3. Elasticity of Supply, Demand and Income

If we increase the tax on gasoline by a dollar, how much will the price increase? (Hint: much less than a dollar!) Will that increase hit richer or poorer people harder? How much of the tax will the buyer and seller each pay? We measure "elasticity" in order to answer such questions.

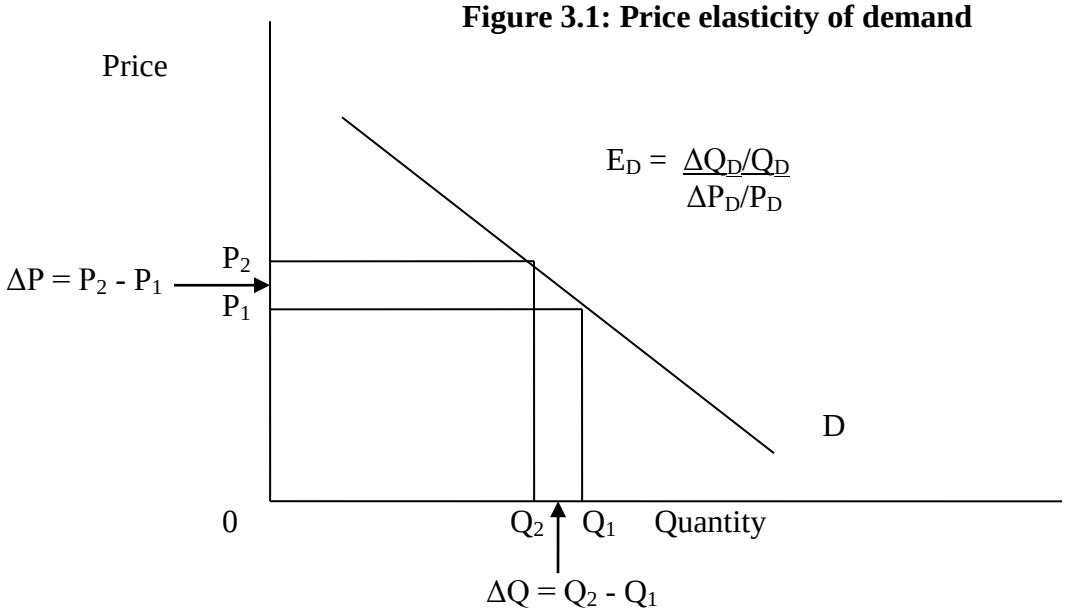
As the word suggests, "elasticity" measures the percent or proportional change in one item in response to change in another. Thus the "price elasticity of demand" is the change in quantity demanded in response to a small change in price. Elasticity has many uses; in particular it helps determine the extent to which taxes are "passed on." I will use the symbol Δ, Greek "delta" for a small change.

I will cover three main types of elasticity: price elasticity of demand, price elasticity of supply and income elasticity of demand.

3.1 Price Elasticity of Demand

Assume P_1 is the initial price of a product and Q_1 is the quantity demanded at that price. P_2 is a very slightly higher (or lower) price and Q_2 is the quantity demanded at that price. See **Figure 3.1**.

Figure 3.1: Price elasticity of demand



Then we can write the elasticity of demand:

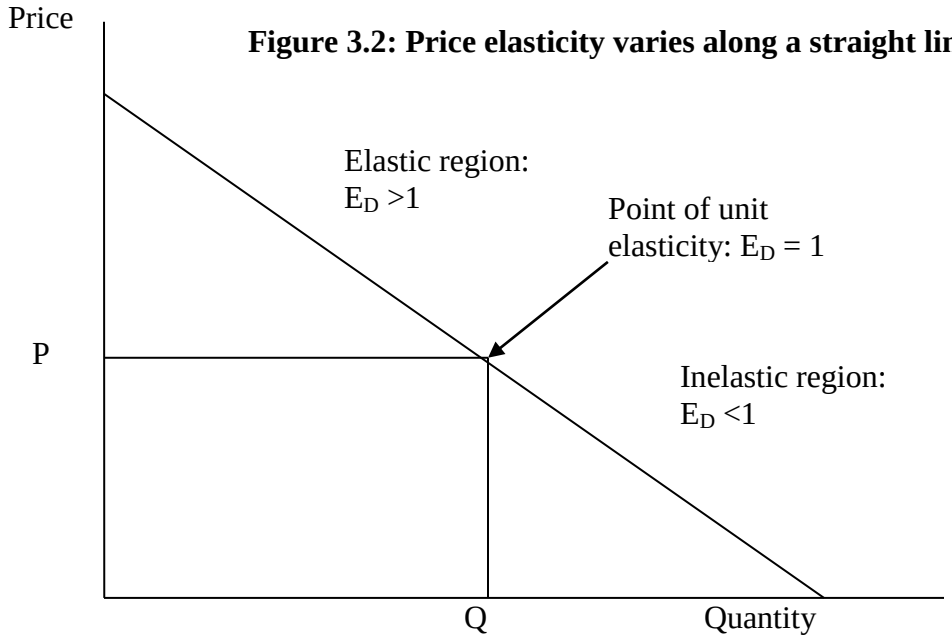
Demand elasticity: $E_D = \left| \frac{(Q_1 - Q_2)/Q_1}{(P_1 - P_2)/P_1} \right| = \left| \frac{\Delta Q/Q_1}{\Delta P/P_1} \right|$ (vertical bars stand for absolute value).

Assuming P1 and P2 are very close, and Q1 and Q2 are very close, we can drop the subscripts and just write

Demand elasticity: $E_D = \left| \frac{\%\_change\_quantity\_demanded}{\%\_change\_price} \right| = \left| \frac{\Delta Q_D / Q_D}{\Delta P_D / P_D} \right| = \left| \frac{P_D / Q_D}{\Delta P_D / \Delta Q_D} \right|$.

So at any point along the demand curve, elasticity is the ratio of price to quantity divided by the slope of the line at that point, $\left| \frac{\Delta P_D}{\Delta Q_D} \right|$. If the slope is constant, as it is in the straight line demand curves we usually draw, then clearly elasticity increases as price rises and quantity demanded falls along the curve. See **Figure 3.2**. It is the increase in elasticity with increasing price that limits how high monopolists can raise prices. Increasing elasticity means that the more they raise the price, the faster their sales fall off. On Figure 3.2, the point of "unit elasticity", $E_D = 1$, occurs at the point where revenue, R = P x Q, is a maximum.

Figure 3.2: Price elasticity varies along a straight line demand curve



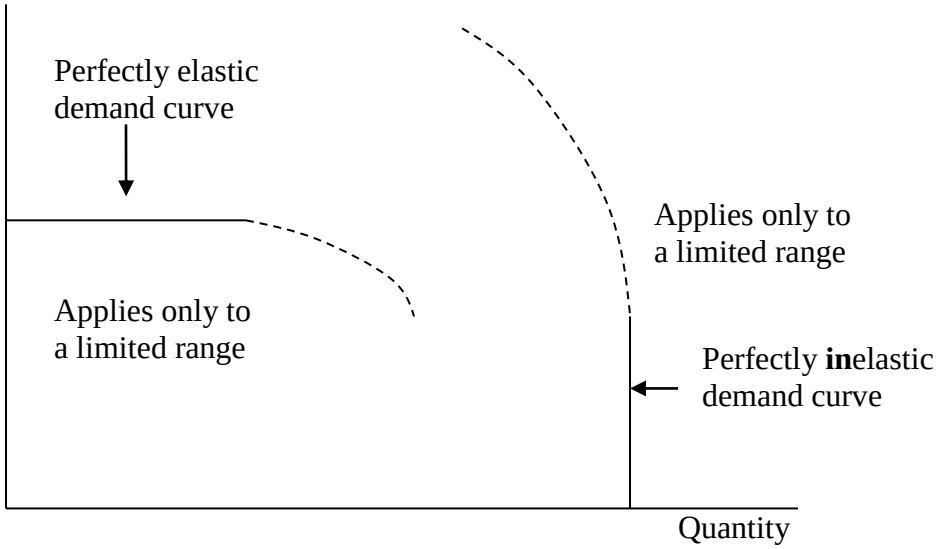
As defined, demand price elasticity is (almost always) negative, because quantity demanded (almost always) falls as price rises. However, it is often written as an absolute value, without the minus sign.

So if demand elasticity is >1 at a particular price and quantity, we say demand is "elastic"; if demand elasticity is < 1 we say it is "inelastic". A high demand elasticity suggests there are many close substitutes, so a small price increase will lead many consumers to switch to a substitute product. A low demand elasticity means it is difficult for consumers to switch to another product.

Textbooks often depict an inelastic demand curve as a steeply sloping line and an elastic demand curve as a shallow line. This can be misleading, as slope depends on scale of the illustration. We can only compare slope of two demand (or supply) curves at the *same* price and quantity.

Textbooks also depict a totally elastic demand curve as a horizontal line, and a totally inelastic demand curve as a vertical line. See **Figure 3.3**. Such a depiction holds at best for a limited range of prices and quantities.

Price **Figure 3.3: Perfectly elastic and perfectly inelastic demand curves**



Demand elasticity depends on two primary factors: the importance of an item in consumers' budgets, and on the availability of substitutes. **Table 3.1** illustrates the effect of these factors. In brief, demand is highly inelastic for goods or services, like vital medicines, which have no close substitutes and make up only a small part of a budget. Demand is highly elastic for goods or services which have close substitutes and which make up a large part of a budget.

TABLE 3.1 INELASTICITY/ ELASTICITY MATRIX FOR DEMAND FROM VIEWPOINT OF A SELLER

	FEW GOOD, CLOSE SUBSTITUTES	MANY GOOD, CLOSE SUBSTITUTES
GOOD OR SERVICE IS A VERY SMALL PART OF BUYER'S BUDGET	**Highly inelastic**. A vital medicine for a rich person. The person won't even notice price changes	**Moderately inelastic**. A brand of tuna fish for a rich person. The person may not notice if one brand becomes more expensive than another, but tends to buy out of habit.
GOOD OR SERVICE IS A VERY LARGE PART OF BUYER'S BUDGET	**Close to unit elastic**. A vital medicine for a poor person, for whom it makes up a large part of her budget. If price rises she will cut back, eg spacing out pills, since alternative is to cut food.	**Highly elastic**. A brand of tuna fish for a poor person. If the price of one brand increases by even a penny, a poor person will switch to another brand.

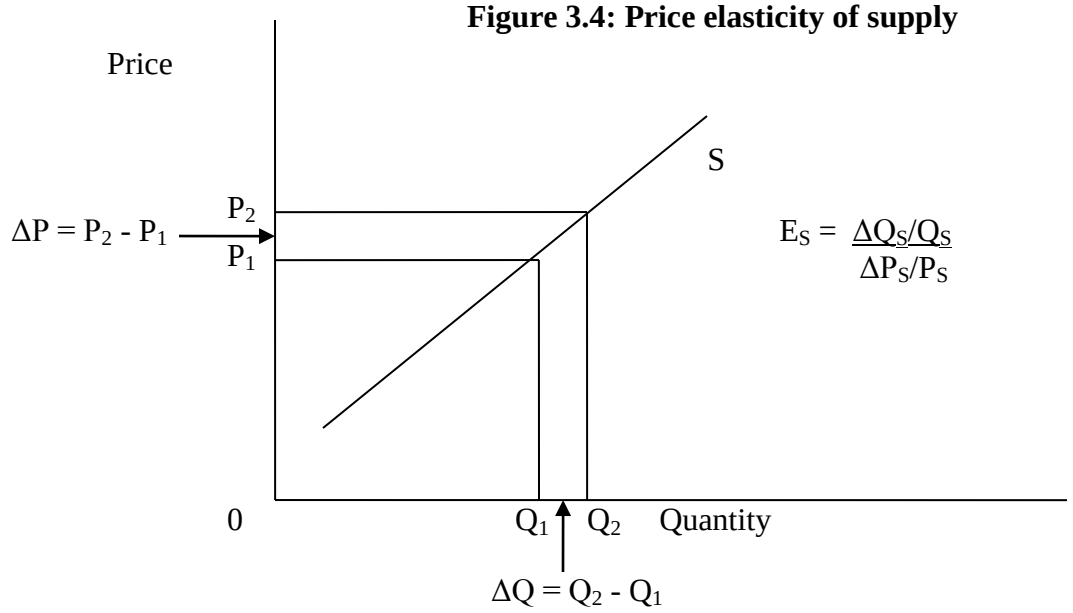
3.2 Price Elasticity of Supply

By analogy to price elasticity of demand, price elasticity of supply can be written:

$$\text{Supply elasticity: } E_S = \frac{\%\_change\_quantity\_supplied}{\%\_change\_price} = \frac{\Delta Q_S / Q_S}{\Delta P_S / P_S} = \frac{P_S / Q_S}{\Delta P_S / \Delta Q_S}.$$

Unlike demand elasticity, supply elasticity is always positive. Because quantity supplied increases as supply price increases, supply elasticity does not obviously increase or decrease as price increases—at least along a conventional straight line supply curve. See **Figure 3.4**. However ultimately supply of anything is limited, so elasticity must eventually decrease as price increases and supply curve becomes more vertical.

Figure 3.4: Price elasticity of supply



Supplies of land and many other natural resources are fixed from the start, regardless of price. So for these we draw a vertical supply curve. See **Figure 3.5**.

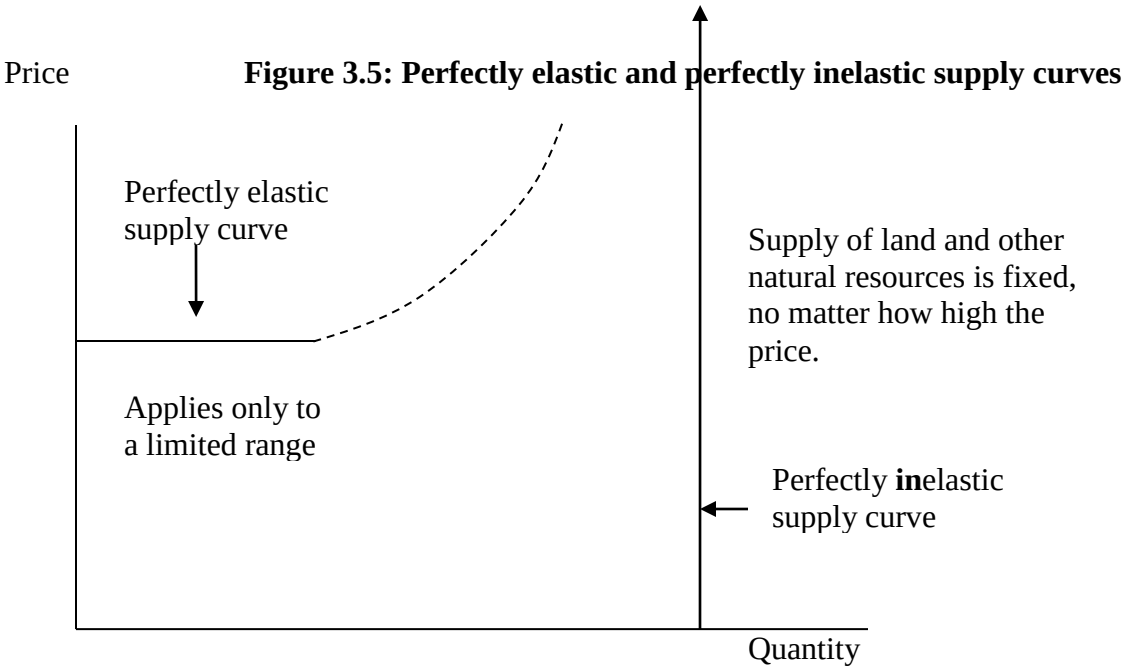


Figure 3.5: Perfectly elastic and perfectly inelastic supply curves

Like demand, supply is affected by importance of a good or service in a supplier's production, and by the availability of substitutes. See **Table 3.2**.

TABLE 3.2 INELASTICITY/ ELASTICITY MATRIX FOR SUPPLY FROM VIEWPOINT OF A BUYER

	FEW GOOD, CLOSE SUBSTITUTES	MANY GOOD, CLOSE SUBSTITUTES
GOOD OR SERVICE IS A VERY SMALL PART OF SELLER'S PRODUCTION—EASY TO INCREASE SUPPLY	**Moderately elastic**. A diamond necklace from Tiffany? No close substitutes, but small part of Tiffany's sales	**Highly elastic**. Nike Athletic shoes. Almost perfectly elastic; your purchase is tiny compared to the supply, and there are plenty of substitutes
GOOD OR SERVICE IS A VERY LARGE PART OF SELLER'S PRODUCTION—HARD OR IMPOSSIBLE TO INCREASE SUPPLY	**Highly or perfectly inelastic**. A parcel of land on the corner of Madison and 42nd. Almost perfectly inelastic; no close substitutes and you're usually trying to buy the whole supply.	**Moderately inelastic**. You're arranging a dinner for 12 at a small restaurant. There are plenty of substitute restaurants, but since you're crowding their capacity, they'll charge extra.

3.3 Intersection of Supply and Demand

At the intersection of supply and demand, the ratio of demand and supply elasticities is the *inverse ratio of slopes*. Price and quantity supplied drop out, because at the intersection, $P_D=P_S$ and $Q_D = Q_S$. This is useful in calculating the impact of taxes; as will be shown, sellers and buyers effectively pay a tax according to the ratio of elasticities. Thus:

$$E_D = \left| \frac{P_D / Q_D}{\Delta P_D / \Delta Q_D} \right| \text{ and } E_S = \frac{P_S / Q_S}{\Delta P_S / \Delta Q_S}$$

$$\text{And } \frac{E_D}{E_S} = \frac{\left| \frac{P_D / Q_D}{\Delta P_D / \Delta Q_D} \right|}{\frac{P_S / Q_S}{\Delta P_S / \Delta Q_S}} = \frac{\Delta P_S / \Delta Q_S}{\left| \Delta P_D / \Delta Q_D \right|} = \frac{Slope_S}{|Slope_D|}$$

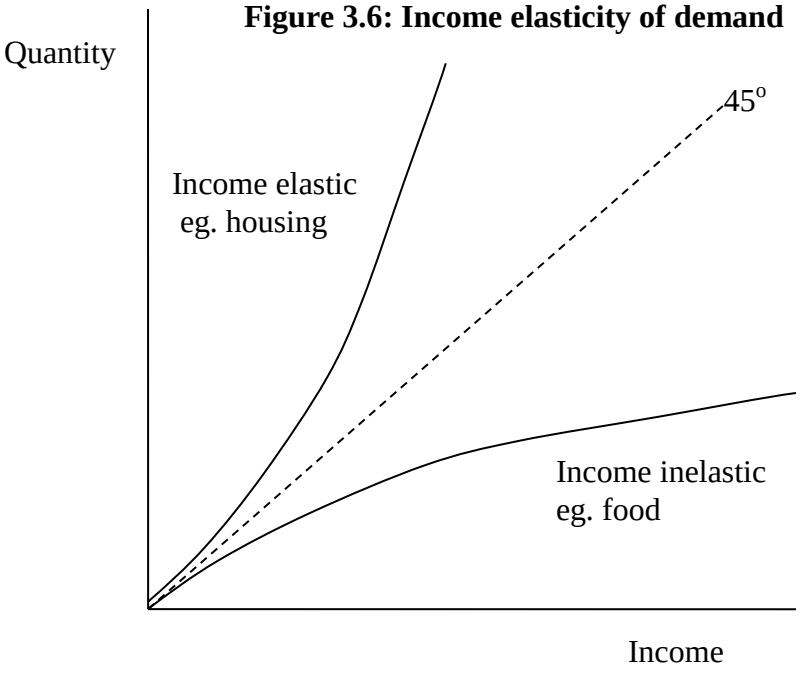
3.4 Income Elasticity of Demand

Do richer people spend more on oil in proportion to income than poorer people? What about food? Clothing? Travel? Housing? Income elasticity of demand measures the proportional increase in spending on a given item as income increases (Y is income):

$$\text{Income elasticity: } E_Y = \frac{\%\_change\_quantity\_purchased}{\%\_change\_income} = \frac{\Delta Q / Q}{\Delta Y / Y} = \frac{Y / Q}{\Delta Y / \Delta Q}$$

In general, richer people spend proportionately more on less immediately urgent items: less on food, and more on bigger houses, boats, and other durable goods. And with bigger houses come even bigger parcels of land. See **Figure 3.6** and **Figure 3.7**.

Figure 3.6: Income elasticity of demand



Quantity x price
as a percent

Figure 3.7: Income elasticity as a percent