CHAPTER 6: ELASTICITY, CONSUMER SURPLUS, AND PRODUCER SURPLUS

Introduction
Consumer responses to changes in prices, incomes, and prices of related products can be explained by the concept of elasticity. Firms and governments use knowledge of elasticity to determine how to raise revenue. Chapter 6 introduces formulas to calculate elasticity, interprets the meaning for product demand and supply, and explains consumer and producer surplus and deadweight loss. Material from Chapter 6 consistently appears on the AP microeconomics exam in a couple of multiple-choice questions and occasionally is included as part of a free-response question.

Price Elasticity of Demand
The Law of Demand explains that consumers buy more at lower prices and less at higher prices. But we know that consumers are more responsive to changes in the price of some products and not as responsive to others. Price elasticity of demand measures how sensitive consumers are to price changes by calculating the change in quantity demanded related to price from two points on the demand curve.

The formula to measure the price elasticity coefficient is

\[ E = \frac{\text{Percentage change in quantity demanded}}{\text{Percentage change in price}} \]

In order to avoid calculation issues, the midpoint formula is the best and easiest to use.

\[ E = \frac{\text{Quantity 1} - \text{Quantity 2}}{(\text{Quantity 1} + \text{Quantity 2}) / 2} \]

\[ \frac{\text{Price 1} - \text{Price 2}}{(\text{Price 1} + \text{Price 2}) / 2} \]

For example, at a price of $5, a consumer will buy 10 products, and at a price of $3, the consumer will buy 20 products. Using the elasticity formula

\[ E = \frac{(10 - 20)}{(10 + 20) / 2} = \frac{-10}{15} = -0.67 \]

\[ \frac{(5 - 3)}{(5 + 3) / 2} = \frac{2}{4} = 0.50 \]

Economists use the absolute value of the elasticity coefficient. Because the demand curve is downward sloping, elasticity of demand must be a negative number. But the minus sign is ignored because we are simply looking at the strength of the relationship.

Bear in Mind
While a question on the AP economics exam may ask for the specific coefficient of elasticity or the meaning of a coefficient, it is far more common for questions to deal with applications of elasticity in specific circumstances or to identify whether demand is elastic or inelastic when consumers or total revenues respond in a particular way.
Interpretation of Price Elasticity of Demand

Perfectly inelastic and elastic demands

If demand is perfectly inelastic, consumers do not change their quantity demanded at all, regardless of price. The result is a vertical demand curve with an elasticity coefficient of zero. It is rare for consumers to buy the same amount at any price, and examples are primarily limited to life-saving medicines and medical procedures.

Demand is inelastic when consumers are not very sensitive to a change in product price. If the elasticity coefficient is less than one, demand is inelastic because even a large change in price causes a relatively small change in quantity demanded. For example, if $E = 0.6$, a 1 percent decrease in price only results in a $0.6\%$ increase in the quantity demanded.

A point of unit elasticity is reached when a change in price causes an identical change in the quantity demanded, for an elasticity coefficient of one. If the price decreases by 3 percent, the quantity demanded increases by the same 3 percent.

Demand is elastic if customers are sensitive to a change in product price. If the elasticity coefficient is greater than one, demand is elastic because a small change in price causes a larger change in the quantity demanded. For example, if $E = 5$, a 1 percent decrease in price results in a 5 percent increase in the quantity demanded.

If demand is perfectly elastic, a small price cut causes customers to change from buying zero to buying as many as can be produced. The result is a horizontal demand curve with an elasticity coefficient of infinity. Again, this is rare but can be seen in the case of individual firms selling in perfectly competitive markets, such as agricultural products.

Taking the EEK! Out of Economics

It's easy to mix up elastic and inelastic demand when you're trying to remember the term for a particular situation. One trick to keep them straight is to replace the word "elastic" with the word "sensitive." If demand is inelastic, consumers are insensitive to the price change; when demand is elastic, consumers are sensitive and change the quantity bought when price changes. Another trick is to remember that the perfectly "I"nelastic demand curve is vertical – it looks like the letter I. Perfectly elastic demand is a horizontal curve.
The Total Revenue Test
An easier way to determine the elasticity of demand is the total revenue test. Firms can use the total revenue test to examine the change in revenue when the price is changed.

Total Revenue = Price × Quantity

Taking the EEK! Out of Economics
It is important to keep in mind that the total revenue test only reflects the change in income to the firm. It tells us nothing about the change in profit, because costs of production are not part of the analysis.

The total-revenue test for price elasticity

When demand is elastic, a decrease in price causes an increase in total revenue. Even though the price is lower, customers respond by buying so many more products that the firm’s revenue actually increases. In figure (a), when the price falls, the total revenue rises from $20 to $40. Elasticity is greater than one. Fast food restaurants, for example, can draw in significant numbers of additional customers with a sale or promotional deal.

If demand is inelastic, a decrease in price causes a decrease in total revenue. Consumers respond only slightly to a lower price, so the firm’s total revenue declines. In figure (b), when the price falls, the total revenue falls from $40 to $20. Elasticity is less than one. Firms also experience this relationship in reverse; when the price rises, consumers only reduce their purchases by a small amount. When gasoline prices rose significantly in recent years, consumers were unhappy, but cut consumption only slightly in the short run.

When demand is unit elastic, a change in price leaves total revenue exactly the same. In figure (c), at a price of $3 and again at a price of $1, the total revenue is $30. Elasticity equals one. With the total revenue test, watch what happens when product price changes. When the product price falls, if total revenue rises, demand is elastic; if total revenue falls, demand is inelastic; and if total revenue remains the same, demand is unit elastic.

Taking the EEK! Out of Economics
In general, demand tends to be elastic in the higher price ranges and inelastic in the lower price ranges of the curve because of the math involved in the calculation. Therefore, it is important to use two specific points on the curve to determine the elasticity of demand between those two points and not rely on how the slope looks to guess at elasticity.
**Determinants of Price Elasticity of Demand**

Why do consumers react strongly to price changes of some products but seem oblivious to others? Demand tends to be more elastic if substitutes are available, the product price is high as a proportion of the consumer’s income, the product is a luxury, or the consumer has time to make changes in behavior that make the product less necessary. Consumer demand is much more inelastic if there are no substitutes for the product, the product price is a small proportion of the consumer’s income, the product is a necessity, or there is little or no time for the consumer to change behaviors to avoid buying the product.

**Uses of Elasticity**

Elasticity is important because it determines what a firm should do to change revenue. If demand is elastic, the firm can lower its price to increase total revenue. But if demand for the product is inelastic, the firm would instead increase its price to raise total revenue.

Price elasticity of demand is also important to the government. When legislatures raise revenues to pay for public goods, they want to place excise taxes on products customers will continue to buy at the higher price (including the tax). For that reason, governments place taxes on products with inelastic demand, such as cigarettes, gasoline, and liquor.

**Price Elasticity of Supply**

Elasticity of supply measures how responsive producers are to changes in the price of their products. The formula is the same as for demand, except that it is measuring the percentage change in quantity supplied rather than quantity demanded:

\[
\text{Elasticity of Supply} = \frac{\text{Percentage Change in Quantity Supplied}}{\text{Percentage Change in Price}}
\]

**Time and elasticity of supply**

Price elasticity of supply relies on how quickly and easily a producer can shift resources to produce more products. In the market period, a firm cannot respond to a price change. If higher demand for apples raised the price, producers could do nothing to immediately increase the quantity of apples because it takes time to grow the trees. In the short run, firms can increase production somewhat but are still constrained by the size of the plant and equipment. If demand for cars significantly increased, producers could add shifts of workers to increase production, but would still be limited by the plant capacity. In the long run, firms can change the size of their plants and other firms can join the industry to produce even more. The more time a firm has, the more responsive it is to price changes.
In some cases, supply remains perfectly inelastic and cannot be increased even with time. A fixed quantity of Van Gogh paintings exists, and with Van Gogh's death, no more can be produced at any price. It is possible that more paintings might be discovered, but Van Gogh cannot respond to a higher price by increasing the quantity supplied.

**Cross (Price) Elasticity of Demand**

Cross (cross-price) elasticity measures the sensitivity of consumers in buying one product when the price of a related product changes. The formula is similar to the price elasticity of demand, but notice that the products differ in the numerator and denominator.

\[
\text{Cross-Price Elasticity} = \frac{\text{Percentage Change in Quantity Demanded for Product X}}{\text{Percentage Change in Price for Product Y}}
\]

In addition, cross-price elasticity can be either positive or negative, so don't disregard the negative sign if one appears in this case. If the cross-price elasticity coefficient is zero or near zero, the products are independent and unrelated.

If cross-price elasticity is positive, the products are substitutes. When the price of Häagen Dazs ice cream increases, the quantity demanded of Ben and Jerry's ice cream increases. Because they move in the same direction, the elasticity is positive. The larger the cross-price elasticity coefficient, the more substitutable the products are.

If cross-price elasticity is negative, the products are complements. When the price of peanut butter increases, the quantity demanded of jelly falls. Because they move in opposite directions, the elasticity is negative. The larger the cross-price elasticity coefficient, the stronger the complementary relationship between the two products.

Firms use knowledge of cross-price elasticity to determine how seriously consumers will respond to a price increase by switching to a competitor's product - or how easily they can draw consumers away from a competitor by lowering their product price. The government also uses this knowledge in determining whether to allow large producers to merge. Firms with a high cross-elasticity of demand may be able to significantly reduce competition by merging, so the government is more reluctant to allow such mergers.

**Income Elasticity of Demand**

Income elasticity of demand measures how consumers respond when their incomes change. As with cross-price elasticity, the negative or positive sign is important. The formula is, again, very similar to the price elasticity of demand, but notice this time that the denominator is income, rather than product price.

\[
E = \frac{\text{Percentage Change in Quantity Demanded}}{\text{Percentage Change in Income}}
\]

If income elasticity of demand is positive, the product is a normal good; as income rises, the quantity demanded rises. Most goods are normal goods, as customers buy more when income increases. If the income elasticity is negative, the product is an inferior good. As income increases, the consumer demands a smaller quantity of inferior goods. With higher incomes, consumers buy fewer generic goods in favor of name-brand products.
Knowledge of income elasticity is important to understand which industries will be most strongly affected by economic downturns. Income elasticity is particularly high for new cars, houses, and vacations, so demand for these products falls significantly during times of serious job loss. On the other hand, income elasticity is low for electricity, toilet paper, and milk, which consumers tend to continue to buy even when incomes fall.

**Taking the EEK! Out of Economics**
Four different elasticity formulas have been introduced in this chapter, but notice that there is very little difference between them. In each case, a change in quantity is in the numerator, because we’re looking at the response to a stimulus. The stimulus is in the denominator — the price of the product for price elasticity of demand and supply, the price of a related product for cross-price elasticity of demand, and income for the income elasticity of demand. Keep in mind which relationship you’re looking for, and that will help you remember which formula to use.

**Bear in Mind**
While previous exams have not asked students to calculate cross-price or income elasticities of demand, it is important to be able to explain how changes in incomes and the prices of related products can affect quantity demanded.

**Consumer and Producer Surplus**

![Diagram of Consumer and Producer Surplus](image)

*Efficiency: maximum combined consumer and producer surplus*

Consumer surplus is the difference between what a consumer was willing to pay for a product and the price that was actually charged. If you ever bought a product for less than you were willing to pay, you enjoyed a consumer surplus. It is represented by the triangle above the price up to the demand curve. If the product price rises, consumer surplus falls. Producer surplus is the difference between the minimum acceptable price to the firm and the price that was actually charged. It is found in the triangle below the price down to the supply curve. If the product price falls, producer surplus falls.

**Deadweight Loss**
At the point of equilibrium, productive and allocative efficiency are achieved and both producer and consumer surplus are maximized. But in some situations, a product is overproduced or underproduced, and efficiency is lost. This deadweight loss is the reduction in consumer and producer surplus as a result of inefficient production.
Efficiency losses (or deadweight losses)

If the quantity produced is too low, at Q2 in this figure, the triangle between equilibrium and the quantity produced to the left (between the supply and demand curves) is the deadweight loss. Both consumer and producer surplus are lost. Consumers are willing to pay more than the minimum price firms will accept, but something is reducing output.

If the quantity produced is greater than the equilibrium, at Q3, consumers are not willing to pay the minimum price firms are willing to accept. The deadweight loss is the triangle to the right of equilibrium, out to the quantity produced (between the supply and demand curves). Inefficiency results from using resources to produce these excess products. In competitive markets, inefficiencies generally resolve themselves as the market returns to equilibrium. But in situations we will examine later, inefficiencies sometimes remain.

Multiple-Choice Questions

1. If customers buy a quantity of seven products per week, regardless of the price, the price elasticity of demand for the product is
   (A) infinity.
   (B) greater than one.
   (C) equal to one.
   (D) less than one.
   (E) zero.

2. The cable television company increases its monthly price for basic service. The firm’s revenues will only increase if
   (A) demand for cable television is price elastic.
   (B) demand for cable television is income elastic.
   (C) supply for cable television is price elastic.
   (D) demand for cable television is price inelastic.
   (E) supply for cable television is unit elastic.

3. A local baseball team’s concession stand sells hot dogs for $2 and earns $600 in revenue. The next week, the price is raised to $3, and the concession stand still earns $600 in revenue. In this situation, the price elasticity of demand is
   (A) perfectly elastic.
   (B) elastic.
   (C) unit elastic.
4. In the elastic portion of a firm's demand curve, the firm can raise its revenue by
(A) reducing the product price.
(B) hiring additional workers.
(C) lowering the quantity produced.
(D) raising the product price.
(E) increasing its cost of production.

5. Demand for a product tends to be more price inelastic if
(A) the consumer can find many available substitutes for the product.
(B) the product is expensive in relation to the consumer's income.
(C) the product is a necessity.
(D) the consumer's income is falling.
(E) the consumer rarely buys complements for the product.

6. If golf clubs and golf balls are complementary goods and the price of golf clubs significantly increases,
(A) the quantity of golf clubs purchased will increase.
(B) the demand for golf balls will decrease.
(C) the demand for tee times at golf courses will increase.
(D) the price of golf balls will increase.
(E) the quantity of golf balls purchased will increase.

7. A change in consumer income is least likely to affect the quantity demanded of
(A) cars.
(B) DVDs.
(C) restaurant meals.
(D) piano lessons.
(E) toothpaste.

8. Consumer surplus is the difference between
(A) the price firms were willing to charge and the equilibrium price.
(B) the quantity consumers were willing to buy and the quantity firms were willing to sell.
(C) the quantity consumers were willing to buy before and after a tax increase.
(D) the price consumers were willing to pay and the equilibrium price.
(E) the quantities supplied and demanded at a price above equilibrium price.

9. The loss of producer and consumer surplus resulting from an under-allocation of resources to produce a good is
(A) deadweight loss.
(B) diminishing returns.
(C) scarcity.
(D) the cross-price coefficient of elasticity.
(E) a negative externality.
Free-Response Question

Paintings by Pablo Picasso have significantly increased in value since the artist’s death in 1973. When a Picasso painting is sold, it is often sold through an auction house, allowing many potential buyers to bid on the painting.

(a) Using a correctly labeled supply and demand graph, illustrate the market for Picasso paintings.
   (i) Determine the elasticity of supply for Picasso’s paintings.
   (ii) Explain why that level of elasticity exists for the paintings.

(b) Now assume incomes significantly increase. Illustrate the effect of the change in incomes on your graph. Explain the effect of higher incomes on
   (i) The price of Picasso paintings, which are normal goods.
   (ii) The quantity of Picasso paintings produced.

Multiple-Choice Explanations

1. (E) If quantity does not change, the numerator in the formula is zero.
2. (D) When demand is price inelastic, consumers are relatively unresponsive and continue to buy at the higher price.
3. (C) If the product price changes and total revenue remains the same, demand is unit elastic between those two points.
4. (A) When consumers are very sensitive to price changes, a lower price increases the quantity sold so significantly that total revenue rises.
5. (C) If the consumer must buy the item regardless of price, demand is inelastic.
6. (B) If golf clubs are more expensive, fewer people will buy them, reducing the demand for golf balls to go with the clubs.
7. (E) Most consumers will continue to buy toothpaste, even if their income falls.
8. (D) Consumers would have been willing to pay more, but the price was lower.
9. (A) Deadweight loss illustrates efficiency lost by not producing at equilibrium.

Free-Response Explanation

6 points (3 + 3)

(a) 3 points:
   • 1 point is earned for a correctly labeled graph with a vertical supply curve.
   • 1 point is earned for stating that supply is perfectly inelastic.
   • 1 point is earned for explaining that the producer cannot increase the quantity supplied in response to a higher price because the artist has died.

(b) 3 points:
   • 1 point is earned for showing a rightward shift of the demand curve (with higher incomes, consumers buy more normal goods).
   • 1 point is earned for stating that the price will increase.
   • 1 point is earned for stating that the quantity produced will not change.