Chapter 6 Lecture - Elasticity: The Responsiveness of Demand and Supply

The Price Elasticity of Demand and Its Measurement

We define price elasticity of demand and understand how to measure it.

Although we saw consumers did change the amount of gasoline they bought, they didn't appear to change it by very much.

- How can we come up with a sensible way to measure how much quantity changes when price changes?

One idea is to look at the slope of the demand curve.

- But this won't work, since the value of the slope depends on the units used to measure on the axes.

Instead, we define an **elasticity**, a measure of how much one economic variable response to changes in another economic variable, based on *percentage changes* in the variables.

Price Elasticity of Demand

Our first elasticity to examine is the **price elasticity of demand**, the responsiveness of the quantity demanded to a change in price:

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

Although the slope and price elasticity of demand are related, they are not the same thing.

Since price and quantity change in opposite directions on the demand curve, the price elasticity of demand is a negative number.

- However we often refer to "more negative" elasticities as being "larger" or "higher". Thus, it is often easier to compensate for the negative value by using the absolute value.

Price Elasticity of Demand Terminology

A "large" value for the price elasticity of demand means that quantity demanded changes a lot in response to a price change.

Formally, we say demand is **elastic** if its price elasticity of demand is larger (in absolute value) than 1.

- So a 10 percent increase in price would result in a greater than 10 percent decrease in quantity demanded.

Demand is **inelastic** if its price elasticity of demand is smaller (in absolute value) than 1.

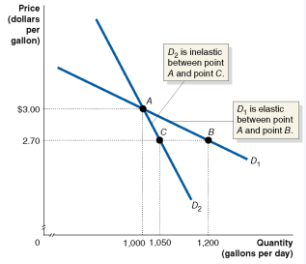
- That is, close to zero, indicating that quantity demanded changes little in response to a price change.

Demand is **unit-elastic** if the price elasticity of demand is exactly equal to (negative) 1.

Figure 6.1 Elastic and Inelastic Demand

Along D_1, cutting the price from $3.00 to $2.70 increases the number of gallons sold from 1,000 per day to 1,200 per day; demand is elastic between point *A* and point *B*.

Along D_2, cutting the price from $3.00 to $2.70 increases the number of gallons sold from 1,000 per day only to 1,050 per day; demand is inelastic between point *A* and point *C*.



Elasticity in More Mathematical Terms

Price elasticity of demand is defined as the percentage change in quantity demanded with respect to a percentage change in the price of the good.

The symbol often used to denote price elasticity of demand is E_d (although different symbols are used in different texts). We keep in mind that Q= Q_d

$$E_d = \frac{\%\Delta Q_d}{\%\Delta P} = \frac{\frac{\Delta Q_d}{Q_d}}{\frac{\Delta P}{P}} = \frac{\Delta Q_d}{Q_d} x \frac{P}{\Delta P} = \frac{\Delta Q_d}{\Delta P} x \frac{P}{Q_d}$$

Elasticity can be defined as

However, since from the law of demand we know that $\frac{\Delta Q_d}{\Delta P}$ is negative (it is simply the reciprocal of the slope of the demand curve). Thus to avoid the value of E_d being negative it is better to define E_d as

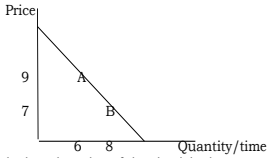
$$E_d = \left|\frac{\%\Delta Q_d}{\%\Delta P}\right| \quad \text{or} \quad E_d = -\frac{\%\Delta Q_d}{\%\Delta P}$$

By putting a negative sign in front of the equation or take the absolute value, the value of elasticity always becomes positive. Some books do not consider the absolute value and treat elasticity as negative. **BE AWARE OF HOW ELASTICITY IS DEFINED**. We will treat the elasticity as a positive value since this is easier.

The Arc Method

Calculating Price Elasticity of Demand by the Arc Elasticity Method

Consider the demand curve below.



$$E_d = \left|\frac{\Delta Q}{\Delta P} x \frac{P}{Q}\right| = \left|\frac{2}{-2} x \frac{9}{6}\right| = 1.5$$

Calculate the value of the elasticity between points A and B.

$\Delta Q = 8 - 6 = 2$ $\Delta P = 9 - 7 = -2$ (price is decreasing). If we use price and quantity at point A, then E_d is that shown beside the diagram.

(NOTE: WE WILL NO LONGER WORRY ABOUT USING NEGATIVE SIGNS OR THE ABSOLUTE SIGN.)

Using price and quantity at point B, then

$$E_d = \frac{\Delta Q}{\Delta P} x \frac{P}{Q} = \frac{2}{2} x \frac{7}{8} = 0.87$$

The Midpoint Method

It can be seen that as we move down along the demand curve the value of the elasticity changes. Thus, the value of the elasticity we calculate from A to B will be different depending on which initial values of P and Q are used. To cope with this, we take the average of price and quantity and use the formula:

$$E_d = \frac{\Delta Q}{\Delta P} x \frac{P^*}{Q^*} \quad \text{where} \quad P^* = \frac{P_1 + P_2}{2} \quad \text{and} \quad Q^* = \frac{Q_1 + Q_2}{2}$$

Using a little bit of algebra, the formula above reduces to:

$$E_d = \frac{\Delta Q}{\Delta P} x \frac{P_1 + P_2}{Q_1 + Q_2}$$

Using the data from before: $E_d = \frac{\Delta Q}{\Delta P} x \frac{P_1 + P_2}{Q_1 + Q_2} = \frac{2}{2} x \frac{9+7}{6+8} = 1.14$

If we have a straight line demand curve we can use determine elasticity at a particular point.

Let our demand curve be P = 10 – 2Q What is the value of the elasticity if Q = 2?

W can see that $\frac{\Delta P}{\Delta Q} = -2$ so $\frac{\Delta Q}{\Delta P} = -\frac{1}{2}$, and at Q = 2, P = 10 – 2 (2) = 6.

Thus, $\frac{\Delta Q}{\Delta P} x \frac{P}{Q} = \frac{1}{2} x \frac{6}{2} = 1.5$

Observations about Elasticity (1 of 2)

While slope and elasticity are not the same, they *are* related:

- If two demand curves go through the same point, the one with the higher slope also has the higher (more negative) elasticity.

A vertical demand curve means that quantity demanded does not change as price changes.

- So elasticity is *zero.*
- A vertical demand curve is *perfectly inelastic*.

Perfectly inelastic demand: The case where the quantity demanded is completely unresponsive to price and the price elasticity of demand equals zero.

Observations about Elasticity (2 of 2)

A horizontal demand curve means quantity demanded is infinitely responsive to price changes.

- Elasticity is *infinite*.
- A horizontal demand curve is *perfectly elastic*.

Perfectly elastic demand: The case where the quantity demanded is infinitely responsive to price and the price elasticity of demand equals infinity.

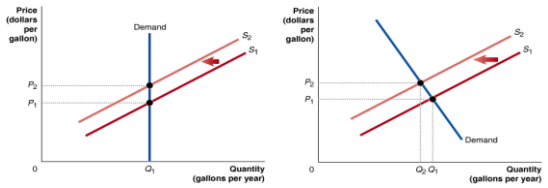
Another special case occurs when a decrease in price results in the same percentage increase in quantity demanded; in this case we say demand is ***unit elastic***.

So, Do People Respond to Changes in the Price of Gasoline?

We can now use our knowledge to answer this question in economic terms:

- Gasoline demand is *inelastic*; the quantity demanded does not change much as the price of gasoline changes.
- It is not *perfectly inelastic*; it is *somewhat* responsive to price.

Which panel shows this?



The Determinants of the Price Elasticity of Demand

We list and explain the determinants of the price elasticity of demand.

Why do some goods have a high price elasticity of demand, while others have a low price elasticity of demand?

There are several characteristics of the good, of the market, etc. that determine this.

1. **The availability of close substitutes**

If a product has more substitutes available, it will have more elastic demand.

- *Example: There are few substitutes for gasoline, so its price elasticity of demand is low.*
- *Example: There are many substitutes for Nikes (Reeboks, Adidas, etc.), so their price elasticity of demand is high.*

More Determinants of the Price Elasticity of Demand

2. The passage of time

Over time, people can adjust their buying habits more easily. Elasticity is higher in the long run than the short run.

Example: If the price of gasoline rises, it takes a while for people to adjust their gasoline consumption. How might they do that?

- *Buying a more fuel-efficient car*
- *Moving closer to work*

3. Whether the good is a luxury or a necessity

People are more flexible with luxuries than necessities, so price elasticity of demand is higher for luxuries.

Example: Many people consider milk and bread necessities; they will buy them every week almost regardless of the price.

Still More Determinants of the Price Elasticity of Demand

4. The definition of the market

The more narrowly defined the market, the more substitutes are available, and hence the more elastic is demand.

Example: You might believe there is no good substitute for jeans, so your demand for jeans is very inelastic.

But if you consider different brands of jeans, you might be more sensitive to the price of a particular brand.

5. The share of a good in a consumer's budget

If a good is a small portion of your budget, you will likely not be very sensitive to its price.

Example: You might buy table salt once a year or less; changes in its price will not affect very much how much you buy.

Table 6.2 Estimated Real-World Price Elasticities of Demand

Product	Estimated Elasticity	Product	Estimated Elasticity
Books (Barnes & Noble)	−4.00	Water (residential use)	−0.38
Books (Amazon)	−0.60	Chicken	−0.37
DVDs (Amazon)	−3.10	Cocaine	−0.28
Post Raisin Bran	−2.50	Cigarettes	−0.25
Automobiles	−1.95	Beer	−0.29
Tide (liquid detergent)	−3.92	Catholic school attendance	−0.19
Coca-Cola	−1.22	Residential natural gas	−0.09
Grapes	−1.18	Gasoline	−0.06
Restaurant meals	−0.67	Milk	−0.04
Health insurance (low-income households)	−0.65	Sugar	−0.04
Bread	−0.40		

The Relationship between Price Elasticity of Demand and Total Revenue

We no explain the relationship between the price elasticity of demand and total revenue.

If you are a business owner, you need to decide how to price your product.

- "How many customers will I gain if I cut my price?"
- "What will happen to my *total revenue* if I cut my price?"

Total revenue: The total amount of funds received by a seller of a good or service, calculated by multiplying the price per unit by the number of units sold.

Knowing the price elasticity of demand for your product can help to answer these questions.

Effect of Cutting Price with Different Elasticities

Suppose demand for your product is relatively price inelastic.

- Customers are not very sensitive to the price of your product.
- As you decrease the price, you expect to gain few additional customers.
- The few additional customers do not compensate for the lost revenue, so overall revenue goes down.

Suppose demand for your product is relatively price elastic.

- Customers are very sensitive to the price of your product.
- As you decrease the price, you expect to gain many additional customers.
- The many additional customers more than compensate for the lost revenue, so overall revenue goes up.

Figure 6.2 The Relationship between Price Elasticity and Total Revenue (1 of 2)

Revenue before price cut (at A):
1,000 × $3.00
= $3,000

Revenue after price cut (at B):
1,050 × $2.70
= $2,835

The decrease in price does not generate enough extra customers (area E) to offset revenue loss (area C).

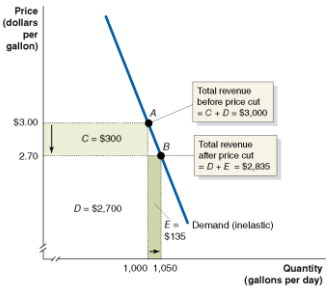


Figure 6.2 The Relationship between Price Elasticity and Total Revenue (2 of 2)

Revenue before price cut (at A):
1,000 × $3.00
= $3,000

Revenue after price cut (at B):
1,200 × $2.70
= $3,240

The decrease in price *does* generates enough extra customers (area E) to more than offset revenue loss (area C).

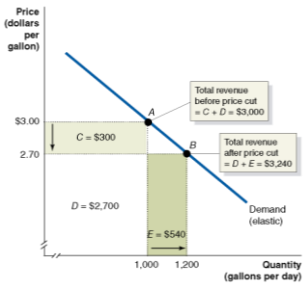


Table 6.3 The Relationship between Price Elasticity and Revenue

If demand is …	then …	because …
elastic	an increase in price reduces revenue	the decrease in quantity demanded is proportionally *greater* than the increase in price.
elastic	a decrease in price increases revenue	the increase in quantity demanded is proportionally *greater* than the decrease in price.
inelastic	an increase in price increases revenue	the decrease in quantity demanded is proportionally *smaller* than the increase in price.
inelastic	a decrease in price reduces revenue	the increase in quantity demanded is proportionally *smaller* than the decrease in price.
unit elastic	an increase in price does not affect revenue	the decrease in quantity demanded is proportionally *the same as* the increase in price.
unit elastic	a decrease in price does not affect revenue	the increase in quantity demanded is proportionally *the same as* the decrease in price.

Why Are Elasticity and Total Revenue Related?

The formula for price elasticity of demand is :

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

So if this is greater than 1 (in absolute terms) then quantity demanded goes up by a higher percentage than price, raising the revenue.

A special case occurs when price elasticity of demand is 1: the percentage change in quantity demanded equals the percentage change in price so revenue does not change

Figure 6.3 Elasticity Is Not Constant along a Linear Demand Curve (1 of 2)

Suppose we have a linear demand curve.

What happens to total revenue as price increases?

- Initially, total revenue rises, suggesting demand is inelastic.
- But then total revenue starts to fall, suggesting demand is elastic!

Price	Quantity Demanded	Total Revenue
$8	0	$0
7	2	14
6	4	24
5	6	30
4	8	32
3	10	30
2	12	24
1	14	14
0	16	0

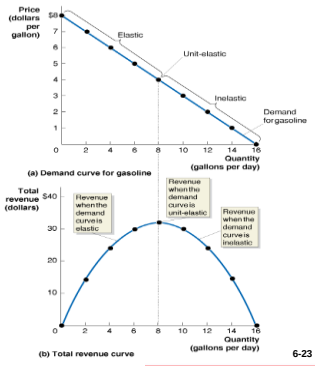
Figure 6.3 Elasticity Is Not Constant along a Linear Demand Curve (2 of 2)

The data from the table are plotted in the graphs.

As price decreases from $8, revenue rises—hence demand is elastic.

As price continues to fall, revenue eventually flattens out—demand is unit elastic.

Then as price falls even further, revenue begins to fall—demand is inelastic.



Other Demand Elasticities

We define cross-price elasticity of demand and income elasticity of demand and understand their determinants and how they are measured.

When we examined demand in Chapter 3, we discussed substitutes and complements:

- *Substitutes*: Goods and services that can be used for the same purpose.
- *Complements*: Goods and services that are used together.

Cross-price elasticity of demand is the percentage change in the quantity demanded of one good divided by the percentage change in the price of another good.

- It measures the *strength* of substitute or complement relationships between goods.

Table 6.4 Summary of Cross-Price Elasticity of Demand

In more mathematical terms:

Cross price elasticity of demand is defined as the percentage change in quantity demanded of good X with respect to a percentage change in the price of good Y.

$$E_{x,y} = \frac{\%\Delta Q_x}{\%\Delta P_y} = \frac{\Delta Q_x}{\Delta P_y} x \frac{P_y}{Q_x}$$ (some books use E_{12})

The cross elasticity of demand for a *substitute* is positive. For a *complement* is negative.

If the products are …	then the cross-price elasticity of demand will be …	Example
Substitutes	positive.	Two brands of smartwatches
Complements	negative.	Smartwatches and applications downloaded from online stores
Unrelated	zero.	Smartwatches and peanut butter

Income Elasticity of Demand

When we examined demand in Chapter 3, we discussed normal and inferior goods.

- *Normal goods*: Goods and services for which the quantity demanded increases as income increases
- *Inferior goods*: Goods and services for which the quantity demanded falls as income increases

Income elasticity of demand is a measure of the responsiveness of the quantity demanded to changes in income, measured by the percentage change in the quantity demanded divided by the percentage change in income.

Table 6.5 Summary of Income Elasticity of Demand

In more mathematical terms:

Income elasticity of demand is defined as the percentage change in the quantity of a good with respect to a percentage change in income.

$$E_I = \frac{\%\Delta Q}{\%\Delta I} = \frac{\Delta Q}{\Delta I} x \frac{I}{Q}$$

- If the income elasticity of demand is greater than 1, demand is *income elastic* and the good is a superior good (some books also call a *normal good).*
- If the income elasticity of demand is greater than zero but less than 1, demand is *income inelastic* and the good is a *normal good.*
- If the income elasticity of demand is less than zero (negative) the good is an *inferior good.*

If the income elasticity of demand is …	then the good is …	Example
positive but less than 1	normal and a necessity.	Bread
positive and greater than 1	normal and a luxury.	Caviar
negative	inferior.	High-fat meat

Making the Connection: Elasticities of Alcoholic Beverages

Christopher Ruhm of the University of Virginia and colleagues estimated elasticities for various alcoholic beverages. According to their study:

- Demand for beer is price inelastic.
- Beer and wine are complements.
- Beer and spirits are also complements, but the relationship is not as strong.
- Beer is a normal good; a *necessity*.

Are any of these results surprising to you? Why or why not?

Price elasticity of demand for beer	−0.30
Cross-price elasticity of demand between beer and wine	−0.83
Cross-price elasticity of demand between beer and spirits	−0.50
Income elasticity of demand for beer	0.09

Using Elasticity to Analyze the Disappearing Family Farm

We can use price elasticity and income elasticity to analyze economic issues.

Over the last century farms have become much more efficient at producing food.

- This might appear to make farming more profitable, and hence encourage more people into farming.

But the number of people in farming has fallen substantially (23 million in 1950, 3 million in 2011).

- Why have productivity gains in farming led to fewer people choosing to farm?

Figure 6.4 Elasticity and the Disappearing Family Farm (1 of 3)

In 1950, U.S. farmers produced 1.0 billion bushels of wheat at a price of $19.53 per bushel.

Over the next 65 years, rapid increases in farm productivity caused a large shift to the right in the supply curve for wheat.

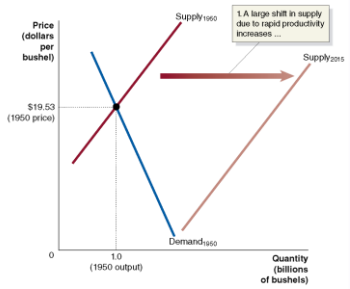


Figure 6.4 Elasticity and the Disappearing Family Farm (2 of 3)

Income elasticity of demand for wheat is low, so demand for wheat increased little over this period.

Demand for wheat is also inelastic, so the large shift in the supply curve and the small shift in the demand curve resulted in a sharp decline in the price of wheat.

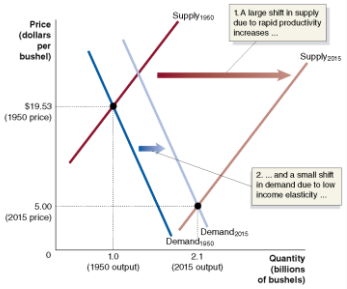
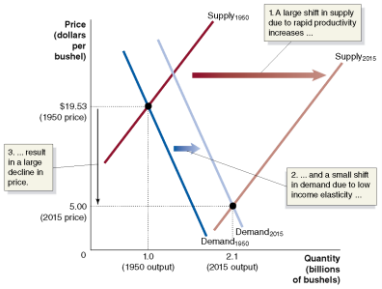


Figure 6.4 Elasticity and the Disappearing Family Farm (3 of 3)

In combination, this led to a dramatic fall in the price of the farmers' output.

Making a living on a small farm has become harder and harder, so the increase in output is supplied by fewer and fewer large-scale farmers.



The Price Elasticity of Supply and Its Measurement

We define price elasticity of supply and understand its determinants and how it is measured.

Price elasticity of supply is the responsiveness of the quantity supplied to a change in price, measured by dividing the percentage change in the quantity supplied of a product by the percentage change in the product's price.

It is very much analogous to price elasticity of demand

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

$$\text{Price elasticity of supply} = \frac{\text{Percentage change in quantity supplied}}{\text{Percentage change in price}}$$

So the same sort of calculation methods apply (midpoint formula, etc.).

Determinants of the Price Elasticity of Supply

In more mathematical terms:

Elasticity of Supply is defined as the percentage change in quantity supplied with respect to a percentage change in the price of the good.

Another symbol commonly used to denote the price elasticity of supply is the letter e.

$$E_s = \frac{\%\Delta Q_s}{\%\Delta P} = \frac{\Delta Q_s}{\Delta P} \times \frac{P}{Q_s}$$

Price elasticity of supply depends on the ability and willingness of firms to alter the quantity they produce as price increases.

The time period in question is critically important for determining the price elasticity of supply.

Suppose the wholesale price of grapes doubled overnight:

- Farmers could do little to increase their quantity immediately; the initial price elasticity of supply would be close to 0.
- Over time, farmers could plant more fields in grapes; so over the course of several years, the price elasticity of supply would rise.

Extreme Cases: Perfectly Elastic and Perfectly Inelastic Supply

If a supply curve is a vertical line, we say it is *perfectly inelastic*.

- Quantity supplied is completely unresponsive to price.
- Price elasticity of supply equals zero.
- *Example: Fixed number of spaces in a parking lot.*

If a supply curve is a horizontal line, we say it is *perfectly elastic*.

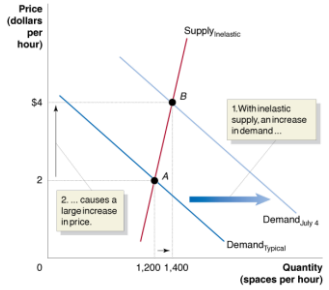
- Supply is infinitely responsive to price.
- Price elasticity of supply equals infinity.
- *Example: Long-run production of agricultural products is (approximately) perfectly elastic: at prices above the cost of production, farmers will supply as much as is demanded.*

Figure 6.5 Changes in Price Depend on the Price Elasticity of Supply (1 of 2)

$Demand_{Typical}$ represents the typical demand for parking spaces on a summer weekend at a beach resort.

$Demand_{July\ 4}$ represents demand on the 4th of July.

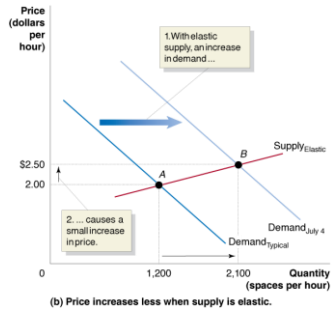
When supply is inelastic, the price increase will be large.



(a) Price increases more when supply is inelastic.

Figure 6.5 Changes in Price Depend on the Price Elasticity of Supply (2 of 2)

If supply is elastic instead, then the resulting price change will be much smaller.

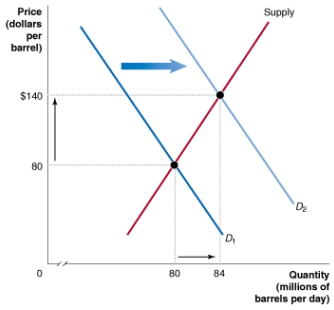


(b) Price increases less when supply is elastic.

Making the Connection: Why Are Oil Prices So Unstable? (1 of 2)

Oil producers cannot change output very quickly.

When demand increases suddenly, price rises, acting as a rationing mechanism for the increased demand.



Making the Connection: Why Are Oil Prices So Unstable? (2 of 2)

On the other hand, during a recession, demand for oil falls.

Oil producers cannot adjust their output quickly, so the price falls dramatically.