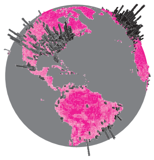
CHAPTER

4

Supply and Demand: Elasticity and Applications



You cannot teach a parrot to be an economist simply by teaching it to say "supply" and "demand."

Anonymous

We now move from our introductory survey to a detailed study of microeconomics—of the behavior of individual firms, consumers, and markets. Individual markets contain much of the grand sweep and drama of economic history and the controversies of economic policy. Within the confines of microeconomics we will study the reasons for the vast disparities in earnings between neurosurgeons and textile workers. Microeconomics is crucial to understanding why computer prices have fallen so rapidly and why the use of computers has expanded exponentially. We cannot hope to understand the bitter debates about health care or the minimum wage without applying the tools of supply and demand to these sectors. Even topics such as illegal drugs or crime and punishment are usefully illuminated by considering the way the demand for addictive substances differs from that for other commodities.

But understanding supply and demand requires more than simply parroting the words. A full mastery of microeconomic analysis means understanding the derivation of demand curves and supply curves, learning about different concepts of costs, and understanding how perfect competition differs from monopoly. All these and other key topics will be our subjects as we tour through the fascinating world of microeconomics.

A. PRICE ELASTICITY OF DEMAND AND SUPPLY

Supply and demand can often tell us whether certain forces increase or decrease quantities. But for these tools to be truly useful, we need to know *how much* supply and demand respond to changes in price. Some purchases, like those for vacation travel, are luxuries that are very sensitive to price changes. Others, like food or electricity, are necessities for which consumer quantities respond very little to price changes. The quantitative relationship between price and quantity purchased is analyzed using the crucial concept of *elasticity*. We begin with a careful definition of this term and then use this new concept to analyze the microeconomic impacts of taxes and other types of government intervention.

PRICE ELASTICITY OF DEMAND

Let's look first at the response of consumer demand to price changes:

The **price elasticity of demand** (sometimes simply called **price elasticity**) measures how much the quantity demanded of a good changes when its price changes. The precise definition of price elasticity is the percentage change in quantity demanded divided by the percentage change in price.

Goods vary enormously in their price elasticity, or sensitivity to price changes. When the price elasticity of a good is high, we say that the good has "elastic" demand, which means that its quantity demanded responds greatly to price changes. When the price elasticity of a good is low, it is "inelastic" and its quantity demanded responds little to price changes.

Goods that have ready substitutes tend to have more elastic demand than those that have no substitutes. If all food or footwear prices were to rise 20 percent tomorrow, you would hardly expect people to stop eating or to go around barefoot, so food and footwear demands are price-inelastic. On the other hand, if mad-cow disease drives up the price of British beef, people can turn to beef from other countries or to lamb or poultry for their meat needs. Therefore, British beef shows a high price elasticity.

The length of time that people have to respond to price changes also plays a role. A good example is that of gasoline. Suppose you are driving across the country when the price of gasoline suddenly increases. Is it likely that you will sell your car and abandon your vacation? Not really. So in the short run, the demand for gasoline may be very inelastic.

In the long run, however, you can adjust your behavior to the higher price of gasoline. You can buy a smaller and more fuel-efficient car, ride a bicycle, take the train, move closer to work, or carpool with other people. The ability to adjust consumption patterns implies that demand elasticities are generally higher in the long run than in the short run.

The price elasticities of demand for individual goods are determined by the economic characteristics of demand. Price elasticities tend to be higher when the goods are luxuries, when substitutes are available, and when consumers have more time to adjust their behavior. By contrast, elasticities are lower for necessities, for goods with few substitutes, and for the short run.

Calculating Elasticities

The precise definition of price elasticity is the percentage change in quantity demanded divided by the percentage change in price. We use the symbol E_D to represent price elasticity, and for convenience we drop the minus signs, so elasticities are all positive.

We can calculate the coefficient of price elasticity numerically according to the following formula:

$$\text{Price elasticity of demand} = E_D = \frac{\text{percentage change in quantity demanded}}{\text{percentage change in price}}$$

Now we can be more precise about the different categories of price elasticity:

- When a 1 percent change in price calls forth more than a 1 percent change in quantity demanded, the good has **price-elastic demand.** For example, if a 1 percent increase in price yields a 5 percent decrease in quantity demanded, the commodity has a highly price-elastic demand.
- When a 1 percent change in price produces less than a 1 percent change in quantity demanded, the good has **price-inelastic demand.** This case occurs, for instance, when a 1 percent increase in price yields only a 0.2 percent decrease in demand.
- One important special case is **unit-elastic demand,** which occurs when the percentage change in quantity is exactly the same as the percentage change in price. In this case, a 1 percent increase in price yields a 1 percent decrease in demand. We will see later that this condition implies that total expenditures on the commodity (which equal $P \times Q$) stay the same even when the price changes.

We illustrate the calculation of elasticities with the example shown in Figure 4-1 and Table 4-1. To begin at point *A*, quantity demanded was 240 units at a price of 90. A price increase to 110 led consumers to reduce their purchases to 160 units, shown as point *B*.

Table 4-1 shows how we calculate price elasticity. The price increase is 20 percent, with the resulting quantity decrease being 40 percent. The price elasticity of demand is evidently $E_D = 40/20 = 2$. The price elasticity is greater than 1, and this good therefore has price-elastic demand in the region from *A* to *B*.

In practice, calculating elasticities is somewhat tricky, and we emphasize three key steps where you have to be especially careful:

1. Recall that we drop the minus signs from the numbers, thereby treating all percentage changes as *positive.* That means all elasticities are written as positive numbers, even though prices and

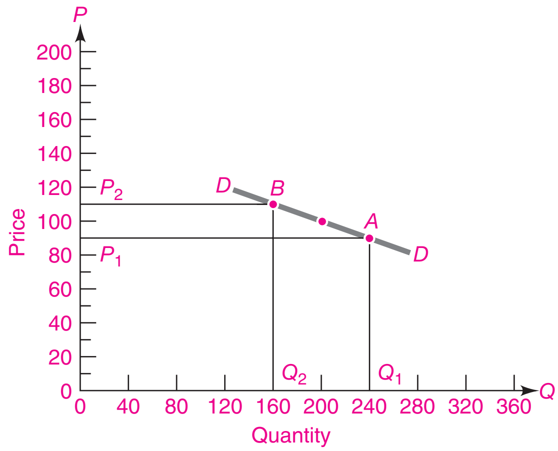


FIGURE 4-1. Elastic Demand Shows Large Quantity Response to Price Change

Market equilibrium is originally at point *A*. In response to a 20 percent price increase, quantity demanded declines 40 percent, to point *B*. Price elasticity is $E_D = 40/20 = 2$. Demand is therefore elastic in the region from *A* to *B*.

Case A: Price = 90 and quantity = 240

Case B: Price = 110 and quantity = 160

Percentage price change = $\Delta P/P = 20/100 = 20\%$

Percentage quantity change = $\Delta Q/Q = -80/200 = -40\%$

Price elasticity = $E_D = 40/20 = 2$

TABLE 4-1. Example of Good with Elastic Demand

Consider the situation where price is raised from 90 to 110. According to the demand curve, quantity demanded falls from 240 to 160. Price elasticity is the ratio of percentage change in quantity divided by percentage change in price. We drop the minus signs from the numbers so that all elasticities are positive.

quantities demanded move in opposite directions for downward-sloping demand curves.

2. Note that the definition of elasticity uses *percentage changes* in price and demand rather than absolute changes. This has the neat effect that a change in the units of measurement does not affect the elasticity. So whether we measure price in pennies or dollars, the price elasticity stays the same.

3. Note the use of *averaging* to calculate percentage changes in price and quantity. The formula for a percentage change is $\Delta P/P$. The value of ΔP in Table 4-1 is clearly $20 = 110 - 90$. But it's not immediately clear what value we should use for P in the denominator. Is it the original value of 90, the final value of 110, or something in between?

   For very small percentage changes, such as from 100 to 99, it does not much matter whether we use 99 or 100 as the denominator. But for larger changes, the difference is significant. To avoid ambiguity, we will take the average price to be the base price for calculating price changes. In Table 4-1, we used the average of the two prices $[P = (90 + 110)/2 = 100]$ as the base or denominator in the elasticity formula. Similarly, we used the average quantity $[Q = (160 + 240)/2 = 200]$ as the base for measuring the percentage change in quantity. The exact formula for calculating elasticity is therefore

$$E_D = \frac{\Delta Q}{(Q_1 + Q_2)/2} \div \frac{\Delta P}{(P_1 + P_2)/2}$$

   where P_1 and Q_1 represent the original price and quantity and P_2 and Q_2 stand for the new price and quantity.

Price Elasticity in Diagrams

It's possible to determine price elasticities in diagrams as well. Figure 4-2 illustrates the three cases of elasticities. In each case, price is cut in half and consumers change their quantity demanded from *A* to *B*.

In Figure 4-2(*a*), a halving of price has tripled quantity demanded. Like the example in Figure 4-1, this case shows price-elastic demand. In Figure 4-2(*c*), cutting price in half led to only a 50 percent increase in quantity demanded, so this is the case of price-inelastic demand. The borderline case of unit-elastic demand is shown in Figure 4-2(*b*); in this example, the doubling of quantity demanded exactly matches the halving of price.

Figure 4-3 displays the important polar extremes where the price elasticities are infinite and zero, or completely elastic and completely inelastic. Completely inelastic demands, or ones with zero elasticity, are ones where the quantity demanded responds not at all to price changes; such demand is seen to be a vertical demand curve. By contrast, when demand is infinitely elastic, a tiny change in price will lead to an

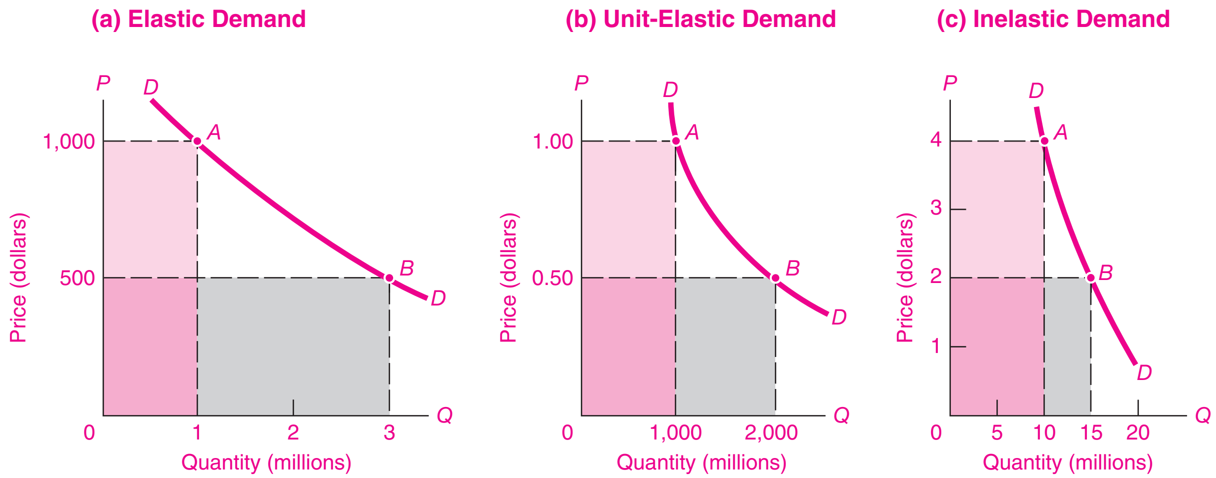


FIGURE 4-2. Price Elasticity of Demand Falls into Three Categories

indefinitely large change in quantity demanded, as in the horizontal demand curve in Figure 4-3.

A Shortcut for Calculating Elasticities

There is a simple rule for calculating the price elasticity of a demand curve:

> The elasticity of a straight line at a point is given by the ratio of the length of the line segment below the point to the length of the line segment above the point.

The procedure is shown in Figure 4-4. At the top of the line, a very small percentage price change induces a very large percentage quantity change, and the elasticity is therefore extremely large. Price

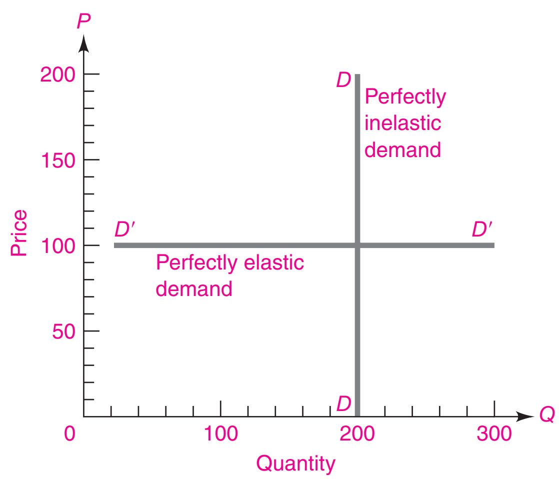


FIGURE 4-3. Perfectly Elastic and Inelastic Demands

Polar extremes of demand are vertical demand curves, which represent perfectly inelastic demand ($E_D = 0$), and horizontal demand curves, which show perfectly elastic demand ($E_D = \infty$).

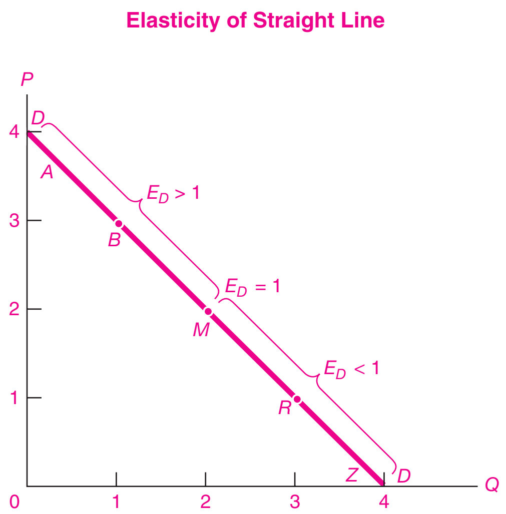


FIGURE 4-4. A Simple Rule for Calculating the Demand Elasticity

We can calculate the elasticity as the ratio of the lower segment to the upper segment at the demand point. For example, at point *B*, the lower segment is 3 times as long as the upper segment, so the price elasticity is 3.

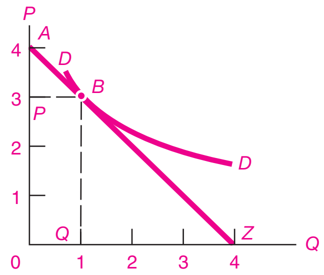


FIGURE 4-5. Calculating the Demand Elasticity for Curved Demand

To calculate the demand elasticity for a nonlinear demand curve, first draw a tangent line at the point. Then take the ratio of the length of the straight-line segment below the point to the length of the line segment above the point. Hence, at point *B* the elasticity can be calculated to be 3.

elasticity is relatively large when we are high up the linear *DD* curve. We use the rule to calculate the elasticity at point *B* in Figure 4-4. Calculate the ratio of the line segment *BZ* to the segment *AB*. Looking at the axes, we see that the ratio is 3. Therefore, price elasticity at point *B* is 3.

A similar calculation at point *R* shows that demand at that point is inelastic, with an elasticity of ⅓.

Finally, calculate elasticity at point *M*. Here, the ratio of the two line segments is one, so demand is unit-elastic at the midpoint *M*.

We can also use the rule to calculate the elasticity of a curved demand curve, as shown in Figure 4-5. For this case, you begin by drawing a line that is tangent to the point, and you then calculate the ratio of segments for the tangent line. This will provide the correct calculation of elasticity for the curved line. Use as an example point *B* in Figure 4-5. We have drawn a tangent straight line. A careful inspection will show that the ratio of the lower to upper segments of the straight line is 3. Therefore, the curved demand has an elasticity of 3 at point *B*.

The Algebra of Elasticities

For the mathematically inclined, we can show the algebra of elasticities for straight-line (linear) demand curves. We begin with a demand curve, which is written as $Q = a - bP$. The demand elasticity at point (P_0, Q_0) is defined as $E_D = (\% \Delta Q)/(\% \Delta P) = (\Delta Q/Q_0)/(\Delta P/P_0) = (\Delta Q/\Delta P)(P_0/Q_0)$. This implies that the elasticity at point (P_0, Q_0) is

$$E_D = b(P_0/Q_0)$$

Note that the elasticity depends upon the slope of the demand curve, but it also depends upon the specific price and quantity pair. Question 11 at the end of this chapter provides examples that allow you to apply this formula.

Elasticity Is Not the Same as Slope

We must always remember not to confuse the elasticity of a curve with its slope. This distinction is easily seen when we examine the straight-line demand curves that are often found in illustrative examples.

What is the price elasticity of a straight-line demand curve? Surprisingly, along a straight-line demand curve, the price elasticity varies from zero to infinity! Table 4-2 gives a detailed set of elasticity calculations using the same technique as that in Table 4-1. This table shows that linear demand curves start out with high price elasticity, where price is high and quantity is low, and end up with low elasticity, where price is low and quantity is high.

This illustrates an important point. When you see a demand curve in a diagram, it is not true that a steep slope for the demand curve means inelastic demand or that a flat slope signifies elastic demand. The slope is not the same as the elasticity because the demand curve's slope depends upon the *changes* in *P* and *Q*, whereas the elasticity depends upon the *percentage changes* in *P* and *Q*. The only exceptions are the polar cases of completely elastic and inelastic demands.

We also illustrate the point in Figure 4-4. This straight-line demand curve has elastic demand in the top region and inelastic demand in the bottom region.

Finally, look at Figure 4-2(*b*). This demand curve is clearly not a straight line with constant slope. Yet it has a constant demand elasticity of $E_D = 1$ because the percentage change in price is equal everywhere to the percentage change in quantity.

Elasticities cannot be inferred by slope alone. The general rule for elasticities is that the elasticity can be calculated as the ratio of the length of the straight-line or tangent segment below the demand point to the length of the segment above the point.

Numerical Calculation of Elasticity Coefficient

Q	ΔQ	P	ΔP	$\frac{Q_1 + Q_2}{2}$	$\frac{P_1 + P_2}{2}$	$E_D = \frac{\Delta Q}{(Q_1 + Q_2)/2} \div \frac{\Delta P}{(P_1 + P_2)/2}$	
0		6					
	10		2	5	5	$\frac{10}{5} \div \frac{2}{5} = 5$	(elastic)
10		4					
	10		2	15	3	$\frac{10}{15} \div \frac{2}{3} = 1$	(unit-elastic)
20		2					
	10		2	25	1	$\frac{10}{25} \div \frac{2}{1} = 0.2$	(inelastic)
30		0					

TABLE 4-2. Calculation of Price Elasticity along a Linear Demand Curve

ΔP denotes the change in price, i.e., $\Delta P = P_2 - P_1$, while $\Delta Q = Q_2 - Q_1$. To calculate numerical elasticity, the percentage change of price equals price change, ΔP, divided by average price $[(P_1 + P_2)/2]$; the percentage change in output is calculated as ΔQ divided by average quantity, $[(Q_1 + Q_2)/2]$. Treating all figures as positive numbers, the resulting ratio gives numerical price elasticity of demand, E_D. Note that for a straight line, elasticity is high at the top, low at the bottom, and exactly 1 in the middle.

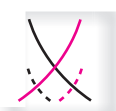
ELASTICITY AND REVENUE

Many businesses want to know whether raising prices will raise or lower revenues. This question is of strategic importance for businesses like airlines, baseball teams, and magazines, which must decide whether it is worthwhile to raise prices and whether the higher prices make up for lower demand. Let's look at the relationship between price elasticity and total revenue.

Total revenue is by definition equal to price times quantity (or $P \times Q$). If consumers buy 5 units at $3 each, total revenue is $15. If you know the price elasticity of demand, you know what will happen to total revenue when price changes:

1. When demand is price-inelastic, a price decrease reduces total revenue.
2. When demand is price-elastic, a price decrease increases total revenue.
3. In the borderline case of unit-elastic demand, a price decrease leads to no change in total revenue.

The concept of price elasticity is widely used today as businesses attempt to separate customers into groups with different elasticities. This technique has been extensively pioneered by the airlines (see the box that follows). Another example is software companies, which have a wide range of different prices for their products in an attempt to exploit different elasticities. For example, if you are desperate about buying a new operating system immediately, your elasticity is low and the seller will profit from charging you a relatively high price. On the other hand, if you are not in a hurry for an upgrade, you can search around for the best price and your elasticity is high. In this case, the seller will try to find a way to make the sale by charging a relatively low price.



Fly the Financial Skies of "Elasticity Air"

Understanding demand elasticities is worth billions of dollars each year to U.S. airlines. Ideally, airlines would like to charge a relatively high price to business travelers, while charging leisure passengers a low-enough price to fill up all their empty seats. That is a strategy for raising revenues and maximizing profits.

But if they charge low-elasticity business travelers one price and high-elasticity leisure passengers a lower price, the airlines have a big problem—keeping the two classes of passengers separate. How can they stop the low-elasticity business travelers from buying up the cheap tickets meant for the leisure travelers and not let high-elasticity leisure flyers take up seats that business passengers would have been willing to buy?

The airlines have solved their problem by engaging in "price discrimination" among their different customers in a way that exploits different price elasticities. **Price discrimination** is the practice of charging different prices for the same service to different customers. Airlines offer discount fares for travelers who plan ahead and who tend to stay longer. One way of separating the two groups is to offer discounted fares to people who stay over a Saturday night—a rule that discourages business travelers who want to get home for the weekend. Also, discounts are often unavailable at the last minute because many business trips are unplanned expeditions to handle an unforeseen crisis—another case of price-inelastic demand. Airlines have devised extremely sophisticated computer programs to manage their seat availability as a way of ensuring that their low-elasticity passengers cannot benefit from discount fares.

The Paradox of the Bumper Harvest

We can use elasticities to illustrate one of the most famous paradoxes of all economics: the paradox of the bumper harvest. Imagine that in a particular year nature smiles on farming. A cold winter kills off the pests; spring comes early for planting; there are no killing frosts; rains nurture the growing shoots; and a sunny October allows a record crop to come to market. At the end of the year, family Jones happily settles down to calculate its income for the year. The Joneses are in for a major surprise: *The good weather and bumper crop have lowered their and other farmers' incomes.*

How can this be? The answer lies in the elasticity of demand for foodstuffs. The demands for basic food products such as wheat and corn tend to be inelastic; for these necessities, consumption changes very little in response to price. But this means farmers as a whole receive less total revenue when the harvest is good than when it is bad. The increase in supply arising from an abundant harvest tends to lower the price. But the lower price doesn't increase quantity demanded very much. The implication is that a low price elasticity of food means that large harvests (high Q) tend to be associated with low revenue (low $P \times Q$).

These ideas can be illustrated by referring back to Figure 4-2. We begin by showing how to measure revenue in the diagram itself. Total revenue is the product of price times quantity, $P \times Q$. Further, the area of a rectangle is always equal to the product of its base times its height. Therefore, total revenue at any point on a demand curve can be found by examining the area of the rectangle determined by the P and Q at that point.

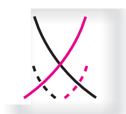
Next, we can check the relationship between elasticity and revenue for the unit-elastic case in Figure 4-2(*b*). Note that the shaded revenue region ($P \times Q$) is $1000 million for both points A and B. The shaded areas representing total revenue are the same because of offsetting changes in the Q base and the P height. This is what we would expect for the borderline case of unit-elastic demand.

We can also see that Figure 4-2(*a*) corresponds to elastic demand. In this figure, the revenue rectangle expands from $1000 million to $1500 million when price is halved. Since total revenue goes up when price is cut, demand is elastic.

In Figure 4-2(*c*) the revenue rectangle falls from $40 million to $30 million when price is halved, so demand is inelastic.

Which diagram illustrates the case of agriculture, where a bumper harvest means lower total revenues for farmers? Clearly it is Figure 4-2(*c*). Which represents the case of vacation travel, where a lower price could mean higher revenues? Surely Figure 4-2(*a*).

Table 4-3 shows the major points to remember about price elasticities.



Cigarette Taxes and Smoking

What is the impact of cigarette taxes on smoking? Some people say, "Cigarettes are so addictive that people will pay anything for their daily habit." Implicitly, when you say that the quantity demanded does not respond to price, you are saying

Value of demand elasticity	Description	Definition	Impact on revenues
Greater than one ($E_D > 1$)	Elastic demand	Percentage change in quantity demanded *greater* than percentage change in price	Revenues *increase* when price decreases
Equal to one ($E_D = 1$)	Unit-elastic demand	Percentage change in quantity demanded *equal* to percentage change in price	Revenues *unchanged* when price decreases
Less than one ($E_D < 1$)	Inelastic demand	Percentage change in quantity demanded *less* than percentage change in price	Revenues *decrease* when price decreases

TABLE 4-3. Elasticities: Summary of Crucial Concepts

that the price elasticity is zero. What does the evidence say about the price elasticity of cigarette consumption?

We can use a historical example to illustrate the issue. New Jersey doubled its cigarette tax from 40 cents to 80 cents per pack. The tax increased the average price of cigarettes from $2.40 to $2.80 per pack. Economists estimate that the effect of the price increase alone was a decrease in New Jersey's cigarette consumption from 52 million to 47.5 million packs.

Using the elasticity formula, you can calculate that the short-run price elasticity is 0.59. (Make sure you can get the same number.) Similar estimates come from more detailed statistical studies. The evidence indicates that the price elasticity of cigarettes is definitely not zero.

PRICE ELASTICITY OF SUPPLY

Of course, consumption is not the only thing that changes when prices go up or down. Businesses also respond to price in their decisions about how much to produce. Economists define the price elasticity of supply as the responsiveness of the quantity supplied of a good to its market price.

More precisely, the **price elasticity of supply** is the percentage change in quantity supplied divided by the percentage change in price.

As with demand elasticities, there are polar extremes of high and low elasticities of supply. Suppose the amount supplied is completely fixed, as in the case of perishable fish brought to market to be sold at whatever price they will fetch. This is the limiting case of zero elasticity, or completely inelastic supply, which is a vertical supply curve.

At the other extreme, say that a tiny cut in price will cause the amount supplied to fall to zero, while the slightest rise in price will coax out an indefinitely large supply. Here, the ratio of the percentage change in quantity supplied to percentage change in price is extremely large and gives rise to a horizontal supply curve. This is the polar case of infinitely elastic supply.

Between these extremes, we call supply elastic or inelastic depending upon whether the percentage change in quantity is larger or smaller than the percentage change in price. In the borderline unit-elastic case, where price elasticity of supply equals 1, the percentage increase of quantity supplied is exactly equal to the percentage increase in price.

You can readily see that the definitions of price elasticities of supply are exactly the same as those for price elasticities of demand. The only difference is that for supply the quantity response to price is positive, while for demand the response is negative.

The exact definition of the price elasticity of supply, E_S, is as follows:

$$E_S = \frac{\text{percentage change in quantity supplied}}{\text{percentage change in price}}$$

Figure 4-6 displays three important cases of supply elasticity: (a) the vertical supply curve, showing completely inelastic supply; (c), the horizontal supply curve, displaying completely elastic supply; and (b), an intermediate case of a straight line, going

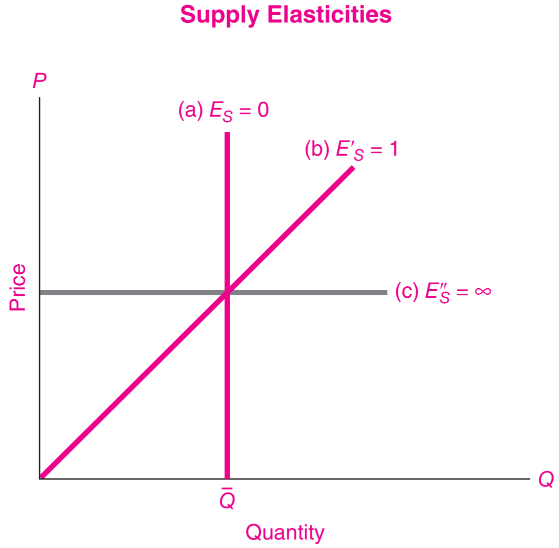


FIGURE 4-6. Supply Elasticity Depends upon Producer Response to Price

When supply is fixed, supply elasticity is zero, as in curve (a). Curve (c) displays an indefinitely large quantity response to price changes. Intermediate case (b) arises when the percentage quantity and price changes are equal.

through the origin, illustrating the borderline case of unit elasticity.[1]

What factors determine supply elasticity? The major factor influencing supply elasticity is the ease with which production in the industry can be increased. If all inputs can be readily found at going market prices, as is the case for the textile industry, then output can be greatly increased with little increase in price. This would indicate that supply elasticity is relatively large. On the other hand, if production capacity is severely limited, as is the case for gold mining, then even sharp increases in the price of gold will call forth but a small response in gold production; this would be inelastic supply.

Another important factor in supply elasticities is the time period under consideration. A given change in price tends to have a larger effect on amount supplied as the time for suppliers to respond increases. For very brief periods after a price increase, firms may be unable to increase their inputs of labor, materials, and capital, so supply may be very price-inelastic. However, as time passes and businesses can hire more labor, build new factories, and expand capacity, supply elasticities will become larger.

We can use Figure 4-6 to illustrate how supply may change over time for the fishing case. Supply curve (a) might hold for fish on the day they are brought to market, where they are simply auctioned off for whatever they will bring. Curve (b) might hold for the intermediate run of a year or so, with the given stock of fishing boats and before new labor is attracted to the industry. Over the very long run, as new fishing boats are built, new labor is attracted, and new fish farms are constructed, the supply of fish might be very price-elastic, as in case (c) in Figure 4-6.

[1] You can determine the elasticity of a supply curve that is not a straight line as follows: (*a*) Draw the straight line that lies tangent to the curve at a point, and (*b*) then measure the elasticity of that tangential straight line.

B. APPLICATIONS TO MAJOR ECONOMIC ISSUES

Having laid the groundwork with our study of elasticities, we now show how these tools can assist our understanding of many of the basic economic trends and policy issues. We begin with one of the major transformations since the Industrial Revolution, the decline of agriculture. Next, we examine the implications of taxes on an industry, using the example of a gasoline tax. We then analyze the consequences of various types of government intervention in markets.

THE ECONOMICS OF AGRICULTURE

Our first application of supply-and-demand analysis comes from agriculture. The first part of this section lays out some of the economic fundamentals of the farm sector. Then we will use the theory of supply and demand to study the effects of government intervention in agricultural markets.

Long-Run Relative Decline of Farming

Farming was once our largest single industry. A hundred years ago, half the American population lived and worked on farms, but that number has declined to less

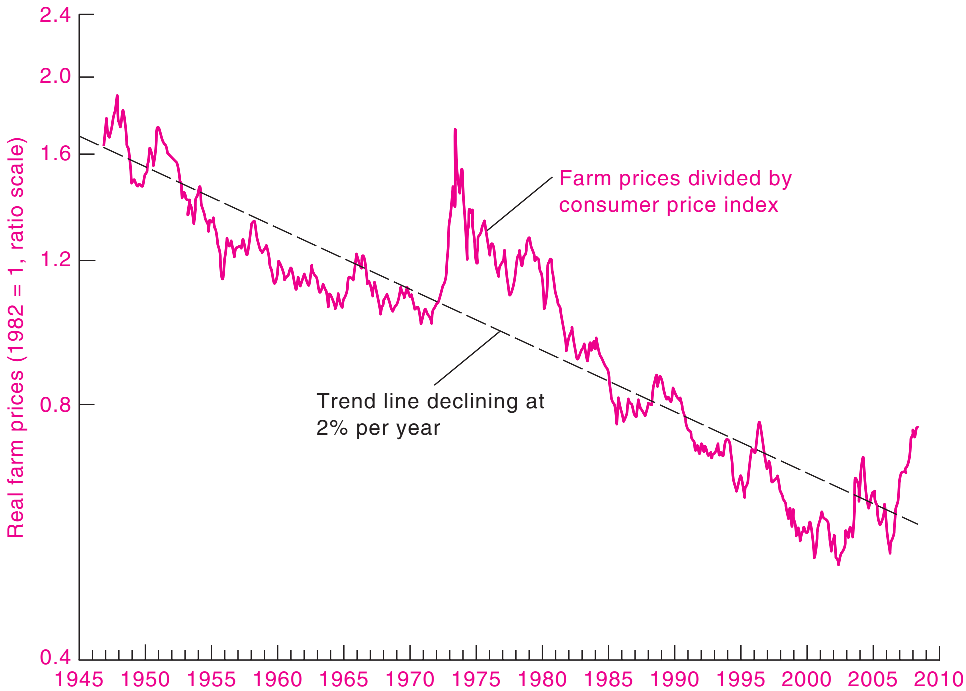


FIGURE 4-7. Prices of Basic Farm Products Have Declined Sharply

One of the major forces affecting the U.S. economy has been the decline in the relative prices of basic farm products—wheat, corn, soybeans, and the like. Over the past decades, farm prices have declined 2 percent per year relative to the general price level. The grain shortages since 2005 have slowed but not reversed the long slide in relative food prices. However, the recent upturn in food prices has contributed to inflation in most countries, and even to food riots in poor countries.

Source: Bureau of Labor Statistics.

than 3 percent of the workforce today. At the same time, prices for farm products have fallen relative to incomes and other prices in the economy. Figure 4-7 shows the steady decline of farm prices over the last half-century. While median family income has more than doubled, farm incomes have stagnated. Farm-state senators fret about the decline of the family farm.

A single diagram can explain the cause of the sagging trend in farm prices better than libraries of books and editorials. Figure 4-8 shows an initial equilibrium with high prices at point *E*. Observe what happens to agriculture as the years go by. Demand for food increases slowly because basic foods are necessities; the demand shift is consequently modest in comparison to growing average incomes.

What about supply? Although many people mistakenly think that farming is a backward business, statistical studies show that productivity (output per unit of input) has grown more rapidly in agriculture than in most other industries. Important advances include mechanization through tractors, combines, and cotton pickers; fertilization and irrigation; selective breeding; and development of genetically modified crops. All these innovations have vastly increased the productivity of agricultural inputs. Rapid productivity growth has increased supply greatly, as shown by the supply curve's shift from *SS* to *S′S′* in Figure 4-8.

What must happen at the new competitive equilibrium? Sharp increases in supply outpaced modest increases in demand, producing a downward trend in farm prices relative to other prices in the economy. And this is precisely what has happened in recent decades, as is seen in Figure 4-7.

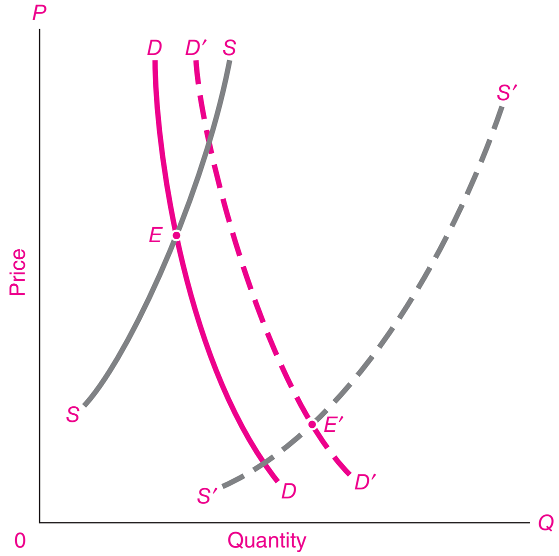


FIGURE 4-8. Agricultural Distress Results from Expanding Supply and Price-Inelastic Demand

Equilibrium at *E* represents conditions in the farm sector decades ago. Demand for farm products tends to grow more slowly than the impressive increase in supply generated by technological progress. Hence, competitive farm prices tend to fall. Moreover, with price-inelastic demand, farm incomes decline with increases in supply.

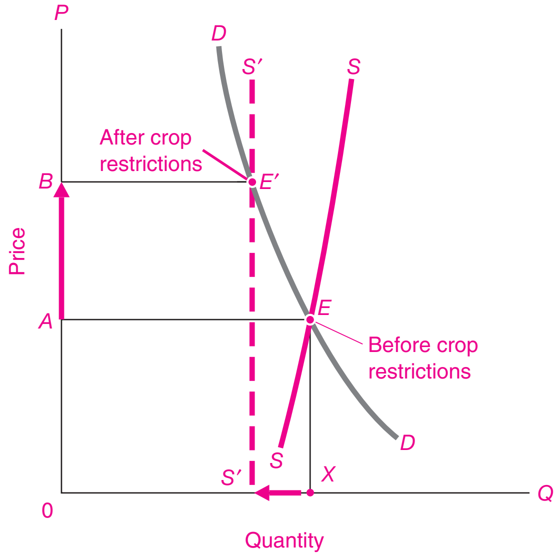


FIGURE 4-9. Crop-Restriction Programs Raise Both Price and Farm Income

Before the crop restriction, the competitive market produces an equilibrium with low price at *E*. When government restricts production, the supply curve is shifted leftward to $S'S'$, moving the equilibrium to E' and raising price to *B*. Confirm that new revenue rectangle $0BE'S'$ is larger than original revenue rectangle $0AEX$—higher revenue being the result of inelastic demand.

Crop Restrictions. In response to falling incomes, farmers have often lobbied the federal government for economic assistance. Over the years, governments at home and abroad have taken many steps to help farmers. They have raised prices through price supports; they have curbed imports through tariffs and quotas; and they sometimes simply sent checks to farmers who agreed *not* to produce on their land.

How can *reducing production* actually *help* farmers? We can use the paradox of the bumper harvest to explain this result. Suppose the government requires every farmer to reduce production. As Figure 4-9 shows, this has the effect of shifting the supply curve up and to the left. Because the demand for food is inelastic, crop restrictions not only raise the price of crops but also tend to raise farmers' total revenues. Just as bumper harvests hurt farmers, crop restrictions raise farm incomes. Of course, consumers are hurt by the crop restrictions and higher prices—just as they would be if a flood or drought created a scarcity of food.

Restrictions on production are a typical example of government interference in individual markets. They often raise the income of one group at the expense of consumers. These policies are generally inefficient: the gain to farmers is less than the harm to consumers.

IMPACT OF A TAX ON PRICE AND QUANTITY

Governments tax a wide variety of commodities—cigarettes, alcohol, imported goods, telephone services, and so on. We are often interested in determining who actually bears the burden of the tax, and here is where supply and demand are essential.

Take the example of gasoline taxes. In 2008, the average tax on gasoline in the United States was around 50 cents per gallon. Many economists and environmentalists advocate much higher gasoline taxes for the United States. They point out that higher taxes would curb consumption, and thereby reduce global warming as well as lower our dependence on insecure foreign sources of oil. Some advocate raising gasoline taxes by $1 or $2 per gallon. What would be the impact of such a change?

For concreteness, suppose that the government decides to discourage oil consumption by levying a gasoline tax of $2 per gallon. Prudent legislators would of course be reluctant to raise gasoline taxes so sharply without a firm understanding of the consequences of such a move. They would want to know the incidence of the tax. *By **incidence** we mean the ultimate economic effect of a tax on the real incomes of producers and consumers.* Just because oil companies write a check for the taxes does not mean that the taxes in fact reduce their profits. By using supply and demand, we can analyze the exact incidence of the tax.

It could be that the burden of the tax is shifted forward to the consumers, which would occur if the retail price of gasoline goes up by the full $2 of the tax. Or perhaps consumers cut back so sharply on gasoline purchases that the burden of the tax is shifted back completely onto the oil companies. Where the actual impact lies between these extremes can be determined only from supply-and-demand analysis.

Figure 4-10 provides the answer. It shows the original pretax equilibrium at *E*, the intersection of the original *SS* and *DD* curves, at a gasoline price of $2 a gallon and total consumption of 100 billion gallons per year. We portray the imposition of a $2 tax in the retail market for gasoline as an upward shift of the supply curve, with the demand curve remaining unchanged. The demand curve does not shift because the quantity demanded at each retail price is unchanged by the gasoline-tax increase. Note that the demand curve for gasoline is relatively inelastic.

By contrast, the supply curve definitely does shift upward by $2. The reason is that producers are willing to sell a given quantity (say, 100 billion gallons) only if they receive the same *net* price as before. That is, at each quantity supplied, the market price must rise by exactly the amount of the tax. If producers had originally been willing to sell 80 billion gallons at $1.80 per gallon, they would still be willing to sell the same amount at a retail price of $3.80 (which, after subtracting the tax, yields the producers the same $1.80 per gallon).

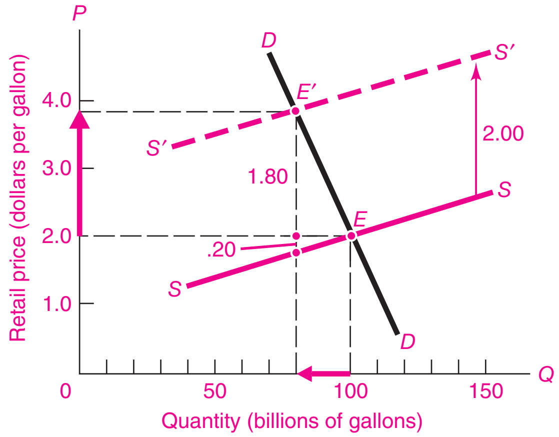


FIGURE 4-10. Gasoline Tax Falls on Both Consumer and Producer

What is the incidence of a tax? A $2 tax on gasoline shifts the supply curve up $2 everywhere, giving a new supply curve, *S′S′*, parallel to the original supply curve, *SS*. This new supply curve intersects *DD* at the new equilibrium, *E′*, where the price to consumers has risen 180 cents and the producers' price has fallen 20 cents. The green arrows show changes in *P* and *Q*. Note that consumers bear most of the burden of the tax.

What is the new equilibrium price? The answer is found at the intersection of the new supply and demand curves at *E′*, where *S′S′* and *DD* meet. Because of the supply shift, the retail price is higher. Also, the quantity supplied and demanded is reduced. If we read the graph carefully, we find that the new equilibrium price has risen from $2 to about $3.80. The new equilibrium output, at which supply and demand are in equilibrium, has fallen from 100 billion to about 80 billion gallons.

Who ultimately pays the tax? What is its incidence? Clearly the oil industry pays a small fraction, for it receives only $1.80 ($3.80 less the $2 tax) rather than $2. But the consumer bears most of the burden, with the retail price rising $1.80, because supply is relatively price-elastic whereas demand is relatively price-inelastic.

Subsidies. If taxes are used to discourage consumption of a commodity, subsidies are used to encourage production. One pervasive example of subsidies comes in agriculture. You can examine the impact of a subsidy in a market by shifting *down* the supply curve. The general rules for subsidies are exactly parallel to those for taxes.

General Rules on Tax Shifting. Gasoline is just a single example of how to analyze tax shifting. Using this apparatus, we can understand how cigarette taxes affect both the prices and the consumption of cigarettes; how taxes or tariffs on imports affect foreign trade; and how property taxes, social security taxes, and corporate-profit taxes affect land prices, wages, and interest rates.

The key issue in determining the incidence of a tax is the relative elasticities of supply and demand. If demand is inelastic relative to supply, as in the case of gasoline, most of the cost is shifted to consumers. By contrast, if supply is inelastic relative to demand, as is the case for land, then most of the tax is shifted to the suppliers. Here is the general rule for determining the incidence of a tax:

The incidence of a tax denotes the impact of the tax on the incomes of producers and consumers. In general, the incidence depends upon the relative elasticities of demand and supply. (1) A tax is shifted *forward* to consumers if the *demand is inelastic* relative to supply. (2) A tax is shifted *backward* to producers if *supply is inelastic* relative to demand.

MINIMUM FLOORS AND MAXIMUM CEILINGS

Sometimes, rather than taxing or subsidizing a commodity, the government legislates maximum or minimum prices. History is full of examples. From biblical days, governments have limited the interest rates that lenders can charge (so-called usury laws). In wartime, governments often impose wage and price controls to prevent spiraling inflation. During the energy crisis of the 1970s, there were controls on gasoline prices. A few large cities, including New York, have rent controls on apartments.[2] Today, there are increasingly stringent limitations on the prices that doctors or hospitals can charge under federal health programs such as Medicare. Sometimes there are price floors, as in the case of the minimum wage.

These kinds of interferences with the laws of supply and demand are genuinely different from those in which the government imposes a tax and then lets the market act through supply and demand. Although political pressures always exist to keep prices down and wages up, experience has taught that sector-by-sector price and wage controls tend to create major economic distortions. Nevertheless, as Adam Smith well knew when he protested against mercantilist policies of an earlier age, most economic systems are plagued by inefficiencies stemming from well-meaning but inexpert interferences with the mechanisms of supply and demand. Setting maximum or minimum prices in a market tends to produce surprising and sometimes perverse economic effects. Let's see why.

Two important examples of government intervention are the minimum wage and price controls on gasoline. These will illustrate the surprising side effects that can arise when governments interfere with market determination of price and quantity.

The Minimum-Wage Controversy

The minimum wage sets a minimum hourly rate that employers are allowed to pay workers. In the United States, the federal minimum wage began in 1938 when the government required that covered workers be paid at least 25 cents an hour. By 1947, the minimum wage was fully 65 percent of the average rate paid to manufacturing workers (see Figure 4-11). The most recent law increased the minimum wage to $7.25 per hour in 2009.

This is an issue that divides even the most eminent economists. For example, Nobel laureate Gary Becker stated flatly, "Hike the minimum wage, and you put people out of work." Another group of Nobel Prize winners countered, "We believe that the federal minimum wage can be increased by a moderate amount without significantly jeopardizing employment opportunities."

How can nonspecialists sort through the issues when the experts are so divided? How can we resolve these apparently contradictory statements? To begin with, we should recognize that statements on the

[2] See question 9 at the end of this chapter for an examination of rent controls.

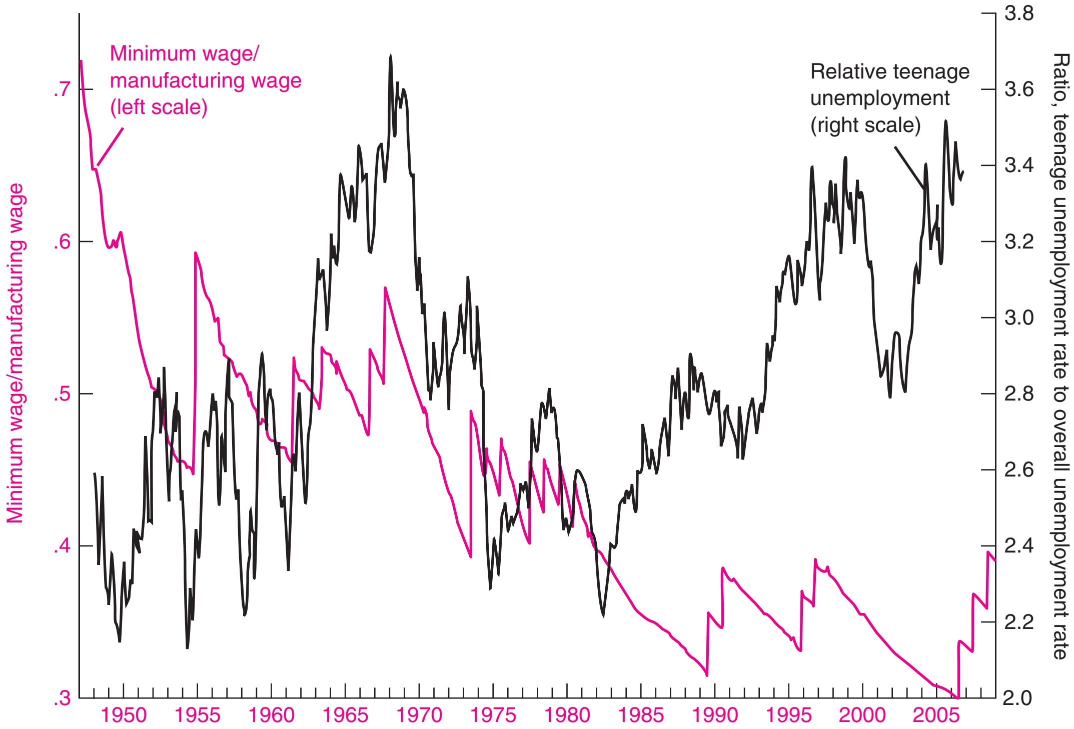


FIGURE 4-11. The Minimum Wage and Teenage Unemployment, 1947–2009

The green line shows the level of the minimum wage relative to average hourly earnings in manufacturing. Note how the minimum wage declined slowly relative to other wages over the last half-century. Additionally, the blue line shows the ratio of teenage unemployment to overall unemployment. Do you see any relationship between the two lines? What does this tell you about the minimum-wage controversy?

Source: Data are from the U.S. Department of Labor. Background on the minimum wage can be found at the Labor Department's website at *www.dol.gov/esa/minwage/q-a.htm*.

desirability of raising the minimum wage contain personal value judgments. Such statements might be informed by the best positive economics and still make different recommendations on important policy issues.

A cool-headed analysis indicates that the minimum-wage debate centers primarily on issues of interpretation rather than fundamental disagreements on empirical findings. Begin by looking at Figure 4-12, which depicts the market for unskilled workers. The figure shows how a minimum wage rate sets a floor for most jobs. As the minimum wage rises above the market-clearing equilibrium at *M,* the total number of jobs moves up the demand curve to *E,* so employment falls. The gap between labor supplied and labor demanded is shown as *U.* This represents the amount of unemployment.

Using supply and demand, we see that there is likely to be a rise in unemployment and a decrease in employment of low-skilled workers. But how large will these magnitudes be? And what will be the impact on the wage income of low-income workers? On these questions, we can look at the empirical evidence.

Most studies indicate that a 10 percent increase in the minimum wage would reduce employment of teenagers by between 1 and 3 percent. The impact on adult employment is even smaller. Some recent studies put the adult employment effects very close to zero, and one set of studies suggests that employment might even increase. So a careful reading of the

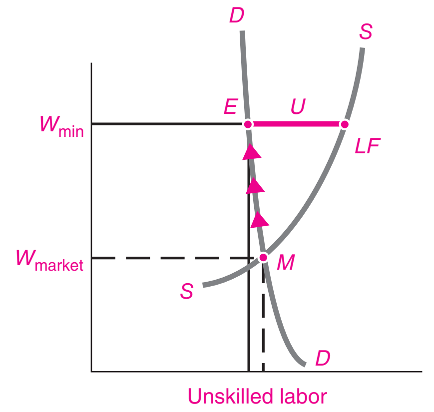


FIGURE 4-12. Effects of a Minimum Wage

Setting the minimum-wage floor at W_{min}, high above the free-market equilibrium rate at W_{market}, results in employment at *E*. Employment is reduced, as the arrows show, from *M* to *E*. Additionally, unemployment is *U*, which is the difference between labor supplied at *LF* and employment at *E*. If the demand curve is inelastic, increasing the minimum wage will increase the income of low-wage workers. To see this, shade in the rectangle of total wages before and after the minimum-wage increase.

quotations from the eminent economists indicates that some economists consider small to be "insignificant" while others emphasize the existence of at least some job losses. Our example in Figure 4-12 shows a case where the *employment* decline (shown as the difference between *M* and *E*) is very small while the *unemployment* caused by the minimum wage (shown by the *U* line) is relatively large.

Figure 4-11 on page 78 shows the history of the minimum wage and teenage unemployment over the last half-century. With the declining power of the labor movement, the ratio of the minimum wage to the manufacturing wage declined from two-thirds in 1947 to around one-third in 2008. There was a slight upward trend in the relative unemployment rate of teenagers over this period. It is worth examining the pattern of changes to see whether you can detect an impact of the minimum wage on teenage unemployment.

Another factor in the debate relates to the impact of the minimum wage on incomes. Virtually every study concludes that the demand for low-wage workers is price-inelastic. The results we just cited indicate that the price elasticity is between 0.1 and 0.3. Given the elasticities just cited, a 10 percent increase in the minimum wage will increase the incomes of the affected groups by 7 to 9 percent. Figure 4-12 shows how the *incomes* of low-income workers rise despite the decline in their *total employment*. This can be seen by comparing the income rectangles under the equilibrium points *E* and *M*. (See question 8*e* at the end of this chapter.)

The impact on incomes is yet another reason why people may disagree about the minimum wage. Those who are particularly concerned about the welfare of low-income groups may feel that modest inefficiencies are a small price to pay for higher incomes. Others—who worry more about the cumulative costs of market interferences or about the impact of higher costs upon prices, profits, and international competitiveness—may hold that the inefficiencies are too high a price. Still others might believe that the minimum wage is an inefficient way to transfer buying power to low-income groups; they would prefer using direct income transfers or government wage subsidies rather than gumming up the wage system. How important are each of these three concerns to you? Depending upon your priorities, you might reach quite different conclusions on the advisability of increasing the minimum wage.

Energy Price Controls

Another example of government interference comes when the government legislates a maximum price ceiling. This occurred in the United States in the 1970s, and the results were sobering. We return to our analysis of the gasoline market to see how price ceilings function.

Let's set the scene. Suppose there is suddenly a sharp rise in oil prices. This has occurred because of reduced cartel supply and booming demand, but it might also come about because of political disturbances in the Middle East due to war or revolution. Figure 3-1 on p. 46 showed the results of the interaction of supply and demand in oil markets.

Politicians, seeing the sudden jump in prices, rise to denounce the situation. They claim that consumers are being "gouged" by profiteering oil companies. They worry that the rising prices threaten to ignite an inflationary spiral in the cost of living. They fret about the impact of rising prices on the poor and the elderly. They call upon the government to "do something." In the face of rising prices, the U.S.

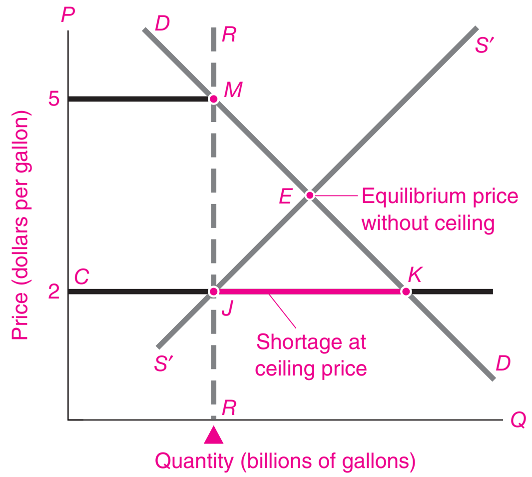


FIGURE 4-13. Price Controls Produce Shortages

Without a legal price ceiling, price would rise to *E*. At the ceiling price of $2, supply and demand do not balance, and shortages break out. Some method of formal or informal rationing is needed to allocate the short supply and bring the actual demand down to supply at *RR*. If *CJ* ration coupons become marketable, this would imply a new supply curve of *RR*. At the ceiling price of $2, coupons would sell for $3, and the total price (coupons plus cash) would be $5.

government might be inclined to listen to these arguments and place a ceiling on oil prices, as it did from 1973 to 1981.

What are the effects of such a ceiling? Suppose the initial price of gasoline is $2 a gallon. Then, because of a drastic cut in oil supply, the market price of gasoline rises sharply. Now consider the gasoline market after the supply shock. In Figure 4-13, the post-shock equilibrium is given at point *E*. If the free market were allowed to operate, the market would clear with a price of perhaps $3.50. Consumers would complain but would willingly pay the higher price rather than go without fuel.

Rationing by the Queue, by Coupons, or by the Purse?

Enter the government, which passes a law setting the maximum price for gasoline at the old level of $2 a gallon. We can picture this legal maximum price as the ceiling-price line *CJK* in Figure 4-13.

At the legal ceiling price, quantities supplied and demanded do not match. The market does not "clear" because it is against the law for sellers to charge the equilibrium price. Consumers want more gasoline than producers are willing to supply at the controlled price. This is shown by the gap between *J* and *K*. There follows a period of frustration and shortage—a game of musical chairs in which somebody is left without gasoline when the pump runs dry.

The inadequate supply of gasoline must somehow be rationed. Initially, this may be done through a first-come, first-served approach. People wait in line—this is rationing by the "queue." Because people's time is valuable, the length of the line will serve as a kind of price that limits demand. We see rationing by the queue today in markets like health care, where the price of medical care is subsidized. This is a wasteful system because much valuable time is spent waiting in line just as a way of preventing prices from reaching equilibrium.

Sometimes, particularly during large wars such as World War II, governments design a more efficient system of nonprice rationing based on formal allocation or coupon rationing. Perhaps people get a gasoline ration that is distributed on the basis of the number of automobiles. Under coupon rationing, each customer must have a coupon as well as money to buy the goods—in effect, there are two kinds of money. When rationing is adopted, shortages disappear because demand is limited by the allocation of the coupons.

Just how do ration coupons change the supply-and-demand picture? In Figure 4-13, suppose the government hands out coupons corresponding to quantity *CJ*. Then, supply and the new demand balance at the ceiling price of $2.

Sometimes, the ration coupons will be marketable. Figure 4-13 shows a supply of coupons of *RR*. With this supply curve, the equilibrium price of gasoline is $5 per gallon, and the price of coupons is given by *JM*, or $3 per gallon. At this point, gasoline is once again a market commodity, where you pay $2 for the gasoline and $3 for a coupon. The price has indeed risen, but in an indirect way. Additionally, people with coupons have been given a new form of income in coupons. Note that because of the price control, quantity supplied is still at the old level, but the total price including coupons ($5) is actually higher than the original equilibrium price without rationing ($3.50).

All of this sounds complicated, and it is. History has shown that legal and illegal evasions of price controls grow over time. The inefficiencies eventually overwhelm whatever favorable impacts the controls might have on consumers. Particularly when there is room for ample substitution (i.e., when elasticities of supply or demand are high), price controls are costly, difficult to administer, and ineffective. Consequently, price controls on most goods are rarely used in most market economies.

There is a profound lesson here: Goods are always scarce. Society can never fulfill everyone's desires. In normal times, price itself rations the scarce supplies. When governments step in to interfere with supply and demand, prices no longer fill the role of rationers. Waste, inefficiency, and aggravation are likely companions of such interferences.

SUMMARY

A. Price Elasticity of Demand and Supply

1. Price elasticity of demand measures the quantitative response of demand to a change in price. Price elasticity of demand (E_D) is defined as the percentage change in quantity demanded divided by the percentage change in price. That is,

$$\text{Price elasticity of demand} = E_D = \frac{\text{percentage change in quantity demanded}}{\text{percentage change in price}}$$

In this calculation, the sign is taken to be positive, and P and Q are averages of old and new values.

2. We divide price elasticities into three categories: (*a*) Demand is elastic when the percentage change in quantity demanded exceeds the percentage change in price; that is, $E_D > 1$. (*b*) Demand is inelastic when the percentage change in quantity demanded is less than the percentage change in price; here, $E_D < 1$. (*c*) When the percentage change in quantity demanded exactly equals the percentage change in price, we have the borderline case of unit-elastic demand, where $E_D = 1$.

3. Price elasticity is a pure number, involving percentages; it should not be confused with slope.

4. The demand elasticity tells us about the impact of a price change on total revenue. A price reduction increases total revenue if demand is elastic; a price reduction decreases total revenue if demand is inelastic; in the unit-elastic case, a price change has no effect on total revenue.

5. Price elasticity of demand tends to be low for necessities like food and shelter and high for luxuries like snowmobiles and vacation air travel. Other factors affecting price elasticity are the extent to which a good has ready substitutes and the length of time that consumers have to adjust to price changes.

6. Price elasticity of supply measures the percentage change of output supplied by producers when the market price changes by a given percentage.

B. Applications to Major Economic Issues

7. One of the most fruitful arenas for application of supply-and-demand analysis is agriculture. Improvements in agricultural technology mean that supply increases greatly, while demand for food rises less than proportionately with income. Hence free-market prices for foodstuffs tend to fall. No wonder governments have adopted a variety of programs, like crop restrictions, to prop up farm incomes.

8. A commodity tax shifts the supply-and-demand equilibrium. The tax's incidence (or impact on incomes) will fall more heavily on consumers than on producers to the degree that the demand is inelastic relative to supply.

9. Governments occasionally interfere with the workings of competitive markets by setting maximum ceilings or minimum floors on prices. In such situations, quantity supplied need no longer equal quantity demanded; ceilings lead to excess demand, while floors lead to excess supply. Sometimes, the interference may raise the incomes of a particular group, as in the case of farmers or low-skilled workers. Often, distortions and inefficiencies result.

CONCEPTS FOR REVIEW

Elasticity Concepts

price elasticity of demand, supply
elastic, inelastic, unit-elastic demand
E_D = % change in Q/% change in P
determinants of elasticity
total revenue = $P \times Q$
relationship of elasticity and revenue change

Applications of Supply and Demand

incidence of a tax
distortions from price controls
rationing by price vs. rationing by the queue

FURTHER READING AND INTERNET WEBSITES

Further Reading

If you have a particular concept you want to review, such as elasticity, you can often look in an encyclopedia of economics, such as John Black, *Oxford Dictionary of Economics,* 2d ed. (Oxford, New York, 2002), or David W. Pearce, ed., *The MIT Dictionary of Modern Economics* (MIT Press, Cambridge, Mass., 1992). The most comprehensive encyclopedia, covering many advanced topics in seven volumes, is Steven N. Durlauf and Lawrence E. Blume, eds., *The New Palgrave Dictionary of Economics* (Macmillan, London, 2008), available in most libraries.

The minimum wage has generated a fierce debate among economists. A recent book by two labor economists presents evidence that the minimum wage has little effect on employment: David Card and Alan Krueger, *Myth and Measurement: The New Economics of the Minimum Wage* (Princeton University Press, Princeton, N.J., 1997).

Websites

There are currently no reliable online dictionaries for terms in economics. There are few good websites for understanding fundamental economic concepts like supply and demand or elasticities. The concise online encyclopedia of economics at *www.econlib.org/library/CEE.html* is generally reliable but covers only a small number of topics. Sometimes, the free site of the *Encyclopaedia Britannica* at *www.britannica.com* provides background or historical material. When all else fails, you can go to the online encyclopedia at *en.wikipedia.org/wiki/Main_Page,* but be warned that it is often unreliable. (For example, the 2008 definition of "price elasticity of demand" is close to incomprehensible.)

Current issues such as the minimum wage are often discussed in policy papers at the website of the Economic Policy Institute, a think tank focusing on economic issues of workers, at *www.epinet.org*.

QUESTIONS FOR DISCUSSION

1. "A good harvest will generally lower the income of farmers." Illustrate this proposition using a supply-and-demand diagram.
2. For each pair of commodities, state which you think is the more price-elastic and give your reasons: perfume and salt; penicillin and ice cream; automobiles and automobile tires; ice cream and chocolate ice cream.
3. "The price drops by 1 percent, causing the quantity demanded to rise by 2 percent. Demand is therefore elastic, with $E_D > 1$." If you change 2 to ½ in the first sentence, what two other changes will be required in the quotation?
4. Consider a competitive market for apartments. What would be the effect on the equilibrium output and price after the following changes (other things held equal)? In each case, explain your answer using supply and demand.
   a. A rise in the income of consumers
   b. A $10-per-month tax on apartment rentals
   c. A government edict saying apartments cannot rent for more than $200 per month
   d. A new construction technique allowing apartments to be built at half the cost
   e. A 20 percent increase in the wages of construction workers
5. Consider a proposal to raise the minimum wage by 10 percent. After reviewing the arguments in the chapter, estimate the impact upon employment and upon

the incomes of affected workers. Using the numbers you have derived, write a short essay explaining how *you* would decide if you had to make a recommendation on the minimum wage.

6. A conservative critic of government programs has written, "Governments know how to do one thing well. They know how to create shortages and surpluses." Explain this quotation using examples like the minimum wage or interest-rate ceilings. Show graphically that if the demand for unskilled workers is price-elastic, a minimum wage will decrease the total earnings (wage times quantity demanded of labor) of unskilled workers.
7. Consider what would happen if a tariff of $2000 were imposed on imported automobiles. Show the impact of this tariff on the supply and the demand, and on the equilibrium price and quantity, of American automobiles. Explain why American auto companies and autoworkers often support import restraints on automobiles.
8. Elasticity problems:
   - **a.** The world demand for crude oil is estimated to have a short-run price elasticity of 0.05. If the initial price of oil were $100 per barrel, what would be the effect on oil price and quantity of an embargo that curbed world oil supply by 5 percent? (For this problem, assume that the oil-supply curve is completely inelastic.)
   - **b.** To show that elasticities are independent of units, refer to Table 3-1. Calculate the elasticities between each demand pair. Change the price units from dollars to pennies; change the quantity units from millions of boxes to tons, using the conversion factor of 10,000 boxes to 1 ton. Then recalculate the elasticities in the first two rows. Explain why you get the same answer.
   - **c.** Jack and Jill went up the hill to a gas station that does not display the prices. Jack says, "Give me $10 worth of gas." Jill says, "Give me 10 gallons of gas." What are the price elasticities of demand for gasoline of Jack and of Jill? Explain.
   - **d.** Can you explain why farmers during a depression might approve of a government program requiring that pigs be killed and buried under the ground?
   - **e.** Look at the impact of the minimum wage shown in Figure 4-12. Draw in the rectangles of total income with and without the minimum wage. Which is larger? Relate the impact of the minimum wage to the price elasticity of demand for unskilled workers.
9. No one likes to pay rent. Yet scarcities of land and urban housing often cause rents to soar in cities. In response to rising rents and hostility toward landlords, governments sometimes impose *rent controls*. These generally limit the increases on rent to a small year-to-year increase and can leave controlled rents far below free-market rents.
   - **a.** Redraw Figure 4-13 to illustrate the impact of rent controls for apartments.
   - **b.** What will be the effect of rent controls on the vacancy rate of apartments?
   - **c.** What nonrent options might arise as a substitute for the higher rents?
   - **d.** Explain the words of a European critic of rent controls: "Except for bombing, nothing is as efficient at destroying a city as rent controls." (*Hint:* What would happen to maintenance?)
10. Review the example of the New Jersey cigarette tax (p. 71). Using graph paper or a computer, draw supply and demand curves that will yield the prices and quantities before and after the tax. (Figure 4-10 shows the example for a gasoline tax.) For this example, assume that the supply curve is perfectly elastic. [*Extra credit:* A demand curve with constant price elasticity takes the form $Y = AP^{-e}$, where Y is quantity demanded, P is price, A is a scaling constant, and e is the (absolute value) of the price elasticity. Solve for the values of A and e which will give the correct demand curve for the prices and quantities in the New Jersey example.]
11. Review the algebra of demand elasticities on p. 69. Then assume that the demand curve takes the following form: $Q = 100 - 2P$.
    - **a.** Calculate the elasticities at $P = 1$, 25, and 49.
    - **b.** Explain why elasticity is different from slope using the formula.