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## I. Elasticity

As we learned in Chapter 4, there is a clear relationship between the quantity demanded of a good and the price of the good. When the price increases, the quantity demanded decreases, and when the price decreases, the quantity demanded increases. We know in what the direction the change occurs, but what we don't know is the magnitude of the change.

The focus on in this chapter is measuring the size of the market demand response when there is a change in price or another factor which affects demand. The tool which we will use to quantify the response in demand is called **elasticity**. In general elasticity quantifies the response of one variable when another variable changes.

$$\text{Elasticity of A with respect to B} = \frac{\text{Percentage Change in A}}{\text{Percentage Change in B}} = \frac{\% \Delta A}{\% \Delta B}$$

Elasticity is an important concept in economics and will help answer questions such as

- By what percentage will demand fall if price increases by 1%
- By what percentage will demand increase if income increases by 1%
- By what percentage will demand for good Y increase if price of good X increases by 1%
- By what percentage will supply increase if price increases by 1%

To start we will look at the relationship between quantity demanded and price.

### I. Price Elasticity of Demand

#### A. Price Elasticity of Demand

To measure the response to price changes, we use **price elasticity of demand**.

$$\text{Price Elasticity of Demand} = \frac{\% \text{ Change in Quantity Demanded}}{\% \text{ Change in Price}}$$

The price elasticity of demand will always be negative. However, since we know that the price elasticity of demand will always be negative, the negative sign is usually dropped by convention (the book explains why). Thus price elasticity of demand will be reported as positive numbers (but keep in mind they are really negative). With this convention, a larger price elasticity implies a greater responsiveness of quantity demanded.

In order to calculate elasticity you need to find the percentage change in output demanded and prices. Let's do a quick review on how to calculate percentage changes. In general to calculate the percentage change in anything, use the following formula:

$$\text{Percentage Change} = \frac{\text{New Value} - \text{Initial Value}}{\text{Initial Value}} \times 100\%$$

With this formula in mind we can proceed to calculate price elasticity of demand

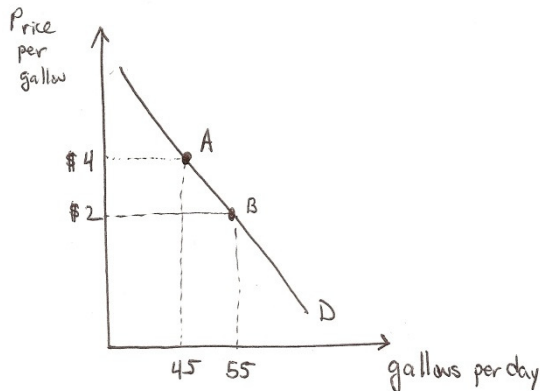
We need to find:

$$(1) \text{ Percentage change in quantity demanded} = \frac{Q_2 - Q_1}{Q_1} \times 100\%$$

Where  $Q_2$  = New quantity demanded;  $Q_1$  = initial quantity demanded

$$(2) \text{ Percentage change in price} = \frac{P_2 - P_1}{P_1} \times 100\%$$

Where  $P_2$  = New price;  $P_1$  = initial price



Let's use these definitions to calculate the elasticity for milk.

Example:

Initial price = \$4

New price = \$2

Initial Quantity = 45

New Quantity = 55

$$\text{Percentage change in quantity demanded} = \frac{55 - 45}{45} \times 100\% = 22.22\%$$

$$\text{Percentage change in price} = \frac{2 - 4}{4} \times 100\% = -50\%$$

$$\frac{\% \text{ Change in Quantity Demanded}}{\% \text{ Change in Price}} = \frac{22.22\%}{-50\%} = -0.44$$

The price elasticity of demand is 0.44 (recall we drop the negative sign by convention). The answer would have been the same whether we used dollars per gallon or cents per gallon (you can easily check this yourself).

## **B. Midpoint Formula**

Unfortunately, we run into a problem when using percentage change to calculate elasticity. Suppose that we return to our school milk example. Suppose that instead of the milk price falling it actually went up. Referring to Figure 1A suppose that instead of going from Point A to Point B, the school is going from Point B to Point A.

In our new example:

Initial price = \$2

New price = \$4

Initial Quantity = 55

New Quantity = 45

$$\text{Percentage change in quantity demanded} = \frac{45 - 55}{55} \times 100\% = -18.18\%$$

$$\text{Percentage change in price} = \frac{4 - 2}{2} \times 100\% = 100\%$$

$$\frac{\% \text{ Change in Quantity Demanded}}{\% \text{ Change in Price}} = \frac{-18.18\%}{100\%} = -0.18$$

Compare this price elasticity with the one we calculated earlier. You'll see we get a different value for elasticity depending on whether we go up the demand curve or go down the demand curve. In actuality, the response to a change in price should be the same whether we go up or down the same point on the demand curve. The only reason the elasticity is different is because different initial values are used. The solution that is used is to use **midpoints** in calculating percentage change.

Percentage Change (Midpoint Formula)

$$\text{Percentage Change} = \frac{\text{New Value} - \text{Initial Value}}{\left(\frac{\text{New Value} + \text{Initial Value}}{2}\right)} \times 100\%$$

Thus using the midpoint formula method we get:

$$(1) \text{ Percentage change in quantity demand} = \frac{Q_2 - Q_1}{\left(\frac{Q_1 + Q_2}{2}\right)} \times 100\%$$

Where  $Q_2$  = New quantity demanded;  $Q_1$  = initial quantity demanded

$$(2) \text{ Percentage change in price} = \frac{P_2 - P_1}{\left(\frac{P_1 + P_2}{2}\right)} \times 100\%$$

$$\text{Percentage change in quantity demanded} = \frac{45 - 55}{50} \times 100\% = -20\%$$

$$\text{Percentage change in price} = \frac{4 - 2}{3} \times 100\% = 66.67\%$$

$$\frac{\% \text{ Change in Quantity Demanded}}{\% \text{ Change in Price}} = \frac{-20\%}{66.67\%} = -0.30$$

(Check to see that the elasticity is the same whether we go from B→A or A→B)

### **C. Types of Price Elasticity of Demand**

**1. Perfectly Inelastic ( $\epsilon_d = 0$ ) :** Demand is perfectly inelastic if the quantity demanded does not change at all when there is a change in price. In other words demand is completely unresponsive to price changes. The price elasticity of demand ( $\epsilon_d$ ) is equal to 0. Graphically, a perfectly inelastic demand curve will be vertical.

Example: If the price of good X increased by 10%, then the quantity demanded of good X will decrease by 0%.

A good example of a product that might have perfectly inelastic demand is cocaine. Cocaine addicts will want to consume the same amount of cocaine even if the price of cocaine went up drastically.

**2. Inelastic ( $0 < \epsilon_d < 1$ )**

Demand is inelastic if the quantity demanded changes a little if the price of the good changes. In other words demand is somewhat responsive to changes in price. The price elasticity of demand will be a number between 0 and -1 and graphically the demand curve will be relatively steep. For example, suppose the price elasticity of demand for milk is 0.4. A 10% increase in the price of milk will reduce the quantity demanded of milk by 4%. Goods that are considered necessities will have an inelastic demand curve.

**3. Unit Elasticity ( $\epsilon_d = 1$ )**

Demand is unit elastic if the quantity demanded changes by the exact same percentage as the change in price. If an increase in 10% in the price of good X will result in a decrease of 10% in the quantity demanded of good X we say that good X is unit elastic.

**4. Elastic ( $1 < \epsilon_d < \infty$ )**

Demand is elastic if the quantity demanded changes a lot when the price of the good changes. A good that has elastic demand will be very responsive to changes in price. The price elasticity of demand will be a number greater than 1, and graphically the demand curve will be relatively flat. For example, suppose that the price elasticity of demand for lobster is 6.7. A 10% increase in the price of lobsters will reduce the quantity demanded by 67%. Goods that are considered luxuries will have an elastic demand curve.

**5. Perfectly Elastic ( $\epsilon_d = \infty$ )**

An extreme example of elastic demand is perfect elasticity. A good is perfectly elastic if the demand drops to 0 even if the price changes by 1 penny. The price elasticity of demand will be equal to negative infinity, and graphically the demand curve will be horizontal. An example of a good with perfectly elastic demand is most farm goods. There is nothing to distinguish the wheat from farmer A from farmer B. If farmer A tries to sell his wheat at a higher price than his neighbor farmer B, everyone will just buy from farmer B and thus the demand for farmer A's wheat will go to 0.

## **D. Relationship Between Price Elasticity of Demand and Total Revenue**

Price elasticity of demand is important to firms, because it can tell firms what would happen to total revenues if they increase or decrease the price they charge for a good. It allows firms to decide what price is optimal to maximize total revenue.

This is true because **total revenue = price x quantity**

1. If the good has an **elastic demand** an **increase in price** will result in **lower total revenue**. This is true because elastic demand means that demand is very responsive to a change in price. For example, if prices go up by 10%, quantity demanded will decline by greater than 10%. The decline in quantity demanded will be greater than the increase in price, thus overall total revenue will decline.
2. If the good has an **elastic demand** a **decrease in price** will result in **higher total revenue**. This is true because elastic demand means that demand is very responsive to a change in price. If prices go down by 10%, quantity demanded will go up by greater than 10%. The increase in quantity demanded will be greater than the decrease in price, thus overall total revenue will increase.
3. If the good has an **inelastic demand**, then an **increase in prices** will result in **higher total revenue**. This is true because elastic demand means that demand is not very responsive to a change in price. If prices go up by 10%, quantity demanded will decline by less than 10%. Thus the increase in prices will be greater than the decline in quantity demanded, thus overall total revenue will increase.
4. If the good has an **inelastic demand**, then a **decrease in prices** will result in **lower total revenue**. If prices go down by 10%, quantity demanded will increase by less than 10%. Thus the decline in prices will be greater than the increase in quantity demanded, thus overall total revenue will fall.

## **E. Elasticity Changes along the Demand Curve**

One interesting property of elasticity, is that elasticity changes as we move down the demand curve. It goes from very elastic at the top of the demand curve to inelastic as we move down. Figure 2 illustrates this idea.

Figure 2

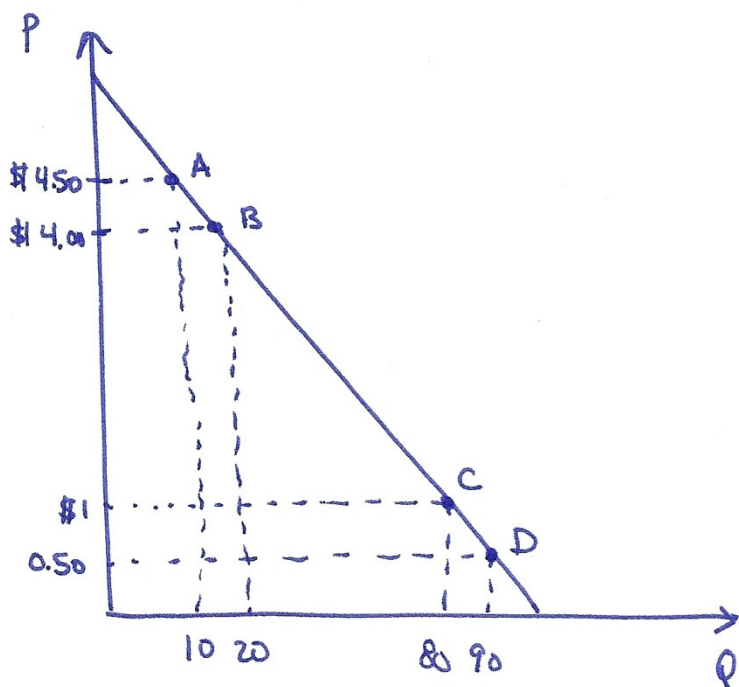


Figure 2 shows the market demand curve for eggs. Suppose that we start at a price of \$4.50 (Point A). At that price the quantity of eggs demanded will be 10. If the price of eggs were to fall to \$4.00, the quantity demanded of eggs will be 20.

What is the price elasticity of demand (using the midpoint method) as we move from A to B?

$$\text{Percentage change in quantity demanded} = \frac{20 - 10}{15} \times 100\% = 66.67\%$$

$$\text{Percentage change in price} = \frac{4.00 - 4.50}{4.25} \times 100\% = -11.76\%$$

$$\frac{\% \text{ Change in Quantity Demanded}}{\% \text{ Change in Price}} = \frac{66.67\%}{-11.76\%} = -5.67$$

As we can see as we go from A to B, the demand for eggs is very elastic. Now consider a different movement along the same demand curve. What is the price elasticity of demand as we move from C to D?

$$\text{Percentage change in quantity demanded} = \frac{90 - 80}{85} \times 100\% = 11.76\%$$

$$\text{Percentage change in price} = \frac{0.50 - 1.00}{0.75} \times 100\% = -66.67\%$$

$$\frac{\% \text{ Change in Quantity Demanded}}{\% \text{ Change in Price}} = \frac{11.76\%}{-66.67\%} = -0.176$$

Now as we measure elasticity from C to D the demand has become inelastic.

What is the economic intuition that would explain this change? The basic idea is that when prices are very low, the firm has already captured most of the market share. That is people who liked the product and wanted to purchase it would already have done so. By lowering the price further, the firm will not see much of an increase in quantity demanded since there are no more new customers. Conversely, when the price is very high, the firm won't have many people demanding their product. As they start lowering their prices, they will see a big response in quantity demanded as people who wanted to purchase the product (but were not willing to pay the super high prices) start buying the good as the prices are lowered.

**Key Point: As we move down the demand curve we go from very elastic demand to inelastic demand.**

## G. Determinants of Price Elasticity of Demand

- 1. The availability of close substitutes.** If a good has a lot of substitutes, then the quantity demanded would be very responsive to price changes (since if the price of a good goes up, households can easily switch to a substitute good). As an example, Coca-Cola would have a high elasticity since there are many substitutes. Thus goods with a lot of close substitutes will have an elastic demand.
- 2. Share of the good in the consumer's budget.** The larger the share of the good in the household's budget, the more elastic is the good. Think about what your response would be if the price of salt went up 40%? Chances are you would hardly notice the difference. Even if you did notice the price increase, would it affect your demand for salt that much? Now think about what would happen if your rent went up 40%? You would certainly notice its effect on your budget and you would be very responsive to the price increase (find another apartment, buy a house, etc...). Thus the more inexpensive a good is relative to a household's income, the more inelastic it will be. The converse is true for an expensive good.
- 3. Luxuries vs. Necessities.** Luxury goods are more elastic since you can afford to live without it. If the price of lobster triples, you'll simply stop buying lobster and consume something else. However, if the price of electricity triples, you can't stop buying electricity (you might reduce demand somewhat), but you are constrained on how much you can reduce your consumption by. Thus goods that are considered necessities are inelastic.

4. **Definition of a market.** The more narrow the definition of a market, the more elastic the good. Returning to the Coca-Cola example, we saw that Coca-Cola should have a high price elasticity since there are many substitutes (such as Pepsi, 7-Up, water, fruit juices, etc). If we use a the broader category of soft-drinks, then the price elasticity is lower since there are fewer substitutes for soft drinks. We could broaden the category further to beverages and find the demand price elasticity will be lower still.

5. **Time horizon.** The longer the time since a price change, the more likely people would have time to adjust their behavior and preferences, thus the good becomes more elastic as time passes. For example, if the price of gasoline triples, households will have few options in the short-term. Over the long-term, households can adjust their behavior, by taking mass transit or by buying a fuel efficient car.

## II. Other Elasticities

### A. **Income Elasticity of Demand**

This elasticity shows the effect of a change in income on the quantity demanded of a good. We quantify this relationship as the income elasticity of demand.

Income Elasticity of Demand =  $\frac{\% \text{ Change in Quantity Demanded}}{\% \text{ Change in Income}}$ . For income elasticity of demand we are interested in both the magnitude and the sign of the elasticity.

If the income elasticity of demand is positive **AND** greater than 1, then the good is a **normal good and is a luxury**.

If the income elasticity of demand is positive **AND** between 0 and 1, then the good is a **normal good and is a necessity**.

If the income elasticity of demand is negative, then the good is **inferior**.

### B. **Cross-Price Elasticity of Demand**

Another relationship we are interested in is the effect of a change of price on 1 good with a related good. We quantify this relationship as the **cross-price elasticity of demand**. The cross-price elasticity of demand measures the effect of a percentage change in the price of good y on the percentage change in the quantity demanded of good x. The sign of the cross-price elasticity of demand is important in determining the nature of the relationship between the two goods.

Cross Price Elasticity of Demand =  $\frac{\% \text{ Change in Quantity Demanded of Good X}}{\% \text{ Change in Price of Good Y}}$



- If the goods have a positive cross-price elasticity of demand then the goods are **substitutes**.
- If the goods have a negative cross-price elasticity of demand then the goods are **complements**.
- If the goods have a cross-price elasticity of demand of 0, then the goods are **not related**.

### C. Price Elasticity of Supply

This elasticity examines the positive relationship between the price of the good and the quantity supplied. It is similar to the price elasticity of demand.

$$\text{Price Elasticity of Supply} = \frac{\% \text{ Change in Quantity Supplied}}{\% \text{ Change in Price}}$$

As with price elasticity of demand, you should use the midpoint formula to calculate the % change in quantity supplied and the percentage change in prices. Since the relationship between quantity supplied and price is always positive, the price elasticity of supply will always be positive. However, the magnitude of the elasticity is important.

If the price elasticity of supply is greater than 1, then the good has **elastic supply**.

If the price elasticity of supply is equal to 1, then the good has **unit-elastic supply**.

If the price elasticity of supply is less than 1, then the good has **inelastic supply**.

As with the price elasticity of demand there are two special cases:

(1) If the price elasticity = 0, then the supply curve is vertical and it is said to be **perfectly inelastic**.

(2) If the price elasticity =  $\infty$ , then the supply curve is horizontal and it is said to be **perfectly elastic**.