CFA Institute

# ECONOMICS

CFA® Program Curriculum

**2027 • PREREQUISITE READING • VOLUME 1**

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# How to Use the CFA Program Curriculum

The CFA® Program exams measure your mastery of the core knowledge, skills, and abilities required to succeed as an investment professional. These core competencies are the basis for the Candidate Body of Knowledge (CBOK™). The CBOK consists of four components:

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# Economics

LEARNING MODULE

# 1

# Topics in Demand and Supply Analysis

**by Richard V. Eastin, PhD, and Gary L. Arbogast, PhD, CFA.**

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## LEARNING OUTCOMES

| *Mastery* | *The candidate should be able to:* |
|---|---|
| ☐ | calculate and interpret price, income, and cross-price elasticities of demand and describe factors that affect each measure |
| ☐ | compare substitution and income effects |
| ☐ | contrast normal goods with inferior goods |
| ☐ | describe the phenomenon of diminishing marginal returns |
| ☐ | determine and interpret breakeven and shutdown points of production |

## INTRODUCTION



In a general sense, *economics* is the study of production, distribution, and consumption and can be divided into two broad areas of study: macroeconomics and microeconomics. **Macroeconomics** deals with aggregate economic quantities, such as national output and national income, and is rooted in **microeconomics**, which deals with markets and decision making of individual economic units, including consumers and businesses.

Microeconomics classifies private economic units into two groups: consumers (or households) and firms. These two groups give rise, respectively, to the theory of the consumer and the theory of the firm as two branches of study. The *theory of the consumer* deals with consumption (the demand for goods and services) by utility-maximizing individuals (i.e., individuals who make decisions that maximize the satisfaction received from present and future consumption). The *theory of the firm* deals with the supply of goods and services by profit-maximizing firms.

It is expected that candidates will be familiar with the basic concepts of demand and supply. In this reading, we will explore how buyers and sellers interact to determine transaction prices and quantities.

# 2 DEMAND CONCEPTS

☐ calculate and interpret price, income, and cross-price elasticities of demand and describe factors that affect each measure

The fundamental model of the private-enterprise economy is the demand and supply model of the market. In this section, we examine three important topics concerning the demand side of the model: (1) elasticities, (2) substitution and income effects, and (3) normal and inferior goods.

The quantity of a good that consumers are willing to buy depends on a number of different variables. Perhaps the most important of those variables is the item's own price. In general, as the price of a good rises, buyers will choose to buy less of it, and as its price falls, they buy more. This is referred to as the **law of demand**.

Although a good's own price is important in determining consumers' willingness to purchase it, other variables also influence that decision. Consumers' incomes, their tastes and preferences, and the prices of other goods that serve as substitutes or complements are just a few of the other variables that influence consumers' demand for a product or service. Economists attempt to capture all these influences in a relationship called the **demand function**. (A function is a relationship that assigns a unique value to a dependent variable for any given set of values of a group of independent variables.)

Equation 1 is an example of a demand function. In Equation 1, we are saying, "The quantity demanded of good $X$ depends on (is a function of) the price of good $X$, consumers' income, and the price of good $Y$":

$$Q_x^d = f\left(P_x, I, P_y\right) \tag{1}$$

where

$Q_x^d$ = the quantity demanded of some good $X$ (such as per household demand for gasoline in liters per month)

$P_x$ = the price per unit of good $X$ (such as € per liter)

$I$ = consumers' income (as in €1,000s per household annually)

$P_y$ = the price of another good, $Y$. (There can be many other goods, not just one, and they can be complements or substitutes.)

Often, economists use simple linear equations to approximate real-world demand and supply functions in relevant ranges. Equation 2 illustrates a hypothetical example of our function for gasoline demand:

$$Q_x^d = 84.5 - 6.39P_x + 0.25I - 2P_y \tag{2}$$

where the quantity of gasoline demanded $\left(Q_x^d\right)$ is a function of the price of a liter of gasoline ($P_x$), consumers' income in €1,000s ($I$), and the average price of an automobile in €1,000s ($P_y$).

The signs of the coefficients on gasoline price (negative) and consumers' income (positive) reflect the relationship between those variables and the quantity of gasoline consumed. The negative sign on average automobile price indicates that if automobiles go up in price, fewer will likely be purchased and driven; hence, less gasoline will be consumed. As discussed later, such a relationship would indicate that gasoline and automobiles have a negative cross-price elasticity of demand and are thus complements.

To continue our example, suppose that the price of gasoline ($P_x$) is €1.48 per liter, per household income ($I$) is €50,000, and the price of the average automobile ($P_y$) is €20,000. In this case, this function would predict that the per-household monthly demand for gasoline would be 47.54 liters, calculated as follows:

$$Q_x^d = 84.5 - 6.39(1.48) + 0.25(50) - 2(20) = 47.54$$

recalling that income and automobile prices are measured in thousands. Note that the sign on the "own-price" variable ($P_x$) is negative; thus, as the price of gasoline rises, per household consumption would decrease by 6.39 liters per month for every €1 increase in gas price. **Own price** is used by economists to underscore that the reference is to the price of a good itself and not the price of some other good.

In our example, there are three independent variables in the demand function and one dependent variable. If any one of the independent variables changes, so does the quantity demanded. It is often desirable to concentrate on the relationship between the dependent variable and just one of the independent variables at a time. To accomplish this goal, we can hold the other independent variables constant and rewrite the equation.

For example, to concentrate on the relationship between the quantity demanded of the good and its own price, $P_x$, we hold constant the values of income and the price of good $Y$. In our example, those values are 50 and 20, respectively. The equation would then be rewritten as

$$Q_x^d = 84.5 - 6.39P_x + 0.25(50) - 2(20) = 57 - 6.39P_x \quad (3)$$

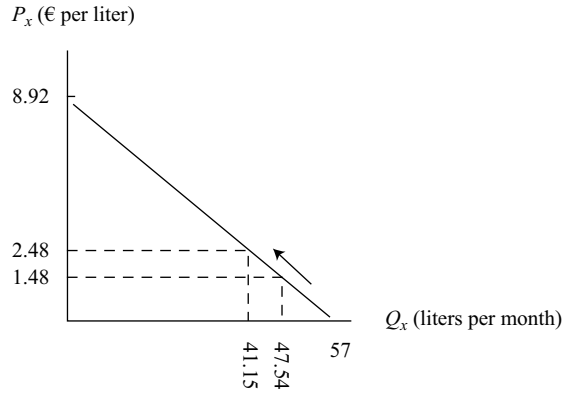
The quantity of gasoline demanded is a function of the price of gasoline ($P_x$ 6.39 per liter), per household income (€50,000), and the average price of an automobile (€20,000). Notice that income and the price of automobiles are not ignored; they are simply held constant, and they are "collected" in the new constant term, 57 [84.5 + (0.25)(50) – (2)(20)]. Notice also that we can solve for $P_x$ in terms of $Q_x^d$ by rearranging Equation 3, which gives us Equation 4:

$$P_x = 8.92 - 0.156\,Q_x^d \quad (4)$$

Equation 4 gives the price of gasoline as a function of the quantity of gasoline consumed per month and is referred to as the **inverse demand function**. $Q_x$ in Equation 4 must be restricted to be less than or equal to 57 so that price is not negative. The graph of the inverse demand function is called the **demand curve** and is shown in Exhibit 1.[1]

1 Following usual practice, we show linear demand curves intersecting the quantity axis at a price of zero. Real-world demand functions may be non-linear in some or all parts of their domain. Thus, linear demand functions in practical cases are approximations of the true demand function that are useful for a relevant range of values.

**Exhibit 1: Household Demand Curve for Gasoline**




The demand curve represents the highest quantity willingly purchased at each price as well as the highest price willingly paid for each quantity. In this example, this household would be willing to purchase 47.54 liters of gasoline per month at a price of €1.48 per liter. If price were to rise to €2.48 per liter, the household would be willing to purchase only 41.15 liters per month.

This demand curve is drawn with price on the vertical ($y$) axis and quantity on the horizontal ($x$) axis. It can be correctly interpreted as specifying *either* the highest quantity a household would buy at a given price *or* the highest price it would be willing to pay for a given quantity. In our example, at a price of €1.48 per liter, households would each be willing to buy 47.54 liters per month. Alternatively, the highest price they would be willing to pay for 47.54 liters per month is €1.48 per liter. If the price were to rise by €1, households would reduce the quantity they each bought by 6.39 units, to 41.15 liters. The slope of the demand curve is measured as the change in price, $P$, divided by the change in quantity, $Q$ ($\Delta P/\Delta Q$, where $\Delta$ stands for "the change in"). In this case, the slope of the demand curve is 1/–6.39, or –0.156.

The general model of demand and supply can be highly useful in understanding directional changes in prices and quantities that result from shifts in one curve or the other. Often, though, we need to measure how sensitive quantity demanded or supplied is to changes in the independent variables that affect them. This is the concept of **elasticity of demand** and **elasticity of supply**. Fundamentally, all elasticities are calculated in the same way: They are ratios of percentage changes. Let us begin with the sensitivity of quantity demanded to changes in the own price.

# 3 PRICE ELASTICITY OF DEMAND

☐ calculate and interpret price, income, and cross-price elasticities of demand and describe factors that affect each measure

In Equation 1, we expressed the quantity demanded of some good as a function of several variables, one of which was the price of the good itself (the good's "own price").

In Equation 3, we introduced a hypothetical household demand function for gasoline, assuming that the household's income and the price of another good (automobiles) were held constant. That function was given by the simple linear expression $Q_x^d = 57 - 6.39P_x$. Using this expression, if we were asked how sensitive the quantity of

gasoline demanded is to changes in price, we might say that whenever price changes by one unit, quantity changes by 6.39 units in the opposite direction; for example, if price were to rise by €1, quantity demanded would fall by 6.39 liters per month. The coefficient on the price variable (–6.39) could be the measure of sensitivity we are seeking.

There is a drawback associated with that measure, however. It is dependent on the units in which we measured $Q$ and $P$. When we want to describe the sensitivity of demand, we need to recall the specific units in which $Q$ and $P$ were measured—liters per month and euros per liter—in our example. This relationship cannot readily be extrapolated to other units of measure—for example, gallons and dollars. Economists, therefore, prefer to use a gauge of sensitivity that does not depend on units of measure. That metric is called **elasticity**. Elasticity is a general measure of how sensitive one variable is to any other variable, and it is expressed as the ratio of percentage changes in each variable: $\%\Delta y/\%\Delta x$. In the case of **own-price elasticity of demand**, that measure is illustrated in Equation 5:

$$E_{p_x}^d = \frac{\%\Delta Q_x^d}{\%\Delta P_x} \tag{5}$$

This equation expresses the sensitivity of the quantity demanded to a change in price. $E_{p_x}^d$ is the good's own-price elasticity and is equal to the percentage change in quantity demanded divided by the percentage change in price. This measure is independent of the units in which quantity and price are measured. If quantity demanded falls by 8% when price rises by 10%, then the elasticity of demand is simply –0.8. It does not matter whether we are measuring quantity in gallons per week or liters per day, and it does not matter whether we measure price in dollars per gallon or euros per liter; 10% is 10%, and 8% is 8%. So the ratio of the first to the second is still –0.8.

We can expand Equation 5 algebraically by noting that the percentage change in any variable $x$ is simply the change in $x$ ($\Delta x$) divided by the level of $x$. So, we can rewrite Equation 5, using a few simple steps, as

$$E_{p_x}^d = \frac{\%\Delta Q_x^d}{\%\Delta P_x} = \frac{\frac{\Delta Q_x^d}{Q_x^d}}{\frac{\Delta P_x}{P_x}} = \left(\frac{\Delta Q_x^d}{\Delta P_x}\right)\left(\frac{P_x}{Q_x^d}\right) \tag{6}$$

To get a better idea of price elasticity, it might be helpful to illustrate using our hypothetical demand function: $Q_x^d = 57 - 6.39P_x$. When the relationship between two variables is linear, $\Delta Q_x^d/\Delta P_x$ is equal to the slope coefficient on $P_x$ in the demand function. Thus, in our example, the elasticity of demand is –6.39 multiplied by the ratio of price to quantity. We need to choose a price at which to calculate the elasticity coefficient. Using our hypothetical original price of €1.48, we can find the quantity associated with that particular price by inserting 1.48 into the demand function as given in Equation 3:

$$Q = 57 - (6.39)(1.48) = 47.54$$

and we find that $Q = 47.54$ liters per month.

The result of our calculation is that at a price of 1.48, the elasticity of our market demand function is –6.39(1.48/47.54) = –0.2. How do we interpret that value? It means, simply, that when price equals 1.48, a 1% rise in price would result in a fall in quantity demanded of 0.2%.

In our example, when the price is €1.48 per liter, demand is not very sensitive to changes in price because a 1% rise in price would reduce quantity demanded by only 0.2%. In this case, we would say that demand is **inelastic**. To be precise, when the magnitude (ignoring algebraic sign) of the own-price elasticity coefficient has a value of less than one, demand is said to be inelastic. When that magnitude is greater than one, demand is said to be **elastic**. And when the elasticity coefficient is equal

to negative one, demand is said to be **unit elastic**, or unitary elastic. Note that if the law of demand holds, own-price elasticity of demand will always be negative because a rise in price will be associated with a fall in quantity demanded, but it can be either elastic (very sensitive to a change in price) or inelastic (insensitive to a change in price). In our hypothetical example, suppose the price of gasoline was very high, say, €5 per liter. In this case, the elasticity coefficient would be –1.28:

$$Q = 57 - (6.39)(5) = 25.05$$

and

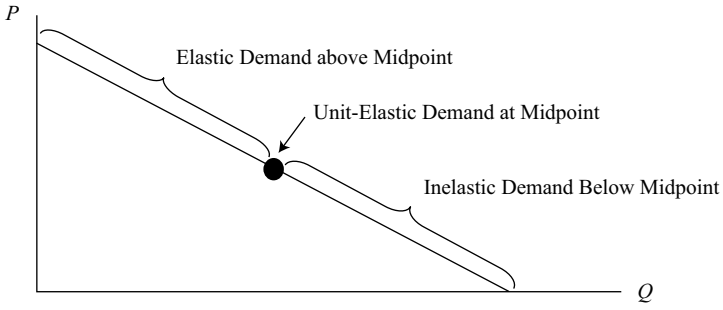
$$-6.39\ (5/25.05) = -1.28$$

Because the magnitude of the elasticity coefficient is greater than one, we know that demand is elastic at that price.[2] In other words, at lower prices (€1.48 per liter), a slight change in the price of gasoline does not have much effect on the quantity demanded, but when gasoline is expensive (€5 per liter), consumer demand for gas is highly affected by changes in price.

- elastic good: the quantity demanded is sensitive to changes in price
- inelastic good: the quantity demanded is not very sensitive to changes in price

By examining Equation 6 more closely, we can see that for a linear demand curve the elasticity depends on where on the curve we calculate it. The first term, $\Delta Q/\Delta P$, which is the inverse of the slope of the demand curve, remains constant along the entire demand curve. But the second term, $P/Q$, changes depending on where we are on the demand curve. At very low prices, $P/Q$ is very small, so demand is inelastic. But at very high prices, $Q$ is low and $P$ is high, so the ratio $P/Q$ is very high and demand is elastic. Exhibit 2 illustrates a characteristic of all negatively sloped linear demand curves. Above the midpoint of the curve, demand is elastic; below the midpoint, demand is inelastic; and at the midpoint, demand is unit elastic.

**Exhibit 2: The Elasticity of a Linear Demand Curve**



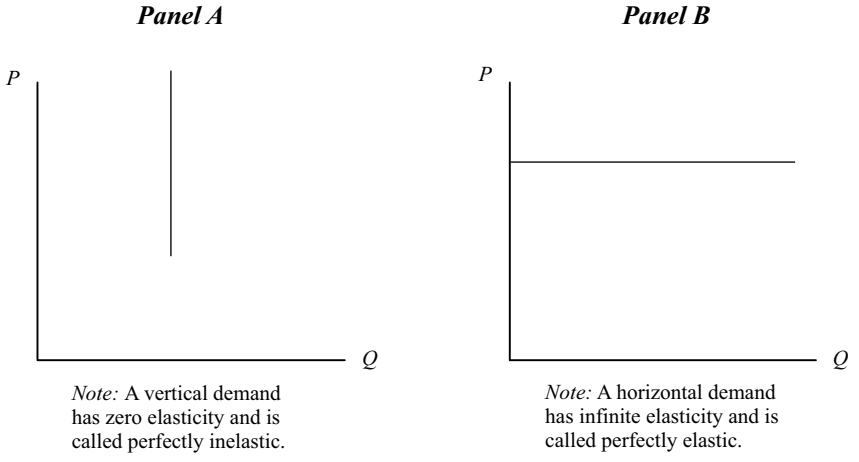

*Note:* For all negatively sloped, linear demand curves, elasticity varies depending on where it is calculated.

2 If interested, evidence on price elasticities of demand for gasoline can be found in Molly Espey, "Explaining the Variation in Elasticity Estimates of Gasoline Demand in the United States: A Meta-analysis," *Energy Journal*, vol. 17, no. 3 (1996): 49–60. The robust estimates were about –0.26 for short-run elasticity—less than one year—and –0.58 for more than a year.

## Extremes of Price Elasticity

There are two special cases in which linear demand curves have the same elasticity at all points: vertical demand curves and horizontal demand curves. Consider a vertical demand curve, as in Panel A of Exhibit 3, and a horizontal demand curve, as in Panel B. In the first case, the quantity demanded is the same, regardless of price. There is no demand curve that is perfectly vertical at all possible prices, but it is reasonable to assume that, over some range of prices, the same quantity would be purchased at a slightly higher price or a slightly lower price. Thus, in that price range, quantity demanded is not at all sensitive to price, and we would say that demand is **perfectly inelastic** in that range.

**Exhibit 3: The Extremes of Price Elasticity**




In the second case, the demand curve is horizontal at some given price. It implies that even a minute price increase will reduce demand to zero, but at that given price, the consumer would buy some large, unknown amount. This situation is a reasonable description of the demand curve facing an individual seller in a perfectly competitive market, such as the wheat market. At the current market price of wheat, an individual farmer could sell all she has. If, however, she held out for a price above market price, it is reasonable to believe that she would not be able to sell any at all; other farmers' wheat is a perfect substitute for hers, so no one would be willing to buy any of hers at a higher price. In this case, we would say that the demand curve facing a seller under conditions of perfect competition is **perfectly elastic**.

# PREDICTING DEMAND ELASTICITY, PRICE ELASTICITY, AND TOTAL EXPENDITURE

# 4

☐ calculate and interpret price, income, and cross-price elasticities of demand and describe factors that affect each measure

Own-price elasticity of demand is a measure of how sensitive the quantity demanded is to changes in the price of a good or service, but what characteristics of a good or its market might be informative in determining whether demand is highly elastic? Perhaps the most important characteristic is whether there are close substitutes for the good in question. If there are close substitutes for the good, then if its price rises even slightly, a consumer would tend to purchase much less of this good and switch to the less costly substitute. If there are no substitutes, however, then it is likely that the demand is much less elastic. Consider a consumer's demand for some broadly defined product, such as bread. There really are no close substitutes for the entire category of bread, which includes all types from French bread to pita bread to tortillas and so on. So, if the price of all bread were to rise, perhaps a consumer would purchase a little less of it each week, but probably not a significantly smaller amount. Now, consider that the consumer's demand is for a particular baker's specialty bread instead of the category "bread" as a whole. Surely, there are close substitutes for Baker Bob's Whole Wheat Bread with Sesame Seeds than for bread in general. We would expect, then, that the demand for Baker Bob's special loaf is much more elastic than for the entire category of bread.

In addition to the degree of substitutability, other characteristics tend to be generally predictive of a good's elasticity of demand. These include the portion of the typical budget that is spent on the good, the amount of time that is allowed to respond to the change in price, the extent to which the good is seen as necessary or optional, and so on. In general, if consumers tend to spend a very small portion of their budget on a good, their demand tends to be less elastic than if they spend a very large part of their income. Most people spend only a little on toothpaste each month, for example, so it really does not matter whether the price rises 10%. They would probably still buy about the same amount. If the price of housing were to rise significantly, however, most households would try to find a way to reduce the quantity they buy, at least in the long run.

This example leads to another characteristic regarding price elasticity. For most goods and services, the long-run demand is much more elastic than the short-run demand. For example, if the price of gasoline rises, we probably would not be able to respond quickly to reduce the quantity we consume. In the short run, we tend to be locked into modes of transportation, housing and employment location, and so on. With a longer adjustment period, however, we can adjust the quantity consumed in response to the change in price by adopting a new mode of transportation or reducing the distance of our commute. Hence, for most goods, long-run elasticity of demand is greater than short-run elasticity. Durable goods, however, tend to behave in the opposite way. If the price of washing machines were to fall, people might react quickly because they have an old machine that they know will need to be replaced fairly soon anyway. So when price falls, they might decide to go ahead and make a purchase. If the price of washing machines were to stay low forever, however, it is unlikely that a typical consumer would buy more machines over a lifetime.

Knowing whether the good or service is seen to be discretionary or non-discretionary helps to understand its sensitivity to a price change. Faced with the same percentage increase in prices, consumers are much more likely to give up their Friday night restaurant meal (discretionary) than they are to cut back significantly on staples in their pantry (non-discretionary). The more a good is seen as being necessary, the less elastic its demand is likely to be.

In summary, own-price elasticity of demand is likely to be greater (i.e., more sensitive) for items that have many close substitutes, occupy a large portion of the total budget, are seen to be optional instead of necessary, or have longer adjustment times. Obviously, not all these characteristics operate in the same direction for all goods, so elasticity is likely to be a complex result of these and other characteristics.

# INCOME ELASTICITY OF DEMAND, CROSS-PRICE ELASTICITY OF DEMAND

5

☐ calculate and interpret price, income, and cross-price elasticities of demand and describe factors that affect each measure

Elasticity is a measure of how sensitive one variable is to change in the value of another variable. Up to this point, we have focused on price elasticity, but the quantity demanded of a good is also a function of consumer income.

Income elasticity of demand is defined as the percentage change in quantity demanded $\left(\%\Delta Q_x^d\right)$ divided by the percentage change in income ($\%\Delta I$), holding all other things constant, as shown in Equation 7:

$$E_I^d = \frac{\%\Delta Q_x^d}{\%\Delta I} \tag{7}$$

The structure of this expression is identical to the structure of own-price elasticity given in Equation 5. (All elasticity measures that we will examine have the same general structure; the only thing that changes is the independent variable of interest.) For example, if the income elasticity of demand for some good has a value of 0.8, we would interpret that to mean that whenever income rises by 1%, the quantity demanded at each price would rise by 0.8%.

Although own-price elasticity of demand will almost always be negative, *income* elasticity of demand can be negative, positive, or zero. Positive income elasticity means that as income rises, quantity demanded also rises. Negative income elasticity of demand means that when people experience a rise in income, they buy less of these goods, and when their income falls, they buy more of the same good.

- normal goods: positive income elasticity
- inferior goods: negative income elasticity

In our discussion of the demand curve, we held all other things constant, including consumer income, to plot the relationship between price and quantity demanded. If income were to change, the entire demand curve would shift one way or the other. For normal goods, a rise in income would shift the entire demand curve upward and to the right. For inferior goods, however, a rise in income would result in a downward and leftward shift in the entire demand curve.

## Cross-Price Elasticity of Demand

We previously discussed a good's own-price elasticity. However, the price of another good might also have an impact on the demand for that good or service, and we should be able to define an elasticity with respect to the other price ($P_y$) as well. That elasticity is called the **cross-price elasticity of demand** and takes on the same structure as own-price elasticity and income elasticity of demand, as represented in Equation 8:

$$E_{P_y}^d = \frac{\%\Delta Q_x^d}{\%\Delta P_y} \tag{8}$$

Note how similar this equation is to the equation for own-price elasticity. The only difference is that the subscript on $P$ is now $y$, where $y$ indicates some other good. This cross-price elasticity of demand measures how sensitive the demand for good $X$ is to changes in the price of some other good, $Y$, holding all other things constant. For some pairs of goods, $X$ and $Y$, when the price of $Y$ rises, more of good $X$ is demanded; the

cross-price elasticity of demand is positive. Those goods are referred to as **substitutes**. In economics, if the cross-price elasticity of two goods is positive, they are substitutes, irrespective of whether someone would consider them "similar."

This concept is intuitive if you think about two goods that are seen to be close substitutes, perhaps like two brands of beer. When the price of one of your favorite brands of beer rises, you would probably buy less of that brand and more of a cheaper brand, so the cross-price elasticity of demand would be positive. For substitute goods, an increase in the price of one good would shift the demand curve for the other good upward and to the right.

Alternatively, two goods whose cross-price elasticity of demand is negative are said to be **complements**. Typically, these goods tend to be consumed together as a pair, such as gasoline and automobiles or houses and furniture. When automobile prices fall, we might expect the quantity of autos demanded to rise, and thus we might expect to see a rise in the demand for gasoline.

Although a conceptual understanding of demand elasticities is helpful in sorting out the qualitative and directional effects among variables, using an empirically estimated demand function can yield insights into the behavior of a market. For illustration, let us return to our hypothetical individual demand function for gasoline in Equation 2, duplicated here for convenience:

$$Q_x^d = 84.5 - 6.39P_x + 0.25I - 2P_y$$

The quantity demanded of a given good $\left(Q_x^d\right)$ is a function of its own price ($P_x$), consumer income ($I$), and the price of another good ($P_y$).

To derive the market demand function, the individual consumers' demand functions are simply added together. If there were 1,000 individuals who represented a market and they all had identical demand functions, the market demand function would be the individual consumer's demand function multiplied by the number of consumers. Using the individual demand function given by Equation 2, the market demand function would be as shown in Equation 9:

$$Q_x^d = 84{,}500 - 6{,}390P_x + 250I - 2{,}000P_y \tag{9}$$

Earlier, when we calculated own-price elasticity of demand, we needed to choose a price at which to calculate the elasticity coefficient. Similarly, we need to choose actual values for the independent variables—$P_x$, $I$, and $P_y$—and insert these values into the "estimated" market demand function to find the quantity demanded. Choosing €1.48 for $P_x$, €50 (in thousands) for $I$, and €20 (in thousands) for $P_y$, we find that the quantity of gasoline demanded is 47,543 liters per month. We now have everything we need to calculate own-price, income, and cross-price elasticities of demand for our market. Those elasticities are expressed in Equation 10, Equation 11, and Equation 12. Each of those expressions has a term denoting the change in quantity divided by the change in each respective variable: own price, $\Delta Q_x/\Delta P_x$; income, $\Delta Q_x/\Delta I$; and cross price, $\Delta Q_x/\Delta P_y$.

As we stated in the discussion of own-price elasticity, when the relationship between two variables is linear, the change in quantity $\left(\Delta Q_x^d\right)$ divided by the change in own price ($\Delta P_x$), income ($\Delta I$), or cross price ($\Delta P_y$) is equal to the slope coefficient on that other variable. The elasticities are calculated by inserting the slope coefficients from Equation 9 into the elasticity formulas.

Own-price elasticity:

$$E_{P_x}^d = \left(\frac{\Delta Q_x^d}{\Delta P_x}\right)\left(\frac{P_x}{Q_x^d}\right) = (-6{,}390)\left(\frac{1.48}{47{,}542.8}\right) = -0.20 \tag{10}$$

Income elasticity:

$$E_I^d = \left(\frac{\Delta Q_x^d}{\Delta I}\right)\left(\frac{I}{Q_x^d}\right) = (250)\left(\frac{50}{47{,}542.8}\right) = 0.26 \tag{11}$$