EE211
PRINCIPLES OF MICROECONOMICS

Topic 3:

Elasticity: Measure of Response

Topics

- Elasticity of demand
  - Price elasticity of demand
  - Income elasticity of demand
  - Cross-price elasticity of demand
- Elasticity of supply

Introduction

$TR_0 = \$120 \times 50\ kg = 6{,}000$ baht

$TR_1 = \$160 \times 40\ kg = 6{,}400$ baht ($TR\uparrow$)

$TR_2 = \$160 \times 30\ kg = 4{,}800$ baht ($TR\downarrow$)

- A scenario…

Suppose you currently sell durians for 120 baht/kg, the price at which you can sell 50 kg. per day.

At the end of the season, the costs rise, and you wish to raise the price to 160 baht/kg.

But the law of demand says that the quantity demanded is lower at a higher price.

Question: How many kilos of durian would you sell at a higher price? Would you revenue increase or decrease?

➔ The answer depends on the price elasticity of demand.

Basic Idea about Elasticity

- **Elasticity** measures how much one variable responds to changes in another variable.

exogenous change
(given)

eg. Q_D

dependent var.

- Formula:

$$Elasticity = \frac{Percentage\ Change\ in\ Y}{Percentage\ Change\ in\ X}$$

independent var.

eg. P

$\Delta Y \equiv Y_1 - Y_0$

$$\varepsilon = \frac{\%\Delta Y}{\%\Delta X} = \frac{\Delta Y/Y}{\Delta X/X}$$

$\Delta X \equiv X_1 - X_0$

<u>Ex</u>

$$\varepsilon_d = \frac{\%\Delta Q_d}{\%\Delta P}$$

Price Elasticity of Demand

- **Price elasticity of demand** measures how much Q_d responds to a change in P.
  - I.e., it measures the price-sensitivity of buyers' demand.

"epsilon"

$$\varepsilon_d = \frac{\%\,\Delta Q_d}{\%\,\Delta P} = \frac{\Delta Q_d / Q_d}{\Delta P / P}$$

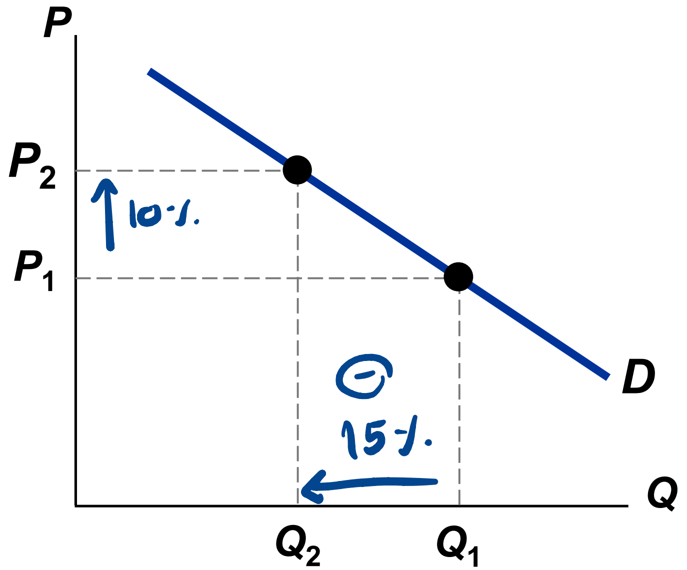
- Example:

Suppose P rises by 10%,

and Q falls by 15%.

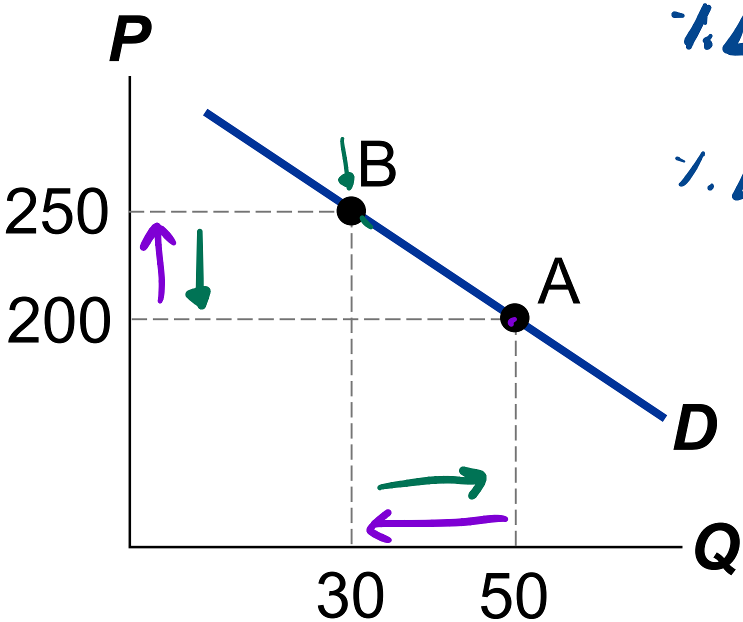
➔ $$\varepsilon_d = \frac{\%\Delta Q_d}{\%\Delta P} = \frac{-15\cancel{\%}}{10\cancel{\%}}$$

$$\varepsilon_d = -1.5$$



Calculating Percentage Change (1)

Demand for durians



The Standard Method:

$$\%Change = \qquad \%\Delta X = \frac{end\ value\ - start\ value}{start\ value} \ x\ 100\%$$

$$\%\Delta X = \left(\frac{X_1 - X_0}{X_0}\right) \times 100\%$$

① A → B :

$$\%\Delta Q_d = \frac{(30-50)}{50} \times 100\% = -40\% \quad (-0.4)$$

$$\%\Delta P = \frac{(250-200)}{200} \times 100\% = 25\% \quad (0.25)$$

$$\Rightarrow \varepsilon_d = \frac{-40\%}{25\%} = -1.6$$

② B → A :

$$\%\Delta Q_d = \left(\frac{50-30}{30}\right) \times 100\% = 0.67$$

$$\%\Delta P = \left(\frac{200-250}{250}\right) \times 100\% = -0.2$$

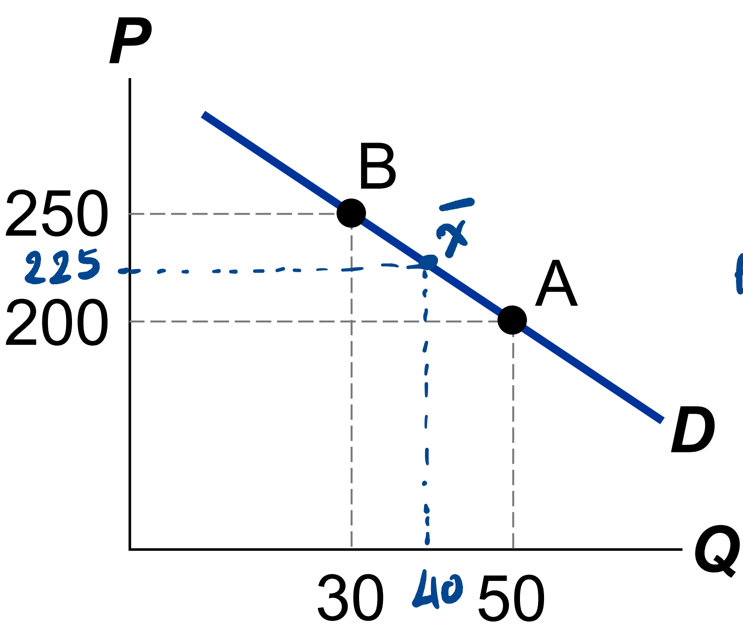
$$\varepsilon_d = \frac{0.67}{-0.2} = -3.35$$

Problem:

The standard method gives different answers depending on where you start.

Calculating Percentage Change (2)

Demand for durians



The Midpoint Method:

$$\%\Delta x = \frac{(x_1 - x_0)}{\left(\frac{x_1 + x_0}{2}\right)} \times 100\%$$

$$\%Change = \frac{end\ value\ - start\ value}{midpoint}\ x\ 100\%$$

A is starting pt.

$$\%\Delta Q_d = \frac{(30-50)}{40} \times 100\% = -0.5$$

$$\%\Delta P = \frac{(250-200)}{225} \times 100\% = 0.22$$

$$\Rightarrow \varepsilon_d = \frac{-0.5}{0.22} = -2.27$$

Check: Start @ B $\Rightarrow$

$$\left.\begin{aligned} \%\Delta Q_d &= \frac{(50-30)}{40} \times 100\% = 0.5 \\ \%\Delta P &= \frac{(200-250)}{225} \times 100\% = -0.22 \end{aligned}\right\} \varepsilon_d = -2.27$$

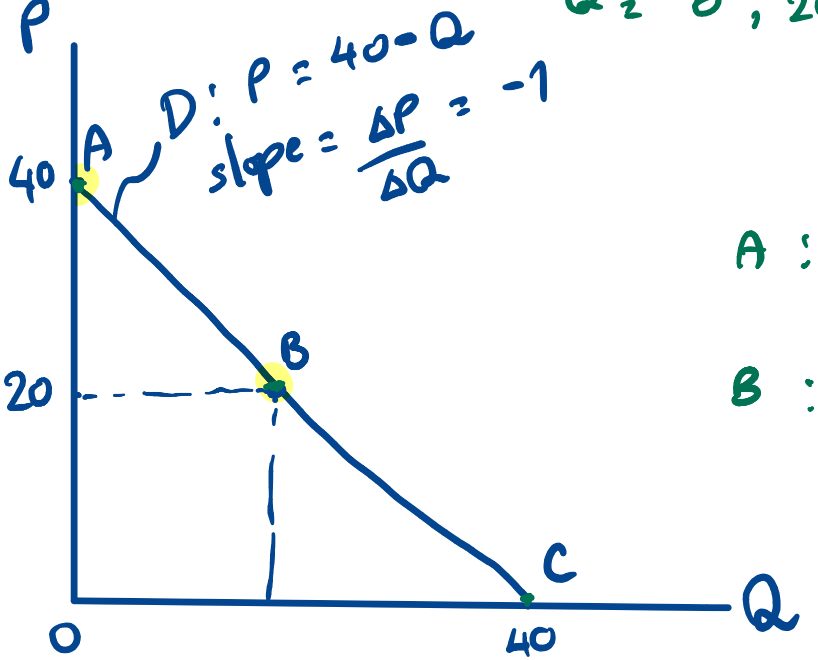
Point Elasticity (Linear Demand Curve)

- $\varepsilon_d = \frac{\%\,\Delta Q_d}{\%\,\Delta P} = \frac{1}{Slope} \times \frac{P}{Q_d}$

$$\varepsilon_d = \frac{\Delta Q_d / Q_d}{\Delta P / P} = \frac{\Delta Q_d}{\Delta P} \times \frac{P}{Q_d} = \frac{1}{\text{slope of } D} \times \frac{P}{Q_d}$$

- Given P = 40 – Q, determine the price elasticities of demand when P = 40, 20, and 0.

$Q = 0,\ 20,\ 40$



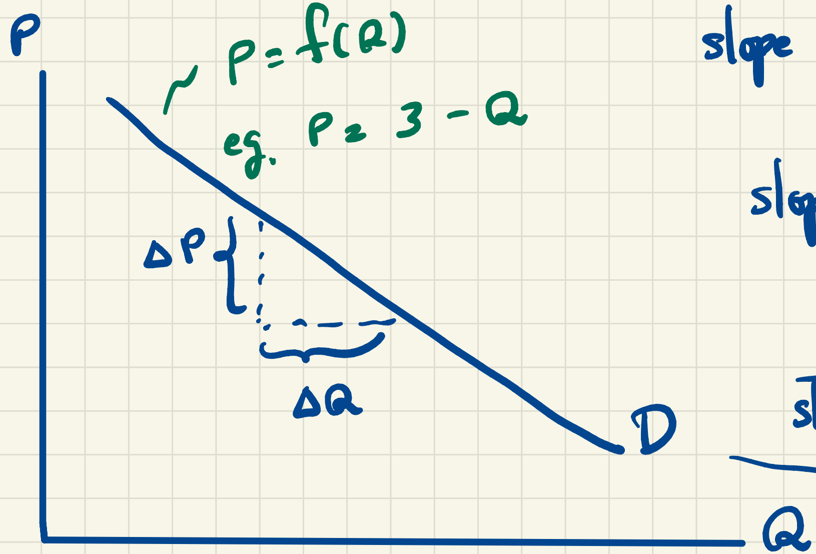
$$\varepsilon_d = \frac{1}{\Delta P / \Delta Q_d} \times \frac{P}{Q_d}$$

$A:\ \varepsilon_d^A = \frac{1}{(-1)} \times \frac{40}{0} = -\infty$

$B:\ \varepsilon_d^B = \frac{1}{(-1)} \times \frac{20}{20} = -1$

$C:\ \varepsilon_d^C = \frac{1}{(-1)} \times \frac{0}{40} = 0$

The slope of a linear demand curve is constant, but its elasticity is not.



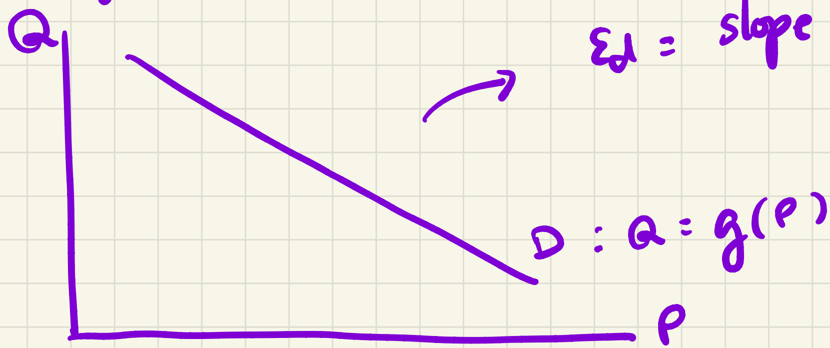
$$\text{slope} = \frac{\Delta Y}{\Delta X}$$

$$\text{slope of D} = \frac{\Delta P}{\Delta Q}$$

$$\frac{1}{\text{slope of D}} = \frac{\Delta Q}{\Delta P}$$

$$\boxed{\varepsilon_d = \frac{1}{\text{slope of } f(Q)} \times \frac{P}{Q_d}}$$

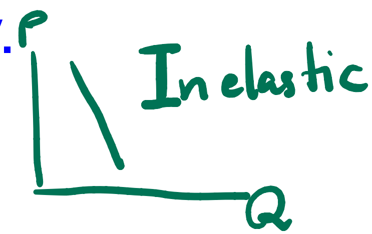
$$Q = g(P) = 3 - P$$



$$\varepsilon_d = \text{slope of } g(P) \times \frac{P}{Q_d}$$

The Variety of Demand Curves

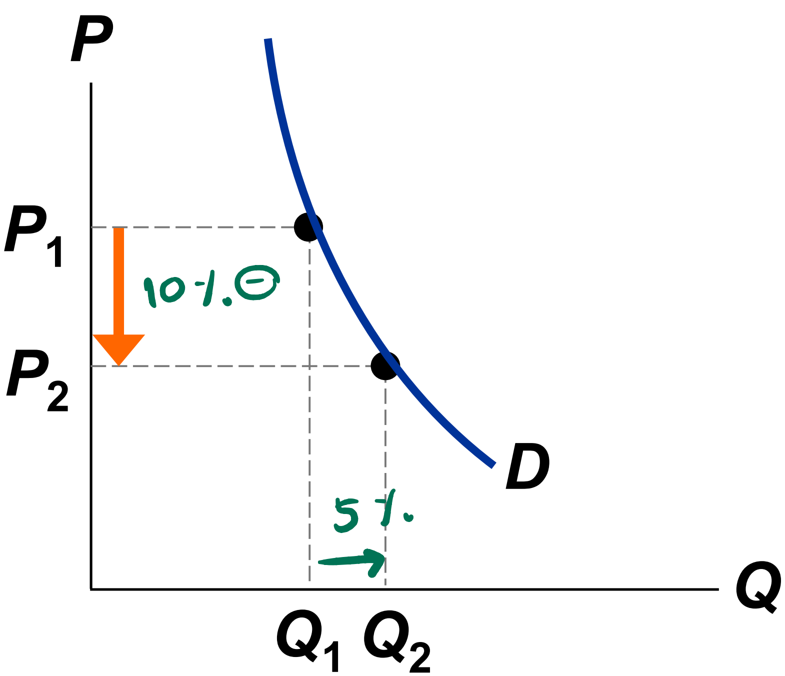
- The price elasticity of demand is closely related to the slope of the demand curve.
- <u>Rule of thumb:</u>
  The flatter the curve, the bigger the elasticity.
  The steeper the curve, the smaller the elasticity.



- Summary:
  1) D is perfectly elastic if $\varepsilon_d = -\infty$ (i.e. $|\varepsilon_d| = \infty$).
  2) D is elastic if $-\infty < \varepsilon_d < -1$ (i.e. $1 < |\varepsilon_d| < \infty$).
  3) D is inelastic if $-1 < \varepsilon_d < 0$ (i.e. $0 < |\varepsilon_d| < 1$).
  4) D is perfectly inelastic if $\varepsilon_d = 0$ (i.e. $|\varepsilon_d| = 0$).
  5) D is unitary elastic if $\varepsilon_d = -1$ (i.e. $|\varepsilon_d| = 1$).

Elastic & Inelastic Demand

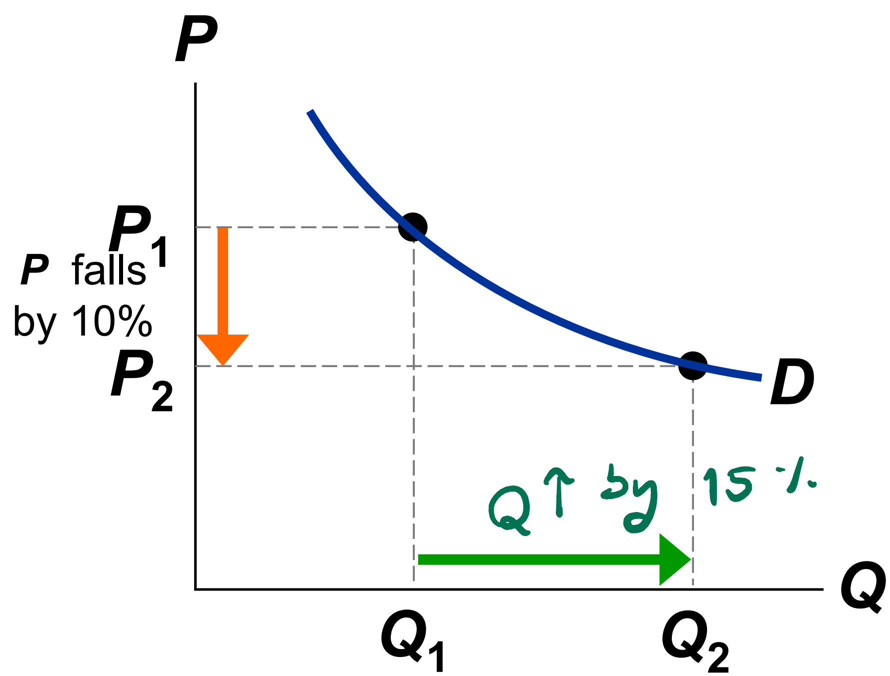
Relatively
- Inelastic demand



$\varepsilon_d = \frac{5\%}{-10\%} = -0.5$

$|\varepsilon_d| < 1$

Relatively
- Elastic demand

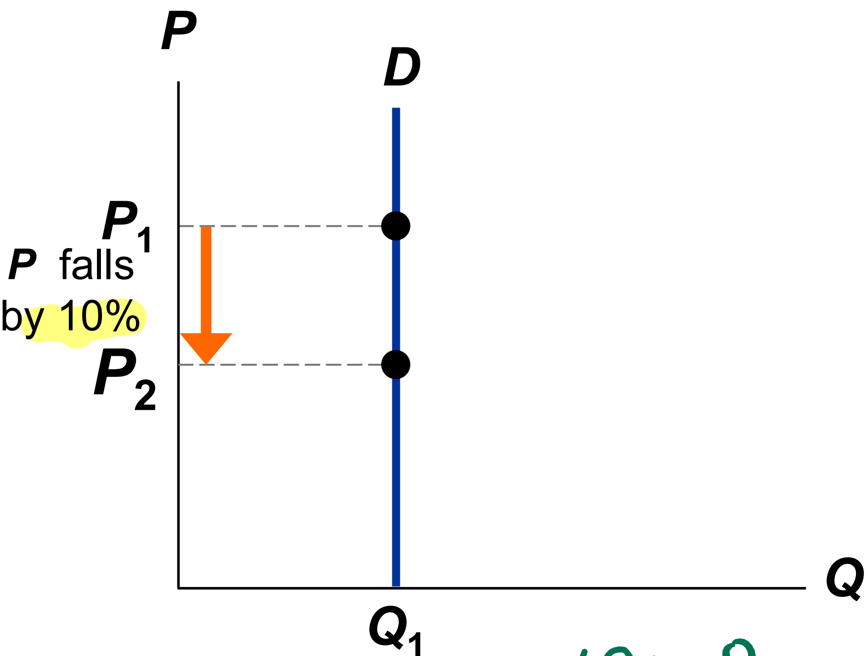


$\varepsilon_d = \frac{15\%}{-10\%} = -1.5$

$|\varepsilon_d| > 1$

Extreme Cases

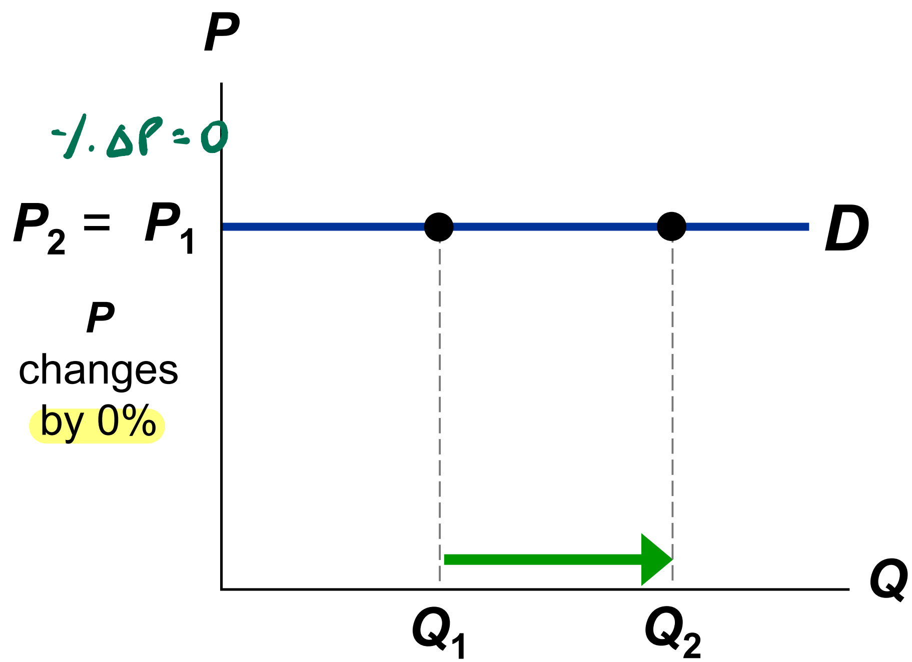
- Perfectly Inelastic Demand
- Perfectly Elastic Demand



Q changes by 0%

$\%Q_d = 0$

$\varepsilon_d = 0$

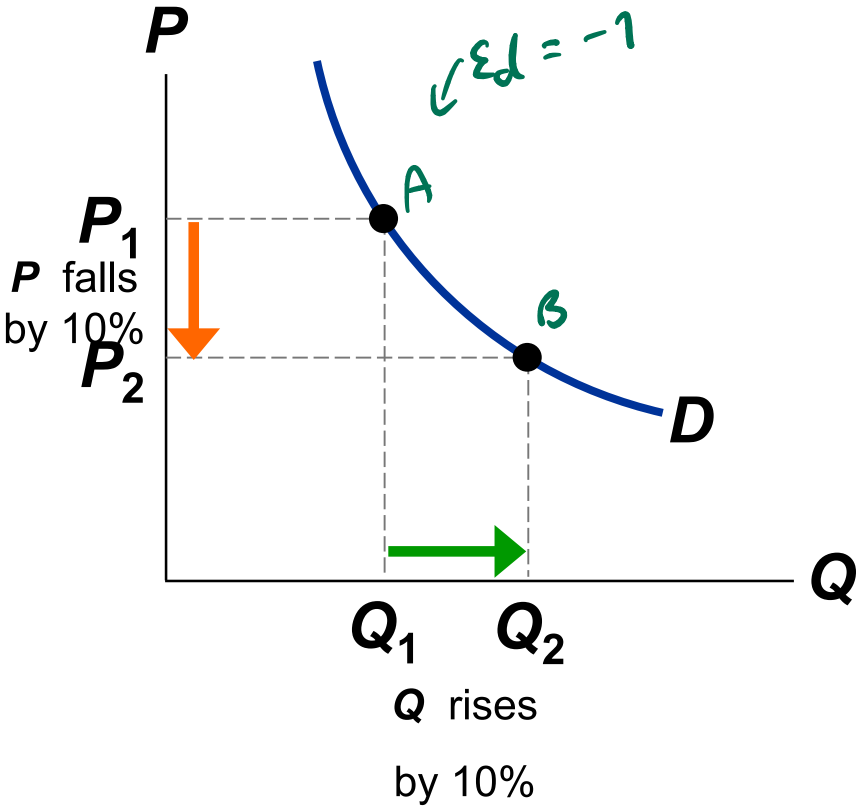


Q changes by any%

$\%\Delta Q_d > 0$

$$\varepsilon_d = \left|\frac{\%\Delta Q_d}{\%\Delta P}\right| = \frac{\%\Delta Q_d}{0} = \infty$$

Unitary Elastic Demand



- The price elasticity of demand is constant along the demand curve, and it is equal to 1. (in absolute value).
- $P = \frac{1}{Q_d}$

$$|\varepsilon_d| = \left|\frac{\%\Delta Q_d}{\%\Delta P}\right| = 1$$

Elasticity

$$\varepsilon = \frac{\%\Delta Y}{\%\Delta X}$$

→ Price elasticity of demand : $\varepsilon_d = \dfrac{\%\Delta Q_d}{\%\Delta P} = \dfrac{\Delta Q_d / Q_d}{\Delta P / P}$

- standard method
- midpoint method
- Point elasticity of demand : $\varepsilon_d = \dfrac{\Delta Q_d}{\Delta P} \cdot \dfrac{P}{Q_d}$

$$= \frac{1}{\text{slope of } D} \cdot \frac{P}{Q_d}$$

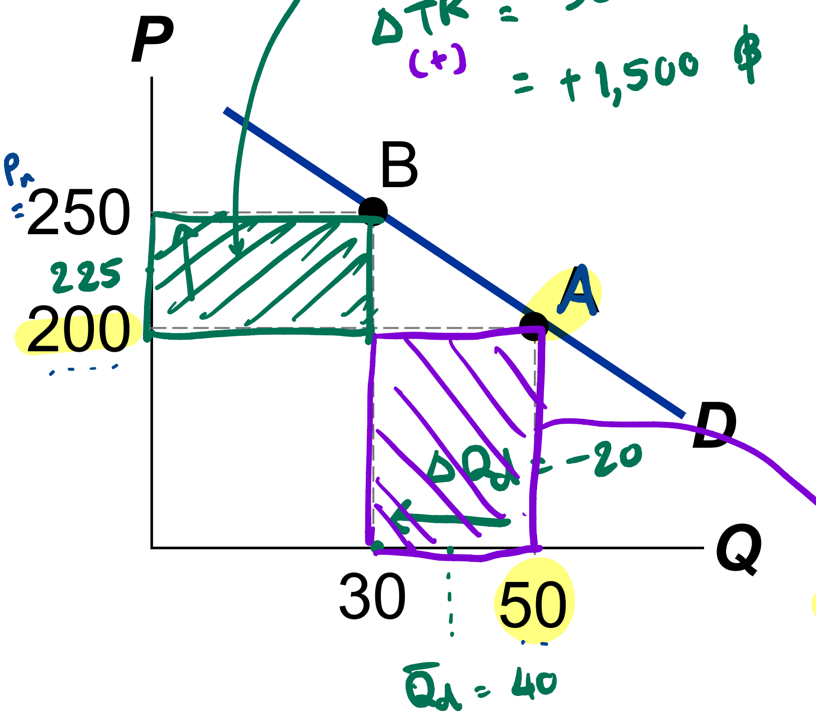
→ ΔTR & ε_d

Price Elasticity and Total Revenue (1)

$\Delta TR = TR_1 - TR_0 = (30 \times ฿250) - (50 \times ฿200)$
$= 7{,}500 - 10{,}000 = -2{,}500$

Demand for durians

↑ in TR b/c P↑:
$\underset{(+)}{\Delta TR} = 30 \times ฿(50)$
$= +1{,}500$ ฿



- TR = P x Q
- $\varepsilon_d = \dfrac{\%\,\Delta Q_d}{\%\,\Delta P}$

(use midpoint method).

- $\varepsilon_d = \dfrac{\Delta Q_d / Q_d}{\Delta P / P} = \dfrac{-20/40}{50/225} = -2.25$

$|\varepsilon_d| > 1 \Rightarrow$ price-elastic demand

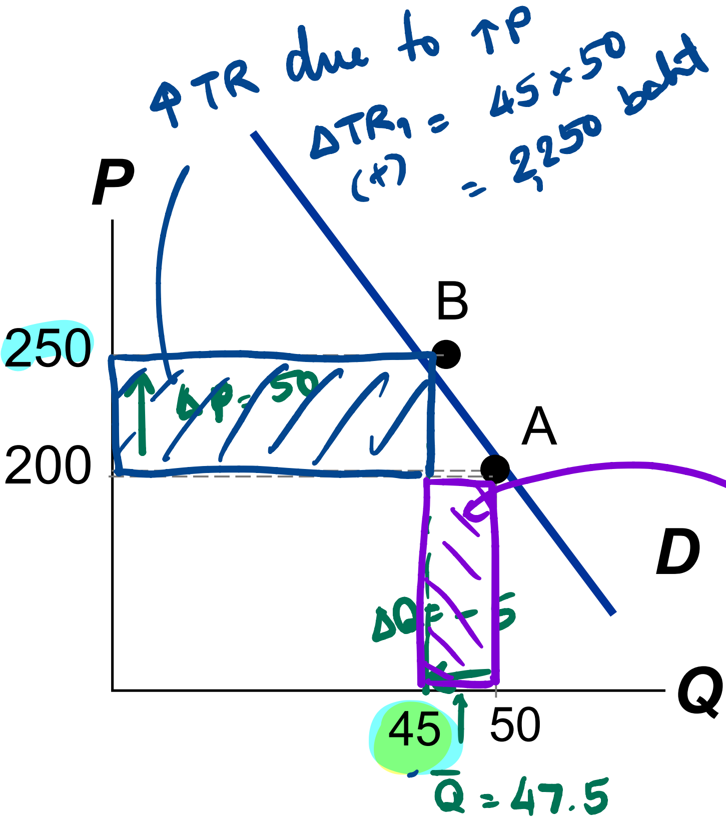
↓ in TR b/c Q↓: $\underset{(-)}{\Delta TR} = (-20) \times ฿200$
$= -4000$ ฿

Total ΔTR = Gain b/c P↑ + Loss b/c Q↓
$= 1500 - 4000$
$= -2{,}500$ baht

When ***D*** is elastic, a price increase causes revenue to fall.

Price Elasticity and Total Revenue (2)

Demand for durians



- TR = P x Q
- $\varepsilon_d = \dfrac{\%\,\Delta Q_d}{\%\,\Delta P}$
- $\varepsilon_d = \dfrac{(-5)/47.5}{50/225} = -0.47$

$|\varepsilon_d| < 1 \Rightarrow$ price-inelastic demand

$\downarrow$ TR due to $\downarrow$Q : $\Delta TR_2 = (-5) \times 200$
$= -1{,}000$ baht.

$\therefore\ \Delta TR =$ Gain due to P$\uparrow$ + Loss due to $\downarrow$Q
$= 2{,}250 - 1{,}000$
$= 1{,}250$ baht

When ***D*** is inelastic, a price increase causes revenue to rise.

Side note on ΔTR & price elasticity of demand

$$TR = P \times Q$$

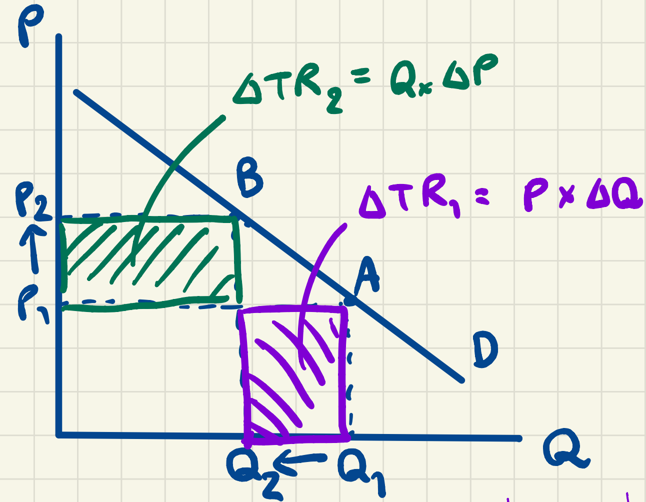
$$\Delta TR = (P \times \Delta Q) + (Q \times \Delta P)$$

$$\Delta TR \approx d(TR)$$ ← differential

$$d(TR) = d(P \times Q)$$
$$= (P \cdot \underbrace{dQ}_{\approx \Delta Q}) + (Q \times \underbrace{dP}_{\approx \Delta P})$$

$$\therefore \boxed{\Delta TR = \underbrace{(P \times \Delta Q)}_{\Delta TR_1} + \underbrace{(Q \times \Delta P)}_{\Delta TR_2}}$$

⊖ ⊕



① If $|\varepsilon_d| > 1$, $|\varepsilon_d| = \dfrac{|\%\Delta Q_d|}{|\%\Delta P|}$

$$|\%\Delta Q_d| > |\%\Delta P|$$

$\Rightarrow$ $|\Delta TR_1|$ (Loss) $>$ $|\Delta TR_2|$ (Gain)

$\therefore$ $\Delta TR < 0$ as $P \uparrow$.

② If $|\varepsilon_d| < 1$, $|\%\Delta Q_d| < |\%\Delta P|$

$\Rightarrow$ $|\Delta TR_1| < |\Delta TR_2|$ as $P \uparrow$

$\therefore$ $\Delta TR > 0$ as $P \uparrow$.

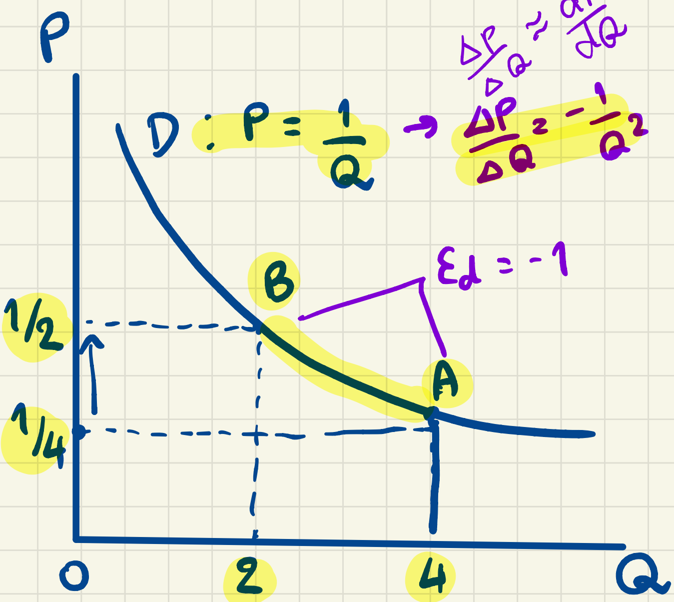
What if $|\varepsilon_d| = 1$? what happens to TR as $P\uparrow$?

$$\varepsilon_d = \frac{\%\Delta Q_d}{\%\Delta P}.$$

If $|\varepsilon_d| = 1$, $|\%\Delta Q_d| = |\%\Delta P|$

$\Delta TR = ?$

$\frac{\Delta P}{\Delta Q} \approx \frac{dP}{dQ}$



Let's compute ΔTR.

$\Delta TR = TR_B - TR_A = ?$

$$\left.\begin{aligned} TR_A &= \$\tfrac{1}{4} \times 4 = \$1 \\ TR_B &= \$\tfrac{1}{2} \times 2 = \$1 \end{aligned}\right\} \Delta TR = 0$$

$$\varepsilon_d = \frac{\Delta Q/Q_d}{\Delta P/P} = \frac{1}{\Delta P/\Delta Q} \cdot \frac{P}{Q_d} = -Q_d^2 \cdot \frac{P}{Q_d}$$

✓ $\varepsilon_d^A = -(4)^2 \times \frac{1}{4} \cdot \frac{1}{4} = -1$

✓ $\varepsilon_d^B = -(2)^2 \times \frac{1}{2} \times \frac{1}{2} = -1$

Determinants of Price Elasticity of Demand

$\varepsilon_d = \frac{\%\Delta Q_d}{\%\Delta P}$

most narrow ↓

more general definition

- Definition of the good

Eg. Covid-19 vaccine vs. mRNA Covid-19 Vaccine vs. Pfizer.

relative more inelastic → more price elastic → relatively more elastic

- Availability of close substitutes

Eg. Pfizer & Moderna → more elastic

Apple pencil → more inelastic

- Whether the good is a necessity or a luxury

more inelastic eg. Oxygen tank

more price elastic eg. scuba diving

- The time horizon: short run and long run

people can adjust

↳ more price elastic

Other Elasticities of Demand

- In addition to its own price, quantity demanded is determined by income and price of other products.
  - Income elasticity of demand

$$\varepsilon_I = \frac{\% \, \Delta Q_d}{\% \, \Delta I}$$

  - Cross-price elasticity of demand for X (with respect to change in price of Y).

$$\varepsilon_{XY} = \frac{\% \, \Delta Q_X}{\% \, \Delta P_Y}$$

Income Elasticity of Demand

- **Income elasticity of demand** measures how much $\boldsymbol{Q_d}$ responds to a change in ***income***: $\varepsilon_I = \dfrac{\%\,\Delta Q_d}{\%\,\Delta I}$. $= \dfrac{\Delta Q_d / Q_d}{\Delta I / I}$

- $\varepsilon_I \geq 0$ ➔ Normal goods   As income increases, $Q_d \uparrow$.
  - $0 \leq \varepsilon_I \leq 1$ ➔ Necessities
  - $1 < \varepsilon_I \leq \infty$ ➔ Luxuries
- $\varepsilon_I < 0$ ➔ Inferior goods   As income increases, $Q_d \downarrow$.

  eg. Potatoes, instant noodles

Example

- Suppose when the average income (I) increases from \$28,000 to \$32,000, the quantity demanded at a given price P_0 rises from 60 to 80 units. What is the income elasticity of demand? (Use midpoint method).

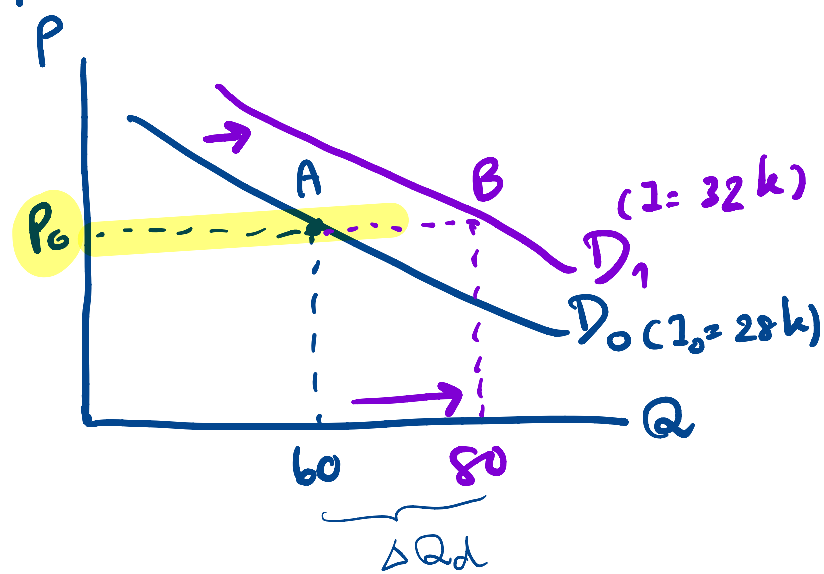
$$\varepsilon_I = \frac{\%\Delta Q_d}{\%\Delta I} = \frac{\Delta Q_d / \bar{Q}_d}{\Delta I / \bar{I}}$$

$$= \frac{20/70}{4{,}000/30{,}000}$$

$$= 2.14$$

$\varepsilon_I > 0 \rightarrow$ normal good

$\varepsilon_I > 1 \rightarrow$ luxury



Cross-Price Elasticity of Demand

- **Cross-price elasticity of demand** measures how much $\boldsymbol{Q_d}$ responds to a change in ***price of other goods***:

$$\varepsilon_{XY} = \frac{\%\,\Delta Q_X}{\%\,\Delta P_Y}.$$

Eg. $P_{Pfizer} \uparrow \rightarrow Q_d^{Moderna} \uparrow$

$\searrow Q_d^{Pfizer} \downarrow$

- $\varepsilon_{XY} < 0 \rightarrow$ X and Y are complements
- $\varepsilon_{XY} > 0 \rightarrow$ X and Y are substitutes.

What if $\varepsilon_{XY} = 0$? $\Rightarrow$ There is no relationship betw them.

eg. eggs & iPhone.

Example

X & Y are complements.

$Q_d^X \uparrow$

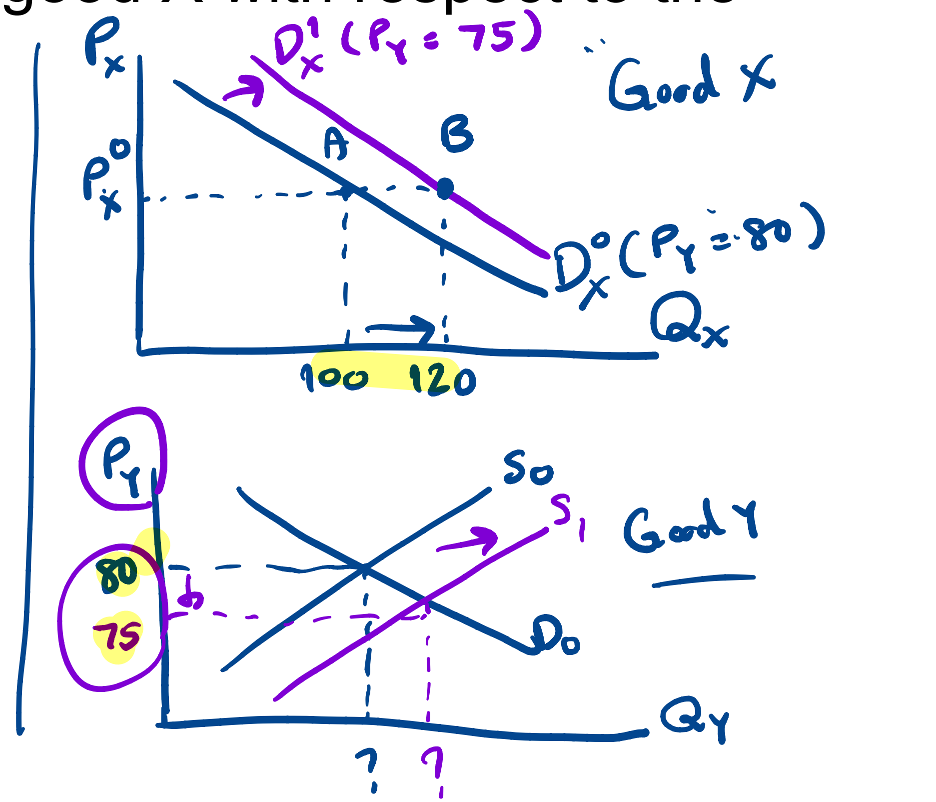
- Suppose the quantity demanded for good X increases from 100 units to 120 units when the per unit price of good Y drops from 80 baht to 75 baht. Determine the cross-price elasticity of the demand for good X with respect to the price of good Y. $P_Y \downarrow$

$$\varepsilon_{XY} = \frac{\%\Delta Q_X}{\%\Delta P_Y} = \frac{\Delta Q_X / Q_X}{\Delta P_Y / P_Y}$$

$$= \frac{20/110}{(-5)/77.5}$$

$$= -2.82$$

X & Y are complementary.



Price Elasticity of Supply

- **Price elasticity of supply** measures how much Q_S responds to a change in P.
  - I.e., it measures the price-sensitivity of sellers' supply.

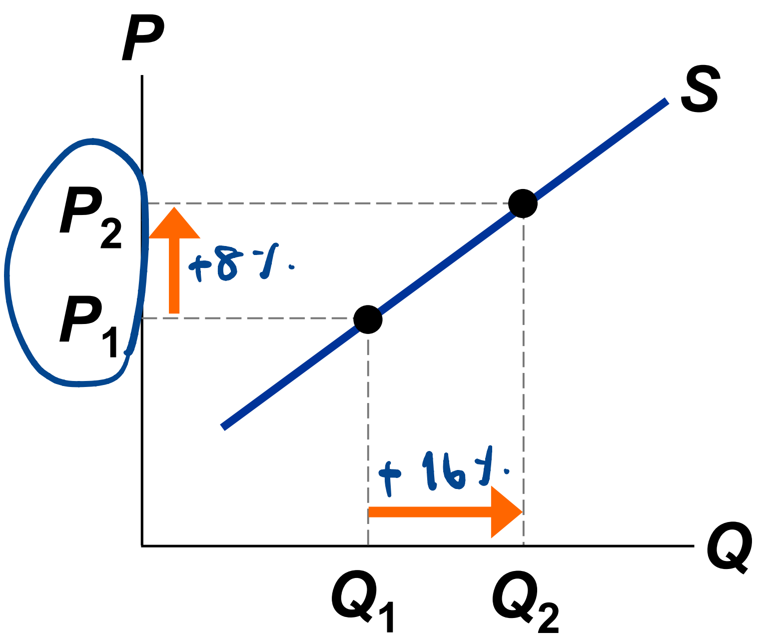
$$\varepsilon_S = \frac{\%\,\Delta Q_S}{\%\,\Delta P} = \frac{\Delta Q_s / Q_s}{\Delta P / P} \geq 0$$

Mid point : $\varepsilon_s = \dfrac{\Delta Q_s / \bar{Q}_s}{\Delta P / \bar{P}}$

- Example:

Suppose P rises by 8%, and Q increases by 16%.

➔ $\varepsilon_s = \dfrac{16\%}{8\%} = 2\%$



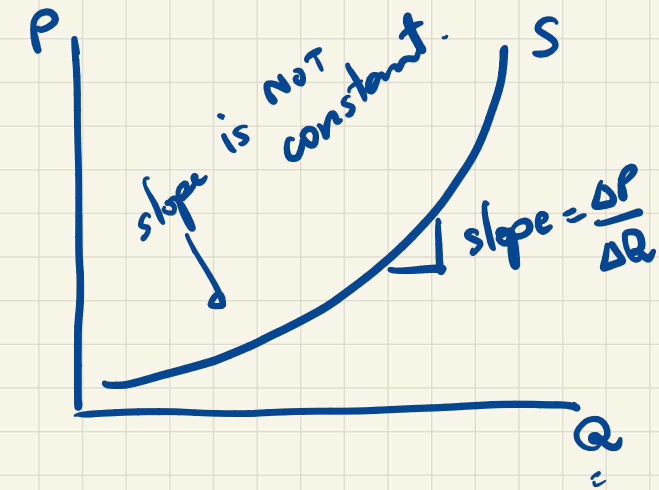
Calculation of ε_s

① Linear supply curve:

$$\varepsilon_s = \frac{\%\Delta Q_s}{\%\Delta P} = \frac{\Delta Q_s / \bar{Q}_s}{\Delta P / \bar{P}} \quad \text{where } \bar{Q}_s = \frac{Q_1^s + Q_2^s}{2}$$

$$\bar{P} = \frac{P_1 + P_2}{2}$$

② Non-linear supply curve:



1/slope

$$\varepsilon_s = \frac{\%\Delta Q_s}{\%\Delta P} = \frac{\Delta Q_s / Q_s}{\Delta P / P} = \frac{\Delta Q_s}{\Delta P} \cdot \frac{P}{Q_s}$$

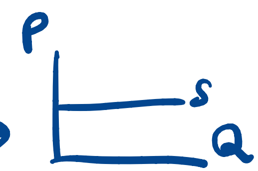
$$\varepsilon_s = \frac{1}{\Delta P / \Delta Q_s} \cdot \frac{P}{Q_s}$$

$$\therefore \varepsilon_s = \frac{1}{\text{slope of S}} \cdot \frac{P}{Q_s}$$

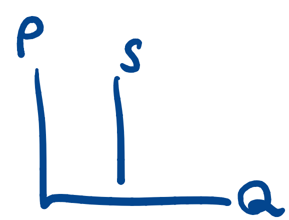
The Variety of Supply Curves

- <u>Rule of thumb:</u>
  The flatter the curve, the bigger the elasticity. (ie. Supply is more price elastic).
  The steeper the curve, the smaller the elasticity.
  ↳ ie. Supply is more price inelastic.

- Summary:
  S is perfectly elastic if $\varepsilon_S = \infty$. →

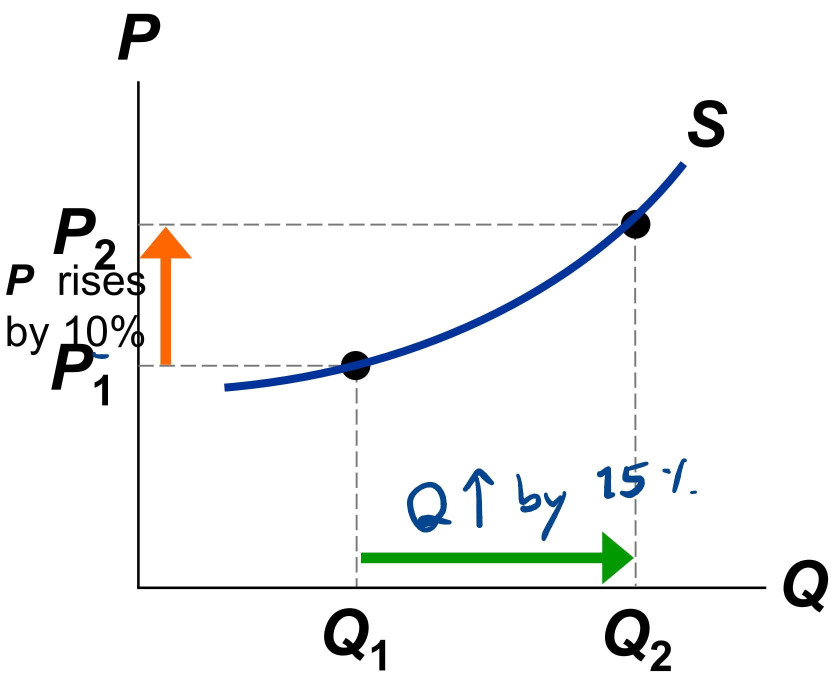


  S is elastic if $\varepsilon_S > 1$.
  S is inelastic if $\varepsilon_S < 1$.
  S is perfectly inelastic if $\varepsilon_S = 0$. →



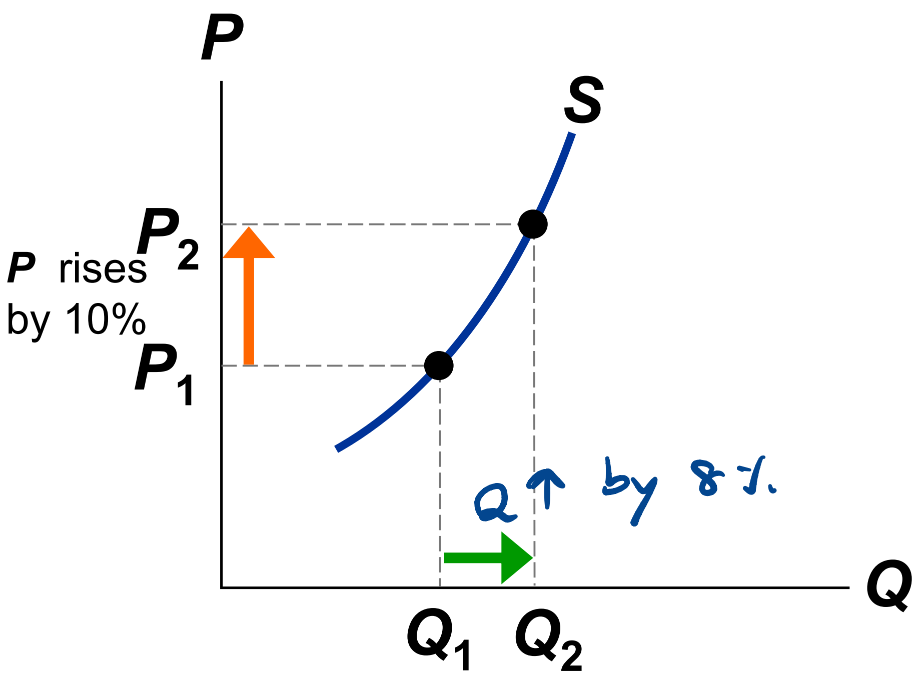
Elastic & Inelastic Supply

- Elastic Supply ← flatter



$\varepsilon_s > 1$

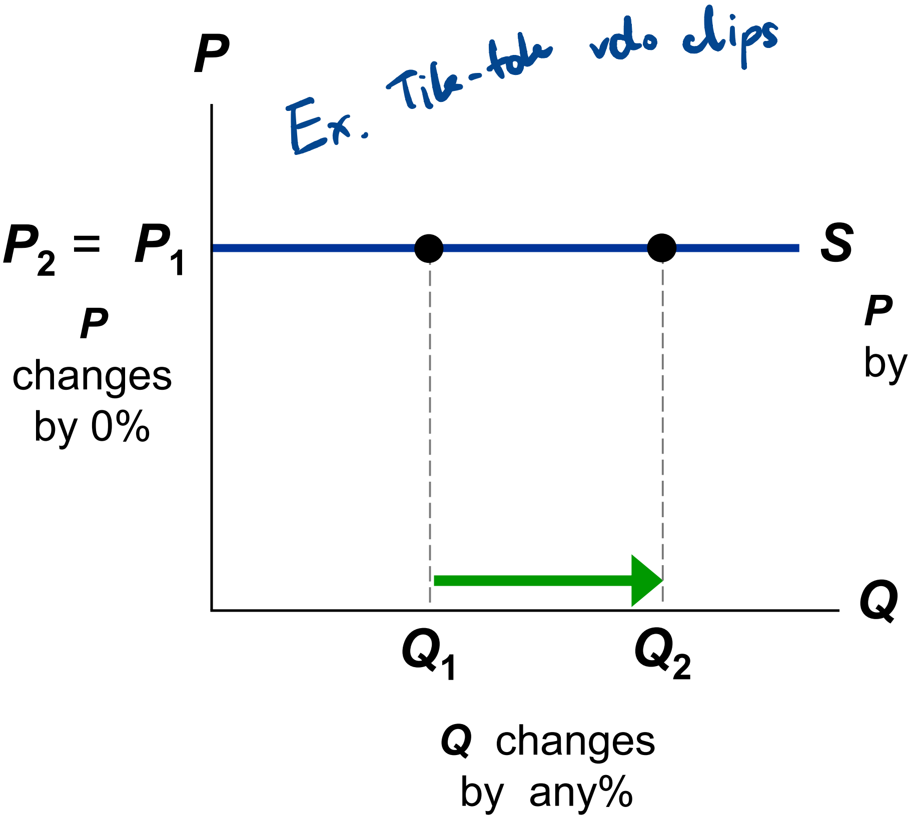
- Inelastic Supply ↙ steeper



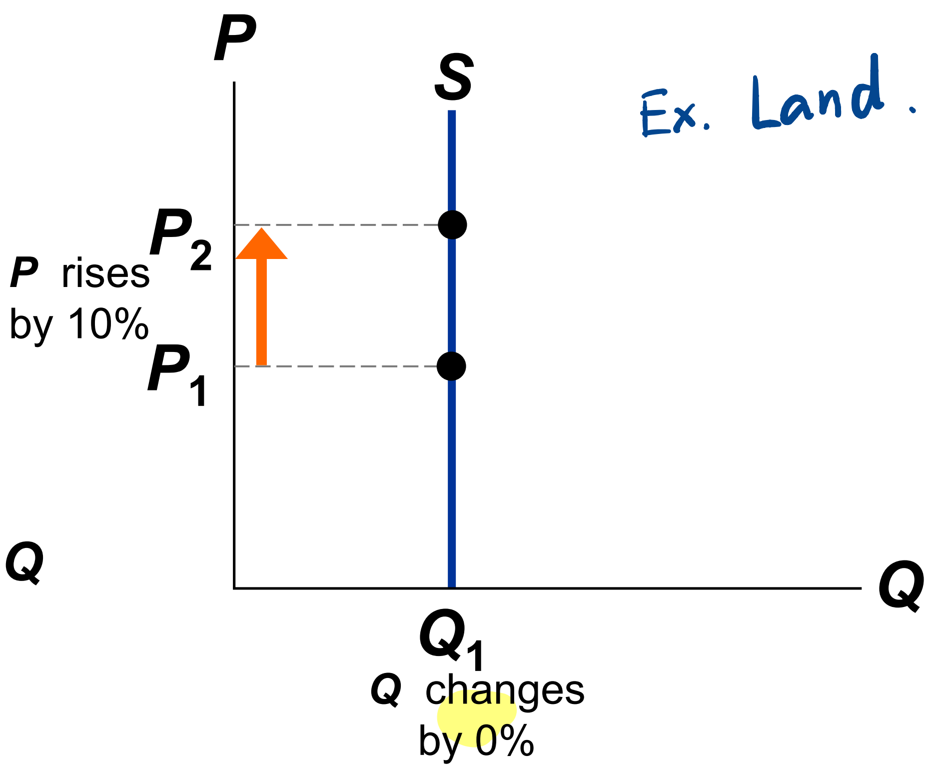
$0 < \varepsilon_s < 1$

Extreme Cases

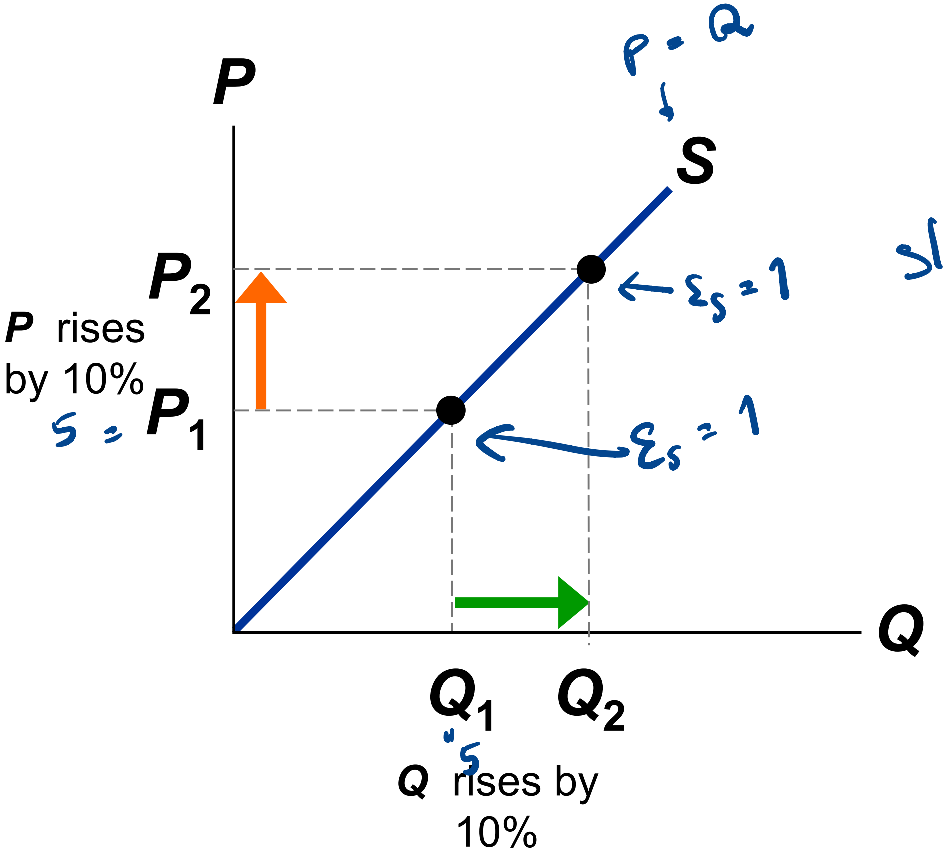
- Perfectly elastic supply



- Perfectly inelastic supply



Unitary Elastic Supply $\varepsilon_s = 1$



Ex. $P = f(Q) = Q$

eg. $P = 5 \rightarrow Q_s = 5$

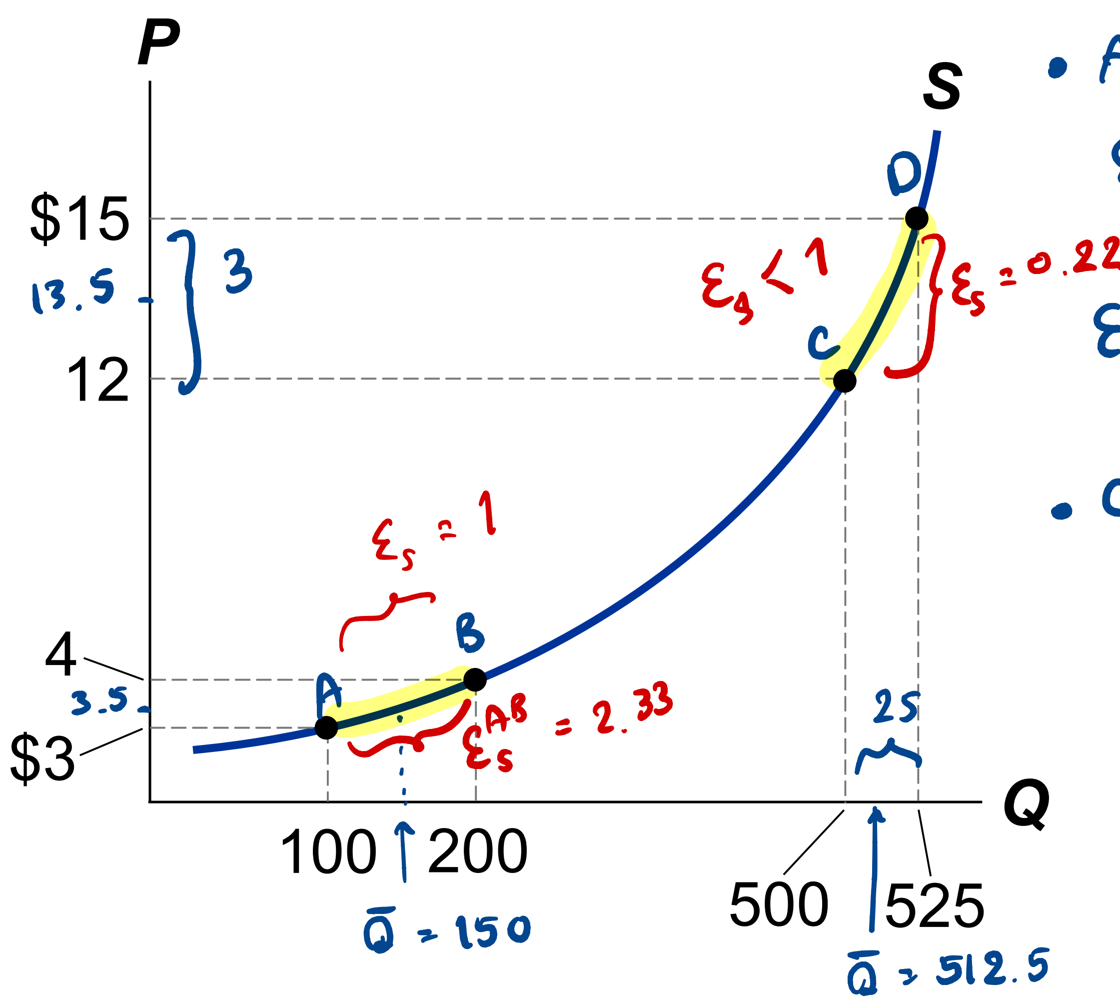
$$\text{slope} = \frac{\Delta P}{\Delta Q} = 1$$

$$\varepsilon_s = \frac{\%\Delta Q_s}{\%\Delta P} = \frac{\Delta Q_s}{\Delta P} \cdot \frac{P}{Q_s}$$

$$= 1 \times \frac{5}{5} = 1$$

How the Price Elasticity of Supply Can Vary

Non-linear supply. Use mid-point method.



• A → B :

$$\varepsilon_s = \frac{\%\Delta Q_s}{\%\Delta P} = \frac{(100) \div 150}{1 \div 3.5}$$

$$\varepsilon_s^{AB} = 2.33$$

• C → D :

$$\varepsilon_s = \frac{\%\Delta Q_s}{\%\Delta P} = \frac{25 \div 512.5}{3 \div 13.5}$$

$$\varepsilon_s^{CD} = 0.219$$

Determinants of Price Elasticity of Supply

- Substitution and production costs.
  - ➢The more easily sellers can change the quantity they produce, the greater the price elasticity of supply.

Eg. Covid-19 vaccine supply is price inelastic.
(there might be equipment or material constraint.)

- The time horizon: Short run and long run

SR → more inelastic

LR → more elastic