What about the demand for a common product like salt? It is highly inelastic on three counts: Few good substitutes are available; salt is a negligible item in the family budget; and it is a "necessity" rather than a luxury.

Time Generally, product demand is more elastic the longer the time period under consideration. Consumers often need time to adjust to changes in prices. For example, when the price of a product rises, time is needed to find and experiment with other products to see if they are acceptable. Consumers may not immediately reduce their purchases very much when the price of beef rises by 10 percent, but in time they may shift to chicken, pork, or fish.

Another consideration is product durability. Studies show that "short-run" demand for gasoline is more inelastic ($E_d = .2$) than is "long-run" demand ($E_d = .7$). In the short run, people are "stuck" with their present cars and trucks, but with rising gasoline prices they eventually replace them with smaller, more fuel-efficient vehicles. They also switch to mass transit where it is available.

Table 4.3 shows estimated price-elasticity coefficients for a number of products. Each reflects some combination of the elasticity determinants just discussed.

Applications of Price Elasticity of Demand

The concept of price elasticity of demand has great practical significance, as the following examples suggest.

Large Crop Yields The demand for most farm products is highly inelastic; E_d is perhaps .20 or .25. As a result, increases in the supply of farm products arising from a good growing season or from increased productivity tend to depress both the prices of farm products and the total revenues (incomes) of farmers. For farmers as a group, the inelastic demand for their products means that large crop yields may be undesirable. For policymakers it means that achieving the goal of higher total farm income requires that farm output be restricted.

Excise Taxes The government pays attention to elasticity of demand when it selects goods and services on which to levy excise taxes. If a $1 tax is levied on a product and 10,000 units are sold, tax revenue will be $10,000 (= $1 × 10,000 units sold). If the government raises the tax to $1.50 but the higher price that results reduces sales to 4000 because of elastic demand, tax revenue will decline to $6000 (= $1.50 × 4000 units sold). Because a higher tax on a product with elastic demand will bring in less tax revenue, legislatures tend to seek out products that have inelastic demand—such as liquor, gasoline, and cigarettes—when levying excises. In fact, the Federal government, in its effort to reduce the budget deficit, increased taxes on those very categories of goods in 1991.

Decriminalization of Illegal Drugs In recent years proposals to legalize drugs have been widely debated. Proponents contend that drugs should be treated like alcohol; they should be made legal for adults and regulated for purity and potency. The current war on drugs, it is argued, has been unsuccessful, and the associated costs—including enlarged police forces, the construction of more prisons, an overburdened court system, and untold human costs—have increased markedly. Legalization would allegedly reduce drug trafficking significantly by taking the profit out of it. Crack cocaine and heroin, for example, are cheap to produce and could be sold at low prices in legal markets. Because the demand of addicts is highly inelastic, the amounts consumed at the lower prices would increase only modestly. Addicts' total expenditures for cocaine and heroin would decline, and so would the street crime that finances those expenditures.

Opponents of legalization say that the overall demand for cocaine and heroin is far more elastic than proponents think. In addition to the inelastic demand of addicts, there is another market segment whose demand is relatively elastic. This segment consists of the occasional users or "dabblers," who use hard drugs when their prices are low but who abstain or substitute, say, alcohol when their prices are high. Thus, the lower prices associated with the legalization of hard drugs would increase consumption by dabblers. Also, removal of the legal prohibitions against using drugs might make drug use more socially acceptable, increasing the demand for cocaine and heroin.

Many economists predict that the legalization of cocaine and heroin would reduce street prices by up to 60 percent, depending on if and how much they were taxed. According to an important study, price declines of that size would increase the number of occasional users of heroin by 54 percent and the number of occasional users of cocaine by 33 percent. The total quantity of heroin demanded would rise by an estimated 100 percent, and the quantity of cocaine demanded would rise by 50 percent.[1] Moreover, many existing and first-time dabblers might in time become addicts. The overall result, say the opponents of legalization, would be higher social costs, possibly including an increase in street crime.

[1]Henry Saffer and Frank Chaloupka, "The Demand for Illegal Drugs," *Economic Inquiry*, July 1999, pp. 401–411.

QUICK REVIEW 4.1

- The price elasticity of demand coefficient E_d is the ratio of the percentage change in quantity demanded to the percentage change in price. The *averages* of the two prices and two quantities are used as the base references in calculating the percentage changes.
- When E_d is greater than 1, demand is elastic; when E_d is less than 1, demand is inelastic; when E_d is equal to 1, demand is of unit elasticity.
- When price changes, total revenue will change in the opposite direction if demand is price-elastic, in the same direction if demand is price-inelastic, and not at all if demand is unit-elastic.
- Demand is typically elastic in the high-price (low-quantity) range of the demand curve and inelastic in the low-price (high-quantity) range of the demand curve.
- Price elasticity of demand is greater (a) the larger the number of substitutes available; (b) the higher the price of a product relative to one's budget; (c) the greater the extent to which the product is a luxury; and (d) the longer the time period involved.

Price Elasticity of Supply

ORIGIN OF THE IDEA
O 4.2
Price elasticity of supply

The concept of price elasticity also applies to supply. If the quantity supplied by producers is relatively responsive to price changes, supply is elastic. If it is relatively insensitive to price changes, supply is inelastic.

We measure the degree of price elasticity or inelasticity of supply with the coefficient E_s, defined almost like E_d except that we substitute "percentage change in quantity supplied" for "percentage change in quantity demanded":

$$E_s = \frac{\text{percentage change in quantity supplied of product X}}{\text{percentage change in price of product X}}$$

For reasons explained earlier, the averages, or midpoints, of the before and after quantities supplied and the before and after prices are used as reference points for the percentage changes. Suppose an increase in the price of a good from \$4 to \$6 increases the quantity supplied from 10 units to 14 units. The percentage change in price would be $\frac{2}{5}$, or 40 percent, and the percentage change in quantity would be $\frac{4}{12}$, or 33 percent. Consequently,

$$E_s = \frac{.33}{.40} = .83$$

In this case, supply is inelastic because the price-elasticity coefficient is less than 1. If E_s is greater than 1, supply is elastic. If it is equal to 1, supply is unit-elastic. Also, E_s is never negative, since price and quantity supplied are directly related. Thus, there are no minus signs to drop, as was necessary with elasticity of demand.

The degree of **price elasticity of supply** depends on how easily—and therefore quickly—producers can shift resources between alternative uses. The easier and more rapidly producers can shift resources between alternative uses, the greater the price elasticity of supply. Take the case of Christmas trees. A firm's response to, say, an increase in the price of trees depends on its ability to shift resources from the production of other products (whose prices we assume remain constant) to the production of trees. And shifting resource takes time: The longer the time, the greater the "shiftability." So we can expect a greater response, and therefore greater elasticity of supply, the longer a firm has to adjust to a price change.

In analyzing the impact of time on elasticity, economists distinguish among the immediate market period, the short run, and the long run.

Price Elasticity of Supply: The Market Period

The **market period** is the period that occurs when the time immediately after a change in market price is too short for producers to respond with a change in quantity supplied. Suppose the owner of a small farm brings to market one truckload of tomatoes that is the entire season's output. The supply curve for the tomatoes is perfectly inelastic (vertical); the farmer will sell the truckload whether the price is high or low. Why? Because the farmer can offer only one truckload of tomatoes even if the price of tomatoes is much higher than anticipated. The farmer might like to offer more tomatoes, but tomatoes cannot be produced overnight. Another full growing season is needed to respond to a higher-than-expected price by producing more than one truckload. Similarly, because the product is perishable, the farmer cannot withhold it from the market. If the price is lower than anticipated, the farmer will still sell the entire truckload.

The farmer's costs of production, incidentally, will not enter into this decision to sell. Though the price of tomatoes may fall far short of production costs, the farmer will nevertheless sell everything he brought to market to avoid a total loss through spoilage. In the market period, both the supply of tomatoes and the quantity of tomatoes supplied are fixed. The farmer offers only one truckload no matter how high or low the price.

FIGURE 4.4 Time and the elasticity of supply. The greater the amount of time producers have to adjust to a change in demand, here from D_1 to D_2, the greater will be their output response. In the immediate market period (a) there is insufficient time to change output, and so supply is perfectly inelastic. In the short run (b) plant capacity is fixed, but changing the intensity of its use can alter output; supply is therefore more elastic. In the long run (c) all desired adjustments, including changes in plant capacity, can be made, and supply becomes still more elastic.

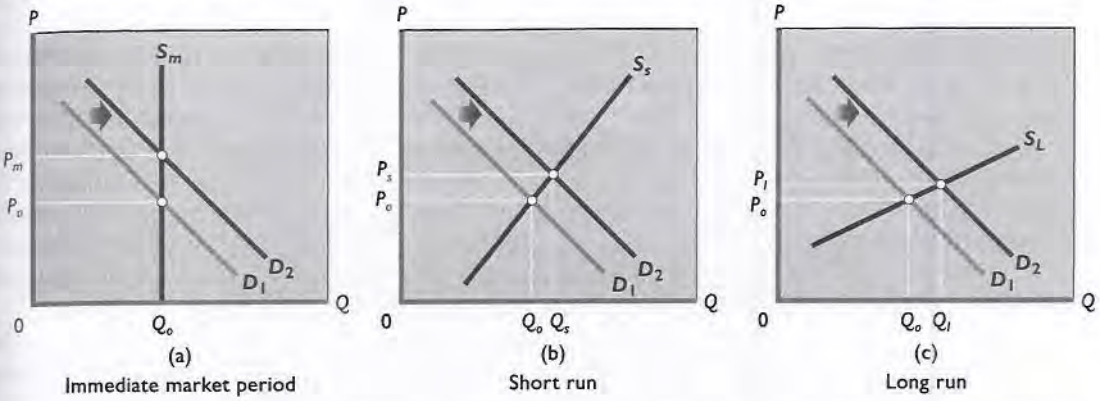


Figure 4.4a shows the farmer's vertical supply curve during the market period. Supply is perfectly inelastic because the farmer does not have time to respond to a change in demand, say, from D_1 to D_2. The resulting price increase from P_0 to P_m simply determines which buyers get the fixed quantity supplied; it elicits no increase in output.

However, not all supply curves are perfectly inelastic immediately after a price change. If the product is not perishable and the price rises, producers may choose to increase quantity supplied by drawing down their inventories of unsold, stored goods. This will cause the market supply curve to attain some positive slope. For our tomato farmer, the market period may be a full growing season; for producers of goods that can be inexpensively stored, there may be no market period at all.

Price Elasticity of Supply: The Short Run

The **short run** in microeconomics is a period of time too short to change plant capacity but long enough to use the fixed-sized plant more or less intensively. In the short run, our farmer's plant (land and farm machinery) is fixed. But he does have time in the short run to cultivate tomatoes more intensively by applying more labor and more fertilizer and pesticides to the crop. The result is a somewhat greater output in response to a presumed increase in demand; this greater output is reflected in a more elastic supply of tomatoes, as shown by S_s in Figure 4.4b. Note now that the increase in demand from D_1 to D_2 is met by an increase in quantity (from Q_0 to Q_s), so there is a smaller price adjustment (from P_0 to P_s) than would be the case in the market period. The equilibrium price is therefore lower in the short run than in the market period.

Price Elasticity of Supply: The Long Run

The **long run** in microeconomics is a time period long enough for firms to adjust their plant sizes and for new firms to enter (or existing firms to leave) the industry. In the "tomato industry," for example, our farmer has time to acquire additional land and buy more machinery and equipment. Furthermore, other farmers may, over time, be attracted to tomato farming by the increased demand and higher price. Such adjustments create a larger supply response, as represented by the more elastic supply curve S_L in Figure 4.4c. The outcome is a smaller price rise (P_0 to P_l) and a larger output increase (Q_0 to Q_l) in response to the increase in demand from D_1 to D_2.

There is no total-revenue test for elasticity of supply. Supply shows a positive or direct relationship between price and amount supplied; the supply curve is upsloping. Regardless of the degree of elasticity or inelasticity, price and total revenue always move together.

Applications of Price Elasticity of Supply

The idea of price elasticity of supply has widespread applicability, as suggested by the following examples.

Antiques and Reproductions

Antiques Roadshow is a popular PBS television program in which people bring antiques to a central location for appraisal by experts. Some people are pleased to learn that their old piece of furniture or funky folk art is worth a large amount, say, $30,000 or more.

The high price of an antique results from strong demand and limited, highly inelastic supply. Because a genuine antique can no longer be reproduced, its quantity

LAST Word Elasticity and Pricing Power: Why Different Consumers Pay Different Prices

Firms and Nonprofit Institutions Often Recognize and Exploit Differences in Price Elasticity of Demand.

All the buyers of a product traded in a highly competitive market pay the same market price for the product, regardless of their individual price elasticities of demand. If the price rises, Jones may have an elastic demand and greatly reduce her purchases. Green may have a unit-elastic demand and reduce his purchases less than Jones. Lopez may have an inelastic demand and hardly curtail his purchases at all. But all three consumers will pay the single higher price regardless of their respective demand elasticities.

In later chapters we will find that not all sellers must passively accept a "one-for-all" price. Some firms have "market power" or "pricing power" that allows them to set their product prices in their best interests. For some goods and services, firms may find it advantageous to determine differences in price elasticity of demand and then charge different prices to different buyers.

It is extremely difficult to tailor prices for each customer on the basis of price elasticity of demand, but it is relatively easy to observe differences in group elasticities. Consider airline tickets. Business travelers generally have inelastic demand for air travel. Because their time is highly valuable, they do not see slower modes of transportation as realistic substitutes. Also, their employers pay for their tickets as part of their business expenses. In contrast, leisure travelers tend to have elastic demand. They have the option to drive rather than fly or to simply not travel at all. They also pay for their tickets out of their own pockets and thus are more sensitive to price.

Airlines recognize the difference between the groups in terms of price elasticity of demand and charge business travelers more than leisure travelers. To accomplish that, they have to dissuade business travelers from buying the less expensive round-trip tickets aimed at leisure travelers. One way to do this is by placing restrictions on the lower-priced tickets. For instance, airlines have at times made such tickets nonrefundable, required at least a 2-week advance purchase, and required Saturday-night stays. These restrictions chase off most business travelers who engage in last-minute travel and want to be home for the weekend. As a result, a business traveler often pays hundreds of dollars more for a ticket than a leisure traveler on the same plane.

supplied either does not rise or rises only slightly as price goes up. The higher price might prompt the discovery of a few more of the remaining originals and thus add to the quantity available for sale, but this quantity response is usually quite small. So the supply of antiques and other collectibles tends to be inelastic. For one-of-a-kind antiques, the supply is perfectly inelastic.

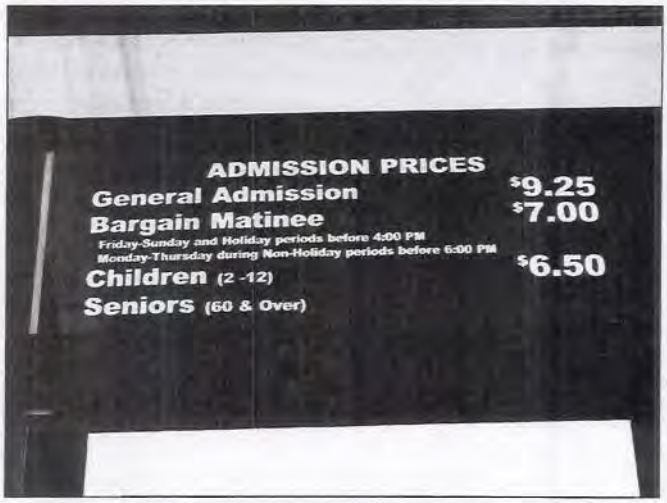
Factors such as increased population, higher income, and greater enthusiasm for collecting antiques have increased the demand for antiques over time. Because the supply of antiques is limited and inelastic, those increases in demand have greatly boosted the prices of antiques.

Contrast the inelastic supply of original antiques with the elastic supply of modern "made-to-look-old" reproductions. Such faux antiques are quite popular and widely available at furniture stores and knickknack shops. When the demand for reproductions increases, the firms making them simply boost production. Because the supply of reproductions is highly elastic, increased demand raises their prices only slightly.

Volatile Gold Prices The price of gold is quite volatile, sometimes shooting upward one period and plummeting downward the next. The main sources of these fluctuations are shifts in demand interacting with highly inelastic supply. Gold production is a costly and time-consuming process of exploration, mining, and refining. Moreover, the physical availability of gold is highly limited. For both reasons, increases in gold prices do not elicit substantial increases in quantity supplied. Conversely, gold mining is costly to shut down and existing gold bars are expensive to store. Price decreases therefore do not produce large drops in the quantity of gold supplied. In short, the supply of gold is inelastic.

The demand for gold is partly derived from the demand for its uses, such as for jewelry, dental fillings, and coins. But people also demand gold as a speculative financial investment. They increase their demand for gold when they fear general inflation or domestic or international turmoil that might undermine the value of currency and more traditional investments. They reduce

Discounts for children are another example of pricing based on group differences in price elasticity of demand. For many products, children have more elastic demands than adults because children have low budgets, often financed by their parents. Sellers recognize the elasticity difference and price accordingly. The barber spends as much time cutting a child's hair as an adult's but charges the child much less. A child takes up a full seat at the baseball game but pays a lower price than an adult. A child snowboarder occupies the same space on a chairlift as an adult snowboarder but qualifies for a discounted lift ticket.



Finally, consider pricing by colleges and universities. Price elasticity of demand for higher education is greater for prospective students from low-income families than similar students from high-income families. This makes sense because tuition is a much larger proportion of household income for a low-income student or family than for his or her high-income counterpart. Desiring a diverse student body, colleges charge different *net* prices (= tuition *minus* financial aid) to the two groups on the basis of price elasticity of demand. High-income students pay full tuition, unless they receive merit-based scholarships. Low-income students receive considerable financial aid in addition to merit-based scholarships and, in effect, pay a lower *net* price.

It is common for colleges to announce a large tuition increase and immediately cushion the news by emphasizing that they also are increasing financial aid. In effect, the college is increasing the tuition for students who have inelastic demand by the full amount and raising the *net* tuition of those with elastic demand by some lesser amount or not at all. Through this strategy, colleges boost revenue to cover rising costs while maintaining affordability for a wide range of students.

There are a number of other examples of dual or multiple pricing. All relate directly to price elasticity of demand. We will revisit this topic again in Chapter 10 when we analyze *price discrimination*—charging different prices to different customers for the same product.

their demand when events settle down. Because of the inelastic supply of gold, even relatively small changes in demand produce relatively large changes in price. (This chapter's Web-based question 1 that is posted online provides an Internet source for finding current and past prices of gold.)

Cross Elasticity and Income Elasticity of Demand

Price elasticities measure the responsiveness of the quantity of a product demanded or supplied when its price changes. The consumption of a good also is affected by a change in the price of a related product or by a change in income.

Cross Elasticity of Demand

The **cross elasticity of demand** measures how sensitive consumer purchases of one product (say, X) are to a change in the price of some other product (say, Y). We calculate the coefficient of cross elasticity of demand E_{xy} just as we do the coefficient of simple price elasticity, except that we relate the percentage change in the consumption of X to the percentage change in the price of Y:

$$E_{xy} = \frac{\text{percentage change in quantity demanded of product X}}{\text{percentage change in price of product Y}}$$

This cross-elasticity (or cross-price-elasticity) concept allows us to quantify and more fully understand substitute and complementary goods, introduced in Chapter 3. Unlike price elasticity, we allow the coefficient of cross elasticity of demand to be either positive or negative.

Substitute Goods If cross elasticity of demand is positive, meaning that sales of X move in the same direction as a change in the price of Y, then X and Y are substitute goods. An example is Evian water (X) and Dasani water (Y). An increase in the price of Evian

causes consumers to buy more Dasani, resulting in a positive cross elasticity. The larger the positive cross-elasticity coefficient, the greater is the substitutability between the two products.

Complementary Goods When cross elasticity is negative, we know that X and Y "go together"; an increase in the price of one decreases the demand for the other. So the two are complementary goods. For example, a decrease in the price of digital cameras will increase the number of memory sticks purchased. The larger the negative cross-elasticity coefficient, the greater is the complementarity between the two goods.

Independent Goods A zero or near-zero cross elasticity suggests that the two products being considered are unrelated or independent goods. An example is walnuts and plums: We would not expect a change in the price of walnuts to have any effect on purchases of plums, and vice versa.

Application The degree of substitutability of products, measured by the cross-elasticity coefficient, is important to businesses and government. For example, suppose that Coca-Cola is considering whether or not to lower the price of its Sprite brand. Not only will it want to know something about the price elasticity of demand for Sprite (will the price cut increase or decrease total revenue?), but it will also be interested in knowing if the increased sales of Sprite will come at the expense of its Coke brand. How sensitive are the sales of one of its products (Coke) to a change in the price of another of its products (Sprite)? By how much will the increased sales of Sprite "cannibalize" the sales of Coke? A low cross elasticity would indicate that Coke and Sprite are weak substitutes for each other and that a lower price for Sprite would have little effect on Coke sales.

Government also implicitly uses the idea of cross elasticity of demand in assessing whether a proposed merger between two large firms will substantially reduce competition and therefore violate the antitrust laws. For example, the cross elasticity between Coke and Pepsi is high, making them strong substitutes for each other. In addition, Coke and Pepsi together sell about 75 percent of all carbonated cola drinks consumed in the United States. Taken together, the high cross elasticities and the large market shares suggest that the government would likely block a merger between Coke and Pepsi because the merger would substantially lessen competition. In contrast, the cross elasticity between cola and gasoline is low or zero. A merger between Coke and Shell oil company would have a minimal effect on competition. So government would let that merger happen.

Income Elasticity of Demand

Income elasticity of demand measures the degree to which consumers respond to a change in their incomes by buying more or less of a particular good. The coefficient of income elasticity of demand E_i is determined with the formula

$$E_i = \frac{\text{percentage change in quantity demanded}}{\text{percentage change in income}}$$

Normal Goods For most goods, the income-elasticity coefficient E_i is positive, meaning that more of them are demanded as incomes rise. Such goods are called normal or superior goods (and were first described in Chapter 3). But the value of E_i varies greatly among normal goods. For example, income elasticity of demand for automobiles is about +3, while income elasticity for most farm products is only about +.20.

Inferior Goods A negative income-elasticity coefficient designates an inferior good. Retread tires, cabbage, long-distance bus tickets, used clothing, and muscatel wine are likely candidates. Consumers decrease their purchases of inferior goods as incomes rise.

Insights Coefficients of income elasticity of demand provide insights into the economy. For example, when

TABLE 4.4 Cross and Income Elasticities of Demand

Value of Coefficient	Description	Type of Good(s)
Cross elasticity:		
Positive ($E_{wz} > 0$)	Quantity demanded of W changes in same direction as change in price of Z	Substitutes
Negative ($E_{xy} < 0$)	Quantity demanded of X changes in opposite direction from change in price of Y	Complements
Income elasticity:		
Positive ($E_i > 0$)	Quantity demanded of the product changes in same direction as change in income	Normal or superior
Negative ($E_i < 0$)	Quantity demanded of the product changes in opposite direction from change in income	Inferior

ns (business downturns) occur and incomes fall, elasticity of demand helps predict which products decline in demand more rapidly than others.

Products with relatively high income elasticity coefficients such as automobiles ($E_i = +3$), housing ($E_i = +1.5$), restaurant meals ($E_i = +1.4$), are generally hit hardest recessions. Those with low or negative income elasticity coefficients are much less affected. For example, food prepared at home ($E_i = +.20$) respond relatively little income fluctuations. When incomes drop, purchases of and toothpaste and toilet paper) drop little compared purchases of movie tickets, luxury vacations, and plasma TVs. Products we view as essential tend to have income elasticity coefficients than products we view luxuries. When our incomes fall, we cannot easily eliminate or postpone the purchase of essential products.

In Table 4.4 we provide a convenient synopsis of the elasticity and income-elasticity concepts.

QUICK REVIEW 4.2

- Price elasticity of supply measures the sensitivity of suppliers to changes in the price of a product. The price-elasticity-of-supply coefficient E_s is the ratio of the percentage change in quantity supplied to the percentage change in price. The elasticity of supply varies directly with the amount of time producers have to respond to the price change.
- The cross-elasticity-of-demand coefficient E_{xy} is computed as the percentage change in the quantity demanded of product X divided by the percentage change in the price of product Y. If the cross-elasticity coefficient is positive, the two products are substitutes; if negative, they are complements.
- The income-elasticity coefficient E_i is computed as the percentage change in quantity demanded divided by the percentage change in income. A positive coefficient indicates a normal or superior good. The coefficient is negative for an inferior good.

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Price elasticity of demand measures consumer response to price changes. If consumers are relatively sensitive to price changes, demand is elastic. If they are relatively unresponsive to price changes, demand is inelastic.

The price-elasticity coefficient E_d measures the degree of elasticity or inelasticity of demand. The coefficient is found by the formula

$$E_d = \frac{\text{percentage change in quantity demanded of X}}{\text{percentage change in price of X}}$$

Economists use the averages of prices and quantities under consideration as reference points in determining percentage changes in price and quantity. If E_d is greater than 1, demand is elastic. If E_d is less than 1, demand is inelastic. Unit elasticity is the special case in which E_d equals 1.

Perfectly inelastic demand is graphed as a line parallel to the vertical axis; perfectly elastic demand is shown by a line above and parallel to the horizontal axis.

Elasticity varies at different price ranges on a demand curve, tending to be elastic in the upper-left segment and inelastic in the lower-right segment. Elasticity cannot be judged by the steepness or flatness of a demand curve.

If total revenue changes in the opposite direction from prices, demand is elastic. If price and total revenue change in the same direction, demand is inelastic. Where demand is of unit elasticity, a change in price leaves total revenue unchanged.

6. The number of available substitutes, the size of an item's price relative to one's budget, whether the product is a luxury or a necessity, and length of time to adjust are all determinants of elasticity of demand.
7. The elasticity concept also applies to supply. The coefficient of price elasticity of supply is found by the formula

$$E_s = \frac{\text{percentage change in quantity supplied of X}}{\text{percentage change in price of X}}$$

The averages of the prices and quantities under consideration are used as reference points for computing percentage changes. Elasticity of supply depends on the ease of shifting resources between alternative uses, which varies directly with the time producers have to adjust to a price change.

8. Cross elasticity of demand indicates how sensitive the purchase of one product is to changes in the price of another product. The coefficient of cross elasticity of demand is found by the formula

$$E_{xy} = \frac{\text{percentage change in quantity demanded of X}}{\text{percentage change in price of Y}}$$

Positive cross elasticity of demand identifies substitute goods; negative cross elasticity identifies complementary goods.