ELASTICITY

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Introduction (quick review)

- The law of demand states that:

- when the relative price of a good increases, the quantity demanded of the good decreases.

- The law of supply states that:

- when the relative price of a good increases, the quantity supplied of the good increases.

- These two laws are primarily concerned with the direction (increase or decrease) of the changes in the quantities when relative prices change.

Introduction (2)

- So the laws of demand and supply answer the following question:
- How (i.e. in which direction) does the quantity demanded change when there is an increase or a decrease in the price?
- In this chapter, we will be focusing on the following question:
- By how much does the quantity demanded change when there is a change in the price?
- This question can be answered with the aid of the concept of elasticity.
- Elasticity is a measure of how much buyers and sellers respond to changes in market conditions.

Introduction (3)

- The different types of elasticity we will study are:
- Price elasticity of demand
- Cross-price elasticity of demand
- Income elasticity of demand
- Price elasticity of supply

Price elasticity of demand

- Let's use gasoline and Snickers as examples:
- When gas becomes more expensive, the quantity demanded of gas declines.
- BUT the decline is RELATIVELY SMALL, because you can't do much without gas. You still need to buy it for your car.
- On the other hand, when Snickers become more expensive, you SIGNIFICANTLY decrease your consumption, because your life doesn't get any worse without Snickers. You don't really care!
- *The prices of both goods increase, but the quantity demanded of Snickers decreases more than the quantity demanded of gas*.

Price elasticity of demand (2)

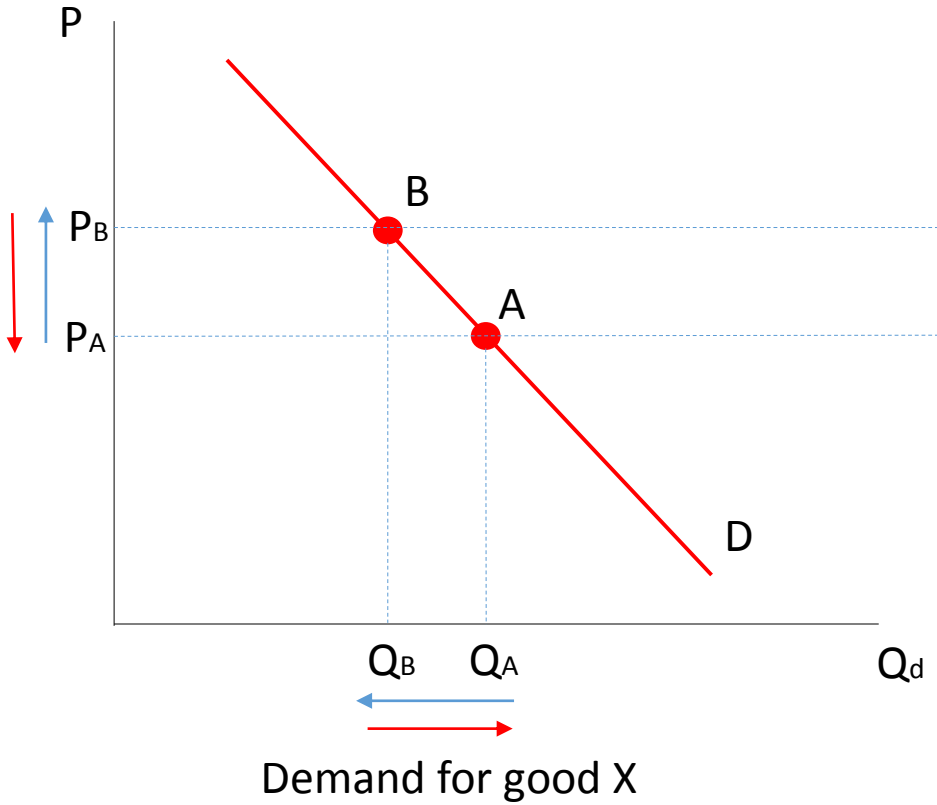
- Therefore, in the face of a price change, consumers adjust their consumption differently depending on each specific good.
- The consumption for some goods is adjusted just a little (e.g. gas and other necessities)
- The consumption of other goods is ‘relatively’ significantly adjusted (less important goods)
- We want to measure how quantity demanded responds to a change in price.
- This measure is called the price elasticity of demand.

Price elasticity of demand (3): definition

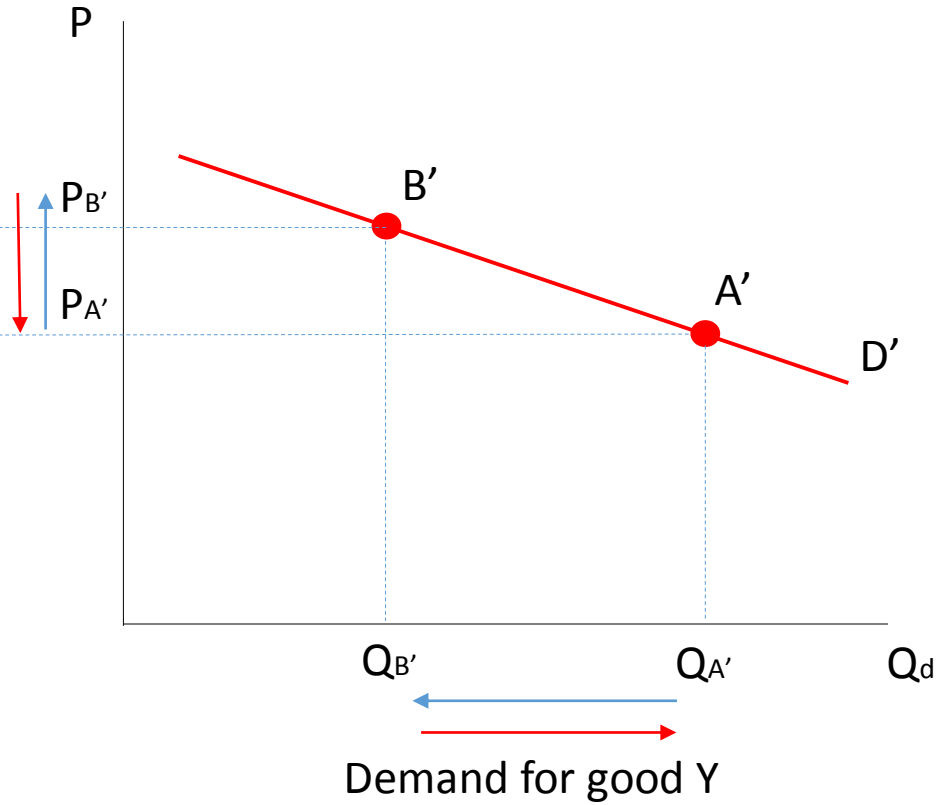
- Price elasticity of demand measures *the degree of responsiveness* of quantity demanded due to a change in price.

Illustration of price elasticity of demand

- Following are the demand curves for two goods: X and Y.

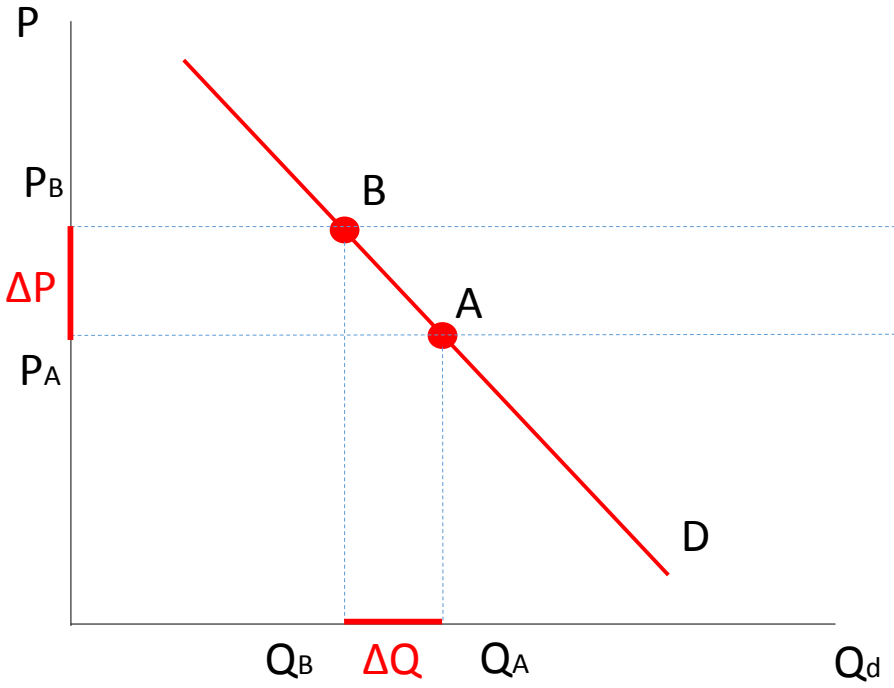


Demand for good X

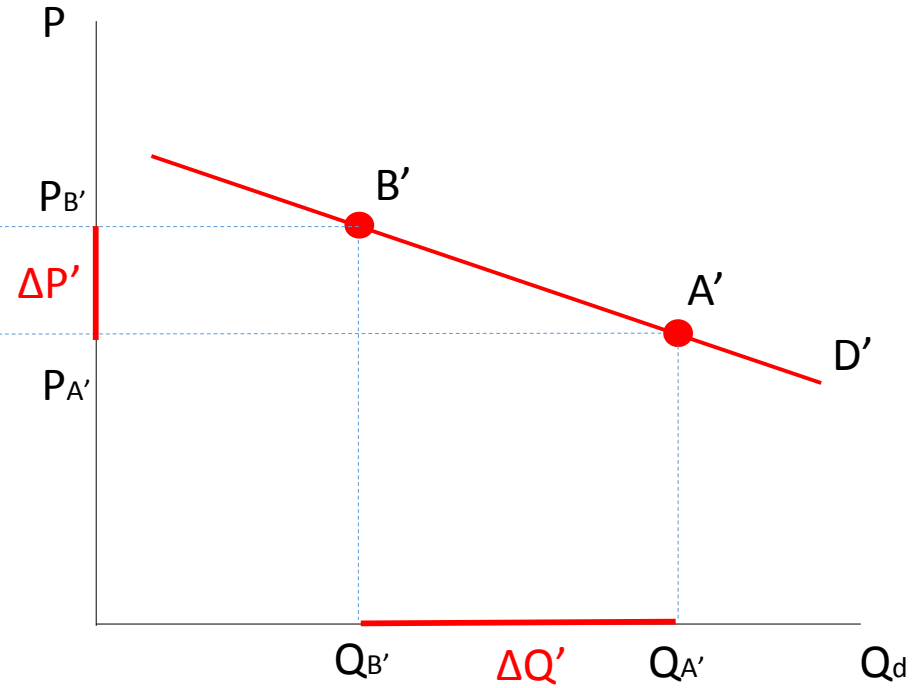


Demand for good Y

Illustration of price elasticity of demand (3)



Demand for good X



Demand for good Y

Illustration of price elasticity of demand (4)

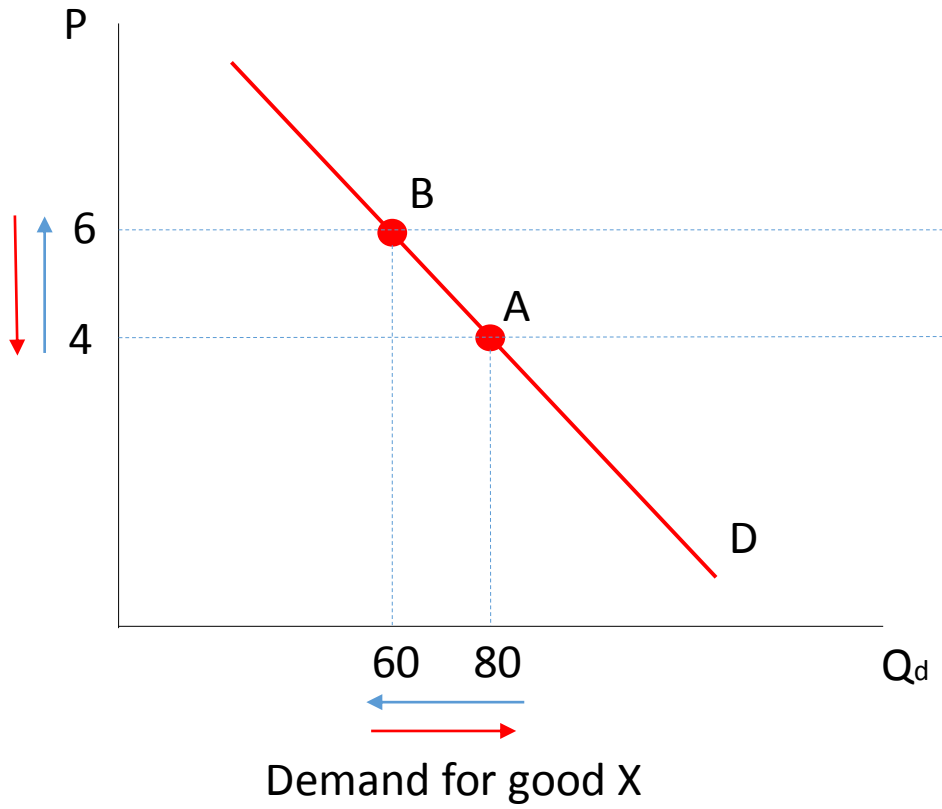
- $\Delta P = P_{new} - P_{old}$: Change in the price of good X
- $\Delta P' = P'_{new} - P'_{old}$: Change in the price of good Y
- $\Delta Q = Q_{new} - Q_{old}$: Change in the quantity demanded of good X
- $\Delta Q' = Q'_{new} - Q'_{old}$: Change in the quantity demanded of good Y
- $|\Delta P| = |\Delta P'|$: The changes in the prices of goods X and Y are of the same magnitude.
- $|\Delta Q| < |\Delta Q'|$: The quantity demanded of good Y changed more than the quantity demanded of good X.

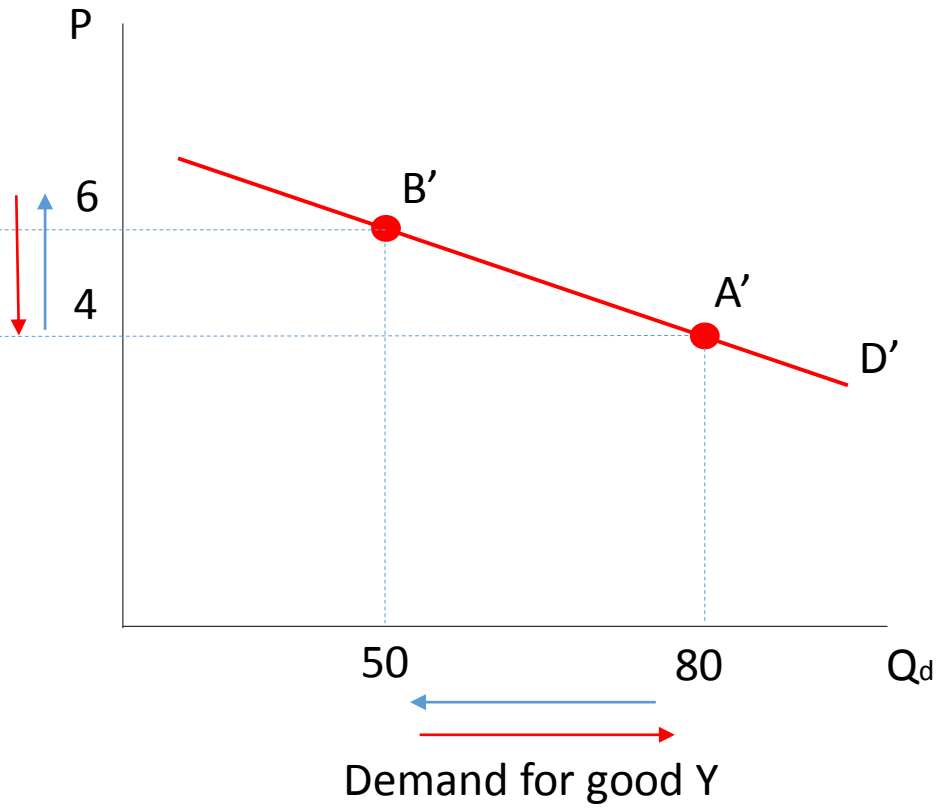
Illustration of price elasticity of demand (5)

- For an equivalent price change, the quantity demanded of good Y responded more significantly than the quantity demanded of good X.
- We say that the demand for good Y is more price elastic than the demand for good X.

Computing price elasticity of demand

- Let's add some figures to our previous graphs:





Computing price elasticity of demand (2)

- We denote the price elasticity of demand by ε_D
- $\varepsilon_D = \left|\frac{\%\Delta Q}{\%\Delta P}\right|$
- %ΔQ: Percentage change in quantity demanded
- $\%\Delta Q = \frac{\Delta Q}{Q_{old}} = \frac{Q_{new} - Q_{old}}{Q_{old}}$
- %ΔP: Percentage change in price
- $\%\Delta P = \frac{\Delta P}{P_{old}} = \frac{P_{new} - P_{old}}{P_{old}}$
- Even though this is the standard formula used to calculate price elasticity of demand, there are some problems with using it…

Computing price elasticity of demand (3)

- Let's assume that the price of good X rises from $4 to $6.
- The quantity demanded of good X declines from 80 to 60.
- $\%\Delta Q = \frac{60 - 80}{80} = -0.25$
- $\%\Delta P = \frac{6 - 4}{4} = 0.5$
- $\varepsilon_D = \left|\frac{-0.25}{0.5}\right| = 0.5$

Computing price elasticity of demand (4)

- Now let's assume that the price of good X falls from $6 to $4.
- The quantity demanded of good X rises from 60 to 80.
- $\%\Delta Q = \frac{80 - 60}{60} = 0.33$
- $\%\Delta P = \frac{4 - 6}{6} = -0.33$
- $\varepsilon_D = \left|\frac{0.33}{-0.33}\right| = 1$

Computing price elasticity of demand (5)

- When the price increases from \$4 to \$6 and the quantity demanded falls from 80 to 60, $\varepsilon_D = 0.5$
- When the price falls from \$6 to \$4 and the quantity demanded rises from 60 to 80, $\varepsilon_D = 1$
- Therefore, this way of computing price elasticity of demand is inconsistent since it gives different results depending on the direction of the change.
- Instead, we use the mid-point estimate of price elasticity of demand

Computing price elasticity of demand (6)

- $\varepsilon_D = \left| \frac{\frac{\Delta Q}{Q_{ave}}}{\frac{\Delta P}{P_{ave}}} \right|$ (mid-point estimate)
- ΔQ: Change in quantity demanded
- ΔP: Change in price
- Q_{ave}: Quantity average: $\frac{Q_{old} + Q_{new}}{2}$
- P_{ave}: Price average: $\frac{P_{old} + P_{new}}{2}$
- Here, the direction of the change does NOT matter.

Computing price elasticity of demand (7)

- $\Delta P = \Delta P' = 6 - 4 = 2$
- $\Delta Q = 80 - 60 = 20$
- $\Delta Q' = 80 - 50 = 30$
- $P_{ave} = \frac{4+6}{2} = 5$
- $Q_{ave} = \frac{60+80}{2} = 70$
- $Q'_{ave} = \frac{50+80}{2} = 65$

- $\varepsilon_D = \left| \frac{\frac{20}{70}}{\frac{2}{5}} \right| = 0.71$
- $\varepsilon'_D = \left| \frac{\frac{30}{65}}{\frac{2}{5}} \right| = 1.15$

- Elasticity is a *unitless* measure.

Computing price elasticity of demand (8)

- The price elasticity of demand:

- For good X: $\varepsilon_D = 0.71$

- For good Y: $\varepsilon'_D = 1.15$

- $\varepsilon_D < \varepsilon'_D$

- Therefore, we can say again that the demand for good Y is more (price) elastic that the demand for good X.
- The consumption of good Y is more responsive to changes in price than the consumption of good X.

Levels of price elasticity of demand

- ε_D < 1: Demand is (price) inelastic (%ΔQ < %ΔP)

- When price changes, the magnitude of the change in quantity demanded is smaller than the magnitude of the change in price.

- ε_D > 1: Demand is (price) elastic (%ΔQ > %ΔP)

- When price changes, the magnitude of the change in quantity demanded is bigger than the magnitude of the change in price.

- ε_D = 1: Demand is unit (price) elastic (%ΔQ = %ΔP)

- When price changes, the magnitude of the change in quantity demanded is equal to the magnitude of the change in price.

Levels of price elasticity of demand (2)

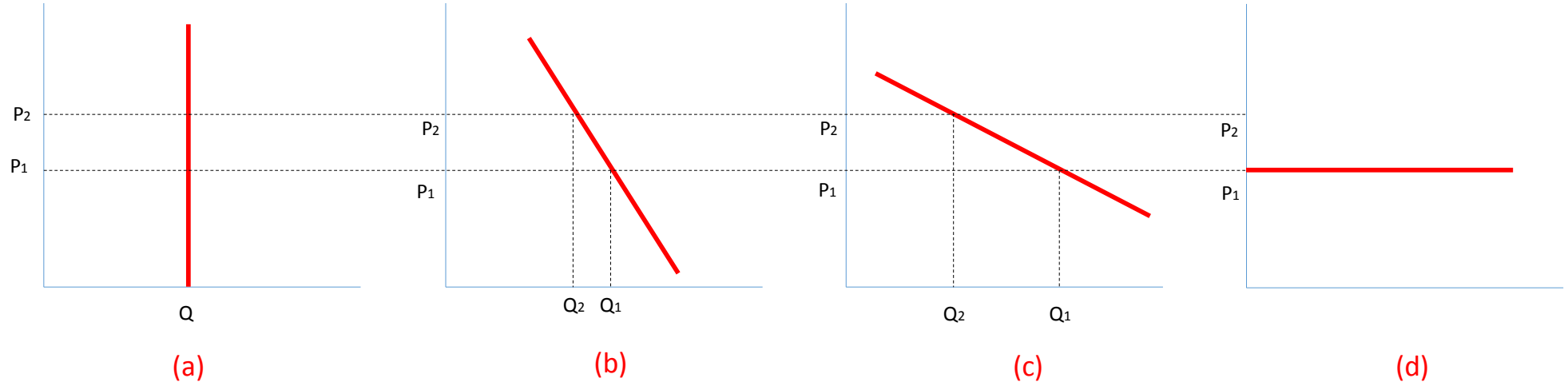
- $\varepsilon_D = 0$: Demand is perfectly (price) inelastic (%ΔQ = 0)

- No matter how price changes (even by a very big margin), the quantity demanded remains the same.

$\varepsilon_D = \infty$: Demand is perfectly (price) elastic

- The slightest change in price will cause quantity demanded to fall to 0.

Levels of price elasticity of demand (3)



(a) Demand is perfectly (price) inelastic.
(b) Demand is relatively (price) inelastic.
(c) Demand is relatively (price) elastic.
(d) Demand is perfectly (price) elastic.

The flatter the demand curve, the more elastic.

Factors that can change the price elasticity of demand

- The price elasticity of demand of a good can be influenced by a number of factors.
- These factors make the demand for a good more elastic or less elastic.
- Following are the most important determinants of price elasticity of demand:

Factors that can change the price elasticity of demand (2)

- Availability of close substitutes

- Goods with more close substitutes have a demand, which is more price elastic.
- When their price changes, it is easier for consumers to switch to other goods.

- Necessities and luxuries

- The demand for necessities is price inelastic.
- Consumers cannot easily alter their consumption of the good when there is a price change (e.g. water, gas, …)

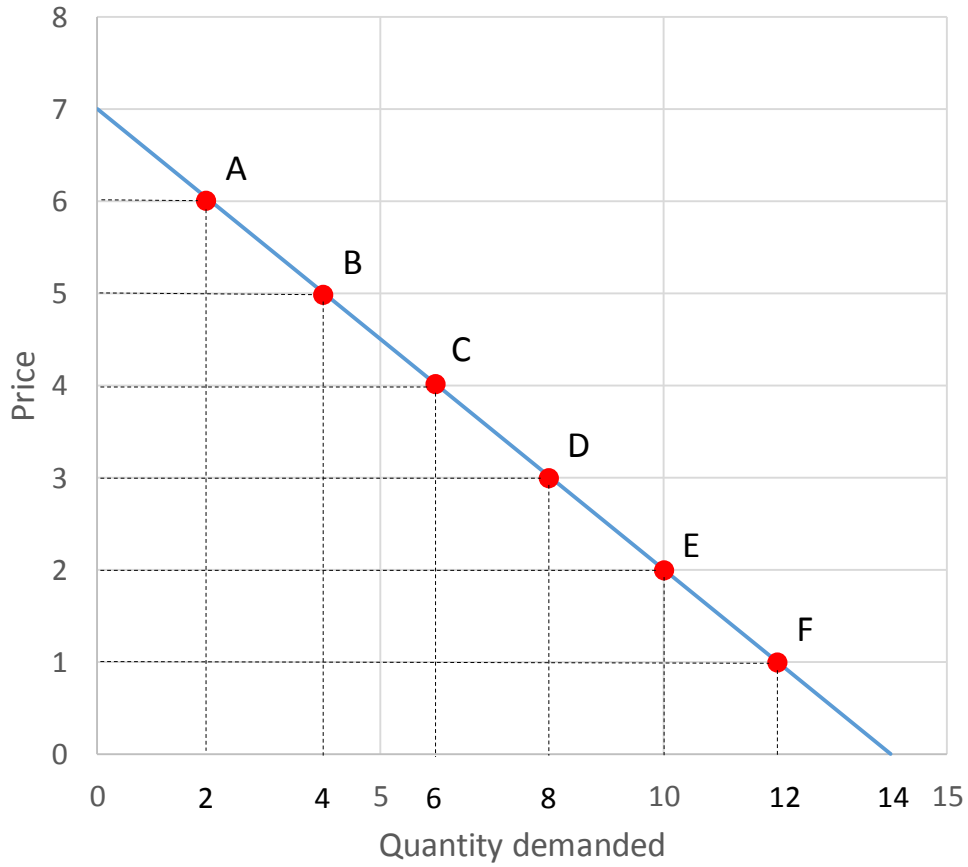
Factors that can change the price elasticity of demand (3)

- The demand for luxuries is price elastic.
- They are not essential to our lives. Consumers can change their consumption freely whenever there's a price change.
- Time horizon
- Goods tend to have a more price elastic demand over longer time horizons.
- For example, the demand for gas is relatively price inelastic.
- However, with time, people buy more fuel efficient alternatives, or move closer to their work or again switch to public transportation.

Price elasticity of demand on a linear demand curve

- Demand curves may be linear or non-linear.
- But they are generally all downward sloping.
- With a linear demand curve, it is possible to comment on the price elasticity of demand depending on where we are on the curve.
- This is difficult to understand without a proper illustration.
- Let's look at the following demand curve.

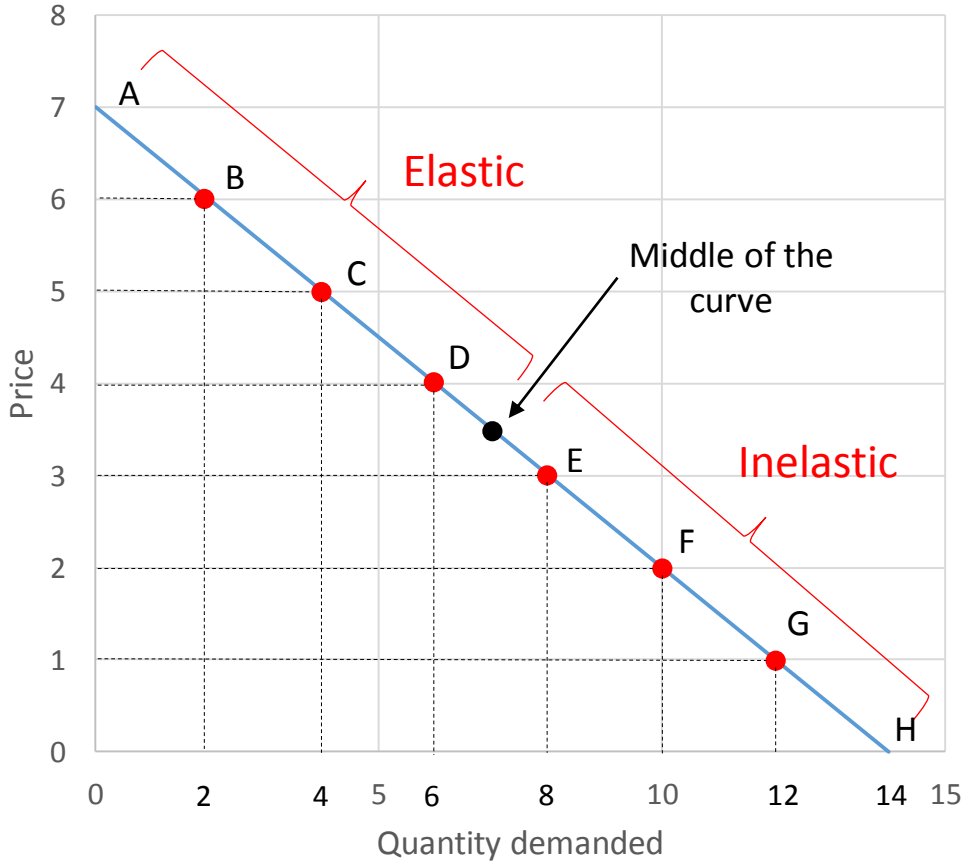
Price elasticity of demand on a linear demand curve (2)



Price elasticity of demand on a linear demand curve (3)

Point	Price ($)	Quantity demanded	Percentage change in quantity |%ΔQ|	Percentage change in price |%ΔP|	Elasticity	Description
A	7	0	-	-	-	-
B	6	2	200	15	13.0	Elastic
C	5	4	67	18	3.7	Elastic
D	4	6	40	22	1.8	Elastic
E	3	8	29	29	1.0	Unit elastic
F	2	10	22	40	0.6	Inelastic
G	1	12	18	67	0.3	Inelastic
H	0	14	15	200	0.1	Inelastic

Price elasticity of demand on a linear demand curve (4)



Price elasticity of demand on a linear demand curve (5)

- On a linear demand curve:

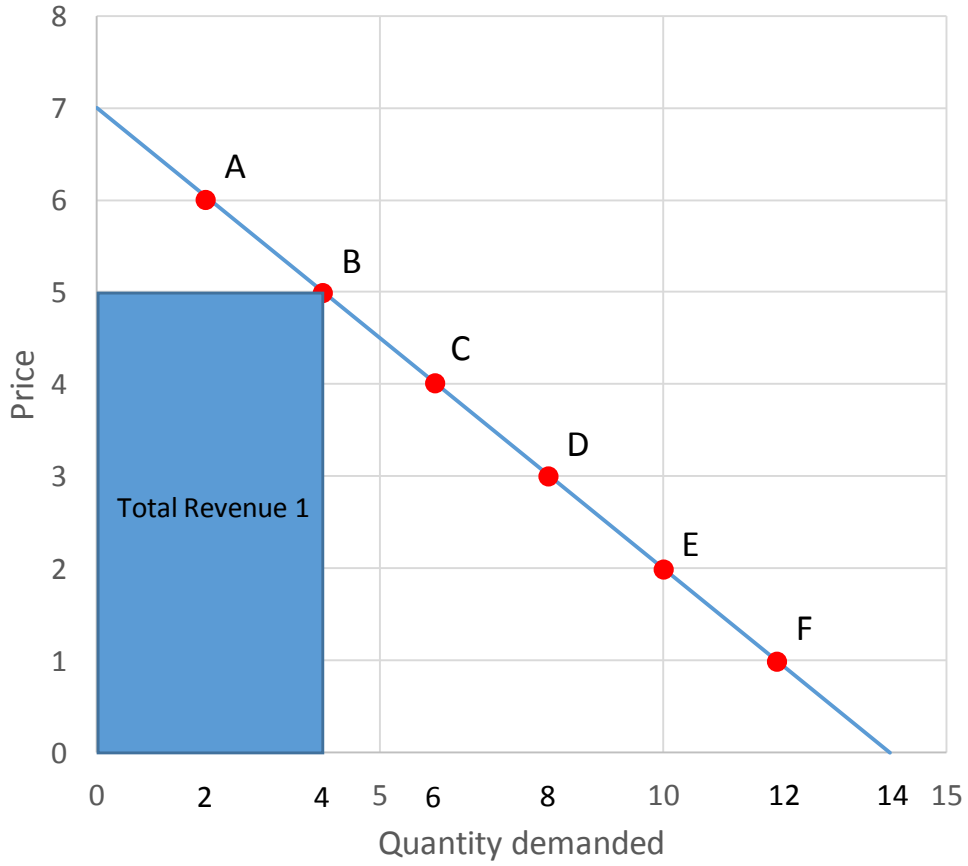
- The demand is price elastic above the middle of the curve.

- The demand is price inelastic below the middle of the curve.

Price elasticity of demand and total revenue

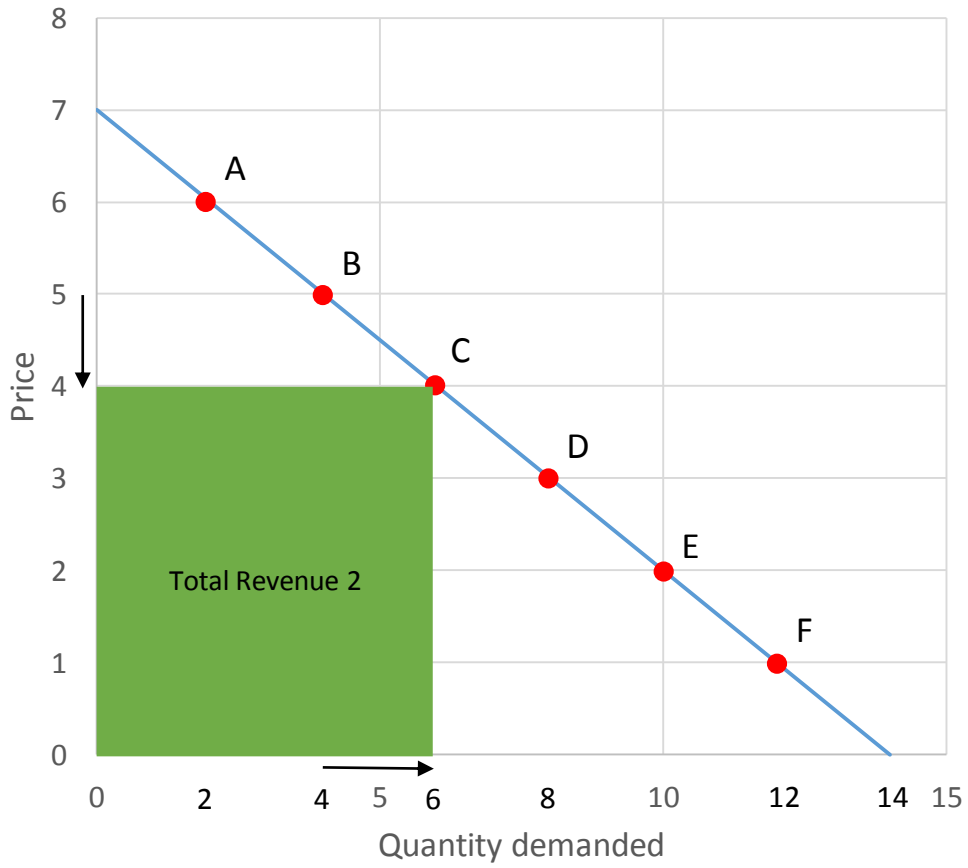
- Total Revenue is the total amount of money received by a producer after selling a certain quantity of goods.
- Total Revenue (TR) = Price (P) * Quantity Sold (Q)
- From a consumer's perspective, we can call it Total Expenditure.

Price elasticity of demand and total revenue (2)



- Assuming the consumers in the economy consume at point B, the price they will pay is $5
- And the quantity they will receive is 4.
- The total revenue is therefore: 5 * 4 = $20
- Graphically, the total revenue is also equivalent to the area of the blue rectangle.
- Area of rectangle = width * height.
- In this case:
- Width = Quantity
- Height = Price

Price elasticity of demand and total revenue (3)

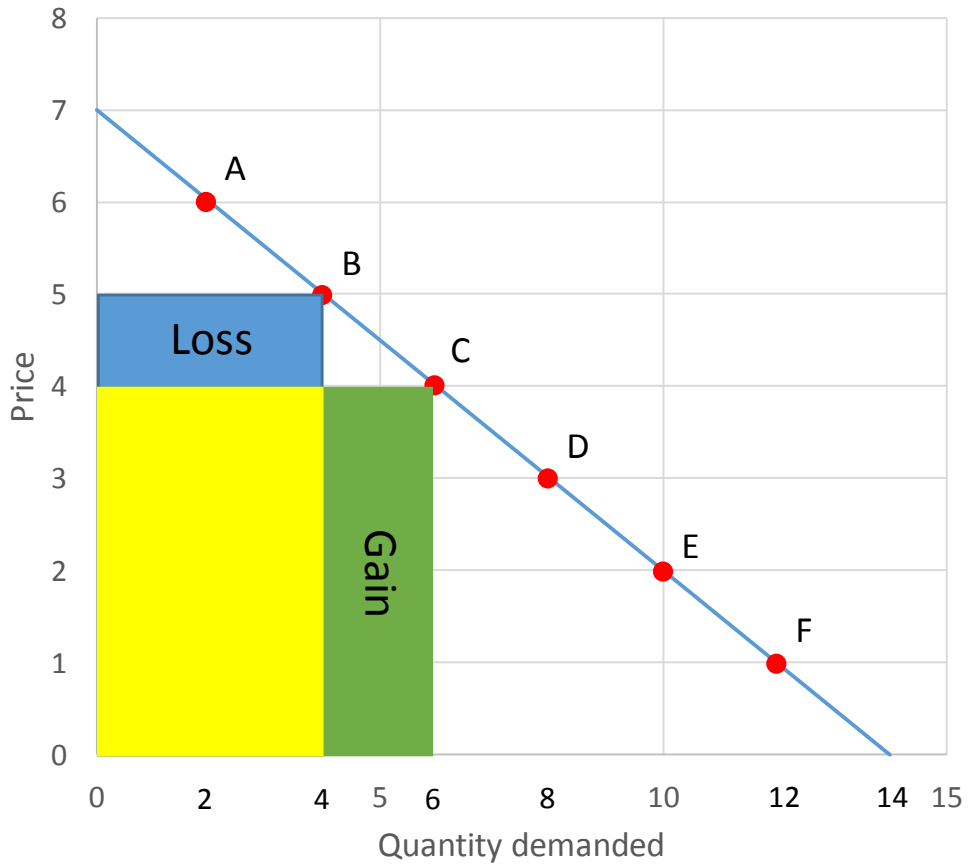


- If the price of the good falls from $5 to $4, the quantity demanded will increase from 4 to 6.
- The total revenue is now: 4 * 6 = $24
- Graphically, the total revenue is equivalent to the area of the green rectangle.

- After a price decrease from $5 to $4, the total revenue increased from $20 to $24.

- What is the reason why?

Price elasticity of demand and total revenue (4)

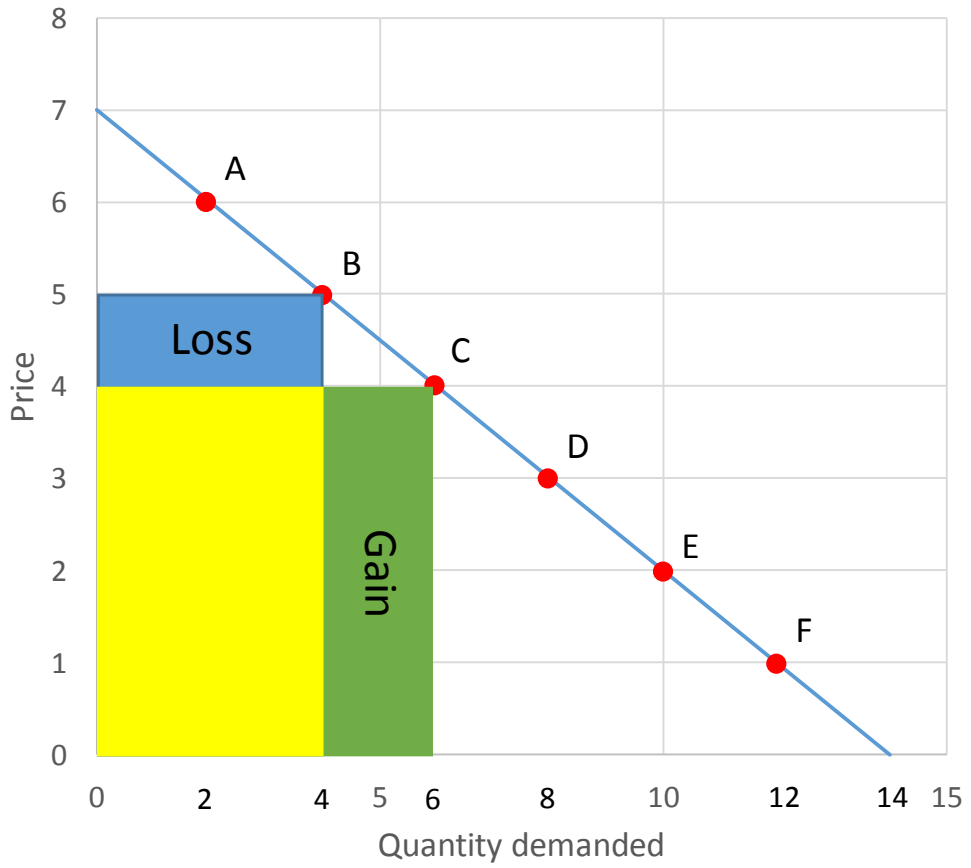


- Let's now superimpose both rectangles.
- The blue area represents part of Total Revenue 1 where price = $5 and quantity = 4
- The green area represents part of Total Revenue 2 were price = 4 and quantity = 6
- The yellow area represents the common area between both Total Revenues.

- When the price fell from $5 to $4, the producers:

- lost the blue area in total revenue but…
- They gained the green area in total revenue

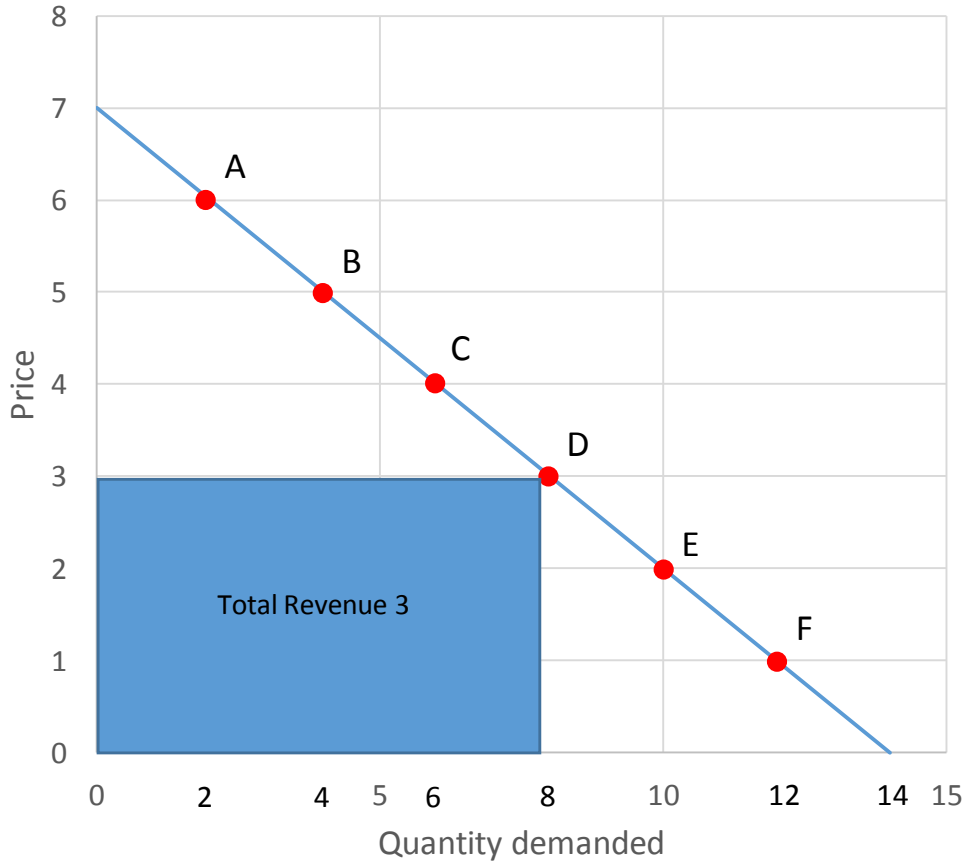
Price elasticity of demand and total revenue (5)



- The size of the gain is bigger than the size of the loss.
- Therefore, the producers in the economy have a net gain in total revenue as a result of decreasing price.
- *Notice also that the change in price was made inside the elastic part of the demand curve (above the middle of the curve).*

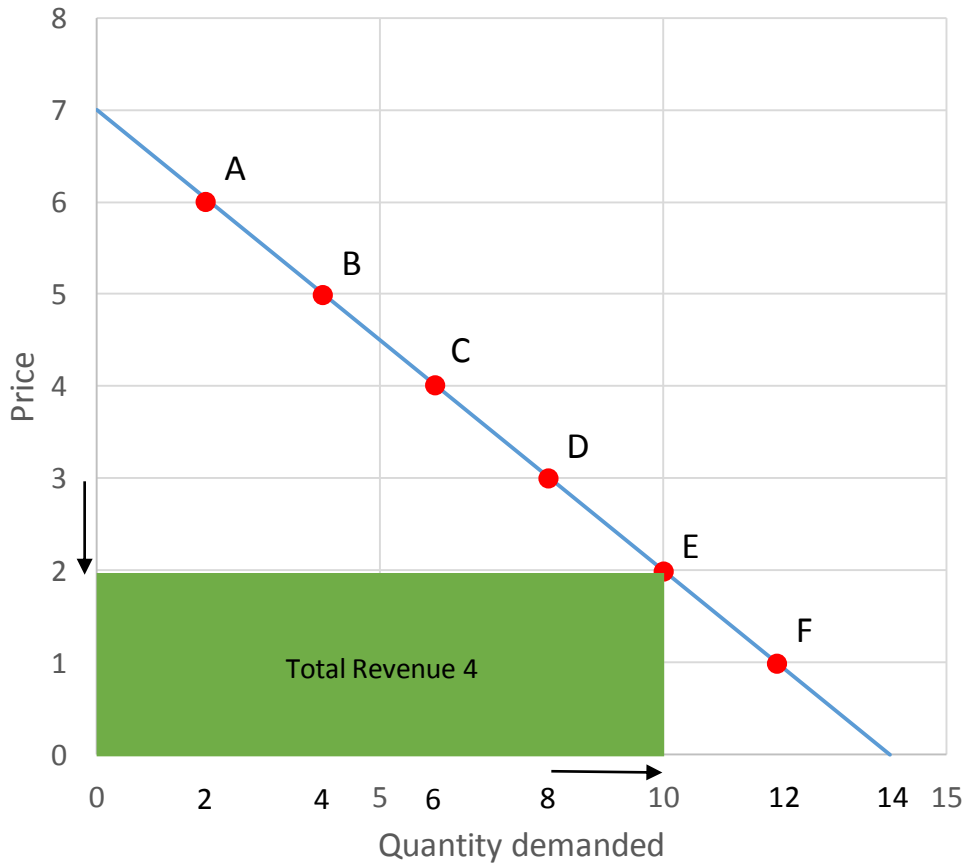
- Conclusion:
- When the demand for a good is price elastic, a decrease (increase) in price will increase (decrease) the total revenue of producers.

Price elasticity of demand and total revenue (6)



- Let's now assume that the consumers in the economy consume at point D, the price they will pay is $3
- And the quantity they will receive is 8.
- The total revenue is therefore: 3 * 8 = $24
- Graphically, the total revenue is equivalent to the area of the blue rectangle.
- Area of rectangle = width * height.
- In this case:
- Width = Quantity
- Height = Price

Price elasticity of demand and total revenue (7)

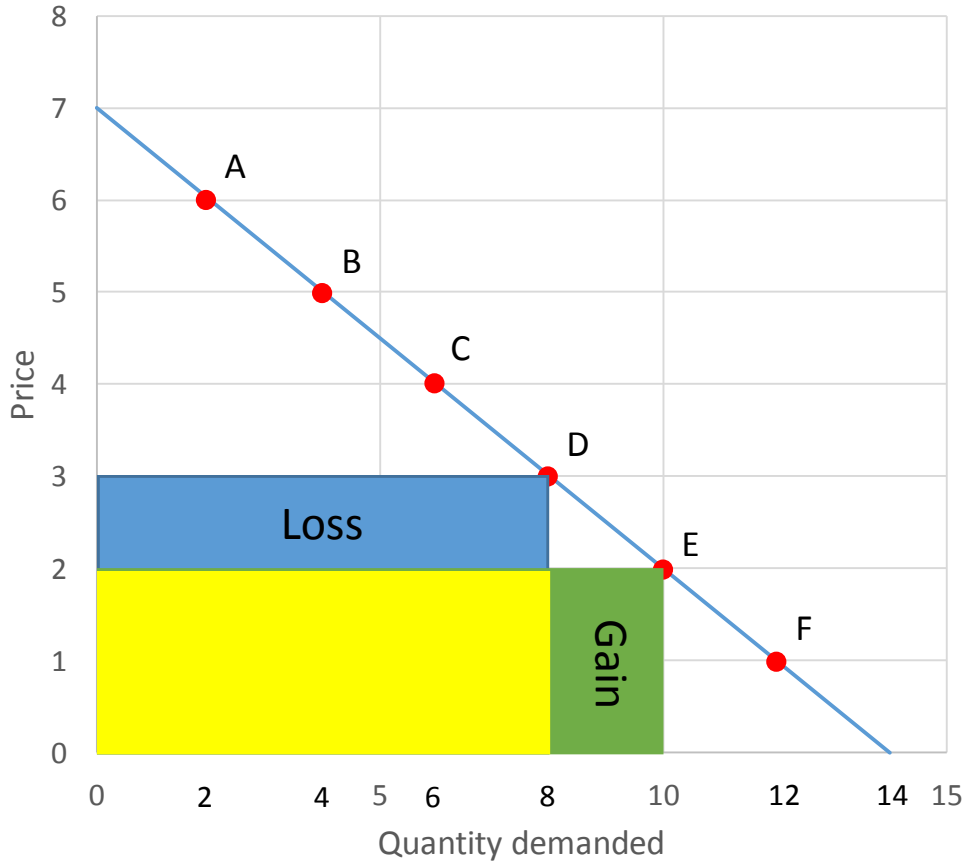


- If the price of the good falls from $3 to $2, the quantity demanded will increase from 8 to 10.
- The total revenue is now: 2 * 10 = $20
- Graphically, the total revenue is equivalent to the area of the green rectangle.

- After a price decrease from $3 to $2, the total revenue decreased from $24 to $20.

- What is the reason why?

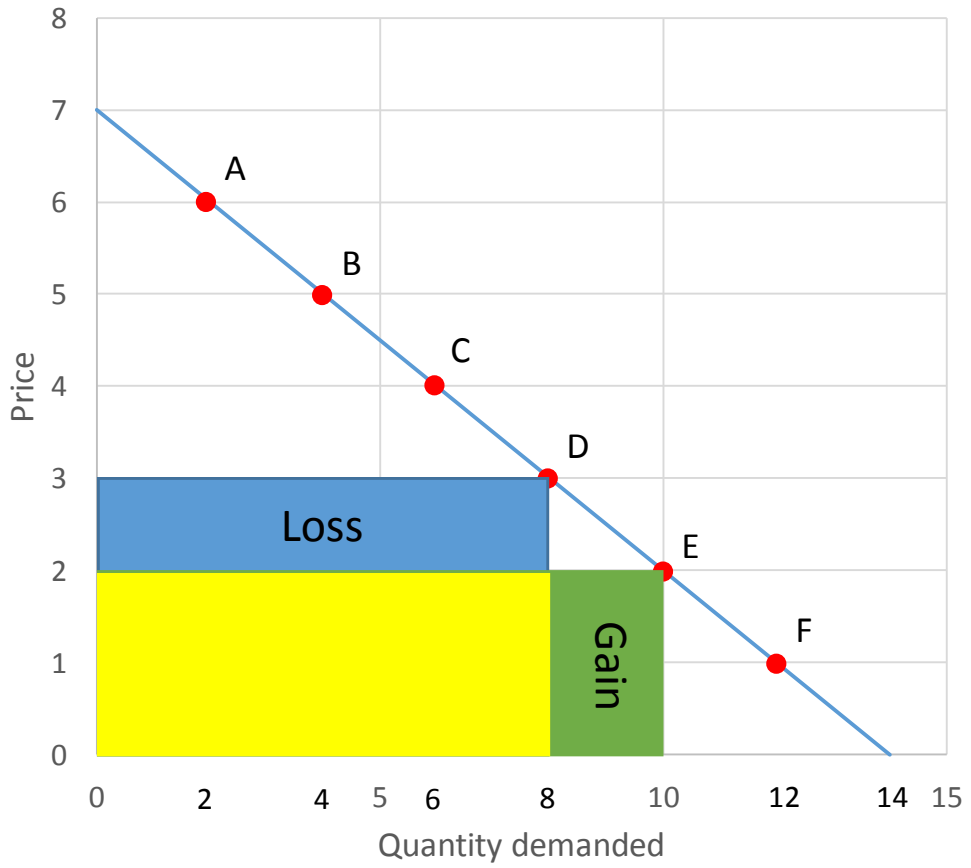
Price elasticity of demand and total revenue (8)



- Let's now superimpose both rectangles.
- The blue area represents part of Total Revenue 1 where price = $3 and quantity = 8
- The green area represents part of Total Revenue 2 were price = $2 and quantity = 10
- The yellow area represents the common area between both Total Revenues.

- When the price fell from $3 to $2, the producers (once again):
- lost the blue area in total revenue but…
- They gained the green area in total revenue

Price elasticity of demand and total revenue (9)



- This time, the size of the gain is smaller than the size of the loss.
- Therefore, the producers in the economy have a net loss in total revenue as a result of decreasing price.
- *Notice also that the change in price was made inside the inelastic part of the demand curve (below the middle of the curve).*

- Conclusion:
- When the demand for a good is price inelastic, a decrease (increase) in price will decrease (increase) the total revenue of producers.

Cross-price elasticity of demand

- Cross-price elasticity of demand measures the responsiveness of the quantity demanded of good due to a change in the price of a related good (i.e. substitute or complement) .
- We denote the cross-price elasticity of demand between good X and good Y as: ε_{XY}
- $$\varepsilon_{xy} = \frac{\frac{\Delta Q_x}{Q_{x.ave}}}{\frac{\Delta P_y}{P_{y.ave}}}$$

Cross-price elasticity of demand (2)

- If ε_{XY} is positive, then good X and good Y are substitutes.
- If ε_{XY} is negative, then good X and good Y are complements.

- Complements are goods that are consumed together (e.g. bread and butter, toothbrush and toothpaste, …)
- Substitutes are goods that are similar, therefore, one is consumed instead of the other (e.g. coke and pepsi, Dell laptops and Asus laptops, …)

Income elasticity of demand

- Income elasticity of demand measures the responsiveness of the quantity demanded of a good due to a change in the income of consumers.
- We denote the cross-price elasticity of demand between good X and good Y as: ε_I
- $$\varepsilon_I = \frac{\frac{\Delta Q}{Q_{ave}}}{\frac{\Delta I}{I_{ave}}}$$

Income elasticity of demand (2)

- If ε_I is positive, then the good is a normal good.
- If ε_I is negative, then the good is an inferior good.

- Normal goods are goods that consumers buy more the higher their income (e.g. designer clothes, DVDs, …)
- Inferior goods are goods that consumers buy less the higher their income (e.g. junk food, preowned clothes, …)

Price elasticity of supply

- The law of supply says that "as the relative price of a good increases, the quantity supplied of the good also increases, ceteris paribus" or
- "as the relative price a good decreases, the quantity supplied of the good decreases"
- Therefore, the law of supply is concerned with the direction of the adjustments in quantity supplied when there is a change in price.
- Now, we want to answer the question: "by how much does the quantity supplied change when there is a change in price?"

Price elasticity of supply (2)

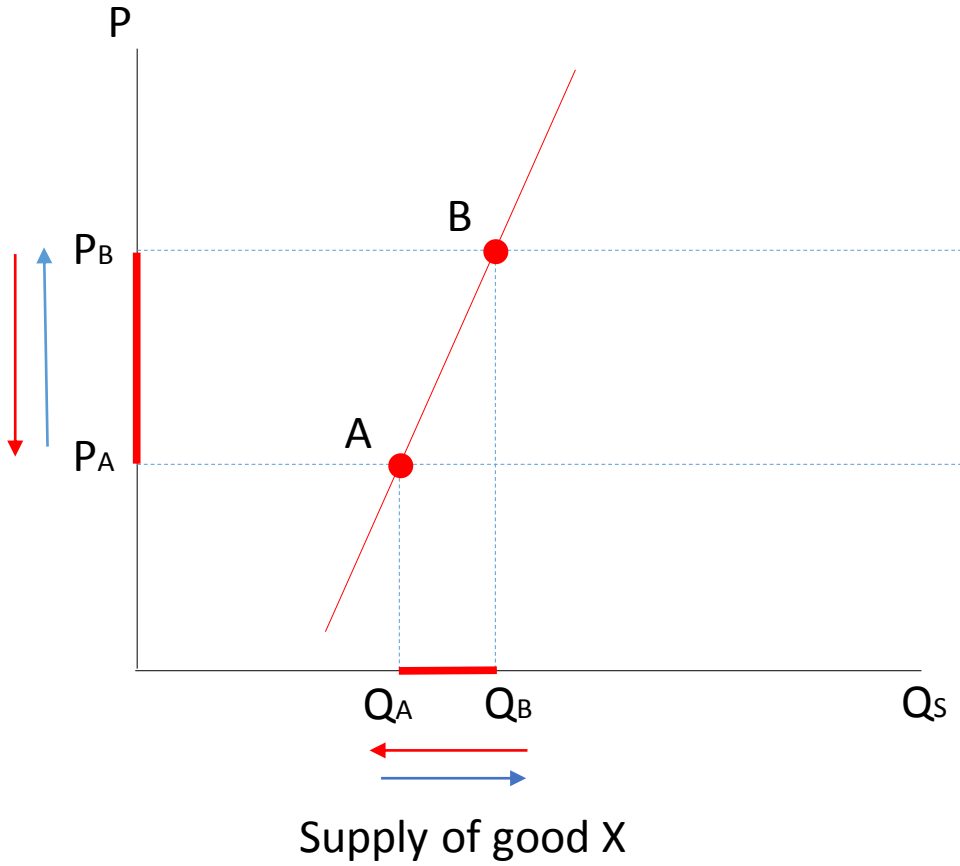
- Here, we'll use cellphone communication and hotdogs as examples:
- When the price of cellphone communication rises, the quantity supplied of communication services also rises.
- BUT the rise is RELATIVELY SMALL, because you can't build more cellphone towers just because of a rise in price!
- On the other hand, when hotdogs become more expensive, hotdog vendors SIGNIFICANTLY increase their production of dogs. It's easier to do.
- *The price of both goods increases and their quantity supplied too. However, the rise in the quantity supplied of cellphone services is RELATIVELY SMALL compared to the rise in the quantity supplied of hotdogs.*

Price elasticity of supply (3): definition

- Price elasticity of supply measures *the degree of responsiveness* of quantity supplied due to a change in price.

Illustration of price elasticity of supply

- Following are the supply curves of two goods: X and Y.



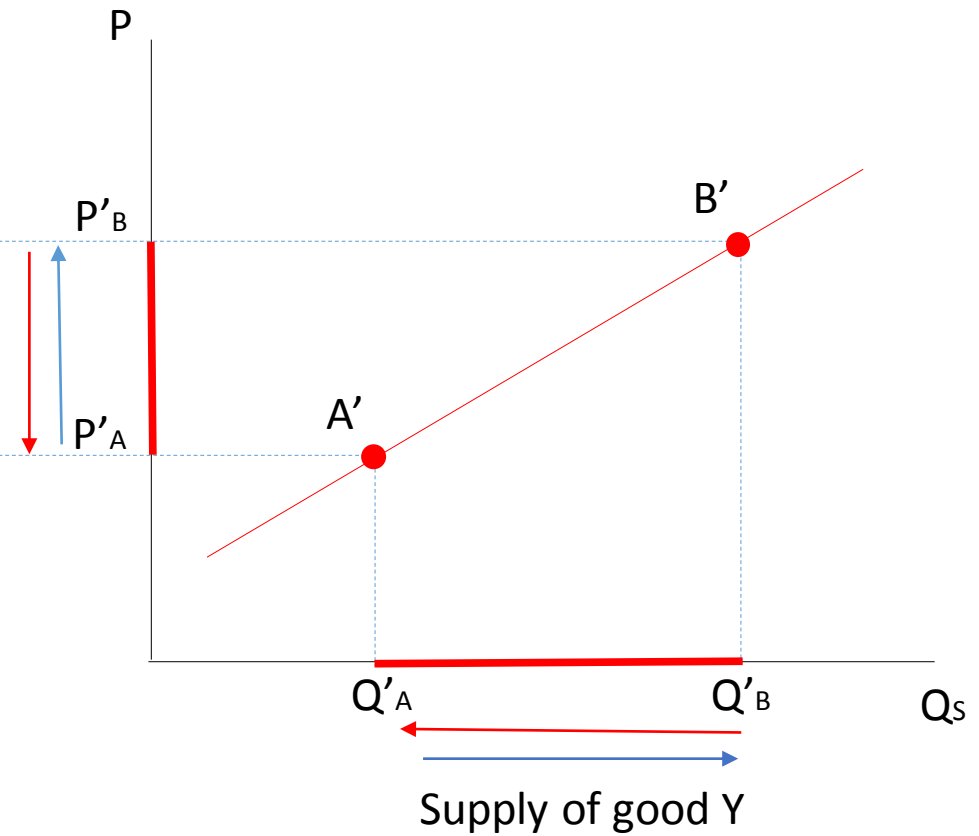
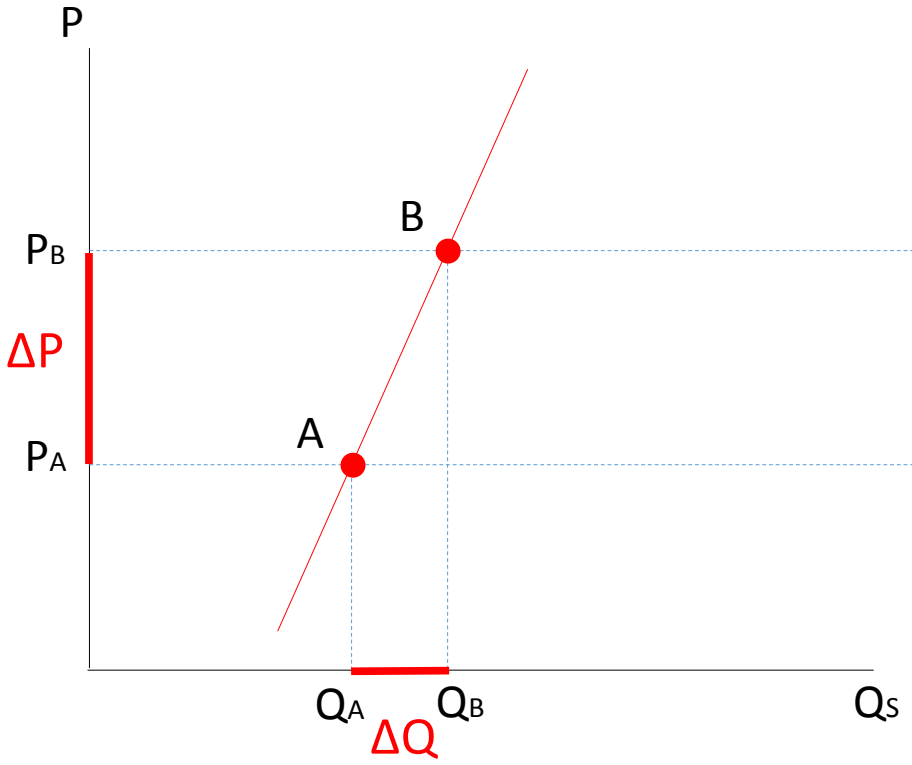
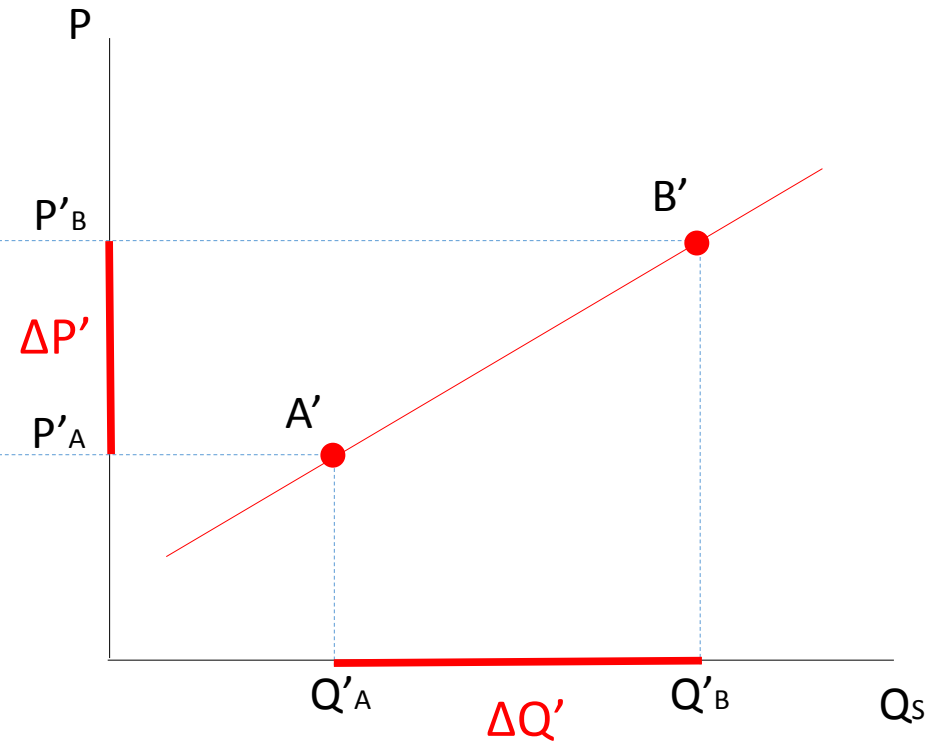


Illustration of price elasticity of supply (3)



Supply of good X



Supply of good Y

Illustration of price elasticity of supply (4)

- $\Delta P = P_{new} - P_{old}$: Change in the price of good X
- $\Delta P' = P'_{new} - P'_{old}$: Change in the price of good Y
- $\Delta Q = Q_{new} - Q_{old}$: Change in the quantity supplied of good X
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Illustration of price elasticity of demand (5)

- For an equivalent price change, the quantity supplied of good Y responded more significantly than the quantity supplied of good X.
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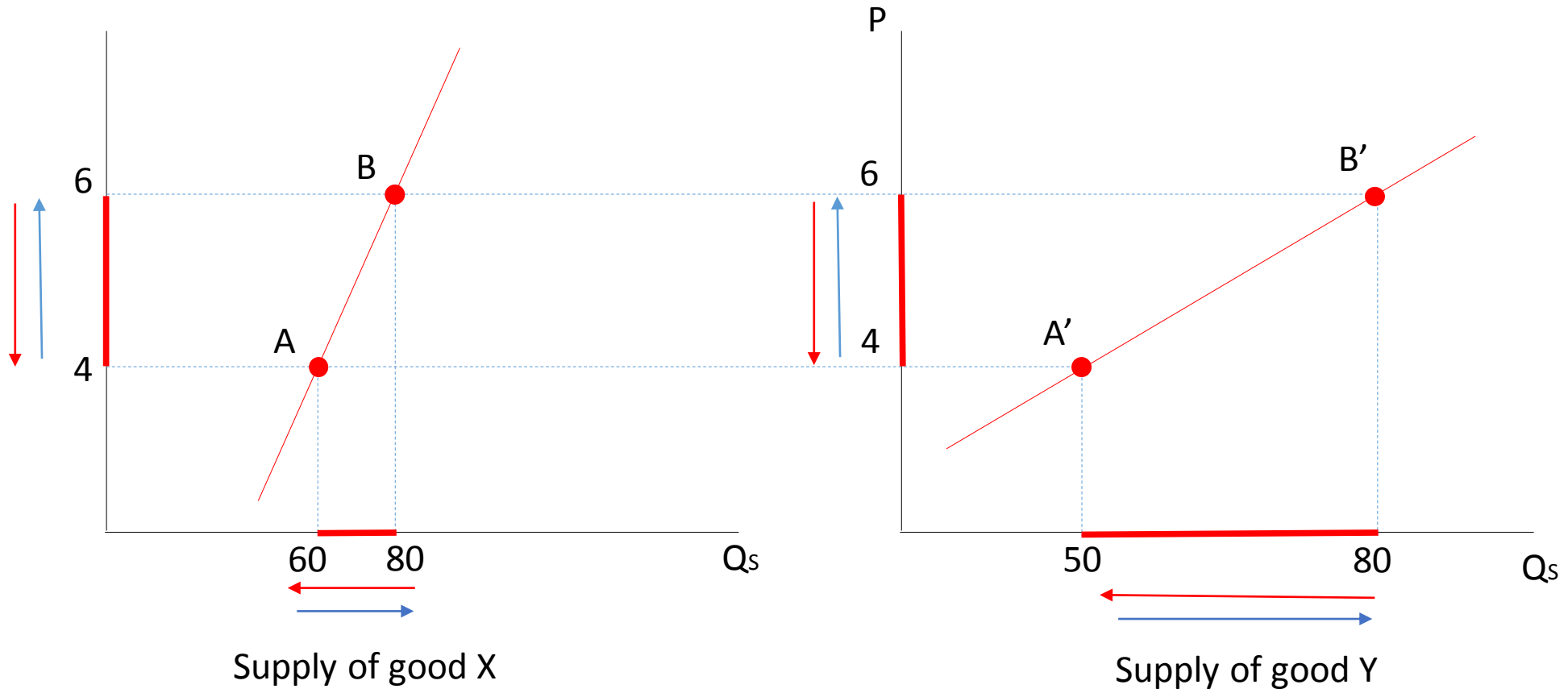
Computing price elasticity of supply

- Let's add some figures to our previous graphs:



Computing price elasticity of supply (2)

- We denote the price elasticity of supply by ε_S
- $\varepsilon_S = \left|\frac{\%\Delta Q}{\%\Delta P}\right|$
- %ΔQ: Percentage change in quantity supplied
- $\%\Delta Q = \frac{\Delta Q}{Q_{old}} = \frac{Q_{new} - Q_{old}}{Q_{old}}$
- %ΔP: Percentage change in price
- $\%\Delta P = \frac{\Delta P}{P_{old}} = \frac{P_{new} - P_{old}}{P_{old}}$
- Even though this is the standard formula used to calculate price elasticity of supply, there are some problems with using it…

Computing price elasticity of supply (3)

- Let's assume that the price of good X rises from $4 to $6.
- The quantity supplied of good X rises from 60 to 80.
- $\%\Delta Q = \frac{80 - 60}{60} = 0.33$
- $\%\Delta P = \frac{6 - 4}{4} = 0.5$
- $\varepsilon_S = \left|\frac{0.33}{0.5}\right| = 0.66$

Computing price elasticity of supply (4)

- Now let's assume that the price of good X falls from $6 to $4.
- The quantity demanded of good X falls from 80 to 60.
- $\%\Delta Q = \frac{60 - 80}{80} = -0.25$
- $\%\Delta P = \frac{4 - 6}{6} = -0.33$
- $\varepsilon_D = \left|\frac{-0.25}{-0.33}\right| = 0.75$

Computing price elasticity of supply (5)

- When the price increases from \$4 to \$6 and the quantity supplied rises from 60 to 80, $\varepsilon_s = 0.66$
- When the price falls from \$6 to \$4 and the quantity supplied drops from 80 to 60, $\varepsilon_s = 0.75$
- Therefore, this way of computing price elasticity of supply is inconsistent since it gives different results depending on the direction of the change.
- Instead, we use the mid-point estimate of price elasticity of supply

Computing price elasticity of supply (6)

- $\varepsilon_S = \left| \frac{\frac{\Delta Q}{Q_{ave}}}{\frac{\Delta P}{P_{ave}}} \right|$ (mid-point estimate)
- ΔQ: Change in quantity supplied
- ΔP: Change in price
- Q_{ave}: Quantity average: $\frac{Q_{old} + Q_{new}}{2}$
- P_{ave}: Price average: $\frac{P_{old} + P_{new}}{2}$
- Here, the direction of the change does NOT matter.

Computing price elasticity of supply (7)

- $\Delta P = \Delta P' = 6 - 4 = 2$
- $\Delta Q = 80 - 60 = 20$
- $\Delta Q' = 80 - 50 = 30$
- $P_{ave} = \frac{4+6}{2} = 5$
- $Q_{ave} = \frac{60+80}{2} = 70$
- $Q'_{ave} = \frac{50+80}{2} = 65$

- $\varepsilon_S = \left| \frac{\frac{20}{70}}{\frac{2}{5}} \right| = 0.71$
- $\varepsilon'_S = \left| \frac{\frac{30}{65}}{\frac{2}{5}} \right| = 1.15$

- Elasticity is a *unitless* measure.

Computing price elasticity of supply (8)

- The price elasticity of supply:

- For good X: $\varepsilon_s = 0.71$

- For good Y: $\varepsilon'_s = 1.15$

- $\varepsilon_s < \varepsilon'_s$

- Therefore, we can say that the supply of good Y is more (price) elastic that the supply of good X.
- The level of production of good Y is more responsive to changes in price than the level of production of good X.

Levels of price elasticity of supply

- ε_S < 1: Supply is (price) inelastic (%ΔQ < %ΔP)

- When price changes, the magnitude of the change in quantity supplied is smaller than the magnitude of the change in price.

- ε_S > 1: Supply is (price) elastic (%ΔQ > %ΔP)

- When price changes, the magnitude of the change in quantity supplied is bigger than the magnitude of the change in price.

- ε_S = 1: Supply is unit (price) elastic (%ΔQ = %ΔP)

- When price changes, the magnitude of the change in quantity supplied is equal to the magnitude of the change in price.

Levels of price elasticity of supply (2)

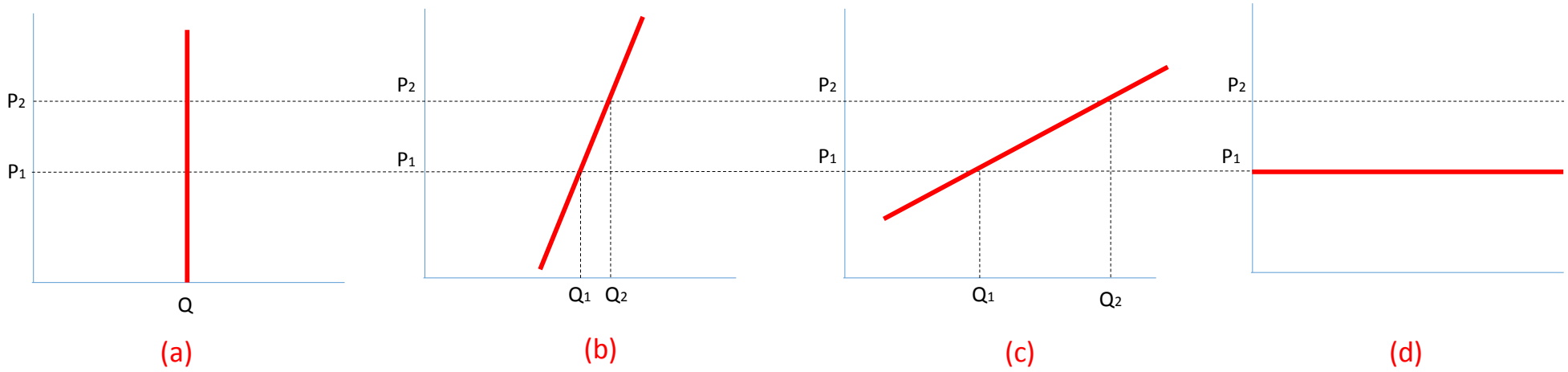
- $\varepsilon_D = 0$: Supply is perfectly (price) inelastic ($\%\Delta Q = 0$)

- No matter how price changes (even by a very big margin), the quantity supplied remains the same.

$\varepsilon_D = \infty$: Supply is perfectly (price) elastic

- The slightest change in price will cause quantity supplied to fall to 0.

Levels of price elasticity of supply (3)



(a) Supply is perfectly (price) inelastic.
(b) Supply is relatively (price) inelastic.
(c) Supply is relatively (price) elastic.
(d) Supply is perfectly (price) elastic.

The flatter the supply curve, the more elastic.

Factors that can change the price elasticity of supply

- Certain factors can influence the price elasticity of supply of a good.
- Here, we will talk about two main factors:

- Flexibility of production
- Time horizon

Factors that can change the price elasticity of supply (2)

- Flexibility of production

- Some goods/services are easier to produce/render than others.
- When prices increase, it is relatively easy to adjust the production of hamburgers.
- Therefore, the supply of hamburgers is relatively elastic.
- However, when rental rates for students housing go up, realtors do not necessarily build new apartment complexes right away.
- Which makes the supply of students' housing relatively inelastic.

Factors that can change the price elasticity of supply (3)

- Time horizon

- Using the students' housing example, even though the supply of apartment complexes can hardly increase right away, this can definitely happen in a longer time horizon.
- With time, realtors will definitely build new apartment complexes to accommodate more students.
- A longer time horizon will therefore make the supply of students' housing more elastic.

You should now be able to…

- Price elasticity of demand
- Define price elasticity of demand and explain its use
- Calculate it using the percentage formula and the mid-point estimate and explain why the mid-point estimate is preferable
- Identify the five levels of price elasticity of demand
- Comment on the price elasticity of demand of a good by looking at the slope of the demand curve
- Identify and explain some factors that affect price elasticity of demand

You should now be able to… (2)

- Comment on the price elasticity of demand of a good which has a linear demand curve
- Determine how total revenue changes when price changes depending on whether a good is elastic or inelastic.
- Cross price elasticity of demand
- Define cross-price elasticity of demand
- Calculate it
- Determine the relationship between two goods depending on the sign of the cross-price elasticity of demand

You should now be able to… (3)

- <u>Income elasticity of demand</u>
- Define income elasticity of demand
- Calculate it
- Determine the type of a good (i.e. normal or inferior) depending on the sign of the income elasticity of demand
- <u>Price elasticity of supply</u>
- Define price elasticity of supply and explain its use
- Calculate it using the percentage formula and the mid-point estimate and explain why the mid-point estimate is preferable

You should now be able to… (4)

- Identify the five levels of price elasticity of supply
- Comment on the price elasticity of supply of a good by looking at the slope of the supply curve
- Identify and explain some factors that affect price elasticity of supply