Elasticity

I. What is Elasticity?

The purpose of this section is to develop some general rules about elasticity, which may them be applied to the four different specific types of elasticity discussed in more detail below.

A. Rubber Band Elasticity

The concept of elasticity, as used in Economics, is quite similar to the concept as applied to simple items such a rubber band, an elastic band. What makes a rubber band more or less elastic? To answer this question, focus on the more fundamental question of what is meant by "elastic."

Essentially, elastic refers to how much the rubber band stretches without breaking and with the ability to return to its former length. The band, however, does not stretch by itself. Rather, some force must be applied to it in order for it to change its length. That force may just be gravity, if one were to hang a weight from the band. Or the force may be applied by manually stretching the rubber band with muscle power. In either case, a force is applied to stretch, to change the length of, the rubber band.

Thus, we now have two variables, the length (L) and the force (F), which can be used to calculate an exact elasticity coefficient. Notice that these two variables are related to each other. One of the variables does not change until acted upon by the other variable. This is, of course, the length and is known as the dependent variable. The force, however, changes independently and acts upon the length to change it. Thus, the force is known as the independent variable. All elasticity coefficients are measured by the use of two variables, an independent variable that acts upon a dependent variable.

How would one use these two variables in order to measure elasticity? Our fundamental idea of elasticity is that a rubber band is more elastic, for the same force applied, if the band stretches more. That is, the elasticity coefficient should increase as the length increases for a given force. On the other hand, if it takes a larger force applied to the band to stretch the band to a given length then we would think that the band is less, not more, elastic. That is, the elasticity coefficient should decrease as the force increases for a given length.

The simplest way to apply the above two concepts in an equation is to simply divide the how much the band stretches (the change in the length) by the change in the force. That is, the elasticity coefficient equals $\Delta L \div \Delta F$, where Δ stands for "change in". In this case, a larger change in the length increases the coefficient all else equal, as desired, while a larger change in the force decreases the coefficient.

However, there does exist a problem with this equation. Consider two rubber bands. Compared to each other, one is inherently more elastic but also much shorter than another that is inherently less elastic but also much longer. Suppose that applying the same force to both of these rubber bands stretches one from 1 inch to 3 inches, a change of 2 inches. However, the same force applied to the longer band stretches it from 12 inches to 18 inches. By the above equation, the shorter and more elastic rubber band would actually have a lower elasticity coefficient in our example than the longer, but less elastic band.

The problem is that the original length has an impact on our measure of elasticity even though it should not. How can this problem be solved so that the original length (and the original force) does not have such an impact? The best solution is to use percentage changes in our equations rather than the absolute changes currently used. Thus, the equation would be:

$$\frac{\%\Delta L}{\%\Delta F}$$

B. General Elasticity Concepts

While not being interested in rubber band elasticity *per se* its discussion allowed the development of three general concepts about elasticity that will be applied to the specific types of elasticity discussed below. The purpose of this section is to clearly identify these general concepts developed to date.

1. Two variables.

   The first step is to identify two variables that are of interest. For rubber band elasticity those two variables were the length and the force. Exactly which two variables are identified will depend upon exactly what it is we are attempting to measure.

2. Identify variable types.

   The second step is to categorize each variable. One variable must be an independent variable. That is, it must change independent of the second variable. The second variable must be a dependent variable. That is, it must change as a result of the change in the first, or independent, variable. For rubber band elasticity the force acts upon or causes the length to change and not the reverse. Hence, the force is independent while the length is dependent.

3. Calculate the elasticity coefficient.

   The formula for calculating all elasticity coefficients used in this course will be the same. They will equal the percentage change in the dependent variable divided by the percentage change in the independent variable ($\%\Delta$ Dependent Variable $\div$ $\%\Delta$ Independent Variable.) One identifies these two variables in steps one and two above. Later another general rule will be added, which identifies how one actually calculates a percentage change for elasticity coefficients.

II. Price Elasticity of Demand

What we know from our discussion of demand is that when the price of a good rises that the quantity demanded of that good falls. Recall that this inverse relationship between price and quantity demanded is known as the law of demand. Although the direction of the relationship is clear what is not clear is by how much quantity demanded will rise or fall as price decreases or increases. That is, how stretchy or how elastic, is the demand curve in response to a change in the price of a good. Thus, price elasticity of demand (η) measures how responsive is demand for a good to changes in the price of that good.

A. Applying the general rules of Elasticity

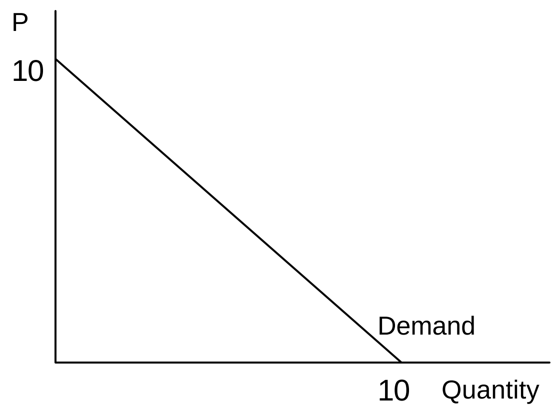
Now apply the general rules of elasticity to price elasticity of demand. First, what are the two variables of interest? Clearly, based upon the above definition one of the variables must the price of a good while the other variable must the quantity demanded of that good.

Second, which of these two variables, price and quantity demanded, is dependent and which independent. That is do consumers choose how much they buy (Q_D) based upon the price of the good – in which case price is independent and Q_D dependent. Or do consumers choose the price based upon how much they want to buy (Q_D)? Although all consumers would prefer to be able to choose the price – and given consumer self-interest or greed the price they would always choose is a price of zero – clearly consumers must take the market price as a given and choose how much they wish to consume based upon that price. Hence, price is the independent variable while quantity demanded is dependent. As a result, the equation for price elasticity of demand (η) equals:

$$\eta = \frac{\%\Delta Q_D}{\%\Delta P} \qquad (1)$$

B. Calculating an Elasticity Coefficient

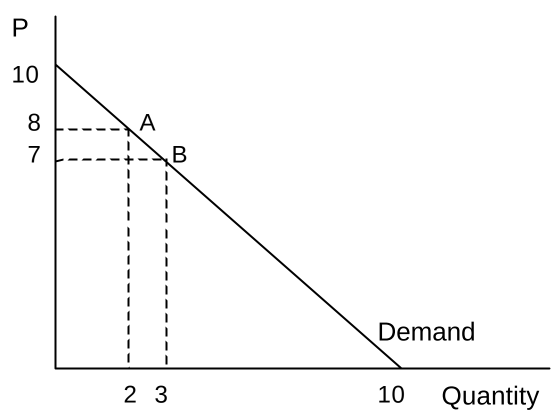
Consider the simple demand curve in Graph 1 to the right. The intercepts on both the price and the quantity axes equal 10. This means that the slope of the demand curve equals minus one, making it quite a simple demand curve to use for our example.



Graph 1

In order to calculate an elasticity coefficient, the first step is to choose two points on the demand curve from which to do the calculations. That is, to find a percentage change in both price and quantity demanded, a change in both variables must be observed along the demand curve. Either price must fall, which quantity demanded rises, or price must rise, while quantity demanded falls.

For this particular example, we will choose a decrease in price from $8 to $7, which means that quantity demand will rise from 2 to 3. This change is reflected by a move from point A on the demand curve illustrated in Graph 2 to the right to point B.



Graph 2

How is the percentage change of a variable calculated? For example, if your income rises when you graduate from college to $15,000 per year to $30,000, by what percentage did your income rise? A doubling of your income, as in this example, represents a 100 percent increase in income.

Most students understand the above example but do not necessarily have a firm grasp on how one calculates percentage changes in general. However, the equation that is commonly used to calculate percentage changes for any variable yields exactly the above answer. That equation is:

(2) $$\frac{\text{Variable}_{\text{NEW}} - \text{Variable}_{\text{OLD}}}{\text{Variable}_{\text{OLD}}}$$

Now, apply the above equation to the example given in Graph 2 to calculate a price elasticity of demand coefficient. Recall, that we are moving from point A to point B.

Table 1 **Elasticity Coefficient Calculated from Point A to Point B**			
$P_{NEW} = 7$	$P_{OLD} = 8$	$Q_D^{NEW} = 3$	$Q_D^{OLD} = 2$
% Δ Price		% Δ Quantity Demanded	
$\frac{P_N - P_O}{P_O} = \frac{7-8}{8} = -\frac{1}{8}$		$\frac{Q_D^N - Q_D^O}{Q_D^O} = \frac{3-2}{2} = \frac{1}{2}$	
$\eta = \frac{\% \Delta Q_D}{\% \Delta P} = \frac{1/2}{-1/8} = \frac{1}{2} * \frac{-8}{1} = \frac{-8}{2} = -4$			

Hence, the price elasticity of demand equals –4 when moving from point A to point B in Graph 2. Next consider the price elasticity of demand when moving in the opposite direction, from point B to point A. In this case, the formula remains identical but which price and quantity demanded is new or old is reversed as follows:

Table 2 **Elasticity Coefficient Calculated from Point B to Point A**			
$P_{NEW} = 8$	$P_{OLD} = 7$	$Q_D^{NEW} = 2$	$Q_D^{OLD} = 3$
% Δ Price		% Δ Quantity Demanded	
$\frac{P_N - P_O}{P_O} = \frac{8-7}{7} = \frac{1}{7}$		$\frac{Q_D^N - Q_D^O}{Q_D^O} = \frac{2-3}{3} = -\frac{1}{3}$	
$\boldsymbol{h} = \frac{\% \Delta Q_D}{\% \Delta P} = \frac{-1/3}{1/7} = \frac{-1}{3} * \frac{7}{1} = \frac{-7}{3} = -2.33$			

Notice that although the sign of each estimate of price elasticity of demand between points A and B are both negative, the size of each estimate varies dramatically. That is, quite different estimates of the elasticity coefficient are obtained dependent upon whether one moves from point A to B, as was done in the first example, or moves from point B to A, as was done in the last example.

Why are different estimates obtained? The answer to this question is illustrated by looking at the calculation of the percentage changes separately. In Table 1, the % Δ Price equals –1/8, while in Table 2 the % Δ Price equals 1/7. The fact that the two percentage changes have different signs in the two tables simply reflects that Price is falling in Table 1, so that % Δ Price is negative, while rising in Table 2, so that in this case % Δ Price is positive. However, the *magnitudes* of the two percentage changes are also quite different, which leads to the question of why such a difference exists.

Notice that, except for the difference in sign, the change between the new and the old price in both tables equals one. That is, price changed by $1, either rising by $1 in Table 2 or falling by $1 in Table 1. Hence, the price change represented by the difference between the new and the old price in the numerator in each table does not explain why the magnitude of the number changes so dramatically. However, notice that the denominator, the base against which the price change is compared, *does* change between the two tables. In each instance, the price change is divided by the old price but which price is old depends upon whether price is rising or falling between $7 and $8. As a result of dividing by a smaller number in Table 2, seven, as compared to Table 1, where the price change is divided by eight, the percentage change in price is determined to be larger in Table 2 than in Table 1.

Likewise, for a similar reason, the percentage change in quantity demanded is determined to be smaller in Table 2 than in Table 1. Hence, in Table 2 a smaller number (% ΔQ_D) is divided by a larger number (% ΔP), which results in a smaller estimate of the price elasticity of demand.

Clearly, what is needed is an equation to obtain an estimate of price elasticity of demand that yields the <u>same</u> estimate regardless of whether it is calculated with price rising or falling. The current method of calculating percentage changes given in equation 2 fails to achieve this goal. The different equation must have a different base, rather than $\text{Variable}_{\text{OLD}}$. Notice that if the old variable were simply replaced with the new variable in the equation, the same problem would exist. As a result, the equation that will be used to calculate percentage changes will be:

$$(3) \qquad \frac{\text{Variable}_{\text{NEW}} - \text{Variable}_{\text{OLD}}}{\text{Variable}_{\text{AVERAGE}}}$$

Where:

$$(4) \qquad \text{Variable}_{\text{AVERAGE}} = \frac{\text{Variable}_{\text{NEW}} + \text{Variable}_{\text{OLD}}}{2}$$

By using the average of the new and the old number, whether it be price or quantity demanded will result in the same estimate of elasticity regardless of whether or not price is rising or falling, which is shown by recalculating the results from Tables 1 and 2.

Table 3 Elasticity Coefficient Calculated from Point A to Point B Using Averages as Bases					
$P_{NEW} = 7$	$P_{OLD} = 8$	$P_{AVG} = 7.5$	$Q_D^{NEW} = 3$	$Q_D^{OLD} = 2$	$Q_D^{AVG} = 2.5$
% Δ Price			% Δ Quantity Demanded		
$\frac{P_N - P_O}{P_A} = \frac{7-8}{7.5} = -\frac{1}{7.5}$			$\frac{Q_D^N - Q_D^O}{Q_A^O} = \frac{3-2}{2.5} = \frac{1}{2.5}$		
$h = \frac{\% \Delta Q_D}{\% \Delta P} = \frac{1/2.5}{-1/7.5} = \frac{1}{2.5} * \frac{-7.5}{1} = \frac{-7.5}{2.5} = -3$					

Table 4 Elasticity Coefficient Calculated from Point B to Point A Using Averages as Bases					
$P_{NEW} = 8$	$P_{OLD} = 7$	$P_{AVG} = 7.5$	$Q_D^{NEW} = 2$	$Q_D^{OLD} = 3$	$Q_D^{AVG} = 2.5$
% Δ Price			% Δ Quantity Demanded		
$\frac{P_N - P_O}{P_A} = \frac{8-7}{7.5} = \frac{1}{7.5}$			$\frac{Q_D^N - Q_D^O}{Q_A^O} = \frac{2-3}{2.5} = -\frac{1}{2.5}$		
$h = \frac{\% \Delta Q_D}{\% \Delta P} = \frac{-1/2.5}{1/7.5} = \frac{-1}{2.5} * \frac{7.5}{1} = \frac{-7.5}{2.5} = -3$					

As can be seen by comparing the results from Tables 3 and 4, the same estimate of price elasticity of demand is obtained regardless of whether price falls from $8 to $7 or the reverse.

C. General Elasticity Concepts Refined

Recall the three general concepts developed above regarding elasticity. Above, a fourth general concept was developed and is now added to the list.

1. Two variables.

   The first step is to identify two variables that are of interest. For rubber band elasticity those two variables were the length and the force. Exactly which two variables are identified will depend upon exactly what it is we are attempting to measure.

2. Identify variable types.

   The second step is to categorize each variable. One variable must be an independent variable. That is, it must change independent of the second variable. The second variable must be a dependent variable. That is, it must change as a result of the change in the first, or independent, variable. For rubber band elasticity the force acts upon or causes the length to change and not the reverse. Hence, the force is independent while the length is dependent.

3. Calculate the elasticity coefficient.

   The formula for calculating all elasticity coefficients used in this course will be the same. They will equal the percentage change in the dependent variable divided by the percentage change in the independent variable (%Δ Dependent Variable ÷ %Δ Independent Variable.) One identifies these two variables in steps one and two above. Later another general rule will be added, which identifies how one actually calculates a percentage change for elasticity coefficients.

4. Calculating percentage changes.

   The percentage change for any variable used in calculating an elasticity coefficient will be calculated by the following equation: $\dfrac{\text{Variable}_{\text{NEW}} - \text{Variable}_{\text{OLD}}}{\text{Variable}_{\text{AVERAGE}}}$

   where $\text{Variable}_{\text{AVERAGE}} = \dfrac{\text{Variable}_{\text{NEW}} + \text{Variable}_{\text{OLD}}}{2}$.

D. Interpretation of Price Elasticity of Demand Coefficients

- The Sign of the Coefficient

  Notice from Tables 3 and 4 that the price elasticity of demand coefficient in that example equaled – 3. What does the negative sign indicate? Recall that the equation used to obtain the price elasticity of demand coefficient equals:

$$\boldsymbol{h} = \frac{\%\Delta Q_D}{\%\Delta P}$$

  Thus, the only way one can get a negative result when dividing two numbers is if one of the numbers is positive and the other is negative. An examination of Tables 3 and 4 illustrates that either the $\%\Delta Q_D$ is positive while the $\%\Delta P$ is negative, as is the case in Table 3 or the $\%\Delta Q_D$ is negative while the $\%\Delta P$ is positive, as is the case in Table 4. But what does such a result mean?

  Notice from all of the Tables above that when a variable is decreasing that the percentage change is negative. On the other hand, when a variable is increasing then the percentage change is positive. Hence, the negative sign on the price elasticity of demand coefficient simply means that:

  1. When the Price of a good rises, then Quantity demanded falls and
  2. When the Price of a good falls, then Quantity demanded rises.

  But, as was discussed when the concept of Demand was originally presented, this inverse relationship between price and quantity demanded is just called the law of demand. Thus, the negative sign of price elasticity of demand coefficients simply reflects the law of demand.

  Because price elasticity of demand is always negative, reflecting the law of demand, and it is easier to work with positive numbers than negative numbers, the common convention is simply to drop the negative sign when reporting and using price elasticity of demand coefficients. That convention will be followed in this class.

- The Size of the Coefficient

  For the demand curve illustrated in Graphs 1 and 2, the elasticity between points A and B was shown to equal 3 (recall that we dropped the negative sign.) What does the <u>size</u> of the coefficient mean? Again, recall that the equation used to obtain the price elasticity of demand coefficient equals:

(5) $$\boldsymbol{h} = \frac{\%\Delta Q_D}{\%\Delta P}$$

Thus, the size of the coefficient can be understood by comparing the numerator (% Δ Q_D) and the denominator (% Δ P) in this equation to each other. Essentially, what we want to know, thinking back to our rubber band elasticity example, is how <u>stretchy</u> is the rubber band as we apply a force to it. If it stretches (Q_D changes) a lot for a little change in the force (the Price) applied, then recall that the rubber band (Demand curve) is considered <u>elastic</u>. Equation 6 illustrates an elastic demand. As required, the percentage change in Q_D exceeds the percentage change in Price. However, as demonstrated by equation 5 above, in this case the elasticity coefficient itself (η) must be greater than one because the numerator (%ΔQ_D) is larger than what it is being divided by (%Δ P).

(6) $$\text{If } \boldsymbol{h} > 1 \Rightarrow \left| \%\,\Delta Q_D \right| > \left| \%\,\Delta P \right| \Rightarrow \text{Demand is Price Elastic}$$

Consider, however, the result if the reverse happens to our rubber band. That is, even though a large force (change in price) is applied to the rubber band, the band simply does not stretch (Q_D does not change). In this case, of course, the rubber band (Demand) is considered <u>inelastic</u>. Equation 7 illustrates the result for an inelastic demand. As required, the percentage change in Q_D is now smaller than the percentage change in price. As a result, the elasticity coefficient (η) is less than one because a larger number is dividing the numerator in equation 5.

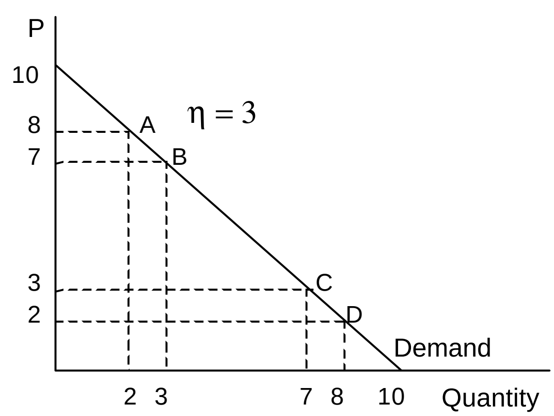
(7) $$\text{If } \boldsymbol{h} < 1 \Rightarrow \left| \%\,\Delta Q_D \right| < \left| \%\,\Delta P \right| \Rightarrow \text{Demand is Price Inelastic}$$

The final possibility, illustrated in equation 8, occurs when the two variables are exactly equal. In this case, demand is considered neither elastic nor inelastic, but instead is called "unitary" (meaning "equal to one".)

(8) $$\text{If } \boldsymbol{h} = 1 \Rightarrow \left| \%\,\Delta Q_D \right| = \left| \%\,\Delta P \right| \Rightarrow \text{Demand is Unitary Elastic}$$

- Is the size of the coefficient constant along the demand curve, as is true of slope?

  Graph 3 at the right will be used to illustrate that the elasticity coefficient and the slope of the demand curve are not equal. Above, the price elasticity of demand coefficient (η) between points A and B in the graph was calculated to equal 3. Now, however, consider the coefficient between two other points on the same curve, points C and D.



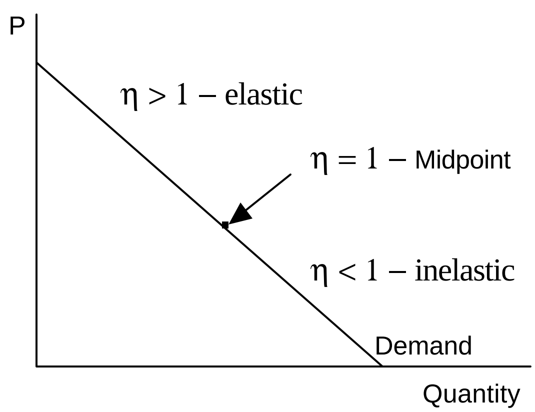
Graph 3

Recall that it doesn't matter, given our new equation for calculation elasticity coefficients, whether we move from point C to point D or the reverse. In either case, the same coefficient will be obtained. Table 5 illustrates the calculation of the elasticity coefficient assuming that we are moving from point C to point D.

Table 5
Elasticity Coefficient Calculated from Point C to Point D
Using Averages as Bases

$P_{NEW} = 2$	$P_{OLD} = 3$	$P_{AVG} = 2.5$	$Q_D^{NEW} = 8$	$Q_D^{OLD} = 7$	$Q_D^{AVG} = 7.5$
% Δ Price			% Δ Quantity Demanded		
$\frac{P_N - P_O}{P_A} = \frac{2-3}{2.5} = -\frac{1}{2.5}$			$\frac{Q_D^N - Q_D^O}{Q_A^O} = \frac{8-7}{7.5} = \frac{1}{7.5}$		
$\boldsymbol{h} = \frac{\% \Delta Q_D}{\% \Delta P} = \frac{1/7.5}{-1/2.5} = \frac{1}{7.5} * \frac{-2.5}{1} = \frac{-2.5}{7.5} = -1/3$					

Recall that once the coefficient is calculated, that the negative sign is dropped. Hence, the price elasticity of demand between points C and D in Graph 3 equals 1/3. However, when elasticity was calculated between points A and B, then we found that the coefficient equaled 3, not 1/3. Clearly, the elasticity coefficient does not stay the same, as does the slope of the curve, along a given, linear, downward-sloping, demand curve. In point of fact, the elasticity coefficient measured along such a demand curve (linear and downward-sloping) has the properties illustrated in Graph 4.



Graph 4

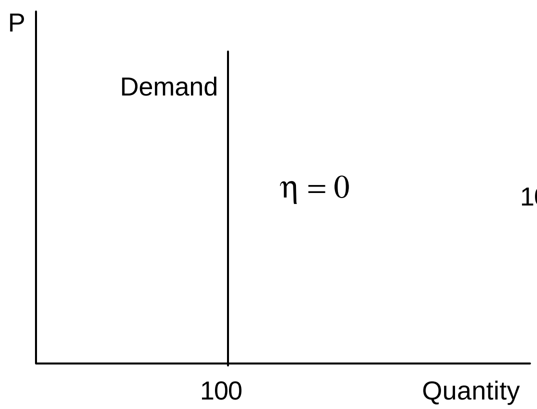
First, similar to Graph 3, the elasticity coefficient will be greater than 1 when the price is high and quantity demanded is low. Likewise, similar to what we just discovered looking at the elasticity coefficient between points C and D in Graph 3, when the price is low and quantity demanded high, then the elasticity coefficient will be less than 1.

Finally, the elasticity coefficient will equal 1 at the midpoint of the demand curve. In Graph 3, the midpoint of the demand curve occurs when price and quantity demanded both equal 5. Furthermore, as one moves down a demand from a high price to a low price, then the elasticity coefficient, which starts out large (elastic), will get smaller and smaller.

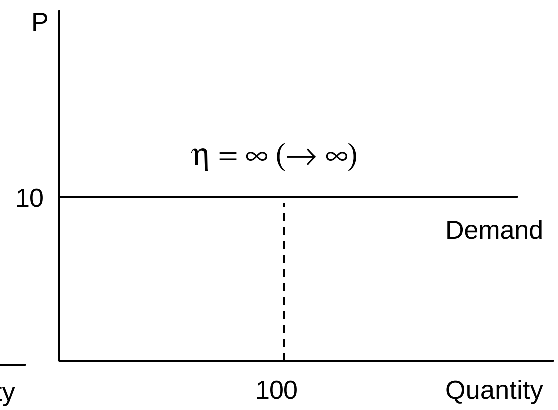
This occurs for <u>two</u> reasons. First, for a given price change, say a decrease in price of \$1, then the percentage change <u>increases</u> as one moves down the demand curve because the \$1 price decrease is being divided by a smaller number to obtain the percentage change. On the other hand, for the same price decrease, the percentage increase in quantity demanded becomes <u>smaller</u> as one moves down the demand curve. Again, this occurs because a larger number to obtain the percentage change is dividing the increase in QD. This fact is illustrated in Tables 3 and 5. When price is high (moving from 8 to 7 in Table 3), then the percentage change in price is low (1/7.5 = 13.3 percent) while the percentage change in Q_D is high (1/2.5 = 40 percent), resulting in an elasticity coefficient equaling 3, greater than one. However, when price is low (moving from 3 to 2 in Table 5), then the percentage change in price is high (1/2.5 = 40 percent) while the percentage change in Q_D is low (1/7.5 = 13.3 percent), resulting in an elasticity coefficient equaling 1/3, less than one.

- Perfectly Inelastic and Perfectly Elastic Demand Curves

  Graph's 5 and 6 illustrate the two extremes for demand curves. In Graph 5, the Demand curve is perfectly vertical. That is, regardless of the change in price, quantity demanded will never change – quantity demanded always equals 100. Thus, the percentage change in Q_D will equal zero, which means that the elasticity coefficient must also equal zero. Not only is this demand inelastic, less responsive to changes in price, but it is totally unresponsive to changes in price. As a result, this type of Demand is called a perfectly inelastic demand.



Graph 5
Perfectly Inelastic Demand



Graph 6
Perfectly Elastic Demand

In contrast, in Graph 6 the Demand curve is perfectly horizontal. That is, the individual in Graph 6 is willing to pay $10 for any amount of quantity of the good, say 100. If the price increases above $10, to say $20, this individual will decrease the amount she buys from 100 to zero. In fact, if the price increases <u>at all</u> above $10, this person will decrease purchases to zero. Even a miniscule increase in price of a penny, or even less, will reduce quantity demanded by 100 percent. Hence, the price elasticity of demand is very large (because the percentage change in Q_D is large while the percentage change in Price is very small.) In mathematical terms the elasticity coefficient approaches infinity, although we will simply refer to elasticity as equaling infinity. Hence, not only is this demand curve elastic, but Q_D reacts so strongly to the smallest changes in price, that it is called perfectly elastic.

E. Elasticity and Total Revenue

As an application of the importance of the concept of elasticity, consider the relationship between price elasticity of demand and total revenue. Total revenue equals the total amount of dollars a firm receives from the sales of its product and is found by multiplying the price they receive times the quantity that they sell.

(9) Total Revenue (TR) = P x Q

A firm's total revenue may actually increase or decrease when it chooses to change its price. This is because a price increase affects total revenue in two distinct ways. For example, suppose that the price of a good rises. Obviously, the price increase will cause total revenue to increase directly. However, there also exists an indirect impact of the price increase. When the firm raises its price then the quantity sold to its customers (Q_D) will also decrease, which will in turn cause total revenue to fall. Because these two separate impacts have opposite effects upon total revenue, the price increase could cause total revenue to rise or fall dependent upon which of the two effects is largest.

In fact, the size of the price elasticity of demand coefficient, tells us which of these two effects, the direct price effect or the indirect quantity effect, is largest. Table 6 illustrates this issue.

Table 6
The Impact of a Price Increase on Total Revenue
The effect of price elasticity of demand

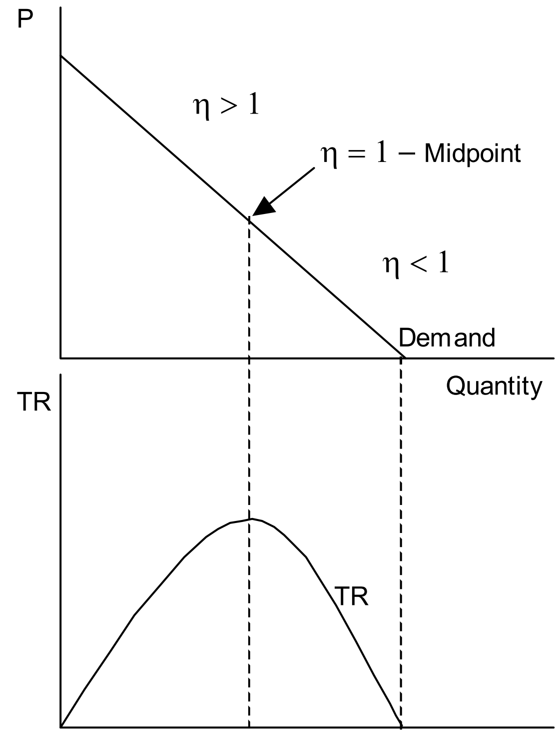
Recall that when the Price increases TR ↑ directly but because Q_D also ↓ with the price increase then TR ↓ indirectly.

Price Elasticity of Demand	Is the Q_D or P effect largest?	Impact on TR
Elastic ($\eta > 1$)	$\lvert \% \Delta Q_D \rvert > \lvert \% \Delta P \rvert$	Q_D effect largest ⇒ TR ↓
Inelastic ($\eta < 1$)	$\lvert \% \Delta Q_D \rvert < \lvert \% \Delta P \rvert$	P effect largest ⇒ TR ↑
Unitary elastic ($\eta = 1$)	$\lvert \% \Delta Q_D \rvert = \lvert \% \Delta P \rvert$	2 effects equal ⇒ TR →

Note: The impact of a price decrease on total revenue would be just the opposite in each instance above.

Thus, when demand is price elastic (inelastic) a price increase causes total revenue to fall. The reverse would be true if the firm lowers its price. Hence, for a decrease in price, total revenue rises (falls) when demand is price elastic (inelastic). Notice that for either an increase or decrease in price, total revenue will remain constant when demand is unitary because the two effects are equal and exactly offset each other.

Graph 7 illustrates this principle for a downward sloping demand curve. Recall that from Graph 4 above we learned that downward sloping demand curves do not have constant elasticity along the curve. Rather, demand is elastic when price is high, inelastic when price is low and unitary at the midpoint of the demand curve.



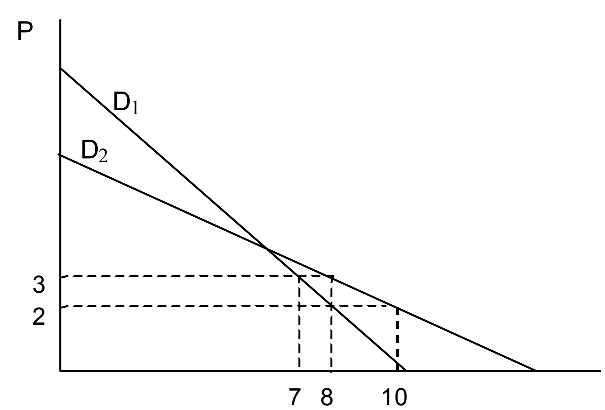
Graph 7

Likewise, we found above that whether total revenue rises or falls as price increases (or decreases) is dependent upon price elasticity of demand. Hence, total revenue must vary along a linear downward sloping demand curve such as that shown in Graph 7. But what does total revenue look like graphically?

Clearly, when the price is equal to zero, as it is where demand intersects the quantity axis, or when the quantity demanded equals zero, as it is when the demand intersects the price axis, total revenue must equal zero. Thus, when a firm either sells none of its goods or sells its good for a zero price, they bring in zero revenue. As is shown in Graph 7, if the firm moves away from either of these intersection points and either begins selling some of their product or begins charging a positive price then their total revenue must increase. Total revenue continues to rise as the firm moves away from the intersections until it reaches a maximum at the midpoint. Notice that total revenue in Graph 7 works in exactly the same manner as illustrated above in Table 6. For a price increase, total revenue rises when demand is inelastic and falls when demand is elastic.

F. What causes a demand curve to be more or less elastic?

The last issue to discuss for price elasticity of demand is what, exactly, causes demand to be more or less elastic. This issue is not referring to simply moving to a different point on a given demand curve, as illustrated above in Graphs 4 and 7. Rather, two downward sloping demand curves may have, for a given price change, different elasticities. Consider the two demand curves presented in Graph 8. Demand curve D_1 is the demand presented above in Graph 3. Demand curve D_2 is flatter than D_1. For a given price decrease from \$3 to \$2, quantity demanded on D_1 increases from 7 to 8, while quantity demand on D_2 increases from 8 to 10.



Graph 8

Recall that elasticity is measuring how responsive demand is to changes in the good's price. Hence, clearly D_2 is more responsive to price changes than D_1 because for the same price change, quantity demanded changes more (on a percentage basis.) In fact, a calculation of the elasticity coefficients for each demand curve will illustrate this point. D_1 is the same demand curve used in the examples above calculating elasticity coefficients. The elasticity coefficient for D_1 when the price falls from \$3 to \$2 was calculated in Table 5 and equals 1/3 (recall we drop the negative sign.) Follow the same rules to calculate the elasticity coefficient for D_2. The percentage change in price is the same for both curves and equals –1/2.5 (see Table 5). As an exercise, calculate the rest of the elasticity coefficient for D_2 and you will find that it equals 5/9. Hence, as expected the elasticity coefficient for D_2 is greater than for D_1, indicating that D_2 is relatively more elastic. In general, demand curves are relatively more elastic the flatter they become. This general phenomenon is also illustrated by a comparison of the perfectly elastic and perfectly inelastic demand curves presented above in Graphs 5 and 6.

It is important to understand that D_2 still has the standard characteristics discussed above for demand curves. For example, if you were to calculate elasticity coefficients between different points along the curve you would find that the coefficients were not constant along the curve. In fact, as illustrated in Graph 4, the curve would be elastic when price was high and inelastic when price is low.

Now that we understand that a demand curve <u>can</u> be relatively more or less elastic than another demand curve, return to our original question: What makes a demand curve more or less elastic?

1. The number of substitutes that exist for that good.

   Consider the price elasticity of demand for a good like insulin, a medicine that is crucial for people with diabetes. If the price of insulin rises, do consumers of insulin tend to decrease their consumption a lot (demand is elastic) or a little (demand is inelastic)? There are no real substitutes for insulin and, hence, no real choices for consumers when the price rises. As a result, demand for insulin tends to be relatively inelastic.

   Think about what would happen, however, if a number of substitutes for insulin were developed. In this case, when the price of insulin rose insulin users could and would switch to the relatively cheaper substitutes. Hence, demand becomes relatively more (less) elastic as the number of substitutes for a good increases (decreases).

2. The cost of the good compared to the household budget.

   Consider the price elasticity of demand for a good such as apples compared to that for a good such as housing. One of the big differences between these two types of goods is that the price of apples is small as a percent of the household budgets while housing is typically a large percentage of such budgets. Doubling the price of apples will not, therefore, have much of an impact relative to one's budget. However, doubling the price of housing <u>will</u> have a large impact relative to one's budget. In fact, soon as the price of such a good continues to increase one must decrease consumption simply because of lack of money.

   Hence, demand for housing will be relatively more elastic than demand for apples, all else equal. Likewise, the larger (smaller) the cost of the good relative to household budget, the more (less) elastic will demand for that good become.

3. Is the good a luxury or necessity?

   Now consider the price elasticity of demand for a good like a luxury sports car versus a necessity like food. As the price of either good rises, for which good will consumers likely reduce their consumption most? Food, being a necessity, is less likely to have much of a reduction in the quantity consumed. That is not to say that consumption of food will not fall, because it will, just that it will not fall as much. However, the quantity of luxury sports cars bought will be more responsive to changes in price for exactly the reason that consumers do not view such cars as necessary. Hence, the more of a luxury a good is, the more elastic is demand for the good. On the other hand, the more a necessity a good is, the less elastic is demand for the good.

4. The time interval over which demand can change.

   Consider what happens as the price of a good such as gasoline doubles. People respond to the higher price by decreasing their use of gas. However, in just a short time period it is more difficult to do this than in a longer period. Essentially, as the time period people have to adjust lengthens, then they can do more things to reduce their consumption of gas. For example, they might be able to move closer to work, buy a more fuel-efficient car, lobby to have public transportation, etc. in a longer time frame. Hence, essentially as the time period lengthens more substitutes for the good whose price increased will be found. As was discussed above, an increase in substitutes makes demand relatively more elastic. As a result, as the time period over which consumers can respond to a price change for a good lengthens (shortens) then demand for that good becomes relatively more (less) elastic.

5. The grouping of the good.

   Consider the relative price elasticity of demand for a good such as apples as compared to a good such as food. What is the difference between apples and food? Apples are, of course, a food but so are lots of other goods as well. Hence, more substitutes exist for <u>apples</u> than exist for the broader category of <u>food</u>. We have already determined that as the number of substitutes increase then so does that goods relative price elasticity of demand. As a result, as the grouping of a good gets narrower (broader) then demand for that good becomes relatively more (less) elastic.

II. Income Elasticity of Demand

What we know from our discussion of demand is that an individual's income has an impact upon demand. Recall that the relationship between income and demand may be inverse or direct, depending upon whether the good is an inferior good or a normal good. Further, what we want to know is also how much will quantity demanded rise or fall as income changes. That is, how stretchy or how elastic, is the demand curve in response to a change in income. Thus, income elasticity of demand (η_Y) measures how responsive is demand for a good to changes in consumer income.

A. Applying the general rules of Elasticity

In sections I and II above we developed four general rules about the calculation of elasticity coefficients. Before continuing, you should take some time to briefly review those general rules (see section I B. and section II C.). The first step in calculating elasticity coefficients is to decide which two variables are of interest. Clearly, as described above, income and quantity demanded are the two variables of interest.

Next, we must decided which of these two variables is dependent, acted upon by the other variable, and which is independent, acts upon the other variable. That is, do consumers choose the quantity they wish to consume given their income? Or, conversely, do consumers choose their income they wish to have given the quantity of the good they are consuming? Clearly, all consumers would prefer to do the latter (and what income would we all choose?) but unfortunately this is not the way markets work. Rather, we make our consumption decisions based upon our income. Hence, income is the independent variable while the quantity we consume (quantity demanded) is the dependent variable. . As a result, the equation for income elasticity of demand (η_Y) equals:

$$\eta_Y = \frac{\%\Delta Q_D}{\%\Delta Y} \qquad (10)$$

where Y stands for income.

The calculation of specific income elasticity coefficients requires one to calculate the respective percentage changes in Q_D and income. As calculating percentage changes follow the same formula as presented above for price elasticity of demand no specific examples are given here. However, students should be prepared to calculate specific coefficients for exams.

B. Interpretation of Income Elasticity of Demand Coefficients

- The Sign of the Coefficient

  The sign of an income elasticity of demand coefficient is dependent upon the movement in the two relevant variables, income (Y) and demand (Q_D). If the two variables move in the same direction, either both rising (both percentage changes are positive) or both falling (both percentage changes are negative) then the coefficient will be positive. If the two variables move in opposite directions, with one rising while the other falls, then the coefficient will be negative. Thus, the issue is what happens to Q_D when income rises or falls.

  In the chapter on demand we discovered that rising income could have a positive or negative impact on demand dependent upon whether the good in question was a normal or an inferior good. For normal goods, an increase (decrease) in income causes demand to increase (decrease). Conversely, for inferior goods an increase (decrease) in income causes demand to decrease (increase.) Hence, the sign of the income elasticity coefficient for a good tells us whether that good is a normal or an inferior good.

  1. If $\eta_Y > 0 \Rightarrow$ the good must be a normal good.
  2. If $\eta_Y < 0 \Rightarrow$ the good must be an inferior good.

- The Size of the Coefficient

  The size of the income elasticity coefficient is similar to that for price elasticity of demand:

$$\text{If } |\eta_Y| > 1 \Rightarrow |\%\,\Delta Q_D| > |\%\,\Delta Y| \Rightarrow \text{Demand is Income Elastic} \tag{11}$$

$$\text{If } |\eta_Y| < 1 \Rightarrow |\%\,\Delta Q_D| < |\%\,\Delta Y| \Rightarrow \text{Demand is Income Inelastic} \tag{12}$$

$$\text{If } |\eta_Y| = 1 \Rightarrow |\%\,\Delta Q_D| = |\%\,\Delta Y| \Rightarrow \text{Demand is Unitary Elastic} \tag{13}$$

  Absolute values are taken so as to allow goods to be normal or inferior and nonetheless still be income elastic, inelastic, or unitary. However, the size of the income elasticity of demand for normal goods tells us something additional than does income elasticity for inferior goods. Consider a normal good where η_Y is greater than zero. Now consider the meaning of a good that is income elastic. Equation 11 above tells us that in this case the percentage of income that the consumer spends on the good will <u>increase</u> as their income increases. Thus, if income were to double spending on the good would more than double. What type of good is it that one spends not only more on the good (which is true of all normal goods) but also more proportionally? Economists refer to these types of goods as luxuries. Thus, the definition of a luxury is a normal good that is income elastic. Likewise, the definition of a necessity is a normal good, but one that is income inelastic.

III. Cross Elasticity of Demand

What we know from our discussion of demand is that prices of related goods have an impact upon demand. Recall that goods may be either complements to or substitutes for the good. If two goods are complements, then as the price of the complement rises, demand for the good will fall. Just the reverse will happen if the two goods are substitutes for each other. Thus, we know that as the price of a related good changes that the demand for the good will also change. What we want to know here is how much will quantity demanded rise or fall as the price of the related good changes. That is, how stretchy or how elastic, is the demand curve in response to changes in prices of related goods. Thus, cross elasticity of demand (η_{XY}) measures how responsive demand for good X is to changes in the price of good Y.

A. Applying the general rules of Elasticity

In sections I and II above we developed four general rules about the calculation of elasticity coefficients. Before continuing, you should take some time to briefly review those general rules (see section I B. and section II C.). The first step in calculating elasticity coefficients is to decide which two variables are of interest. Clearly, as described above, the price of good X and the quantity demanded of good Y are the two variables of interest.

Next, we must decided which of these two variables is dependent, acted upon by the other variable, and which is independent, acts upon the other variable. That is, do consumers choose the quantity they wish to consume given prices of related goods? Or, conversely, do consumers choose the prices of related goods given the quantity of the good they are consuming? Clearly, all consumers would prefer to do the latter (and prices would equal zero, of course) but unfortunately this is not the way markets work. Rather, we make our consumption decisions based upon prices in markets, including the prices of related goods. Hence, the price of the related good is the independent variable while the quantity we consume (quantity demanded) is the dependent variable. As a result, the equation for cross elasticity of demand (η_{XY}) equals:

$$\eta_{XY} = \frac{\%\Delta Q_D^X}{\%\Delta P_Y} \tag{14}$$

Again, the calculation of specific cross elasticity coefficients requires one to calculate the respective percentage changes in Q_D of good X and P_Y. As noted above for income elasticity of demand, calculating percentage changes follow the same formula as presented above for price elasticity of demand. Hence, no specific examples are given here and students are referred to the examples given in section II above. Students should, however, be prepared to calculate specific coefficients for exams.

B. Interpretation of Cross Elasticity of Demand Coefficients

- The Sign of the Coefficient

  As with income elasticity of demand, the sign of a cross elasticity of demand coefficient is dependent upon the movement in the two relevant variables, quantity demand for good X (Q_D^X) and the price of good Y (P_Y). If the two variables move in the same direction, either both rising (both percentage changes are positive) or both falling (both percentage changes are negative) then the coefficient will be positive. If the two variables move in opposite directions, with one rising while the other falls, then the coefficient will be negative. Thus, the issue is what happens to Q_D^X when P_Y rises or falls. In fact, the sign is dependent upon whether or not the two goods involved are substitutes or complements in consumption.

1. Substitutes in consumption.

   Recall from our discussion of demand that when two goods are substitutes in consumption that with a rise in the price of one good, consumers respond by buying less of that good (law of demand). However, consumers also respond by switching to the consumption of the good's substitute. Thus, a rise (fall) in the price of a substitute increases (decreases) demand for a good, resulting in a positive cross elasticity coefficient. Hence, if a cross elasticity coefficient between two goods is positive, then the two goods must be substitutes in consumption.

2. Complements in consumption.

   Recall from our discussion of demand that when two goods are complements in consumption that with a rise in the price of one good, consumers respond by buying less of that good (law of demand). However, consumers also respond by buying less of the goods that they consume with it, its complements. Thus, a rise (fall) in the price of a complement decreases (increases) demand for a good, resulting in a negative cross elasticity coefficient. Hence, if a cross elasticity coefficient between two goods is negative, then the two goods must be complements in consumption.

- The Size of the Coefficient

  The size of cross elasticity of demand coefficient is primarily used to indicate the strength of the relationship between the two goods in question. Consider, for example, the meaning when a cross elasticity coefficient equals zero. According to equation 14 a zero coefficient can only occur when, regardless of the size or direction of the price change in good Y, the change in the quantity bought of good X is zero. That is, a change in the price of one of the goods does not affect the quantity bought of the other good. Of course, such a zero cross elasticity coefficient means that the two goods are not related, that they are neither substitutes nor compliments.

  When the coefficient increases from zero (in absolute value) this simply indicates that the two goods are now related, either as complements or as substitutes. Thus, as the size increases this simply indicates that the two goods are more closely related. Thus, if η_{XY} equals .5 while η_{XZ} equals 20, then we would conclude (1) both good Y and good Z are substitutes for good X and (2) Z is a much better substitute for X than is Y.

  A special case occurs when the cross elasticity coefficient gets very large, approaches infinity, in absolute. In this case, the two goods are either perfect substitutes or perfect complements. Perfect substitutes are two goods where the consumer simply treats the two goods as identical, even though there may exist real differences. However, for the particular consumer those differences are irrelevant. An example of perfect substitutes for Dr. Olsen is blue pens and black pens – I don't care how many of either I have, simply that enough are available to write on the board. (Red and green pens, on the other hand, are not perfect substitutes because they don't show to students in the back of the room.)

  Perfect complements are two goods that a consumer always consumes together. For virtually all of us right shoes and left shoes are examples of perfect complements. In fact, so many people always buy these goods together that they are always sold together as pairs of shoes.

IV. Price Elasticity of Supply

What we know from our discussion of supply is that when the price of a good rises that the quantity supplied of that good also rises. Recall that this positive relationship between price and quantity supplied is known as the law of supply. Although the direction of the relationship is clear what is not clear is by how much quantity supplied will rise or fall as price increases or decreases. That is, how stretchy or how elastic, is the supply curve in response to a change in the price of a good. Thus, price elasticity of supply (η_S) measures how responsive supply for a good is to changes in the price of that good.

A. Applying the general rules of Elasticity

Now apply the general rules of elasticity to price elasticity of supply. First, based upon the above definition one of the variables must the price of a good while the other variable must the quantity supplied of that good.

Second, which of these two variables, price and quantity supplied, is dependent and which independent. That is do firms choose how much they sell (Q_S) based upon the price of the good – in which case price is independent and Q_S dependent. Or do firms choose the price based upon how much they want to sell (Q_S)? Although all firms would prefer to be able to choose the price – and given firm self-interest the price they would always choose is a very high price – clearly firms must take the market price as a given and choose how much they wish to produce based upon that price. Hence, price is the independent variable while quantity supplied is dependent. As a result, the equation for price elasticity of supply (η_S) equals:

$$\eta_S = \frac{\%\Delta Q_S}{\%\Delta P} \tag{15}$$

Again, the calculation of specific price elasticity of supply coefficients requires one to calculate the respective percentage changes in Q_S and price. As noted above, calculating percentage changes follow the same formula as presented above for price elasticity of demand. Hence, no specific examples are given here and students are referred to the examples given in section II above. Students should, however, be prepared to calculate specific coefficients for exams.

B. Interpretation of Price Elasticity of Supply Coefficients

- The Sign of the Coefficient

  Signs of elasticity coefficients are dependent upon the movement in the two relevant variables, in this case the quantity supplied (Q_S) and the price (P) of a good. Again, if the two variables move in the same direction, either both rising (both percentage changes are positive) or both falling (both percentage changes are negative) then the coefficient will be positive. If the two variables move in opposite directions, with one rising while the other falls, then the coefficient will be negative.

  Thus, the issue is what happens to the quantity supplied when the price rises or falls. However, as we discussed in the chapter on demand and supply, the law of supply indicates that price and quantity supplied have a positive relationship, always moving in the same direction. This means that the price elasticity of supply coefficients will always be positive, reflecting the law of supply.

- The Size of the Coefficient

  The interpretation of the size of the price elasticity of supply coefficient is similar to that for price elasticity of demand:

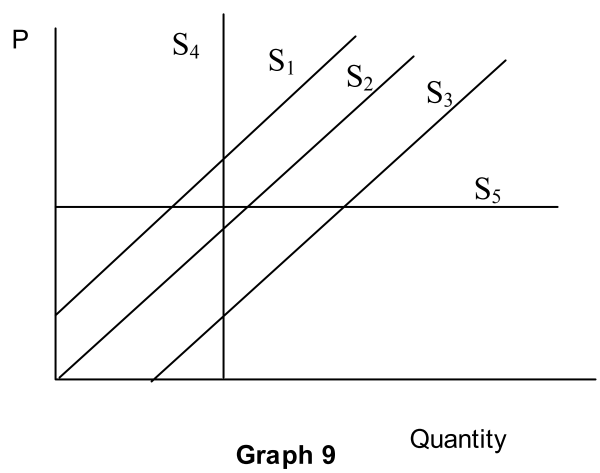
  (16) $$\text{If } |\eta_S| > 1 \Rightarrow |\%\,\Delta Q_S| > |\%\,\Delta P| \Rightarrow \text{Supply is Price Elastic}$$

  (17) $$\text{If } |\eta_S| < 1 \Rightarrow |\%\,\Delta Q_S| < |\%\,\Delta P| \Rightarrow \text{Supply is Price Inelastic}$$

  (18) $$\text{If } |\eta_S| = 1 \Rightarrow |\%\,\Delta Q_S| = |\%\,\Delta P| \Rightarrow \text{Supply is Unitary Elastic}$$

- Relatively more/less Elastic Supply Curves

  Graph 9 shows upward sloping supply curves with three different types of intercepts, on the price axis (S_1), at the origin (S_2) and on the quantity axis (S_3). These different types of supply curves illustrate changes in relative elasticity. All curves that, like S_1, intercept on the price axis are relatively elastic, having price elasticities greater than one. All curves that, like S_2, intercept at the origin regardless of the slope are unitary elastic, having price elasticities equal to one. Further, all curves that, like S_3, intercept on the quantity axis are relatively inelastic, having price elasticities less than one. Thus, by shifting supply to the right (left) the supply curve becomes less (more) elastic.

  Graph 9

  Supply also become relatively more elastic as they become flatter and more inelastic as they become steeper. In fact, similar to demand curves, supply curves that are perfectly vertical, like curve S_4 in Graph 9, are perfectly inelastic. Similarly, supply curves that are perfectly horizontal, like curve S_5 in Graph 9, are perfectly elastic.

V. Using Elasticity Coefficients

Students will need to be able to do a number of things with the different elasticity coefficients on the test. You should carefully read all of the above material in detail. However, there are some questions and uses that are in common between each of the different elasticity coefficients, which are briefly discussed below.

1. Students should be prepared to use the equations to calculate the four different types of elasticity coefficients. Be careful and not make mistakes – the most common mistakes include dividing by the wrong number (the percentage change in Q_D or Q_s is always in the numerator in the calculations) or calculating the percentage changes incorrectly (using the old value of the variable rather than the average.)
2. What does the sign of the coefficient indicate? Although the interpretation differs, for each type the sign gives information about the demand or supply of the good. Make sure you understand how signs of elasticity coefficients are interpreted.
3. What does the size of the coefficient indicate? Again, this differs for the different types but the size always tells us something about the goods in question.

4. Using the coefficient to make predictions.

Suppose that the income elasticity of demand for a good equals 2. From this we know that the good is a normal good (because $\eta_Y > 0$) and we know that the good is a luxury (because $\eta_Y > 1$). But we can also predict what will happen to the quantity demanded for the good for a given percentage change in income. For example, if income rises by 10 percent, then the coefficient tells us that quantity demanded for the good will also rise by 20 percent. How do we know this? Recall that:

$$\eta_Y = \frac{\%\Delta Q_D}{\%\Delta Y} = 2$$

However, the only number that can be divided by 10 percent and yield a 2, is 20 percent. Another way to find this answer is to algebraically solve the equation above for the $\%\Delta Q_D$. Doing so yields:

$$\%\Delta Q_D = \eta_Y \times \%\Delta Y$$

Thus, 2 times the 10 percent increase in income yields a 20 percent increase in Q_D. Students should be prepared to do the same for each of the four different types of elasticity coefficients

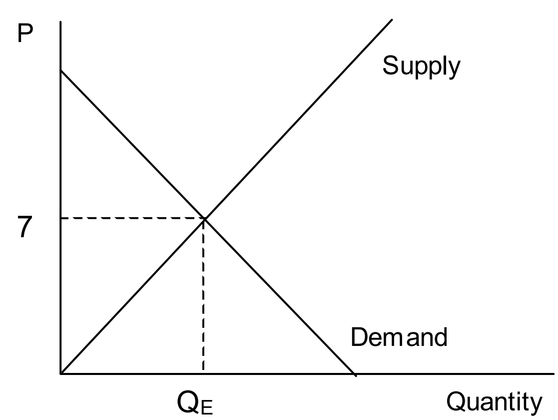
VI. Elasticity and Taxation

Finally, taxation is used to illustrate the usefulness of elasticity in analyzing and understanding economic issues. The main question to be addressed in this application is the simple one of understanding who pays for taxes on goods and services imposed by the government – consumers or firms? When asked, most people (consumers) commonly respond with the belief that they do, that firms simply pass taxes on to them. But is this really the case or not?

A. Who Pays for the Tax?

Consider the imposition of a tax on a good such as first-run movies (in theatres). Assume that the situation is as outlined in Graph 10 prior to the imposition of the tax where the equilibrium price of movies equals $7.

Now consider what happens in the market if the government imposes a tax of one dollar on each movie ticket sold. The test of whether or not firms simply pass this tax on to consumers is to simply ask whether doing so results in market equilibrium, where quantity demanded equals quantity supplied. If market equilibrium does occur, then firms will pass on taxes fully to consumers. If market equilibrium does not occur, however, even though firms would certainly prefer to pass on taxes, they will be unable to do so.



Graph 10

In order to analyze equilibrium, we must clearly understand the impact of the imposition of the tax and the conditions necessary for equilibrium to occur. Prior to the imposition of the tax, the equilibrium is as shown in Graph 10. The market price equals $7 and at that price $Q_D = Q_S = Q_E$. However, <u>after</u> the tax there no longer exists a single market price. The tax works by the government collecting a dollar from movie theatres each time a ticket is sold. Hence, there exist two prices now, one paid by consumers and one collected by firms, which differ by the amount of the tax.

$$P_S = P_C - \text{tax} \tag{19}$$

Where P_S is the price firms receive and P_C is the price consumers pay.

Hence, if firms simply pass on the tax to consumers, P_S will remain \$7 while P_C will rise to \$8. Is this an equilibrium, where $Q_D = Q_S$? As shown by Graph 10, clearly simply passing on the full tax is not an equilibrium. Simply comparing quantity demanded and supplied under the new prices illustrates the lack of an equilibrium. When P_S remains at \$7, firms respond by keeping their Q_S at the same level, Q_E. However, when P_C increases to \$8 consumers respond by decreasing their Q_D below its old level at Q_E. Hence, if firms attempt to simply pass on the tax to consumers, then a surplus will develop. Recall from the chapter on equilibrium that surpluses cause prices, in this case both P_C and P_S, to decrease.

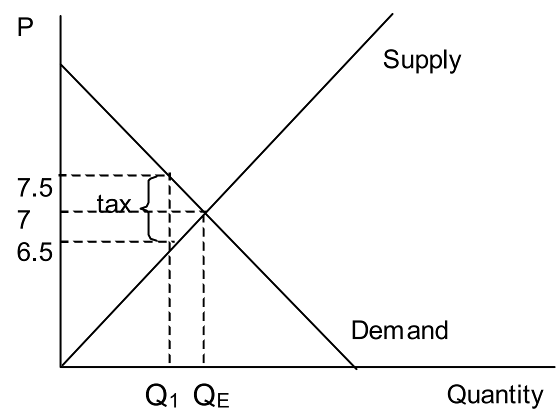
If consumers don't pay for the tax, then do firms? In this case, P_C would remain at \$7 while P_S would decrease by the amount of the tax to \$6. Is this an equilibrium, where $Q_D = Q_S$? Again, as shown by Graph 10, the answer to this question is clearly no. When P_C remains at \$7, consumers respond by keeping their Q_D at the same level, Q_E. However, when P_S falls to \$6 firms respond by reducing their Q_S below its old level at Q_E. Hence, if firms don't pass on any of the tax to consumers, then a shortage will develop. Again, our discussion of equilibrium above illustrates that shortages cause prices to increase.

Hence, neither consumers nor firm fully pay for the tax. Equilibrium prices will be somewhere between both of these two extremes with both parties bearing part, but not all, of the tax burden. Where is the actual equilibrium? As it turns out, where it ends up depends upon the relative price elasticities of demand and supply. However, it can be illustrated very simply with the demand and supply curves first presented above in Graph 10, and recreated in Graph 11.

Recall that two conditions must exist for equilibrium. First, the two prices must differ by the amount of the tax, as shown by equation 19. Second, at these two different prices for consumers and firms, quantity demanded must equal quantity supplied. We discovered above that prices must lie between the two extremes of either consumers paying all or none of the tax. That is, both consumers and firms must pay part of the tax. Hence, P_C must rise while P_S must fall, but not by the full amount of the tax. But in this case, both quantity demanded and supplied will fall. Hence, the new equilibrium must be to the left of the old equilibrium quantity, Q_E. Graph 11 illustrates this new equilibrium.

The equilibrium exists where the distance between the demand and the supply curve, to the left of Q_E just equals the amount of the tax. At this quantity, Q_1, P_C is given by the demand curve and equals \$7.50 while P_S is given by the supply curve and equals \$6.50. The tax is the difference between the two prices and, as required, equals \$1. Notice that both equilibrium requirements are satisfied here.

In this particular case, both firms and consumers share the tax equally. However, this will not always be the case. Rather, who bears the burden of taxes will depend upon the relative elasticities of demand and supply.

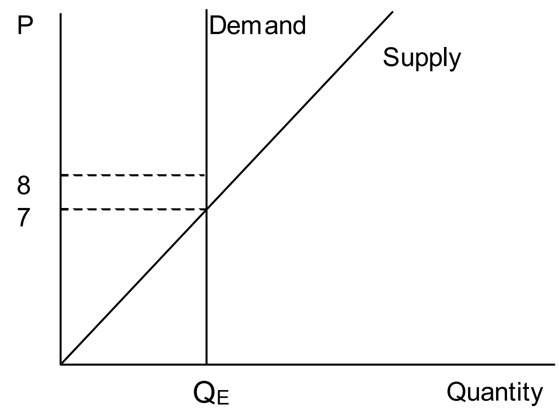


Graph 11
Relatively Elastic Demand and Supply
Consumers and Firms Share Tax Burden

B. The Impact of Supply and Demand Elasticities on the Tax Burden.

The main purpose of this section is to illustrate the usefulness of elasticity in an application. So far, the analysis has mainly used demand and supply analysis to illustrate whom pays for a tax on a good. However, the relative price elasticities of demand and supply are crucial in understanding tax burdens. Their importance will be illustrated by comparing different types of demand and supply curves and again asking which party, consumers or firms, pays for the tax.

Initially, the impact of changes in the relative elasticity of demand curves will be examined. Consider the equilibrium when a tax is imposed and demand is perfectly inelastic. In this case, illustrated in Graph 12, firms <u>can</u> simply pass on the entire tax to consumers. Above in Graph 11, firms could not do this because when they tried consumers responded by reducing the amount they bought, creating a surplus. But in Graph 12, a rise in the price to consumers does not result in a reduction in Q_D. As a result, if P_C rises to \$8, then consumers continue to consume Q_E. Likewise, firms continue to produce Q_E because their price remains at \$7 (P_C – tax).



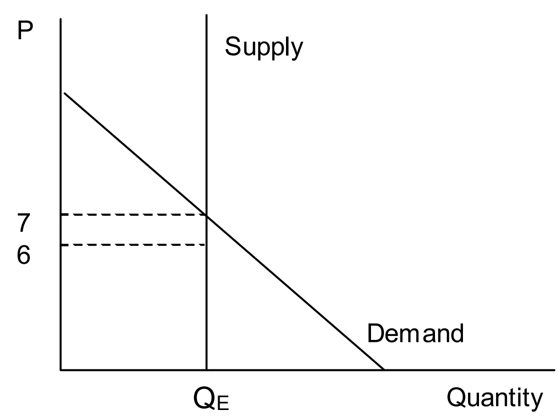
Graph 12
Perfectly Inelastic Demand
Consumers Bear the Full Tax Burden

Thus, when consumers are completely inflexible (demand is perfectly inelastic) they will end up paying the entire tax. Whereas, when consumers are more flexible (demand is relatively elastic), as was the case in Graph 11, consumers pay less of the tax. A comparison between Graph 11, with a relatively elastic demand, and Graph 12, with a perfectly inelastic demand, illustrates the following conclusions:

- As demand becomes more elastic (Graph 11), consumers pay less of the tax and suppliers pay more of the tax.
- As demand becomes less elastic (Graph 12), consumers pay more of the tax and supplies pay less of the tax.

Next consider the relative sharing of the tax burden between firms and consumers when firms, rather than consumers, are inflexible. Thus, in contrast to Graph 12, the supply curve is perfectly inelastic while the demand remains downward sloping. In this case, we would suspect that firms would bear the tax burden. Is this an equilibrium? Graph 13 illustrates this situation and demonstrates that firms would bear the tax burden.

In Graph 13, if firms keep P_C constant at \$7 after the tax is imposed, then consumers respond by keeping their quantity demanded at Q_E. After paying the tax, P_S would fall to \$6. However, at a price of \$6, firms would continue to produce Q_E because they are always willing to do so. Hence, quantity demanded equals quantity supplied, even though firm and consumer prices differ by the amount of the tax and an equilibrium exists.



Graph 13
Perfectly Inelastic Supply
Firms Bear the Full Tax Burden

Comparing Graph 13, where supply is perfectly inelastic, to Graph 11, where supply is more elastic, we can make the following conclusions:

- As supply becomes more elastic (Graph 11), firms pay less of the tax and consumers pay more of the tax.

- As supply becomes less elastic (Graph 13), firms pay more of the tax and consumers pay less of the tax.

C. Applications to Public Policy

Now consider what we've learned about relative tax burdens between consumers and firms. First, we've found that except when demand or supply is perfectly inelastic, taxes have the impact of reducing equilibrium quantities exchanged. Second, we've found that relative tax burdens depend upon relative elasticities of demand and supply, with each party bearing more (and the other party less) of the tax burden as they become more inflexible in the market.

Next, what are the possible goals of the government in taxing certain goods or services? Clearly, there exist at least two possible goals. The first goal that comes to mind is a goal of raising revenue. For a given tax, more revenue from the tax will be raised the more inelastic is supply or demand. This is because, as is illustrated by Graphs 12 and 13, relatively inelastic supply or demand leads to a smaller reduction in the quantity of the good purchased. Second, the government may also have the goal of imposing the tax in an attempt to reduce the quantity consumed. These taxes are sometimes referred to as "sin taxes." Clearly, sin taxes are more likely to be successful when they are imposed on goods with relatively elastic demand or supply curves.

Goods which have sin taxes commonly imposed are goods like cigarettes or alcohol. The public policy rhetoric is that such taxes are needed in order to curb consumption. Drugs are another example of such a good, in some instances. However, these goods all tend to have relatively inelastic demand curves. As a result, the impact of the tax on consumption would be expected to be relatively minor.

Are governments simply making a mistake in imposing sin taxes on such goods? Perhaps, but another possibility is that the real goal of the tax is to raise revenue rather than to reduce consumption. That raises the issue of why the public rhetoric about the tax as an attempt to reduce consumption, when it is known that the tax is unlikely to have that effect. One possible answer is that politically it is easier to get taxes viewed as sin taxes passed even when raising revenue is the actual goal.