Chapter 2

Consumer Choice and Demand

2.1 Motives and objectives

Broadly

We study choices by consumers and properties of consumer demand. It is important to understand consumer behavior in order to set the price of your own product or to predict how market prices will evolve due to changing market conditions. Either way, you need information how demand depends on prices and other variables. The analysis of how consumers make choices can help you predict how consumers will respond to price changes that have never before been observed. Alternatively, if the proposed prices are within a range of past prices, then you can estimate demand from past data.

More specifically

This chapter has three parts.

Interpretation of demand functions and demand curves. A demand function is a mathematical formula that relates demand for a good to its determinants, such as the price of the good, prices of other good, income of the consumers, and advertising expenditures. A demand curve describes demand merely as a function of the good's own price. We present some forms of demand functions, we categorize how prices and income affect demand, and we relate demand functions to demand curves.

Elasticity of demand. How responsive is demand to changes in price or other variables? We measure this as percentage changes using *elasticity*.

A model of consumer choice with one good. We then extend the model of consumer behavior developed in Chapters 1A and 1B. In those chapters, each consumer purchases either zero or one unit of an indivisible good. In our extension, the consumer may choose any quantity of the good. We model consumer preferences via total valuation: how much a consumer is willing to pay for each amount of the product, compared to not trading at all. We relate this to marginal valuation, to demand, and to consumer surplus. This model of consumer behavior and demand will be a workhorse for subsequent chapters on competitive, monopolistic, and oligopolistic markets.

2.2 Interpretation of demand functions and curves

Examples of demand functions

The demand for a good depends on many factors besides the price of the good, such as the prices of other goods, advertising expenditures, and seasonal variations. The relationship between demand and these factors is called a *demand function*.

To estimate demand functions, you can use econometric regression on either historical data (demand observed in the past) or data generated by consumer surveys, focus groups, or market experiments. Such estimation involves using a limited amount of data to predict demand in market situations (prices of goods, income, etc.) that have not been observed. To make best use of the limited data, we must start with only a few parameters to estimate. This means:

1. we should focus on only a few prices or other factors that affect demand; and
2. we should restrict attention to a simple parametric relationship between the variables.

The simplest relationship is linear:

$$Y = a_0 + a_1 X_1 + \cdots + a_n X_n,$$

where Y is the dependent variable, $X_1, \dots, X_n$ are the independent variables, and $a_0, a_1, \dots, a_n$ are the parameters we need to estimate. We can use the methods of linear regression (taught in statistics courses) to estimate these parameters.

For example, a 1992 study estimated the demand for Coca-Cola (measured by volume of undiluted syrup) in the United States to be

$$Q_c = 26.17 - 3.98P_c + 2.25P_p + 2.60A_c - 0.62A_p + 9.58S + 0.99I, \tag{2.1}$$

where

$$\begin{aligned} Q_c &= \text{quarterly quantities of syrup sold by Coca-Cola;} \\ P_c, P_p &= \text{syrup prices (1986 dollars) of Coke and Pepsi;} \\ A_c, A_p &= \text{quarterly advertising expenses (1986 dollars) on Coke and Pepsi;} \\ S &= \text{dummy variable, set to 1 if spring or summer and set to 0 otherwise;} \\ I &= \text{real income (1986 dollars).} \end{aligned}$$

This is an approximation, because (a) there are other variables that affect demand for Coke and (b) the relationship between the included variables and demand for Coke is not perfectly linear. These effects were picked up in the error term of the regression. Adding more variables or more parameters to the functional form might seem to give a more accurate description of the market, but it will weaken the empirical estimates we obtain of the coefficients for the other variables.[1]

1. In regression theory, we say that there is a loss of “degrees of freedom”. The goodness of fit (R^2) goes up as we

Also simple are *exponential* functions:

$$Y = a_0 X_1^{a_1} \cdots X_n^{a_n}.$$

Again, $a_0, a_1, \ldots, a_n$ are the parameters we wish to estimate. This is not a linear equation, but we can turn it into one by taking the *logarithm*, which turns multiplication into addition and exponents into multiplication. Thus, we have

$$\log(Y) = \log(a_0) + a_1 \log(X_1) + \cdots + a_n \log(X_n). \tag{2.2}$$

Because there is a linear relationship between the logarithms of the variables, this functional form is also called *log-linear*. By treating the data as $\log(X_1), \ldots, \log(X_n)$ and $\log(Y)$, we can again use the standard methods of linear regression.

Classification of how price and income affect demand

The following terms classify the direction of change in demand for a good in response to a change in other variables. They can be applied to the demand of an individual consumer or the aggregate demand in a market. We group them by the variable that changes.

Own price. Because demand for a good nearly always goes down when its price goes up, there is no special term for this case.

Prices of other goods. If an increase in the price of good B causes the demand for good A to increase, then these goods are *substitutes*. If it causes the demand for good A to decrease, then they are *complements*.

Income. If an increase in income causes demand to fall, then the good is *inferior*. Otherwise, it is *normal*. If expenditure on the good increases at a faster rate than income (i.e., if as income rises the percentage of income spent on the good rises), then the good is a *luxury* good. (Luxury goods are a subcategory of normal goods.)

Exercise 2.1. Consider the U.S. demand Q for minivans (measured in hundred thousands of units) as a function of the price P of minivans (measured in thousands of dollars), the price P_s of station wagons (measured in thousands of dollars), the price P_g of gasoline (measured in dollars), and per-capita income I (measured in thousands of dollars). Suppose the demand function is linear, as follows:

$$Q = 12 - 0.6P + 0.2P_s - 3P_g + 0.2I. \tag{E2.1}$$

Based on the form of this demand function (instead of on your prior knowledge about the minivan market), answer the following questions.

a. Are minivans normal goods?

add more explanatory variables, but the accuracy of the estimates of the coefficients for the explanatory variables eventually goes down.

b. Are minivans and station wagons substitutes or complements?

c. Are minivans and gasoline substitutes or complements?

Demand as a function of a single variable

When working analytically with demand, it helps to focus on the relationship between demand and a single explanatory (independent) variable. To illustrate how we go from a multi-variable demand function to a single-variable function, let's start with the hypothetical demand function for minivans that was presented in Exercise 2.1:

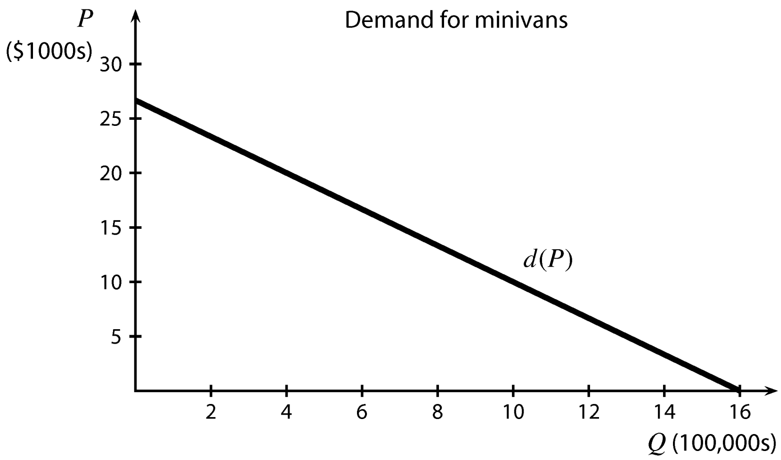
$$Q = 12 - 0.6P + 0.2P_s - 3P_g + 0.2I.$$

Suppose we want to focus on the relationship between demand for minivans and their own price P. This relationship depends on the values of the other variables. If the price of station wagons is \$15K, the gallon price of gasoline is \$1, and per-capita income is \$20K, then we have

$$\begin{aligned} Q &= 12 - 0.6P + (0.2 \times 15) - (3 \times 1) + (0.2 \times 20) \\ &= 16 - 0.6P. \end{aligned}$$

The relationship between demand for a good and the good's price—keeping other variables fixed—is called the good's *demand curve*. We typically use the symbol $d(P)$ and graph demand curves with price on the vertical axis. Figure 2.1 shows the demand curve $Q = 16 - 0.6P$.

Figure 2.1

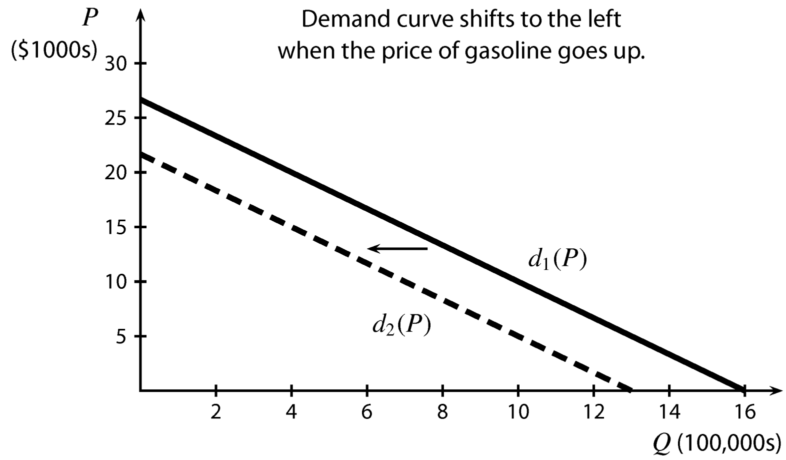


When working with demand curves instead of demand functions, we have to distinguish between a *movement along the demand curve*, meaning that demand changes because of a change in the good's own price, and a *shift in the demand curve*, meaning that the demand curve changes because of a change in some other variable that affects demand.

For example, if the price of gasoline rises from \$1 to \$2, then the demand curve becomes

$Q = 13 - 0.6P$. In the graph, it shifts to the *left* by 3 units because 3 fewer units are consumed at each price. The new demand curve $d_2(P)$ is drawn as a dashed line in Figure 2.2.

Figure 2.2



If instead we write demand as a function only of income, then we obtain the good's *Engel curve*. If the price of minivans is $22K, the price of station wagons is $15K, and the gallon price of gasoline is $1, then the Engel curve is

$$\begin{aligned} Q &= 12 - (0.6 \times 22) + (0.2 \times 15) - (3 \times 1) + 0.2I \\ &= -1.2 + 0.2I. \end{aligned}$$

Exercise 2.2. Consider the demand function for minivans shown in equation (E2.1) of Exercise 2.1.

a. What is the demand curve when the price of station wagons is $16K, the price of gasoline is $3 per gallon, and per-capita income is $25K?

b. What is the Engel curve when the price of minivans is $18K, the price of station wagons is $16K, and the price of gasoline is $2 per gallon?

Exercise 2.3. Indicate whether each of the following factors will increase or decrease demand for the Peugeot 206, a subcompact sold in Europe, at any price charged by Peugeot, thereby shifting the demand curve to the right or the left.

a. A trade journal does a cover story favorable to the 206.

b. Peugeot lowers the price of the 206.

c. Automobile workers win a wage increase.

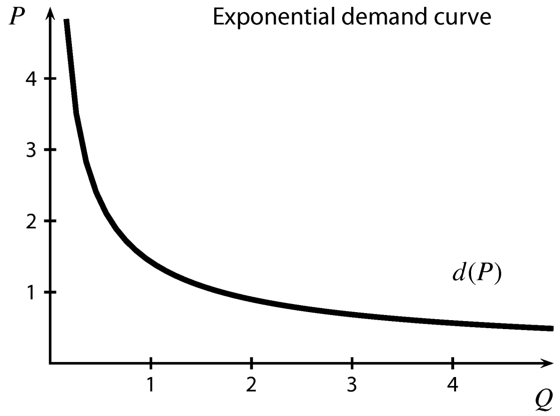
d. The European Commission reduces the imports of Japanese subcompacts into Europe.

Linear and exponential demand curves

The general form of a linear demand curve is $Q = A - BP$, where A and B are positive numbers. Demand is zero at the price $\bar{P} = A/B$; we call $\bar{P}$ the *choke price*. It is the vertical intercept of the demand curve. For example, Figure 2.1 shows the demand curve $Q = 16 - 0.6P$. The choke price is $16/0.6 = 26.67$.

We write an exponential demand curve as $Q = AP^{-B}$, where A and B are positive numbers. The log-linear form is $\log Q = \log(A) - B\log(P)$. Figure 2.3 shows the demand curve $Q = 1.7P^{-1.5}$.

Figure 2.3



2.3 Elasticity of demand

Overview

Here are some cases in which sensitivity of demand is important:

1. For a firm with market power, its optimal price depends on the price sensitivity of the demand for its good. For example, the benefit of raising its price depends on how abruptly demand would fall.
2. The impact of a tax on the competitive equilibrium price—and also the tax revenue generated and the deadweight loss—depend on the price sensitivity of demand and supply.
3. If a supply curve shifts, perhaps because of change in technology, the effect on the price depends on the price sensitivity of demand.

In particular, price sensitivity will be a very important concept during our study of pricing by a monopolist or imperfectly competitive firms.

You might expect to measure price sensitivity by the slope of a demand curve. However, a more useful measure of the sensitivity of a dependent variable Y to an independent variable

X is, for many applications, *elasticity*: the *percentage* change in Y divided by the *percentage* change in X. This is true for all the applications of price sensitivity described above.

Thus, we measure the responsiveness of demand to changes in a good's own price by the *(own-price) elasticity of demand*, which we denote by E.

$$E = -\frac{\%\text{ change in } Q}{\%\text{ change in } P}. \tag{2.3}$$

Since the change in demand goes in the opposite direction of the change in price, we have inserted a negative sign to make sure that elasticity is a positive number (and that a higher number means more responsive demand). This makes it much easier to discuss elasticity. (This convention is common practice among economists in discourse and some textbooks. However, for the formal definition of elasticity and in some other textbooks, elasticity of demand is a negative number.)

Own-price elasticity and a motivating example

By the end of this book, you will surely be convinced that elasticity is an important concept. In the meantime, I need to motivate you to learn about it in this section. In particular, why not measure sensitivity by slope?

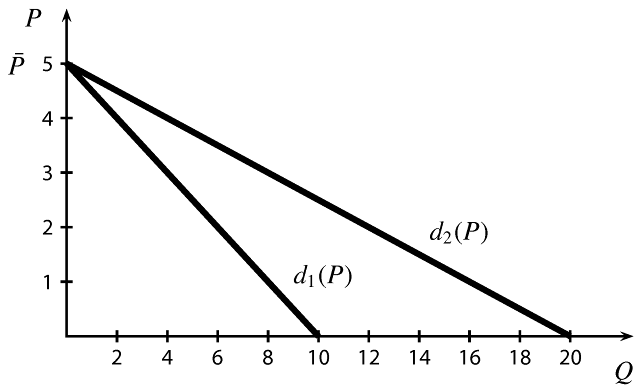
One advantage of elasticity is that it is "unit free". A percentage change is the same whether we measure quantity in liters or gallons or whether we measure price in euros or bahts, whereas any such change in units would change the slope of a demand curve.

However, this is a technicality. The big reason is that elasticity gives us the right answers. Here is one example, from Chapter 7.

The following statement is intuitive: "Consider a firm that can segment its market. The firm should charge a higher price in the market segment in which demand is less price sensitive." We will see that this statement is correct if we measure price sensitivity by elasticity. It is false if we measure it by slope.

For example, consider Figure 2.4, which shows two demand curves d_1 and d_2. Suppose these are the demand curves of a firm's two market segments.

Figure 2.4



Demand curve d_1 has a lower slope than d_2. (Beware: the steeper demand curve has a lower slope because we graphed the independent variable on the vertical axis.) Therefore, if we use slope as a measure of price sensitivity, we would predict that the firm would charge a higher price in the segment with demand curve d_1. We would be wrong! (Alternatively, we might predict a higher price for demand curve d_2 because the quantity demanded is higher. We would again be wrong.) These two demand curves have the same elasticity (comparing elasticities at the same price) and the firm should charge the same price in both market segments!

We can see why the two demand curves d_1 and d_2 in Figure 2.4 have the same elasticity. Observe that $d_2(P) = 2d_1(P)$. Consider a particular change in price. The change in demand is twice as high for d_2 as for d_1. But the baseline level of demand is also twice as high; hence, the percentage change is the same.

Before any more applications, w need to get a good understanding of the "mathematics" of elasticity. This we do in the next few sections. We begin by making the intuitive formula in equation (2.3) more precise.

Discrete changes: Arc elasticity

Elasticity varies along a demand curve; that is, the responsiveness of demand to a change in price depends on the initial price that is being charged. Furthermore, quantitatively it measures responses to small changes in price. We say therefore that elasticity is a *local* property of demand. This introduces a few technical issues when translating the intuitive equation (2.3) into specific formulas.

Consider first the elasticity that we measure based on a discrete change in the price level. Suppose that the price changes from P_1 to P_2 and that demand changes from Q_1 to Q_2 as a result. We end up with different numbers for the elasticity depending on whether we measure changes as percentages of the initial or of the final values. Which price level should we treat as the status quo?

We give the two points equal status by measuring changes as percentages of the averages of the initial and final values. This yields the formula

$$E = -\ \frac{Q_2 - Q_1}{\frac{1}{2}(Q_1 + Q_2)} \bigg/ \frac{P_2 - P_1}{\frac{1}{2}(P_1 + P_2)},$$

which is called the *arc elasticity* between the points (P_1, Q_1) and (P_2, Q_2) on the demand curve.

Example 2.1 Suppose the demand function is

$$Q = 16 - 0.6P.$$

Suppose the price is initially \$20K and hence demand is 4. Suppose the price increases to \$20.2K and hence demand falls to 3.88. Then the arc elasticity is

$$\frac{0.12}{\frac{1}{2}(4 + 3.88)} \bigg/ \frac{0.2}{\frac{1}{2}(20 + 20.2)} = 3.06.$$

Smooth changes: Point elasticity

If the demand function is smooth, then we have a nice definition of the elasticity at a point on the demand curve:

$$E = -\frac{dQ}{dP}\,\frac{P}{Q}.$$

This is called the *point elasticity*. The slope dQ/dP is "normalized" by multiplying by P/Q (and by -1 so that it is positive). The point elasticity is approximately equal to the arc elasticity for small price changes.

Point elasticity is a local measure: When you use it to predict a change in demand due to a discrete change in price, your answer will only be approximate—but with the percentage error going to zero as the size of the price change gets smaller. (With linear demand, it ends up perfectly accurate, but this is unusual.)

Example 2.2 In Example 2.1, the demand curve is $Q = 16 - 0.6P$. Let's calculate the point elasticity at $P = \$20$ and $Q = 4$. The slope dQ/dP of the demand curve is -0.6. Hence, the point elasticity is

$$E = 0.6\,\frac{20}{4} = 3.$$

A taxonomy of elasticities

Elasticity can range from 0 to ∞ (the symbol for infinity). We have the following terminology for the different values of the elasticity.

Table 2.1

We say demand is …	if …
perfectly inelastic	$E = 0$
inelastic	$E < 1$
unit elastic	$E = 1$
elastic	$E > 1$
perfectly elastic	$E = \infty$

Elasticity with respect to other parameters

It is possible to measure how demand responds to changes in other parameters, such as income and prices of other goods. For example, the responsiveness to changes in the price P_s of another good is measured by

$$\frac{\%\text{ change in } Q}{\%\text{ change in } P_s}.$$

This is called the *cross-price elasticity of demand*. Cross-price elasticity is positive if the two goods are substitutes and is negative if the two goods are complements.

The responsiveness to changes in income is measured by

$$\frac{\%\text{ change in } Q}{\%\text{ change in } I}$$

and is called the *income elasticity of demand*. It is positive if the good is normal; it is negative if the good is inferior.

The elasticity with respect to changes in the good's own price is called the *own-price elasticity of demand*, when it is necessary to distinguish it from these other elasticities. In this text, we make use mainly of own-price elasticity of demand and so refer to it simply as the elasticity of demand.

2.4 Elasticity of special demand curves

Elasticity of linear demand curves

The slope of a linear demand curve $Q = A - BP$ is $dQ/dP = -B$. Thus, point elasticity when the price is P equals

$$E = -\frac{dQ}{dP}\frac{P}{Q} = B\frac{P}{A - BP} = \frac{P}{A/B - P} = \frac{P}{\bar{P} - P}.$$

Thus, elasticity at a given price depends on the parameters A and B of the demand function only through their ratio A/B, which is the choke price $\bar{P}$.

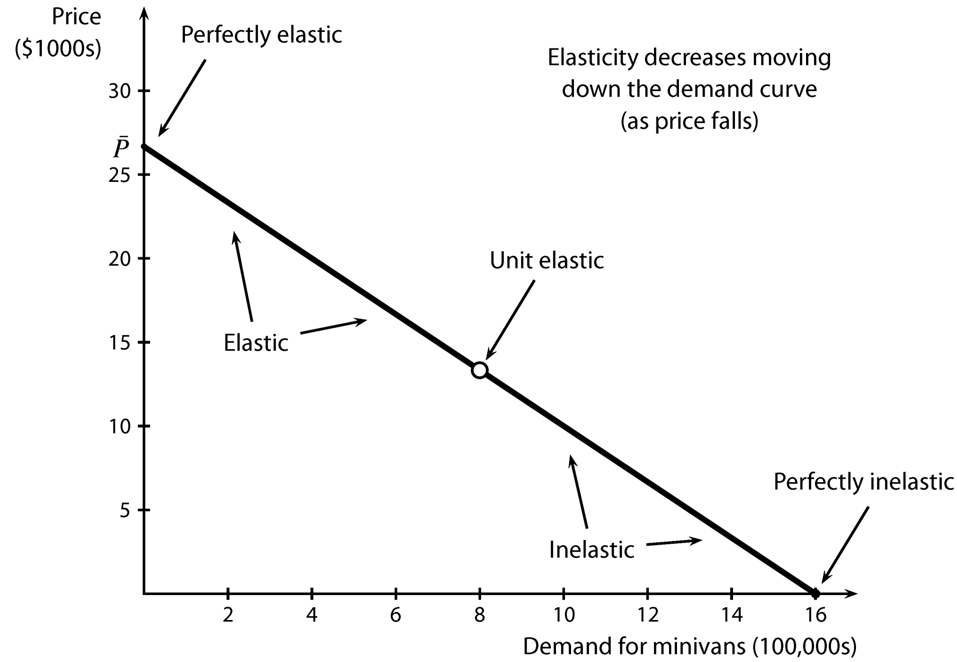
Observe that demand becomes less elastic as the price falls. In fact, if the price is close to zero then the elasticity is close to zero, whereas elasticity of demand increases without bound as P approaches the choke price $\bar{P}$. Demand has unit elasticity when $P/(\bar{P} - P) = 1$, that is, when $P = \bar{P}/2$.

Example 2.3 Recall our linear demand curve for minivans:

$$Q = 16 - 0.6P.$$

The choke price is $\bar{P} = 16/0.6 = 26.67$, so demand has unit elasticity when $P = 13.33$. Figure 2.5 shows the demand curve and labels the regions of elastic, unit elastic, and inelastic demand.

Figure 2.5



Exercise 2.4. A market research study revealed that the market demand function for home exercise equipment is

$$Q = 2400 - 2P - 15P_v,$$

where P is the price of exercise equipment and P_v is the price of exercise videos. The current price of exercise equipment is 300 and the current price of exercise videos is 20.

a. Given these prices, calculate the own-price elasticity of demand for exercise equipment.

b. Are exercise videos and exercise equipment complements or substitutes?

c. Suppose the price of exercise videos increases to 40. Does the own-price elasticity of demand increase or decrease?

Constant-elasticity demand curves

For an exponential demand curve $Q = A\,P^{-B}$, elasticity equals B everywhere on the demand curve. Hence, a third name for exponential or log-linear demand curves is *constant-elasticity* demand curves.

Linear demand versus constant-elasticity demand

Linear demand functions and exponential demand functions are the simplest classes of demand functions. Neither is a true representation of real world demand functions (which are too complicated to work with or measure exactly) but each is a useful approximation. One might say that linear functions are too straight and exponential functions are too curved, with the curvature of real-world demand functions lying between the two.

We can now see for what purposes each form is useful.

Linear demand: for simple graphical and algebraic illustrations. A linear demand curve is easy to draw and work with. Furthermore, it has the property that demand becomes more elastic moving up the demand curve, which holds in the real world and is important for certain qualitative conclusions pursued in this book.

Exponential demand: for empirical estimation. One cannot accurately estimate an entire demand curve—instead, the goal is to get a good local estimate in the region of the data used for the estimation. Furthermore, one is typically interested in estimating the elasticity of demand (you will see why in subsequent applications of elasticity). This is best done using an exponential demand function in its log-linear form. When you estimate the linear regression equation

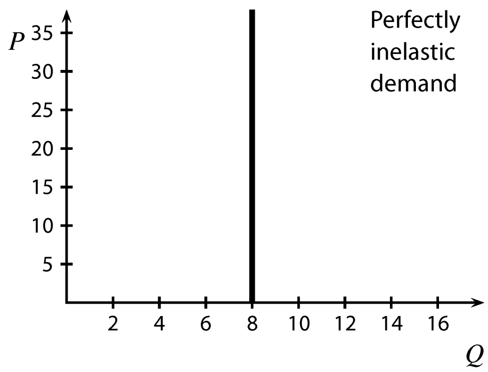
$$\log(Q) = \log(A) - B\log(P),$$

the coefficient B is simply the elasticity.

Perfectly inelastic and elastic demand

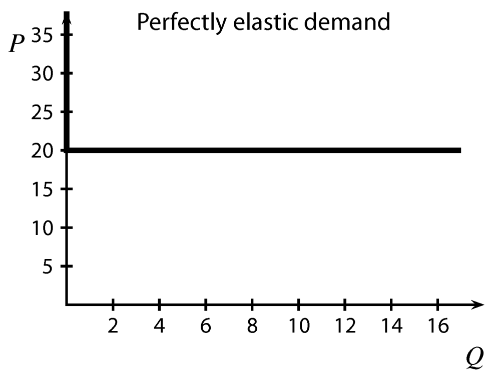
Sometimes demand is very inelastic. We can be approximate such inelastic demand by the limiting case of a *perfectly inelastic* demand curve: demand is the same no matter what price is charged, so the demand curve is a vertical line. Figure 2.6 shows an example.

Figure 2.6



In the other extreme, demand may be very elastic. There is a price P such that (a) when the price is a little higher than P, demand drops off quickly; and (b) when it is little below P, demand rises quickly. It can be useful to approximate such elastic demand by the limiting case in which demand is zero when the price is higher than P, is infinite when the price is below P, and is any amount when the price equals P. The demand curve is a horizontal line at P. Such a demand curve is *perfectly elastic*. Figure 2.7 shows an example.

Figure 2.7



2.5 A model of consumer choice and welfare

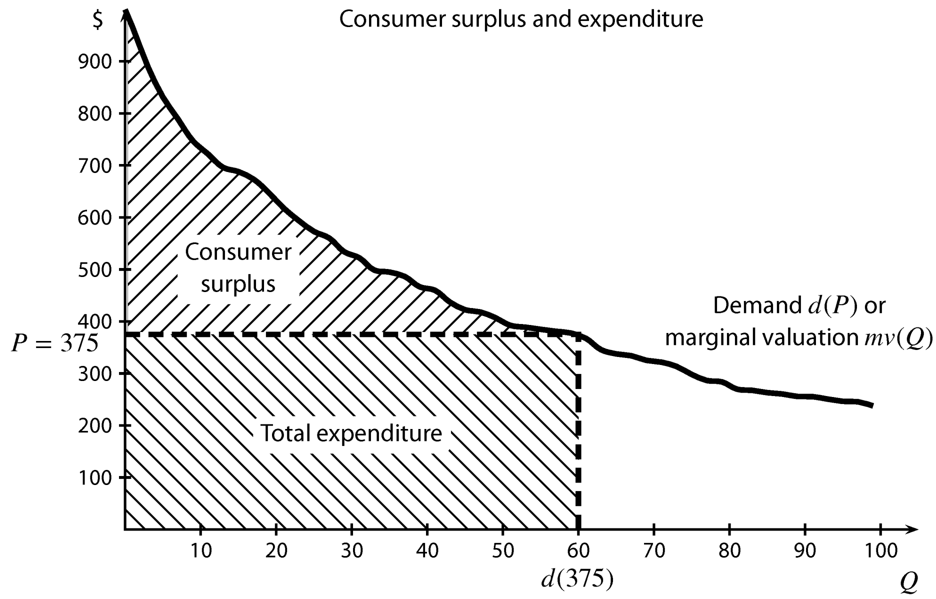
We have analyzed the properties of demand functions. Now we study the consumer behavior that lies behind these demand functions. We limit ourselves to a simple but powerful model in which a consumer chooses quantities of a single good, depending on the price of that good. We keep other prices fixed. The purpose is twofold: (a) to be able to evaluate the gains from trade realized in markets; and (b) to have a model that will work for fancy pricing strategies by firm, for which a demand curve does not summarize what the firm needs to know about the buyers.

As you read this section, it should look similar to the model of valuation and demand in Chapters 1A and 1B. Analytically, the following models are the same:

(a) many consumers, each of whom buys one unit;
(b) one consumer, who may buy any number of units; and
(c) many consumers, each of whom can buy any number of units.

You already studied (a), and so models (b) and (c) presented in this section contain little that is new other than their interpretation. In particular, in all cases the following familiar picture is valid:

Figure 2.8



This picture illustrates the following points:

1. The inverse of the demand curve is the marginal valuation curve of the consumer or consumers, and vice-versa.
2. When graphed with price on the vertical axis, the area under the demand curve (i.e., marginal valuation curve) up to a quantity Q is equal to the total valuation of the consumer or consumers who receive the Q units.
3. Total consumer surplus at price P equals the area between the horizontal line at P and the demand curve.

A consumer's valuation and demand

For each quantity Q that the consumer might purchase, we can define the valuation $v(Q)$ for this quantity in the same way as we defined the valuation of a single unit. That is, $v(Q)$ is the maximum amount the consumer would pay for Q units if the alternative is to buy none of this good. The difference between his valuation for Q and the amount he spends on Q is his *consumer surplus*. It measures the consumer's gain from the trade compared to not trading at all.

We assume that the consumer ranks the possible quantities by their consumer surplus. The consumer's decision is analogous to a firm's output decision. Whereas the firm chooses how much to produce and sell based on trade-offs between revenue and cost, the consumer chooses how much to demand based on trade-offs between valuation and expenditure.

Marginal valuation $mv(Q)$ is the extra amount the consumer would pay to have Q units instead of $Q-1$ units (or, in the smooth case, it is the extra amount per-unit that the consumer would pay to increase consumption by a small amount). It is typically the case that marginal valuation is decreasing. The marginal condition for maximizing surplus is that the marginal valuation equal the marginal expenditure.

The marginal expenditure as consumption rises is just the price P of the good. Thus, the marginal condition is $mv(Q) = P$: the consumers buys up to the point that his marginal valuation equals the price. (If instead $MV > P$, he can increase his surplus by consuming a little more; if $MV < P$, he can increase his surplus by consuming a little less.) Therefore, to find the demand curve, we solve the equation $mv(Q) = P$ for Q. This means that the demand curve is the inverse of the marginal valuation curve.

For example, suppose a consumer's valuation curve is $v(Q) = 6Q^{1/2}$. Then his marginal valuation is $mv(Q) = 3Q^{-1/2} = 3/Q^{1/2}$. We solve $mv(Q) = P$ for Q to obtain the demand curve:

$$\begin{aligned} 3/Q^{1/2} &= P \\ 3/P &= Q^{1/2} \\ Q &= 9/P^2. \end{aligned}$$

From individual demand to market demand

Consider now a market with many consumers. The demand at a price P is just the total demand of all consumers at this price. This aggregate or market demand curve can be used in the same way as individual demand curves to measure total valuation, marginal valuation, and consumer surplus, as follows.

1. *The inverse of the aggregate demand curve is the marginal valuation curve of the consumers*: At a given price, all consumers choose a quantity that equates their marginal valuation to this price.
2. *The area under the aggregate demand curve up to a quantity Q is equal to the collective total valuation of the consumers*: Suppose we distribute Q efficiently among the consumers—so that their marginal valuations are equal—and suppose we then sum the consumers' valuations of their allocated amounts. This total valuation of Q is then equal to the area under the demand curve.

3. *Total consumer surplus is equal to the area between the horizontal line at P and the demand curve:* Total consumer surplus when the price is P is equal to total valuation (area under the demand curve, as noted above) minus the total expenditure (area under the horizontal line at P up to its intersection with the demand curve).

2.6 Wrap-up

This chapter had three main objectives. First, we considered how to interpret demand functions and we categorized how prices and income affect demand. Second, we introduced a measure of the sensitivity of demand, called elasticity. Third, we developed a model of consumer behavior in which the consumer decides how much of a single good to consume given a per-unit price.

Additional exercises

Exercise 2.5. What will be the effect (increase or decrease) of the following events on the demand for French wine? Be sure to distinguish between shifts of the demand curve and movements along the curve.

a. A decrease in the price of French wine.

b. A new study linking longevity with moderate amounts of red wine.

c. An increase in the price of Californian wine.

d. A severe drought in the wine growing regions of France.

Exercise 2.6. Calculate the price elasticity at current prices in the following examples. If you do not have enough information, say so.

a. The firm's demand curve is $Q = 2000 - 5P$ and the firm's output is 500.

b. The firm's demand curve is $Q = 5P^{-1.55}$; the firm's price and output are unobserved.

Exercise 2.7. (Valuation) A newspaper poll in Columbus showed that two thirds of the voters rated an excellent school system as one of the city's important assets. However, in an election the voters turned down a school bond issue. Does this mean the poll was faulty or that voters are irrational?

Exercise 2.8. (Inferior goods) It has been observed that the amount consumed of the services of domestic servants declined in most Western countries during the first half of the 20th century while per-capita income was increasing. Does this mean that domestic servants are an inferior good?

Exercise 2.9. (Elasticity) The January 23, 1992 issue of *The Economist* stated that, owing to a wet spring, truffle production in France was expected to reach 16 tons, up from the previous year's production of 8 tons. The price of truffles, which reached $690/pound in the previous year, was expected to fall to approximately $290/pound this year.

a. Assuming that the demand function for truffles has not changed, what is the arc elasticity of demand for this price change?

b. Do you think that truffle producers are happy about the good truffle-growing weather?

Exercise 2.10. (Elasticity, shifts in demand) Table E2.1 shows actual data about the prices of Model T touring cars in different years and the sales volumes at those prices.

Table E2.1

Year	Retail Price	Sales Volume
1908	850	5,986
1909	950	12,292
1910	780	19,293
1911	690	40,402
1912	600	78,611
1913	550	182,809
1914	490	260,720
1915	440	355,276
1916	360	577,036

a. Assuming that these data represent points on a fixed demand curve, calculate the arc elasticity of demand comparing the data (i) for years 1910 and 1911 and (ii) for years 1915 and 1916.

b. Give two reasons why we might not want to consider these data to be points on a fixed demand curve.