Q^* = 7.5$ million metric tons per year (mmt/yr); price $P^* = 75$ cents per pound; elasticity of supply $E_S = 1.6$; elasticity of demand $E_D = -0.8$. (The price of copper has fluctuated during the past decade between 50 cents and more than \$1.30, but 75 cents is a reasonable average price for 1980-1990.)

We begin with the supply curve equation (2.4b) and use our two-step procedure to calculate numbers for c and d. The long-run price elasticity of supply is 1.6, $P^* = .75$, and $Q^* = 7.5$.

Step One: Substitute these numbers in equation (2.5b) to determine d:

[10] The supply elasticity is for total supply, as shown in Table 2.3. The demand elasticity is a regionally aggregated number based on Fisher, Cootner, and Baily, "An Econometric Model." Quantities refer to what was then the non-Communist world market.

$$1.6 = d(0.75/7.5) = 0.1d,$$

so that $d = 1.6/0.1 = 16$.

Step Two: Substitute this number for d, together with the numbers for P^* and Q^*, into equation (2.4b) to determine c:

$$7.5 = c + (16)(0.75) = c + 12,$$

so that $c = 7.5 - 12 = -4.5$. We now know c and d, so we can write our supply curve:

$$\textit{Supply:} \qquad Q = -4.5 + 16P$$

We can now follow the same steps for the demand curve equation (2.4a). An estimate for the long-run elasticity of demand is -0.8. First, substitute this number, and the values for P^* and Q^*, in equation (2.5a) to determine b:

$$-0.8 = -b(0.75/7.5) = -0.1b$$

so that $b = 0.8/0.1 = 8$. Second, substitute this value for b and the values for P^* and Q^* in equation (2.4a) to determine a:

$$7.5 = a - (8)(0.75) = a - 6,$$

so that $a = 7.5 + 6 = 13.5$. Thus, our demand curve is

$$\textit{Demand:} \qquad Q = 13.5 - 8P$$

To check that we have not made a mistake, set supply equal to demand and calculate the equilibrium price that results:

$$\text{Supply} = -4.5 + 16P = 13.5 - 8P = \text{Demand}$$

$$16P + 8P = 13.5 + 4.5,$$

or $P = 18/24 = 0.75$, which is indeed the equilibrium price we began with.

We have written supply and demand so that they depend only on price, but they could easily depend on other variables as well. For example, demand might depend on income as well as price. We would then write demand as

$$Q = a - bP + fI \qquad (2.6)$$

where I is an index of aggregate income or GNP. (For example, I might equal 1.0 in a base year and then rise or fall to reflect percentage increases or decreases in aggregate income.)

For our copper market example, a reasonable estimate for the long-run income elasticity of demand is 1.3. For the linear demand curve (2.6), we can then calculate f by using the formula for the income elasticity of demand: $E = (I/Q)(AQ/AI)$. Taking the base value of I as 1.0, we have

$$1.3 = (1.0/7.5)(f)$$

so $f = (1.3)(7.5)/(1.0) = 9.75$. Finally, substituting the values $b = 8$, $f = 9.75$, $P^* = 0.75$, and $Q^* = 7.5$ into (2.6), we can calculate that a must equal 3.75.

We have seen how to fit linear supply and demand curves to data. Now, to see how these curves can be used to analyze markets, look at Example 2.6 on the behavior of copper prices and Example 2.7 on the world oil market.

EXAMPLE 2.6 DECLINING DEMAND AND THE BEHAVIOR OF COPPER PRICES

After reaching a level of about $1.00 per pound in 1980, the price of copper fell sharply to about 60 cents per pound in 1986. In real (inflation-adjusted) terms, this price was even lower than during the Great Depression 50 years earlier. Only in 1988-1989 did prices recover somewhat, as a result of strikes by miners in Peru and Canada that disrupted supplies. Figure 2.18 shows the behavior of copper prices in 1965-1993 in both real and nominal terms.

The world-wide recessions of 1980 and 1982 contributed to the decline of copper prices; as mentioned above, the income elasticity of copper demand is about 1.3. But copper demand did not pick up as the industrial economies re-

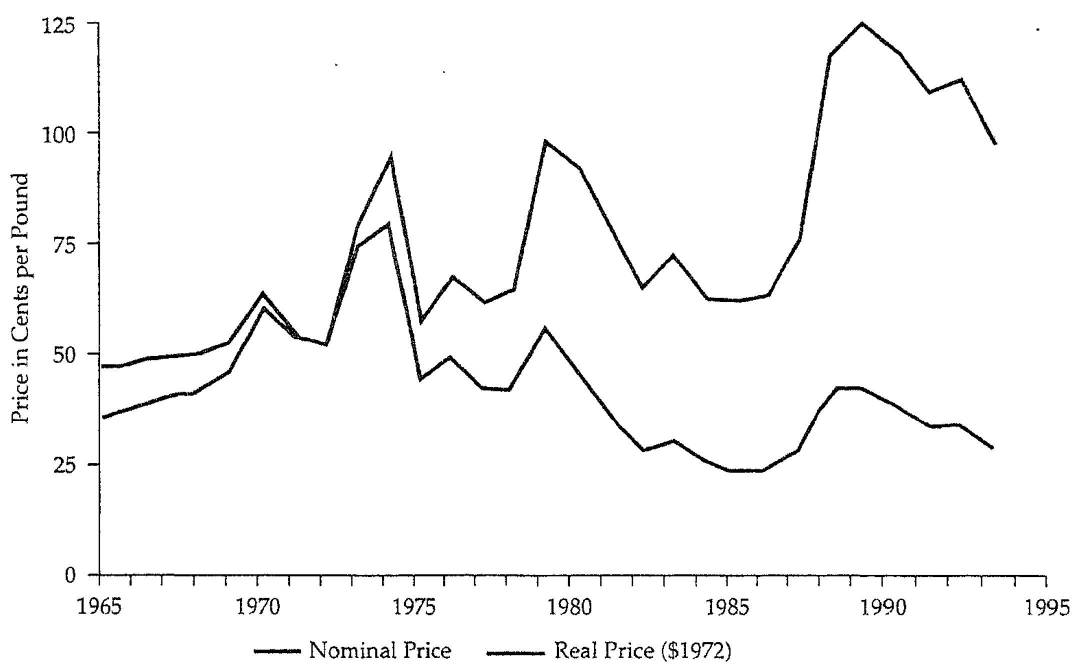


FIGURE 2.18 Copper Prices 1965-1993. Copper prices are shown in both nominal (no adjustment for inflation) and real (inflation-adjusted) terms. In real terms copper prices declined steeply from the early 1970s through the mid-1980s as demand fell. In 1988-1990 copper prices rose in response to supply disruptions caused by strikes in Peru and Canada, but prices later fell after the strikes ended.

covered during the mid-1980s. Instead, the 1980s saw the beginning of a deep decline in the demand for copper.

This decline occurred for two reasons. First, a large part of copper consumption is for the construction of equipment for electric power generation and transmission. But by the late 1970s, the growth rate of electric power generation had fallen dramatically in most industrialized countries. (For example, in the United States the growth rate fell from over 6 percent per annum in the 1960s and early 1970s fro less than 2 percent in the late 1970s and 1980s.) This meant a big drop in what had been a major source of copper demand. Second, in the 1980s other materials, such as aluminum and fiber optics, were increasingly substituted for copper.

Copper producers are concerned about the possible effects of further declines in demand, particularly as strikes end and supplies increase. Declining demand will depress prices; to find out how much, we can use the linear supply and demand curves that we just derived. Let us calculate the effect on price of a 20 percent decline in demand. Since we are not concerned here with the effects of GNP growth, we can leave the income term fI out of demand.

We want to shift the demand curve to the left by 20 percent. In other words, we want the quantity demanded to be 80 percent of what it would be otherwise for every value of price. For our linear demand curve, we simply multiply the right-hand side by 0.8:

$$Q = (0.8)(13.5 - 8P) = 10.8 - 6.4P$$

Supply is again $Q = -4.5 + 16P$. Now we can equate supply and demand and solve for price:

$$16P + 6.4P = 10.8 + 4.5$$

or $P = 15.3/22.4 = 68.3$ cents per pound. A decline in demand of 20 percent therefore implies a drop in price of roughly 7 cents per pound, or 10 percent.

EXAMPLE 2.7 THE WORLD OIL MARKET ON THE BACK OF AN ENVELOPE

Since 1974, the world oil market has been dominated by the OPEC cartel. By collectively restraining output, OPEC succeeded in pushing world oil prices well above what they would have been in a competitive market. OPEC producers could do this because they accounted for a large fraction of world oil production (about two-thirds in 1974).

We discuss OPEC's pricing strategy in more detail in Chapter 12 as part of our analysis of cartels and the behavior of cartelized markets. But for now, let's see how simple linear supply and demand curves (and the back of a small envelope) can be used to predict what should happen, in the short and longer run, following a cutback in production by OPEC.

This example is set in 1973-1974, so all prices are measured in 1974 dollars (which, because of inflation, were worth much more than today's dollars). Here are some rough figures: 1973 world price = $4 per barrel, world demand and total supply = 18 billion barrels per year (bb/yr), 1973 OPEC supply = 12 bb/yr and competitive (non-OPEC) supply = 6 bb/yr. And here are price elasticity estimates consistent with linear supply and demand curves:[11]

	Short-run	Long-run
World Demand:	−0.05	−0.40
Competitive Supply:	0.10	0.40

You should verify that these numbers imply the following for demand and competitive supply in the *short run:*

Short-run Demand: $D = 18.9 - 0.225P$

Short-run Competitive Supply: $S_c = 5.4 + 0.15P$

Of course, *total* supply is competitive supply *plus* OPEC supply, which we take as constant at 12 bb/yr. Adding this 12 bb/yr to the competitive supply curve above, we obtain the following for total short-run supply:

Short-run Total Supply: $S_T = 17.4 + 0.15P$

You should check that demand and total supply are equal at a price of $4 per barrel.

You should also verify that the corresponding demand and supply curves for the *long run* are

Long-run Demand: $D = 25.2 - 1.8P$

Long-run Competitive Supply: $S_c = 3.6 + 0.6P$

Long-run Total Supply: $S_T = 15.6 + 0.6P$

Again, you can check that supply and demand equate at a price of $4.

Now let's calculate what should happen if OPEC cuts production by one-fourth, or 3 bb/yr. For the *short-run,* just subtract 3 from total supply:

Short-run Demand: $D = 18.9 - 0.225P$

Short-run Total Supply: $S_T = 14.4 + 0.15P$

By equating this total supply with demand, we can see that in the short run, the price should rise to $12 per barrel, which in fact it did. Figure 2.19 illustrates the shift in supply and its effect on price. The initial equilibrium is at

[11]These elasticities are larger when price is higher. For the sources of these numbers and a more detailed discussion of OPEC oil pricing, see Robert S. Pindyck, "Gains to Producers from the Cartelization of Exhaustible Resources," *Review of Economics and Statistics* 60 (May 1978): 238-251, and James M. Griffin and David J. Teece, *OPEC Behavior and World Oil Prices* (London: Allen & Unwin, 1982).

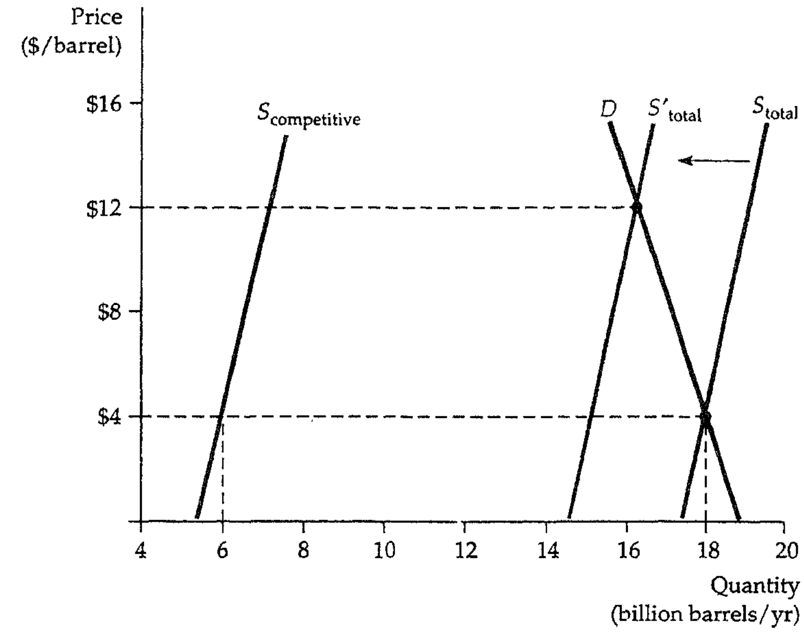


FIGURE 2.19 OPEC Production Cut. Total supply is the sum of competitive (non-OPEC) supply and the 12 billion barrels per year of OPEC supply. These are short-run supply and demand curves. If OPEC reduces its production, the supply curve will shift to the left. In the short run, price will increase sharply.

the intersection of S_{total} and *D*. After the drop in OPEC production, the equilibrium occurs where S'_{total} and *D* cross.

In the *long run,* however, things will be different. Because both demand and competitive supply are more elastic in the long run, a one-fourth cut in production by OPEC will no longer support a $12 price. By subtracting 3 from the long-run total supply function and equating with long-run demand, we can see that the price will be only $5.25. This is $1.25 above the old $4 price but much lower than $12.

We would therefore expect to see a sharp increase in price, followed by a gradual decline,as demand falls and competitive supply rises in response to price. And this is what did occur, at least until 1979. But during 1979-1980 the price of oil again rose dramatically. What happened? The Iranian Revolution and the outbreak of the Iran-Iraq war. By cutting about 1.5 bb/yr from Iranian production and nearly 1 bb/yr from Iraqi production, the revolution and war allowed oil prices to continue to increase, and consequently they were a blessing for the other members of OPEC.

Yet even though the Iran-Iraq war dragged on, by 1986 oil prices had fallen much closer to competitive levels. This was largely due to the long-run response of demand and competitive supply. As demand fell and competitive supply expanded, OPEC's share of the world market fell to about one-third, as compared with almost two-thirds in 1973.

2.6 *Effects of Government Intervention—Price Controls*

In the United States and most other industrial countries, markets are rarely free of government intervention. Besides imposing taxes and granting subsidies, governments often regulate markets (even competitive markets) in a variety of ways. Here we will see how to use supply and demand curves to analyze the effects of one common form of government intervention: price controls. Later, in Chapter 9, we examine the effects of price controls and other forms of government intervention and regulation in more detail.

Figure 2.20 illustrates the effects of price controls. Here P_0 and Q_0 are the equilibrium price and quantity that would prevail without government regulation. The government, however, has decided that P_0 is too high and has mandated that the price can be no higher than a maximum allowable *ceiling price,* denoted by P_{max}. What is the result? At this lower price, producers (particularly those with higher costs) will produce less, and supply will be Q_1. Consumers, on the other hand, will demand more at this low price; they would like to purchase the quantity Q_2. So demand exceeds supply, and a shortage develops, known as *excess demand.* The amount of excess demand is $Q_2 - Q_1$.

This excess demand sometimes takes the form of queues, as when drivers lined up to buy gasoline during the winter of 1974 and the summer of 1979. (In both instances, the gasoline lines were the result of price controls; the government prevented domestic oil and gasoline prices from rising along with world oil prices.) Sometimes it takes the form of curtailments and supply rationing, as with natural gas price controls and the resulting gas shortages of the mid-1970s, when industrial consumers of gas had their supplies cut off, forcing factories to close. And sometimes it spills over to other markets, where it artificially increases demand. For example, natural gas price controls caused potential buyers of gas to use oil instead.

Some people gain and some lose from price controls. As Figure 2.20 suggests, producers lose-they receive lower prices, and some leave the industry. Some but not all consumers gain. Consumers who can purchase the good at a lower price are clearly better off, but .those who have been "rationed out" and cannot buy the good at all are worse off. How large are the gains to the winners, how large are the losses to the losers, and do the total gains exceed the total losses? To answer these questions we need a method to measure the

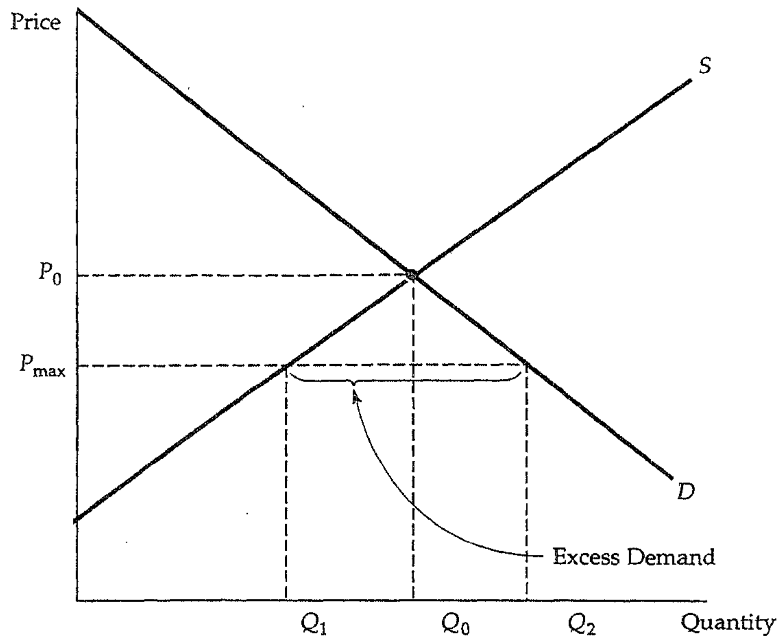


FIGURE 2.20 Effects of Price Controls. Without price controls the market clears at the equilibrium price and quantity P_0 and Q_0. If price is regulated to be no higher than P_{max}, supply falls to Q_1, demand increases to Q_2, and a shortage develops.

gains and losses from price controls and other forms of government intervention. We discuss such a method in Chapter 9.

EXAMPLE 2.8 PRICE CONTROLS AND THE NATURAL GAS SHORTAGE

In 1954, the federal government began regulating the wellhead price of natural gas. Initially the controls were not binding; the ceiling prices were above those that cleared the market. But in about 1962, these ceiling prices did become binding, and excess demand for natural gas developed and slowly began to grow. In the 1970s, this excess demand, spurred by higher oil prices, became severe and led to widespread curtailments. Ceiling prices were far below those that would have prevailed in a free market.[12]

[12] This regulation began with the Supreme Court's 1954 decision requiring the then Federal Power Commission to regulate wellhead prices on natural gas sold to interstate pipeline companies. These price controls were largely removed during the 1980s, under the mandate of the Natural Gas Policy Act of 1978. For a detailed discussion of natural gas regulation and its effects, see Paul W. MacAvoy and Robert S. Pindyck, *The Economics of the Natural Gas Shortage* (Amsterdam: North-Holland, 1975) R. S. Pindyck, "Higher Energy Prices and the Supply of Natural Gas," *Energy Systems and Policy 2* (1978): 177-209, and Arlon R. Tussing and Connie C. Barlow, *The Natural Gas Industry* (Cambridge Mass.: Ballinger, 1984).

To analyze the impact of these price controls, we will take 1975 as a case in point. Based on econometric studies of natural gas markets and the behavior of those markets as controls were gradually lifted during the 1980s, the following data describe the market in 1975. The free market price of natural gas would have been about $2.00 per mcf (thousand cubic feet), and production and consumption would have been about 20. Tcf (trillion cubic feet). The average price of oil (including both imports and domestic production), which affects both supply and demand for natural gas, was about $8/barrel.

A reasonable estimate for the price elasticity of supply is 0.2. Higher oil prices also lead to more natural gas production because oil and gas are often discovered and produced together; an estimate of the cross-price elasticity of supply is 0.1. As for demand, the price elasticity is about -0.5, and the cross-price elasticity with respect to oil price is about 1.5. You can verify that the following linear supply and demand curves fit these numbers:

$$\text{Supply: } Q = 14 + 2P_G + .25P_O$$

$$\text{Demand: } Q = -5P_G + 3.75P_O$$

where Q is the quantity of natural gas (in Tcf), P_G is the price of natural gas (in dollars per mcf), and P_O is the price of oil (in dollars per barrel). You can also verify, by equating supply and demand and substituting $8.00 for P_O, that these supply and demand curves imply an equilibrium free market price of $2.00 for natural gas.

The regulated price of gas in 1975 was about $1.00 per mcf. Substituting this price for P_G in the supply function gives a quantity supplied (Q_1 in Figure 2.20) of 18 Tcf. Substituting for P_G in the demand function gives a demand (Q_2 in Figure 2.20) of 25 Tcf. Price controls thus created an excess demand of 25 - 18 = 7 Tcf, which manifested itself in the form of widespread curtailments.

Price regulation was a major component of U.S. energy policy during the 1960s and 1970s, and it continued to influence the evolution of natural gas markets in the 1980s. In Example 9.1 of Chapter 9, we show how to measure the gains and losses that result from natural gas price controls.

Summary

1. Supply-demand analysis is a basic tool of microeconomics. In competitive markets, supply and demand curves tell us how much will be produced by firms and how much will be demanded by consumers as a function of price.
2. The market mechanism is the tendency for supply and demand to equilibrate (i.e., for price to move to the market-clearing level), so that there is neither excess demand nor excess supply.

3. Elasticities describe the responsiveness of supply and demand to changes in price, income, or other variables. For example, the price elasticity of demand measures the percentage change in the quantity demanded resulting from a 1 percent increase in price.
4. Elasticities pertain to a time frame, and for most goods it is important to distinguish between short-run and long-run elasticities.
5. If we can estimate, at least roughly, the supply and demand curves for a particular market/we can calculate the market-clearing price by equating supply and demand. Also, if we know how supply and demand depend on other economic variables, such as income or the prices of other goods, we can calculate how the market-clearing price and quantity will change as these other variables change. This is a means of explaining or predicting market behavior.
6. Simple numerical analyses can often be done by fitting linear supply and demand curves to data on price and quantity and to estimates of elasticities. For many markets such data and estimates are available, and simple "back of the envelope" calculations can help us understand the characteristics and behavior of the market.

Questions for Review

1. Suppose that unusually hot weather causes the demand curve for ice cream to shift to the right. Why will the price of ice cream rise to a new market-clearing level?

2. Use supply and demand curves to illustrate how each of the following events would affect the price of butter and the quantity of butter bought and sold: (a) an increase in the price of margarine; (b) an increase in the price of milk; (c) a decrease in average income levels.

3. Suppose a 3 percent increase in the price of corn flakes causes a 6 percent decline in the quantity demanded. What is the elasticity of demand for corn flakes?

4. Why do long-run elasticities of demand differ from short-run elasticities? Consider two goods: paper towels and televisions. Which is a durable good? Would you expect the price elasticity of demand for paper towels to be larger in the short run or in the long run? Why? What about the price elasticity of demand for televisions?

5. Explain why for many goods, the long-run price elasticity of supply is larger than the short-run elasticity.

6. Suppose the government regulates the prices of beef and chicken and sets them below their market-clearing levels. Explain why shortages of these goods will develop and what factors will determine the sizes of the shortages. What will happen to the price of pork? Explain briefly.

7. In a discussion of tuition rates, a university official argues that the demand for admission is completely price inelastic. As evidence she notes that while the university has doubled its tuition (in real terms) over the past 15 years, neither the number nor quality of students applying has -decreased. Would you accept this argument? Explain briefly. (Hint: The official makes an assertion about the demand for admission, but does she actually observe a demand curve? What else could be going on?)

8. Use supply and demand curve shifts to illustrate the effect of the following events on the market for apples. Make clear the direction of the change in both price and quantity sold.

a. Scientists find that an apple a day does indeed keep the doctor away.
b. The price of oranges triples.
c. A drought shrinks the apple crop to one-third its normal size.
d. Thousands of college students abandon the academic life to become apple pickers.
e. Thousands of college students abandon the academic life to become apple growers.

Exercises

1. Consider a competitive market for which the quantities demanded andsupplied (per year) at various prices are given as follows:

Price ($)	Demand (millions)	Supply (millions)
60	22	14
80	20	16
100	18	18
120	16	20

a. Calculate the price elasticity of demand when the price is $80. When the price is $100.
b. Calculate the price elasticity of supply when the price is $80. When the price is $100.
c. What are the equilibrium price and quantity?
d. Suppose the government sets a price ceiling of $80. Will there be a shortage, and if so, how large will it be?

2. Refer to Example 2.3 on the market for wheat. Suppose that in 1985 the Soviet Union had bought an additional 200 million bushels of U.S. wheat. What would the free market price of wheat have been and what quantity would have been produced and sold by U.S. farmers?

3. The rent control agency of New York City has found that aggregate demand is $Q_D = 100 - 5P$, with quantity measured in tens of thousands of apartments, and price, the average monthly rental rate, measured in hundreds of dollars. The agency also noted that the increase in Q at lower P results from more three-person families coming into the city from Long Island and demanding apartments. The city's board of realtors acknowledges that this is a good demand estimate and has shown that supply is $Q_s = 50 + 5P$.

a. If both the agency and the board are right about demand and supply, what is the free market price? What is the change in city population if the agency sets a maximum average monthly rental of $100, and all those who cannot find an apartment leave the city?
b. Suppose the agency bows to the wishes of the board and sets a rental of $900 per month on all apartments to allow landlords a *"fair"* rate of return. If 50 percent of any long-run increases in apartment offerings comes from new construction, how many apartments are constructed?

4. Much of the demand for U.S. agricultural output has come from other countries. From Example 2.3, total demand is $Q = 3{,}550 - 266P$. In addition, we are told that domestic demand is $Q_D = 1{,}000 - 46P$. Domestic supply is $Q = 1{,}800 + 240P$. Suppose the export demand for wheat falls by 40 percent.

a. U.S. farmers are concerned about this drop in export demand. What happens to the free market price of wheat in the United States? Do the farmers have much reason to worry?
b. Now suppose the U.S. government wants to buy enough wheat each year to raise the price to $3.00 per bushel. Without export demand, how much wheat would the government have to buy each year? How much would this cost the government?

5. In Example 2.6 we examined the effect of a 20 percent decline in copper demand on the price of copper, using the linear supply and demand curves developed in Section 2.5. Suppose the long-run price elasticity of copper demand were -0.4 instead of -0.8.

a. Assuming, as before, that the equilibrium price and quantity are $P^* = 75$ cents per pound and $Q^* = 7.5$ million metric tons per year, derive the linear demand curve consistent with the smaller elasticity.

b. Using this demand curve, recalculate the effect of a 20 percent decline in copper demand on the price of copper.

6. Example 2.7 analyzes the world oil market. Using the data given in that example,

a. Show that the short-run demand and competitive supply curves are indeed given by

$$D = 18.9 - 0.225P$$
$$S_C = 5.4 + 0.15P$$

b. Show that the long-run demand and competitive supply curves are indeed given by

$$D = 25.2 - 1.8P$$
$$S_C = 3.6 + 0.6P$$

c. Use this model to calculate what would happen to the price of oil in the short run *and* the long run if OPEC were to cut its production by 6 billion barrels per year.

7. Refer to Example 2.8, which analyzes the effects of price controls on natural gas.

a. Using the data in the example, show that the following supply and demand curves did indeed describe the market in 1975:

$$\textit{Supply:} \quad Q = 14 + 2P_G + 0.25P_O$$
$$\textit{Demand:} \quad Q = -5P_G + 3.75P_O$$

where P_G and P_O are the prices of natural gas and oil, respectively. Also, verify that if the price of oil is \$8.00, these curves imply a free market price of \$2.00 for natural gas.

b. Suppose the regulated price of gas in 1975 had been \$1.50 per million cubic feet, instead of \$1.00. How much excess demand would there have been?

c. Suppose that the market for natural gas had *not* been regulated. If the price of oil had increased from \$8 to \$16, what would have happened to the free market price of natural gas?