

A close-up photograph of a hand holding a yellow rubber band that is stretched horizontally. The rubber band is taut, and the hand is visible on the left side, with fingers gripping it. The background is a plain, light-colored surface.

Elasticities

Recall: The Law of Demand

- As the price of a good falls, the quantity of the good demanded increases.
- As the price of a good go up , the quantity of the good demanded decreases.
- **The law of Demand:** The **negative** causal relationship between price and quantity demanded.

➡ **Negative relationship.**

➡ **Causal relationship.**

*How much
quantity responds
to change in price?*

Elasticity

Elasticity is a measure of the responsiveness of a variable to changes in price or any of the variable's determinants.

In this chapter, We will examine:

- Price elasticity of demand (PED)
- Income elasticity of demand (YED)

A close-up photograph of a hand stretching a yellow rubber band between the thumb and index finger of both the left and right hands. The rubber band is taut and horizontal, spanning the width of the frame. The background is a plain, light-colored surface.

Price Elasticity of demand (PED)

I am a psychological therapist. My hourly charge rate: 400 RMB and I have 20 patients (one hour per week)

I want to buy a small flat in shanghai, so I want to raise my overall income, I am considering to raise my hourly charge rate to 500 RMB.

What is the effect of my rise in price? How much quantities of demand will fall if I charge 500 RMB/hour?



Price elasticity of demand (PED)

Price elasticity of demand (PED): a measure of the responsiveness of the quantity of a good demanded to changes in its price, given by the percentage change in quantity demanded divided by the percentage change in price.

$$\text{Price elasticity of demand (PED)} = \frac{\% \text{ change in quantity demanded}}{\% \text{ change in price}} = \frac{\% \Delta Q}{\% \Delta P}$$

- It measures how much quantity responds to change in price. i.e.: **the price-sensitivity of buyers' demand.**
- We use **percentage changes** rather than units change.

The formula for PED

$$\text{Price elasticity of demand (PED)} = \frac{\% \text{ change in quantity demanded}}{\% \text{ change in price}} = \frac{\% \Delta Q}{\% \Delta P}$$

$\Delta Q = Q_{\text{final value}} - Q_{\text{initial value}}$

$Q = Q_{\text{initial value}}$

$\Delta P = P_{\text{final value}} - P_{\text{initial value}}$

$P = P_{\text{initial value}}$

$$\text{PED} = \frac{\frac{Q_{\text{final value}} - Q_{\text{initial value}}}{Q_{\text{initial value}}} * 100\%}{\frac{P_{\text{final value}} - P_{\text{initial value}}}{P_{\text{initial value}}} * 100\%} = \frac{\frac{\Delta Q}{Q}}{\frac{\Delta P}{P}} \quad (\text{Always take the absolute value})$$

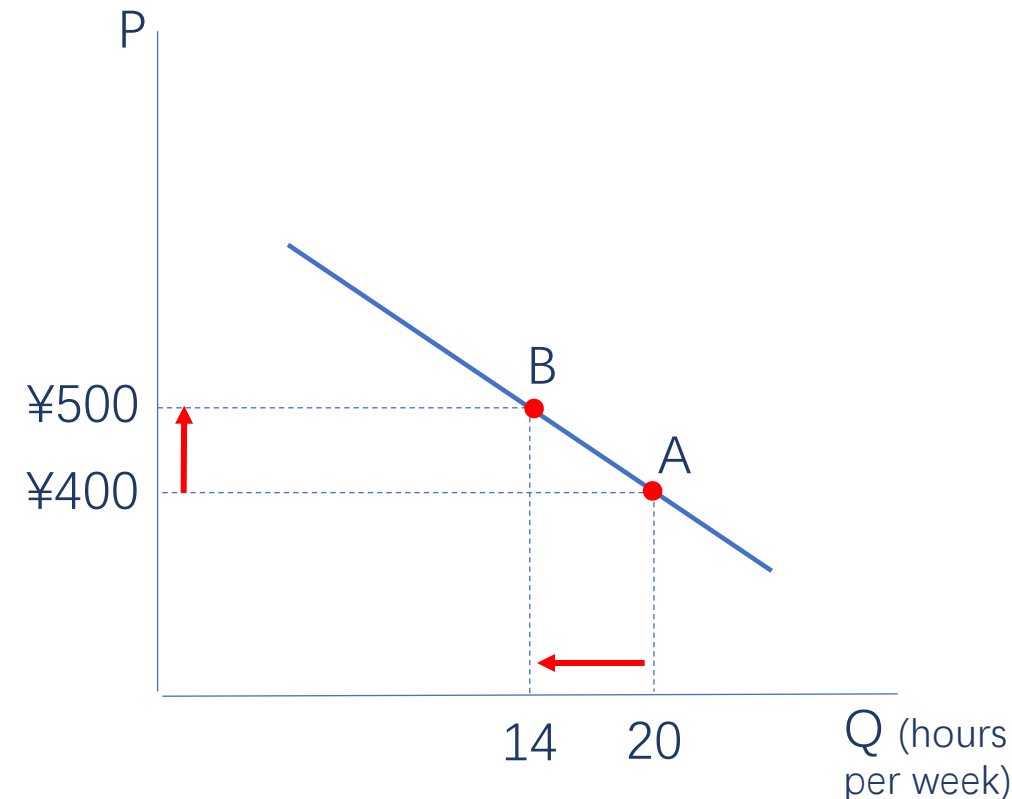
Calculation of the percentage change

$$\% \Delta Q = (Q_{\text{final value}} - Q_{\text{initial value}}) / Q_{\text{initial value}} * 100\%$$

$$= (14 - 20) / 20 * 100\% = -30\%$$

$$\% \Delta P = (P_{\text{final value}} - P_{\text{initial value}}) / P_{\text{initial value}} * 100\%$$

$$= (500 - 400) / 400 * 100\% = 25\%$$



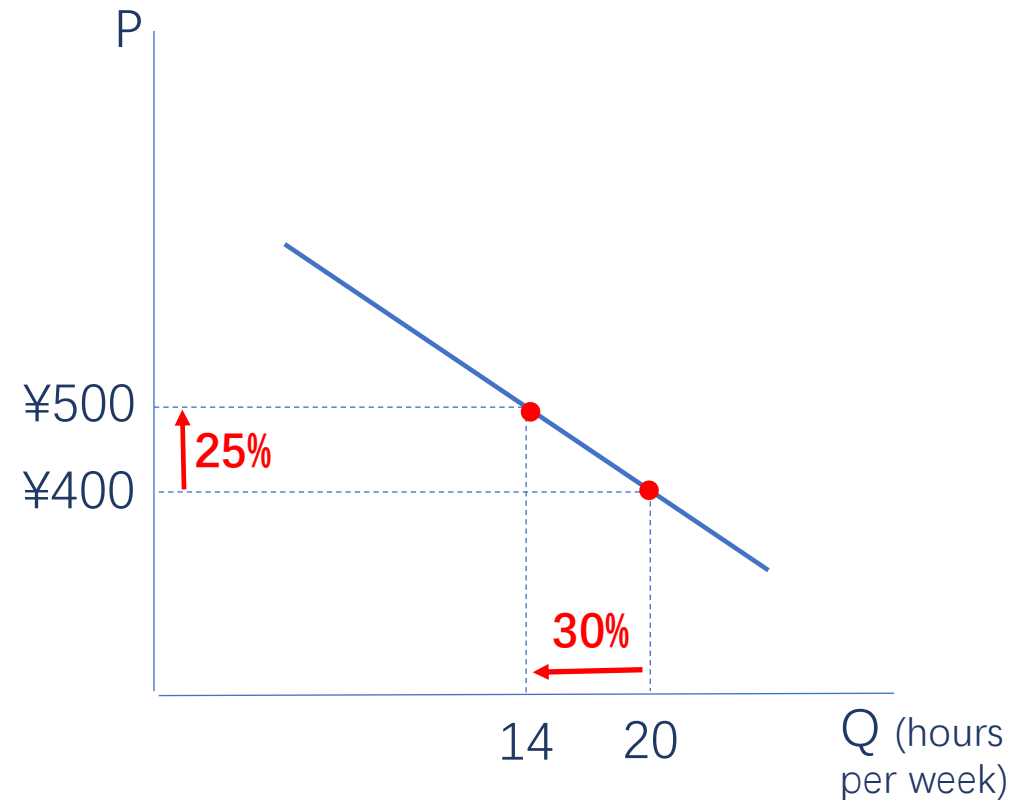
Calculation of the PED

$$\text{Price elasticity of demand (PED)} = \frac{\% \Delta Q}{\% \Delta P}$$

As my hourly rate increased by 25%, the demand for my therapy service decreased by 30%

$$\text{PED} = -30\% / 25\% = 1.20$$

* P & Q have negative causal relationships, thus the PED will be negative. For better comparison, we drop the minus sign and use absolute value for the PED.



Calculation of PED

- If we know the PED = 3, the % change in Q is 15%, calculate the % change in P

$$\text{PED} = 3 = 15\% / \% \Delta Q$$

$$\% \Delta Q = 15\% / 3 = 5\%$$

Similar calculation method for % ΔP .

Class exercise



The original price for beach house hotel on one Maldives' island was 200 dollar/room/per night
demand=20 room/per night

The owner of the hotel launched a big discount to 150 dollar/room/night, the demand increase to 30 room/per night.

Calculate the PED.



Excise answer

$$\begin{aligned}\% \Delta Q &= (Q_{\text{final value}} - Q_{\text{initial value}}) / Q_{\text{initial value}} * 100\% \\ &= (30 - 20) / 20 * 100\% = 50\%\end{aligned}$$

$$\begin{aligned}\% \Delta P &= (Q_{\text{final value}} - Q_{\text{initial value}}) / Q_{\text{initial value}} * 100\% \\ &= (150 - 200) / 200 * 100\% = -25\%\end{aligned}$$

$$\boxed{\text{Price elasticity of demand (PED)}} = \frac{\boxed{\% \Delta Q}}{\boxed{\% \Delta P}} = 50\% / -25\% = 2$$

Price elasticity of demand (PED)

- If quantity demanded is highly responsive to a change in price
→ Price elastic
- If quantity demanded is not very responsive to a change in price
→ Price inelastic

The range of values for PED

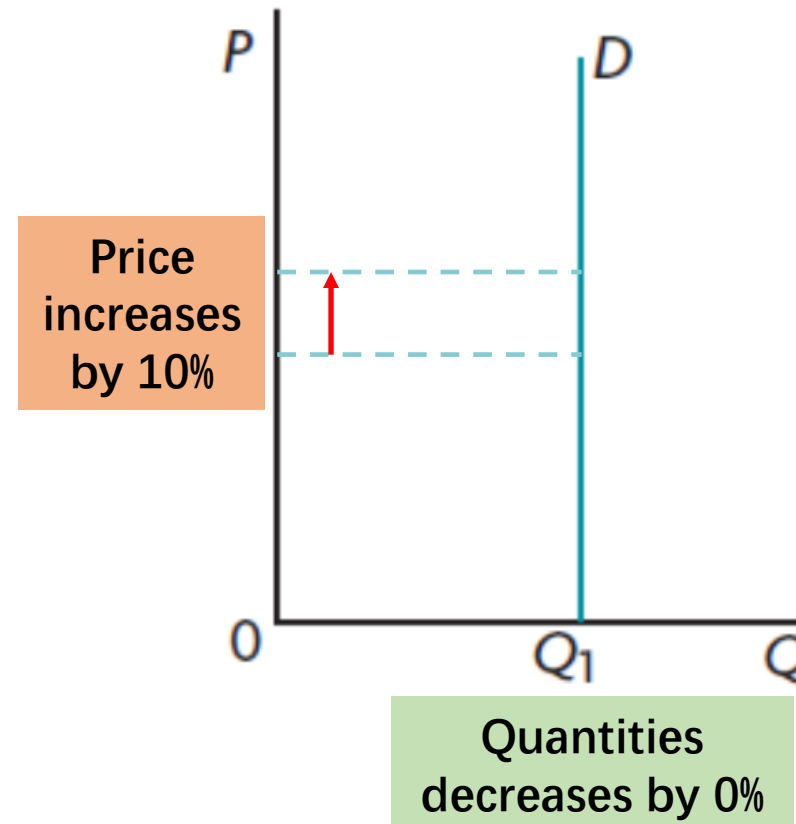
$$\text{Price elasticity of demand (PED)} = \frac{\% \Delta Q}{\% \Delta P} = \frac{0}{10\%} = 0$$

1. when $PED = 0$, Demand is **perfectly inelastic**

- Shape: Vertical
- Consumer' sensitivity to price: None
- Q always keep constant no matter what happens to price.

*Special case

d Perfectly inelastic demand: $PED = 0$



The range of values for PED

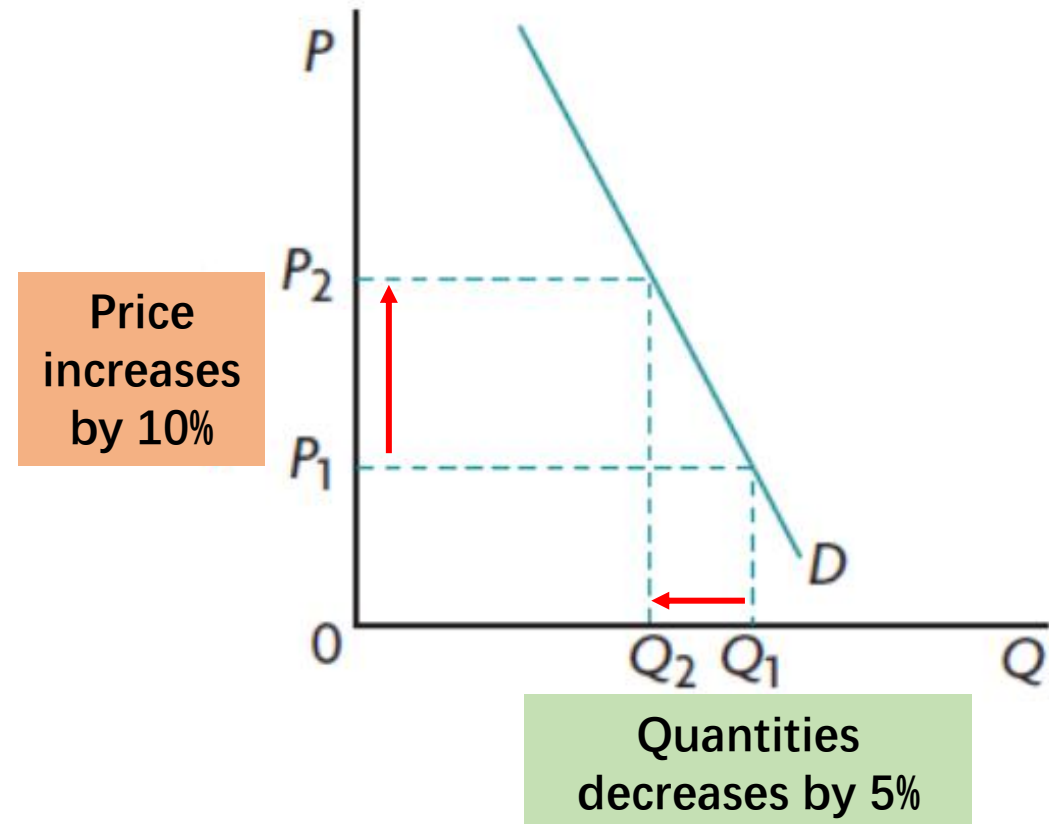
$$\text{Price elasticity of demand (PED)} = \frac{\% \Delta Q}{\% \Delta P} = \frac{5\%}{10\%} = 0.5$$

2. When $0 < PED < 1$: **Price inelastic**

The % change in quantity demanded is smaller than the % change in price.

- Shape: Relatively steep
- Consumer' sensitivity to price: relatively low
- Q is relatively unresponsive to Δ in price.

a Price inelastic demand: $0 < PED < 1$



The range of values for PED

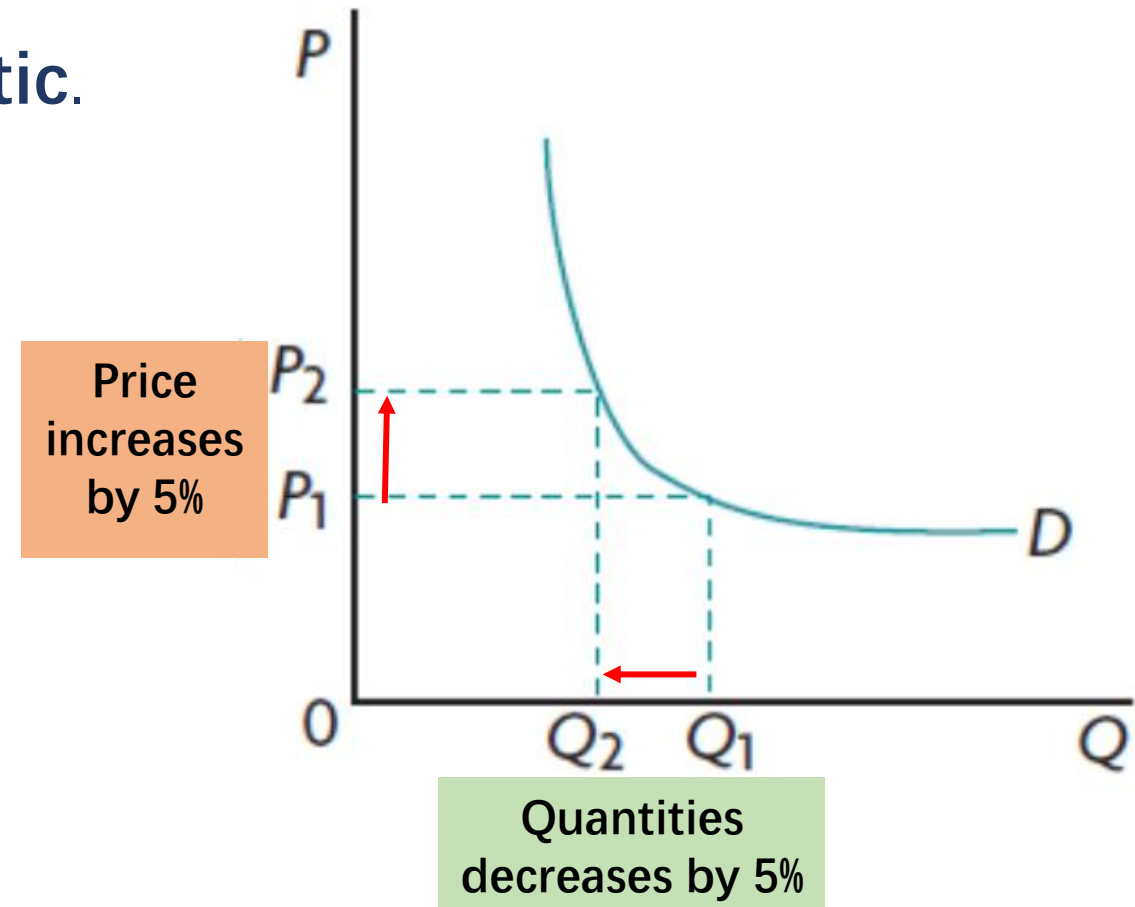
$$\text{Price elasticity of demand (PED)} = \frac{\% \Delta Q}{\% \Delta P} = \frac{5\%}{5\%} = 1$$

Unit elastic demand: $PED = 1$

3. when $PED = 1$ Demand is **unit elastic**.

- Shape: intermediate
- Consumer' sensitivity to price: intermediate
- unitary PED.

*Special case



The range of values for PED

$$\text{Price elasticity of demand (PED)} = \frac{\% \Delta Q}{\% \Delta P} = \frac{10\%}{5\%} = 2$$

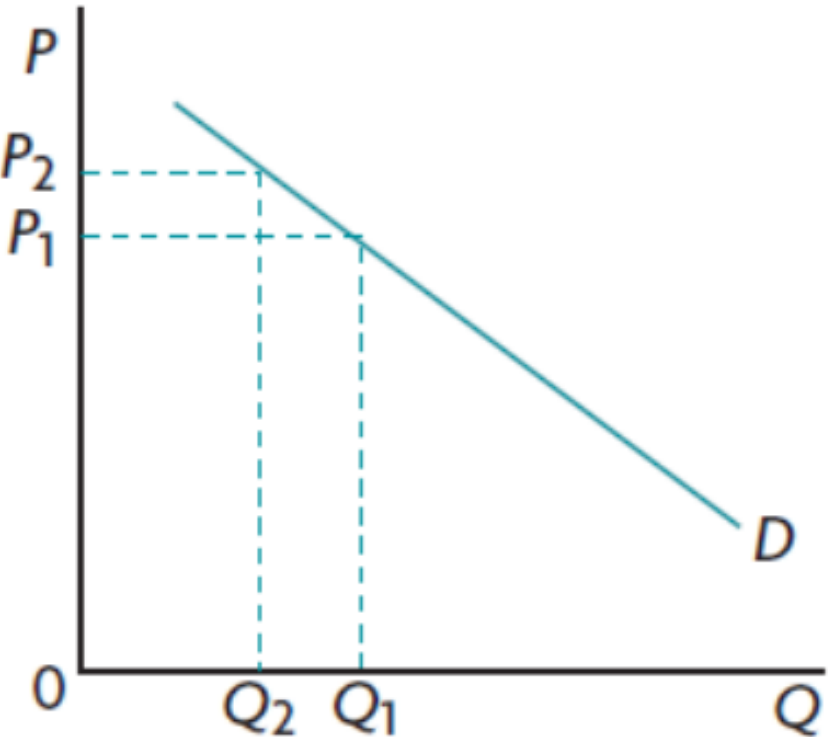
b Price elastic demand: $1 < PED < \infty$

4. When $1 < PED < \infty$: **Price elastic**

The % change in quantity demanded is larger than the % change in price.

- Shape: Relatively flat
- Consumer' sensitivity to price: relatively high
- Q is relatively responsive to Δ in price.

Price increases by 5%



Quantities decreases by 10%

The range of values for PED

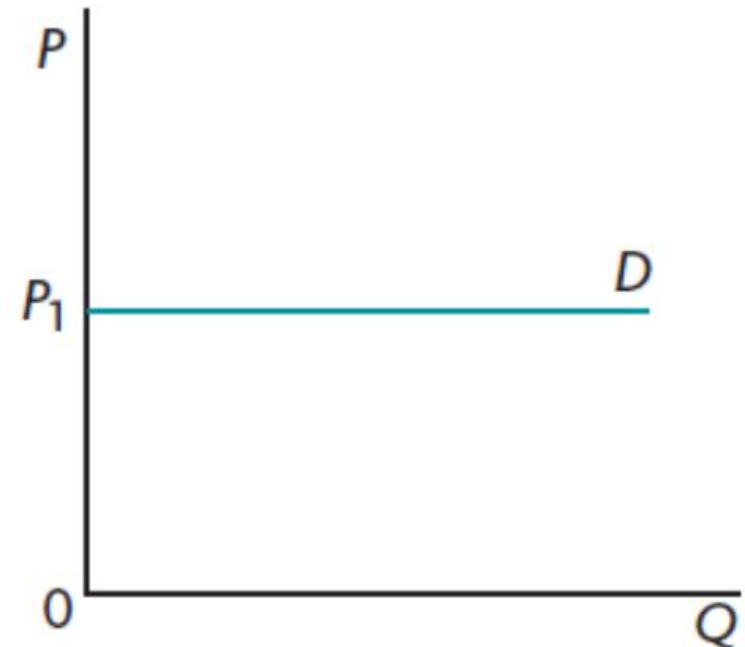
$$\text{Price elasticity of demand (PED)} = \frac{\% \Delta Q}{\% \Delta P} = \frac{\text{Any } \%}{0\%} = \text{infinity}$$

5. Demand is **perfectly elastic** when $PED = \text{infinity}$

- Shape: horizontal
- Consumer' sensitivity to price: extremely high
- A change in price results in an infinitely large response in quantity demanded.

*Special case

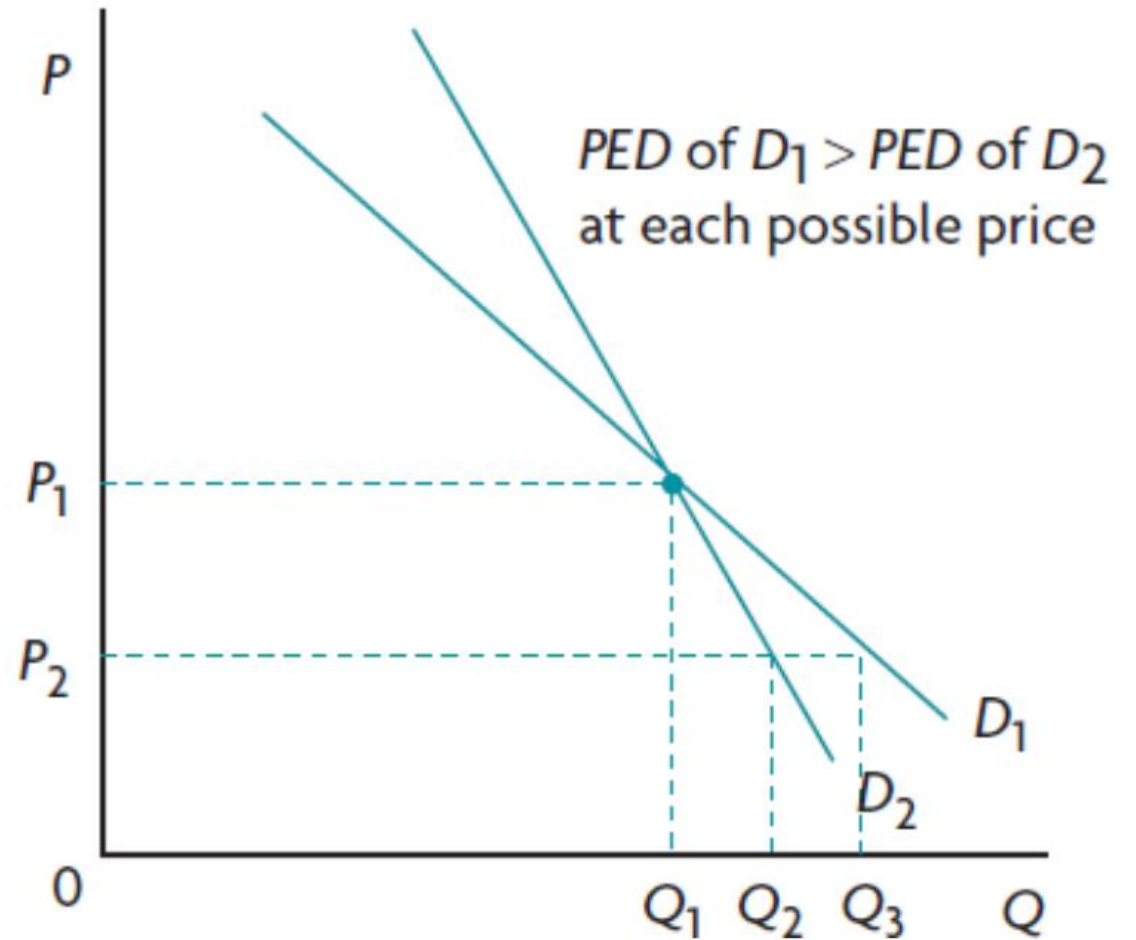
e Perfectly elastic demand: $PED = \infty$



PED & the steepness of the demand curve

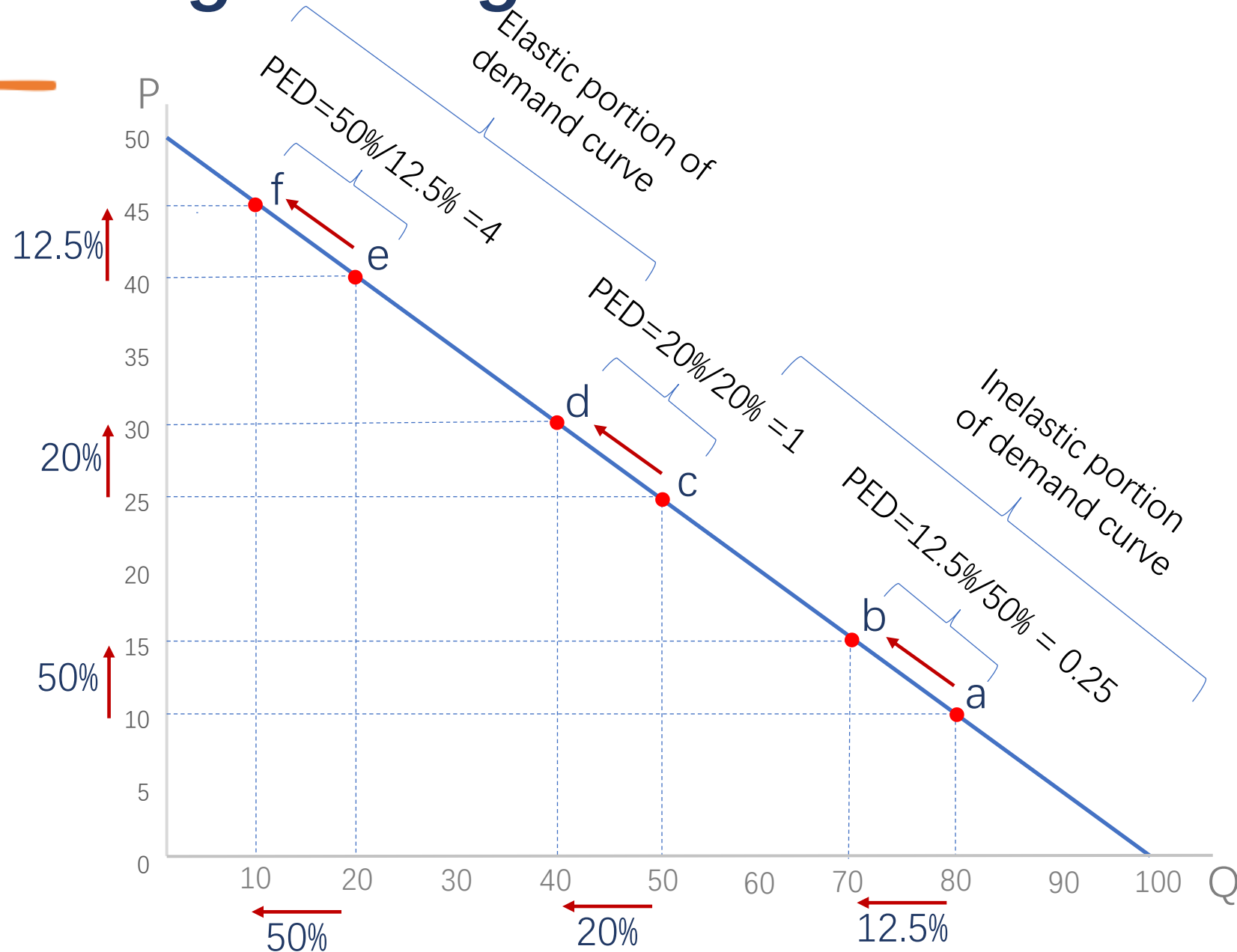
- When demand curves intersect at some point:
- The flatter the demand curve, the more elastic the demand (higher)
- The steeper the demand curve, the less elastic the demand.(lower)

Intersecting demand curves and PEDs



Variability of PED along a straight-line demand

- Moving along a demand curve, **the slope keeps constant** while the **PED varies**.
- With low price and high quantity, demand is inelastic.
- With high price and low quantity, demand is elastic.



Determinants of price elasticity of demand

- The price of Milk tea increased by 20%
- The price of gasoline increased by 20%

Which product will lose more quantities of demand? Why?



Determinants of price elasticity of demand

- Milk tea has numbers of substitutes, such as ice tea, coffee, soft drinks, etc. Buyers are more price sensitive, they can easily switch to other products

→ higher elasticity

- Gasoline have no substitute, so buyers have to buy despite of the price level

→ lower elasticity

1. Number of substitutes

The more substitutes a good or services has, the more elastic is its demand.



Determinants of price elasticity of demand

- The price of Pizza hut increased by 20%
- The price of iPhone increased by 20%
- Which product will lose more quantity of demand? Why?



Determinants of price elasticity of demand

- Pizza hut has numbers of close substitutes, there are huge numbers of similar pizza restaurant around providing similar taste of food. Buyers are more price sensitive, they can easily switch to other brands
→ higher elasticity
- iPhone's has higher function and system uniqueness, so buyers are less sensitive to the price increase
→ lower elasticity.

2. Closeness of substitutes

The closer two substitutes are to each other, the greater the responsiveness of quantity demanded to a change in the price of the substitute, hence the greater the PED.



Determinants of price elasticity of demand

- The price of cherry increased by 20%
- The price of fruit increased by 20%

Which product will lose more quantity of demand? Why?



Determinants of price elasticity of demand

- Cherry is a relatively narrow definition, when the price of cherry increase, consumer can easily switch to buy other types of fruit.
→ higher elasticity
- Fruit is a broader definition with less alternative opportunities
→ lower elasticity.



3. The definition extent of the goods

Whether the good is defined broadly or narrowly.

Determinants of price elasticity of demand

- The price of insulin for diabetes increased by 20%
- The price of beach house hotel increased by 20%
- Which product will lose more quantity of demand? Why?



Determinants of price elasticity of demand

- Insulin are necessities for the diabetes patient, they will be less price sensitive
→ lower elasticity.
- Beach house hotel is a luxury consumption which is not essential.
→ higher elasticity

4. Necessities versus luxuries

The demand for necessities is less elastic than the demand for luxuries.



Determinants of price elasticity of demand

- The price of gasoline increased by 20%
 - In 6 months – short run
 - In 5 years – long run
- What is the effect to quantity of gasoline demand in short run and long run? Why?

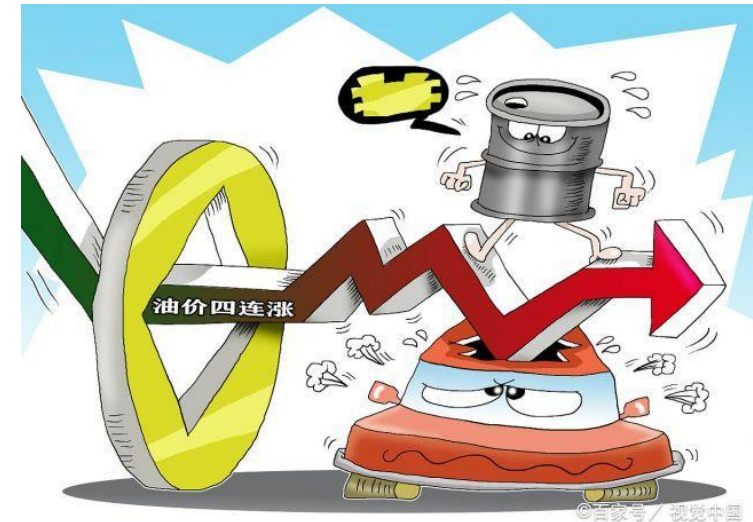
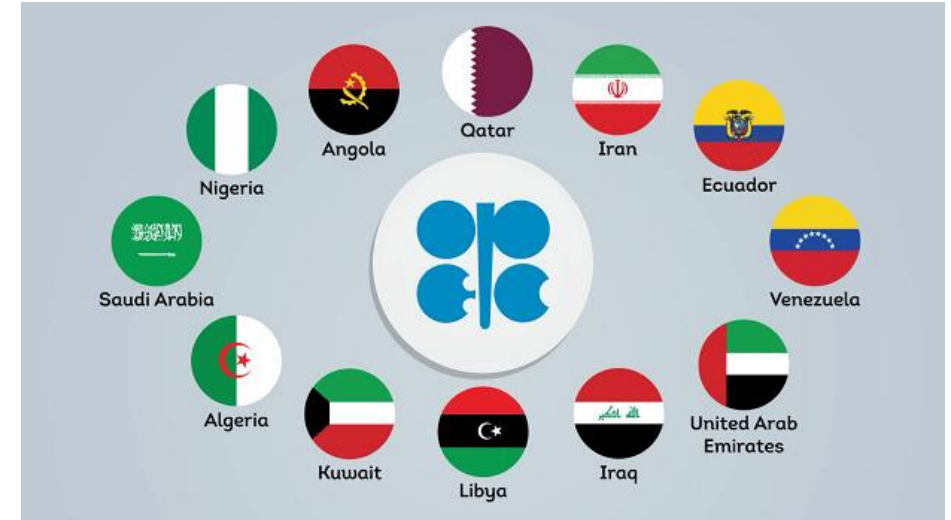


Determinants of price elasticity of demand

- In short period, consumers are unable to change their demand for gasoline, so the demand will be less elastic.
- In long period, consumers will try to reduce their cost by purchasing lower fuel consumption car or electrical car. So the demand will be elastic in long run.

5. Length of time

The longer the time period in which a consumer makes a purchasing decision, the more elastic the demand.



Determinants of price elasticity of demand

- The price of metro ticket increased by 20%
- The price of car increased by 20%

Which product will lose more quantity of demand? Why?



Determinants of price elasticity of demand

- Metro ticket only takes up a small proportion of one's income, consumer will be less sensitive to the price increase.
→ price relatively inelastic demand
- Car takes up a big proportion of one's income, consumer will be more sensitive to the price change.
→ price relatively elastic demand

6. Proportion of income spent on a good

The larger the proportion of one's income needed to buy a good, the more elastic the demand.



Total Revenue(TR) and PED

Total revenue is the amount of money received by firms when they sell a good (or service), and is equal to the price (P) of the good times the quantity(Q) of the good sold.

$$TR = P * Q$$

As a therapist, when I raise my hour rate from 400 to 500 RMB,

- Higher P means I will earn more for each unit of hour.
- But according to the law of demand, I will sell less (Q)

So which factor will have bigger influence on my revenue, it will depends on my PED...

When demand is elastic ($PED > 1$)

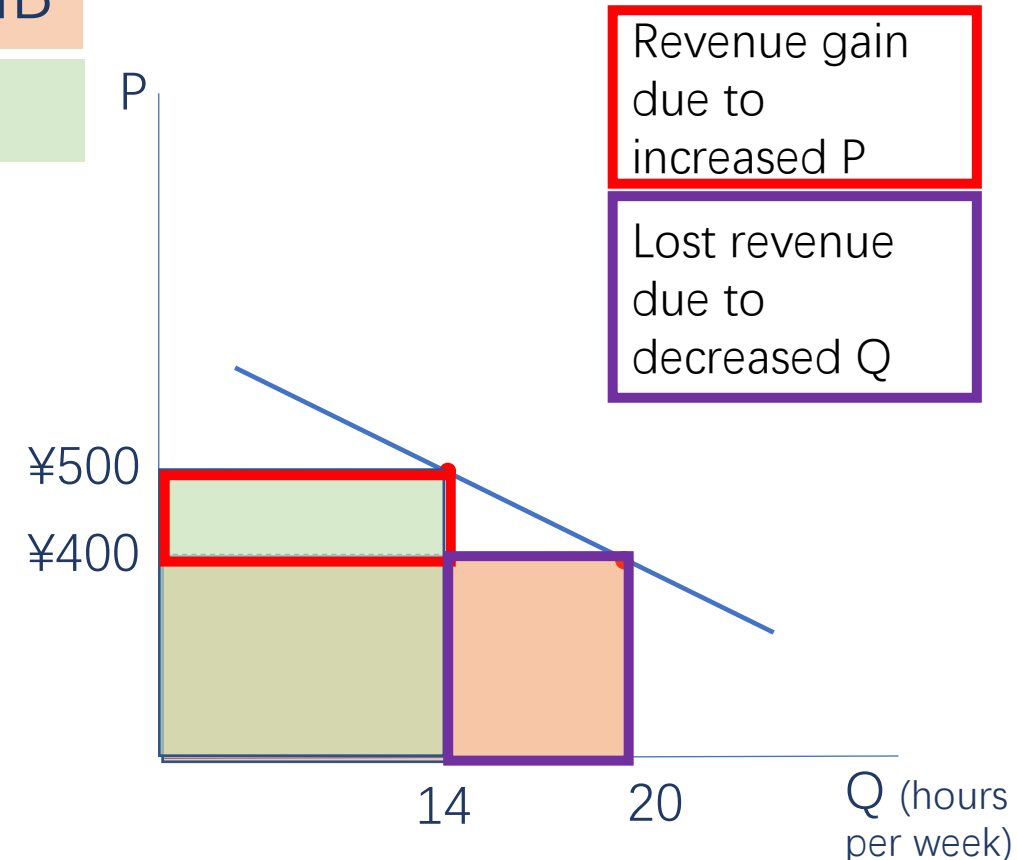
If I raised my hourly rate from 400 to 500 RMB, my clients decreased from 20 to 14, my $PED = 30\% / 25\% = 1.2$

My original TR = $P \cdot Q = 400 \cdot 20 = 8,000$ RMB

My new TR = $P \cdot Q = 500 \cdot 14 = 7,000$ RMB



- **P increase** → larger decrease in Q
Effect to TR: $P < Q \rightarrow$ **TR falls**
- **P decrease** → larger increase in Q
Effect to TR: $P < Q \rightarrow$ **TR rises**



When demand is elastic ($PED > 1$)

If I raised my hourly rate from 400 to 500 RMB, my clients decreased from 20 to 14, my $PED = 30\% / 25\% = 1.2$

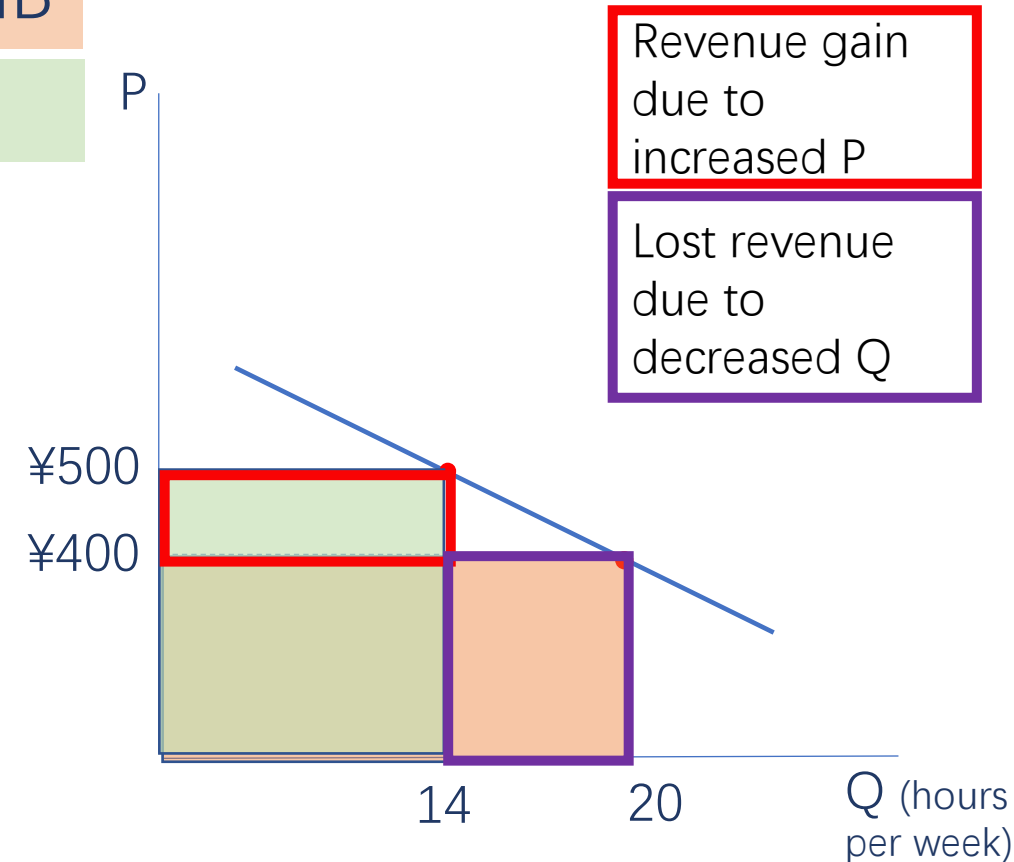
My original TR = $P \times Q = 400 \times 20 = 8,000$ RMB

My new TR = $P \times Q = 500 \times 14 = 7,000$ RMB



When demand is elastic, $\% \Delta Q > \% \Delta P$:

- an increase in price causes a fall in total revenue
- a decrease in price causes a rise in total revenue.



When demand is inelastic ($0 < PED < 1$)

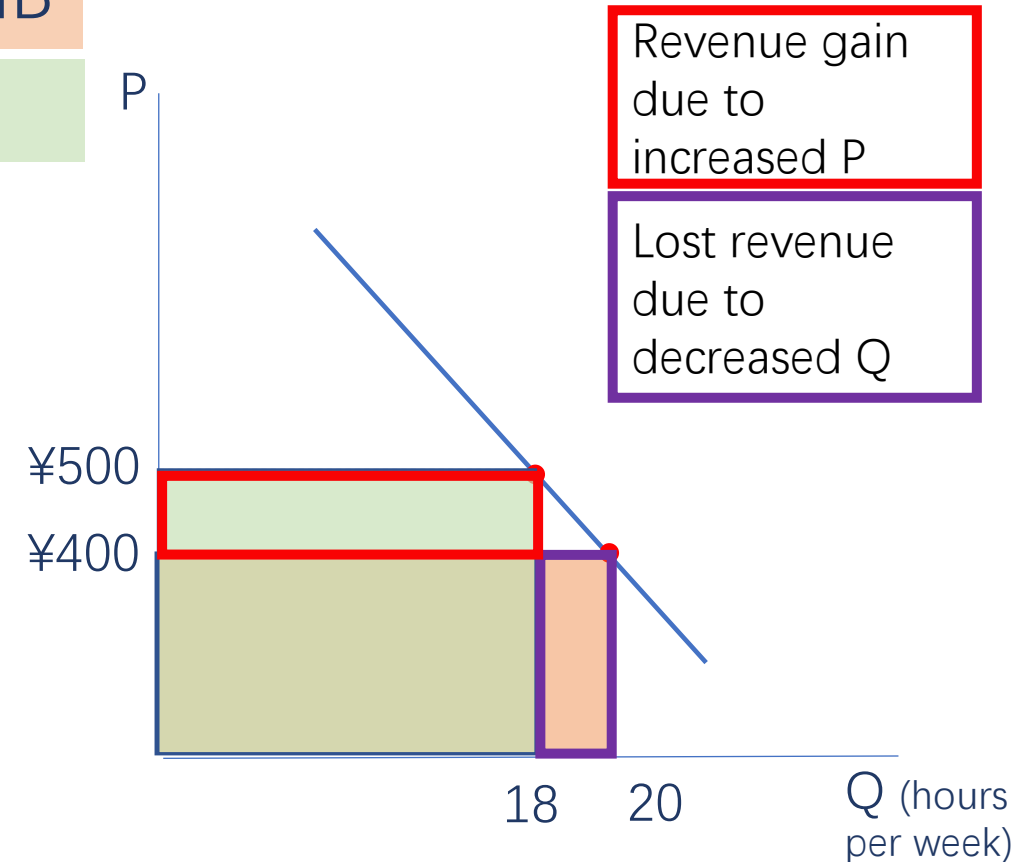
If I raised my hourly rate from 400 to 500 RMB, my clients decreased from 20 to 18, my $PED = 10\% / 25\% = 0.4$

My original $TR = P \cdot Q = 400 \cdot 20 = 8,000$ RMB

My new $TR = P \cdot Q = 500 \cdot 18 = 9,000$ RMB



- P increase \rightarrow smaller decrease in Q
Effect to TR: $P > Q \rightarrow$ TR rises
- P decrease \rightarrow smaller increase in Q
Effect to TR: $P > Q \rightarrow$ TR falls



When demand is inelastic ($0 < PED < 1$)

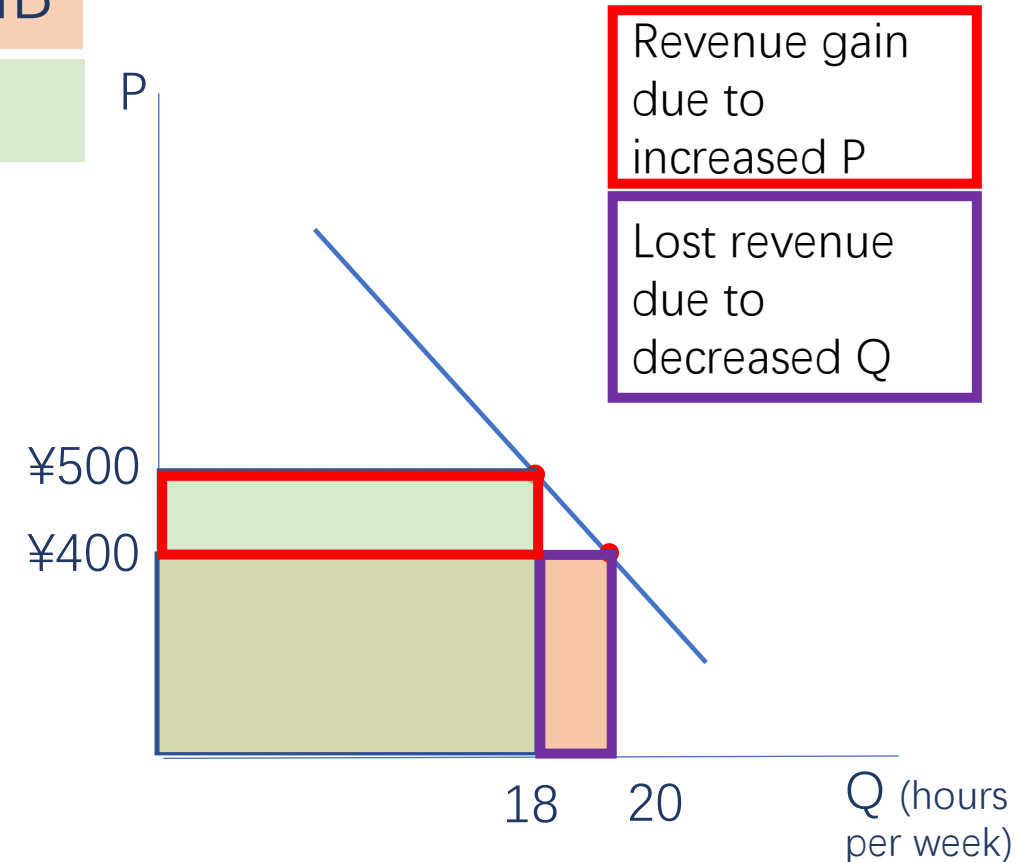
If I raised my hourly rate from 400 to 500 RMB, my clients decreased from 20 to 18, my $PED = 10\% / 25\% = 0.4$

My original $TR = P \cdot Q = 400 \cdot 20 = 8,000$ RMB

My new $TR = P \cdot Q = 500 \cdot 18 = 9,000$ RMB



When demand is inelastic, $\% \Delta Q < \% \Delta P$:
an increase in price causes a rise in total revenue
a decrease in price causes a fall in total revenue.

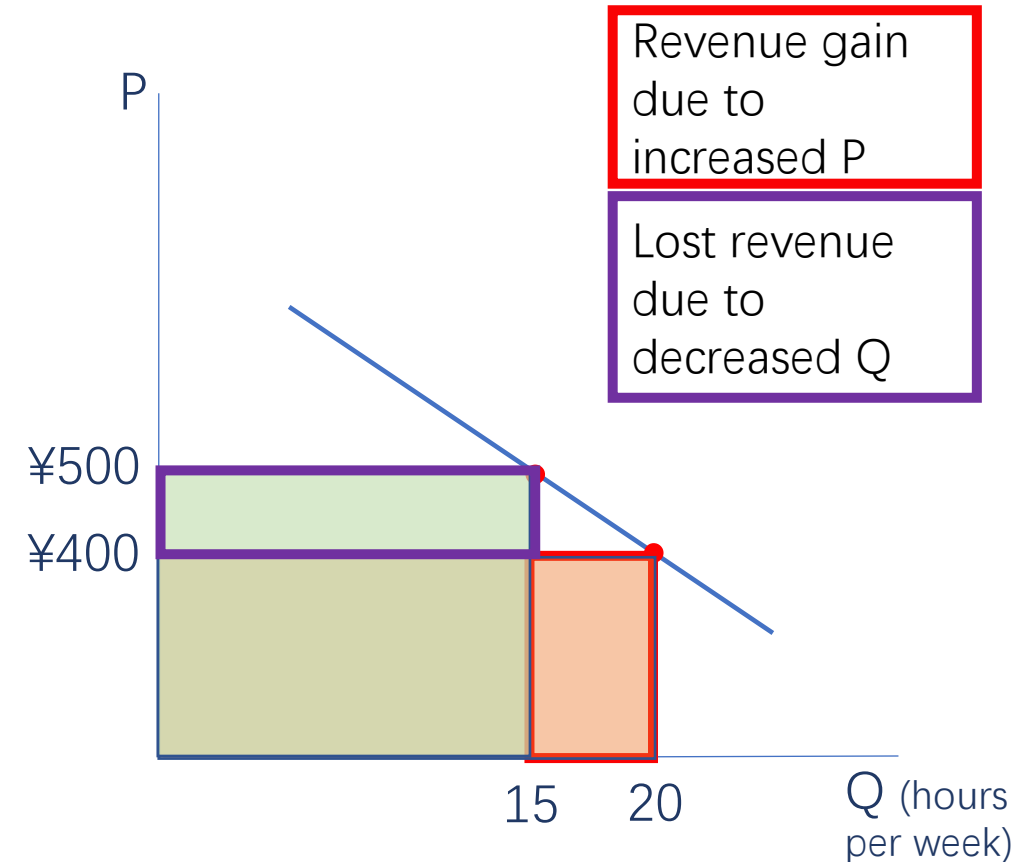


When demand is unit elastic (PED = 1)

If I raised my hourly rate from 400 to 500 RMB, my clients decreased from 20 to 15, my PED = 25% / 25% = 1



- P increase → same proportional decrease in Q
Effect to TR: $P = Q \rightarrow$ TR keeps the same
- P decrease → same proportional decrease in Q
Effect to TR: $P = Q \rightarrow$ TR keeps the same

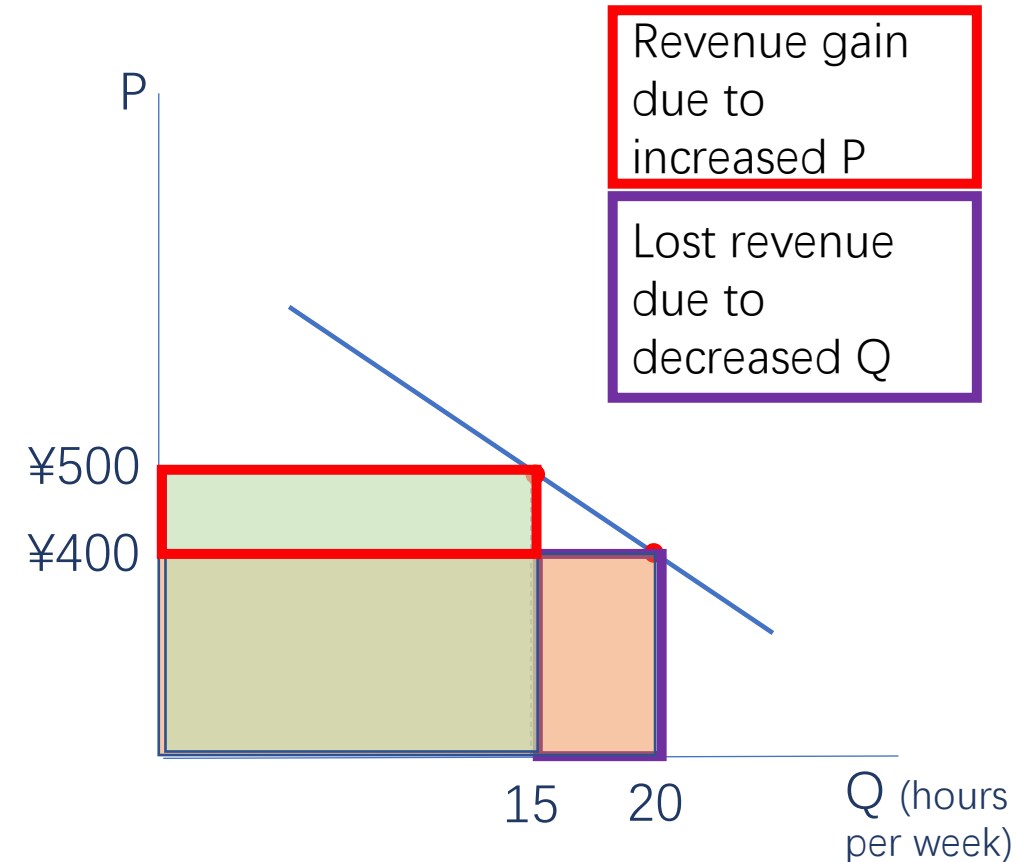


When demand is unit elastic (PED = 1)

If I raised my hourly rate from 400 to 500 RMB, my clients decreased from 20 to 15, my PED = 20% / 20% = 1



In unit elastic demand, $\% \Delta Q = \% \Delta P$:
The gain of TR = The loss of TR
Total revenue keeps constant



PED and firm pricing decisions

When firm is making the pricing decision:

- If their product demand is elastic → lower the price
 - E.g.: FMCG(fast moving consumer goods)
- If their product demand is inelastic → increase the price
 - E.g.: drugs, patented product, etc.
- If their product demand is unit elastic → unable to change their TR.

PED and indirect taxes

- If you are a government policy advisor, for the purpose of increasing tax revenue, which kind of product/services would you suggest to impose higher indirect taxes? (VAT, tariff, consumption tax)
- Before we decide, we shall consider the effect of PED...



Illustration of indirect taxes

- Original pre-tax equilibrium price P^* and Q^*
- Government imposes indirect tax on the good, S_1 shifts upwards to S_2 , The imposition of a specific tax will **parallel shift** the supply curve to the left by the value of the tax.
- D curve unchanged. 'drive a wedge'
- New equilibrium with P_c and Q_t .
- P_c = the price consumer paid
- $P_c - P_p$ = the tax amount paid to government.
- P_p = the price producer received.
- Government's tax revenue = tax per unit * Q_t . (blue shadow area)

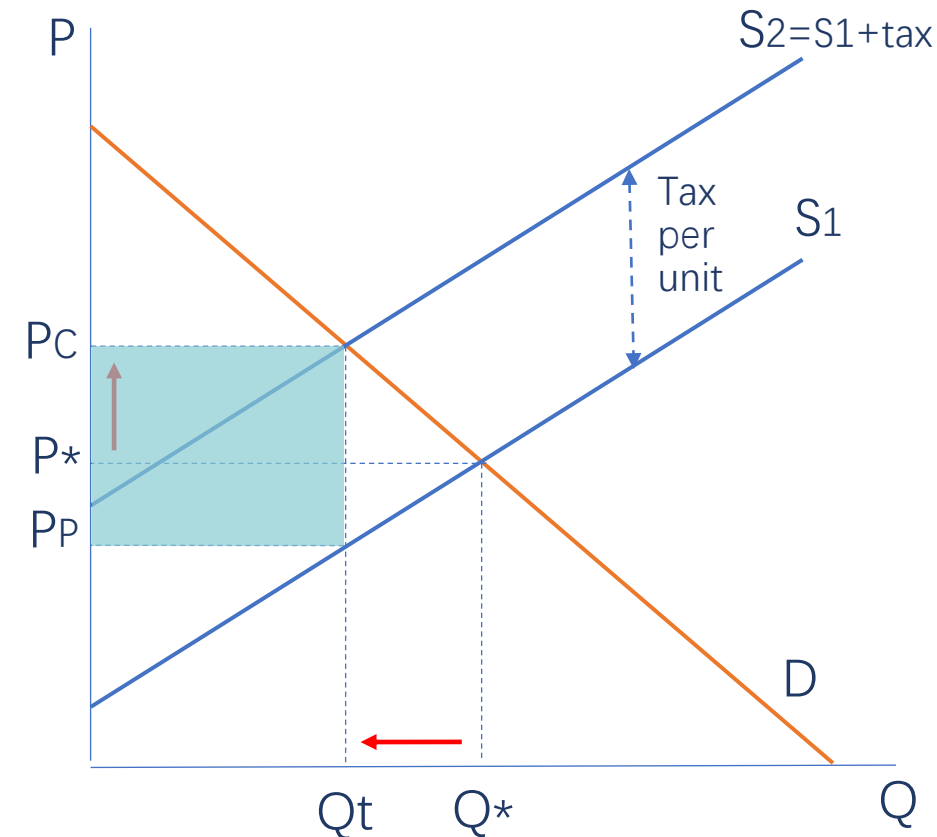
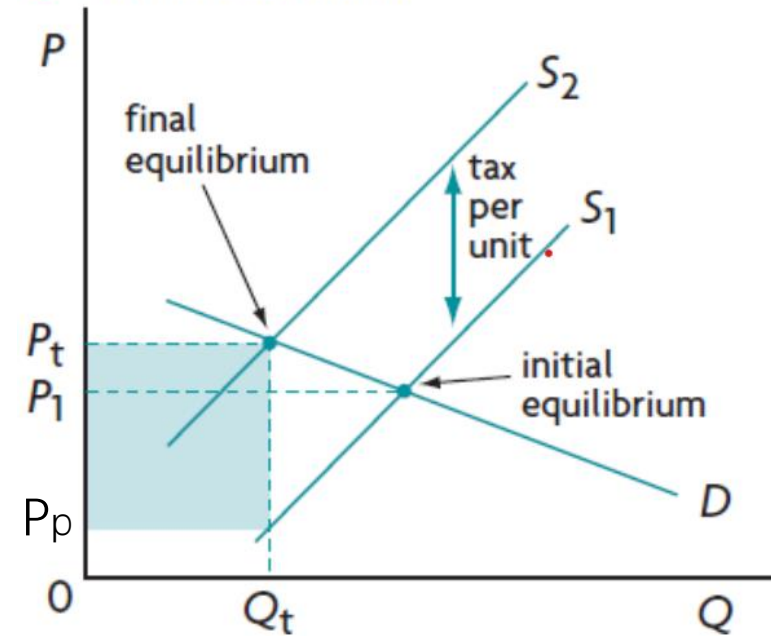


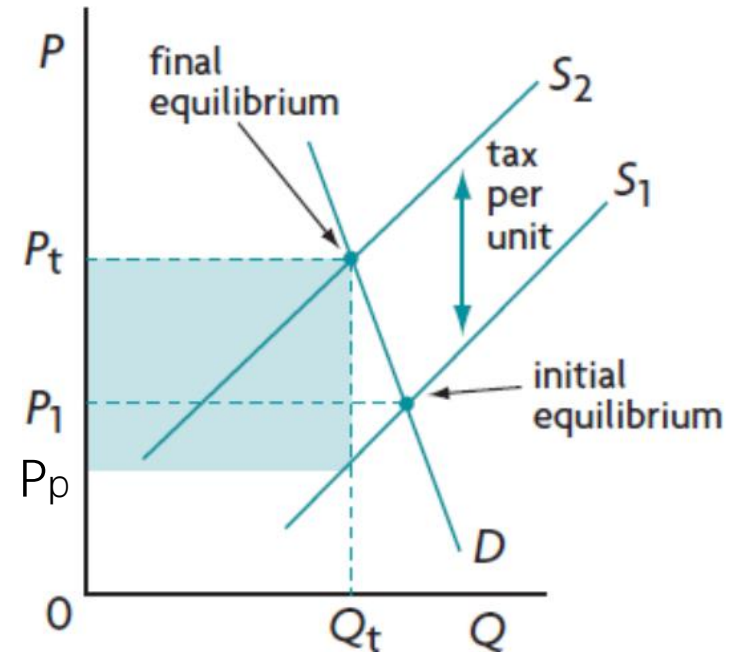
Diagram Illustration

- Tax shift the S curve upwards(leftwards) with the vertical distance between S_1 and S_2 equals to the tax per unit of output.
- New equilibrium with P_t and Q_t .
- Government's tax revenue = tax per unit * Q_t . (blue shadow area)
- Consumers pay for the amount above P_1 .
- Firms pay for the amount below P_1 .
- The price paid by consumer: P_t
- The price received by producer: P_p
- Government tax per unit: $P_t - P_p$

b Elastic demand



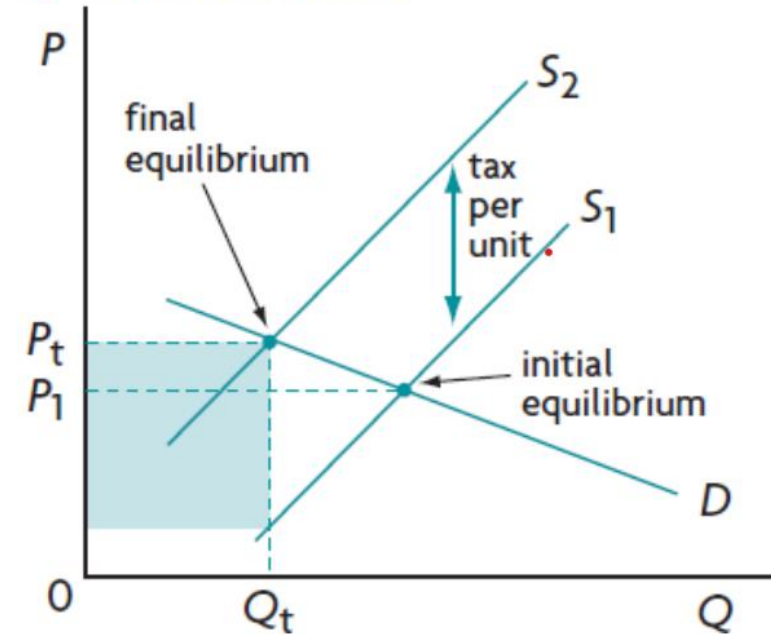
a Inelastic demand



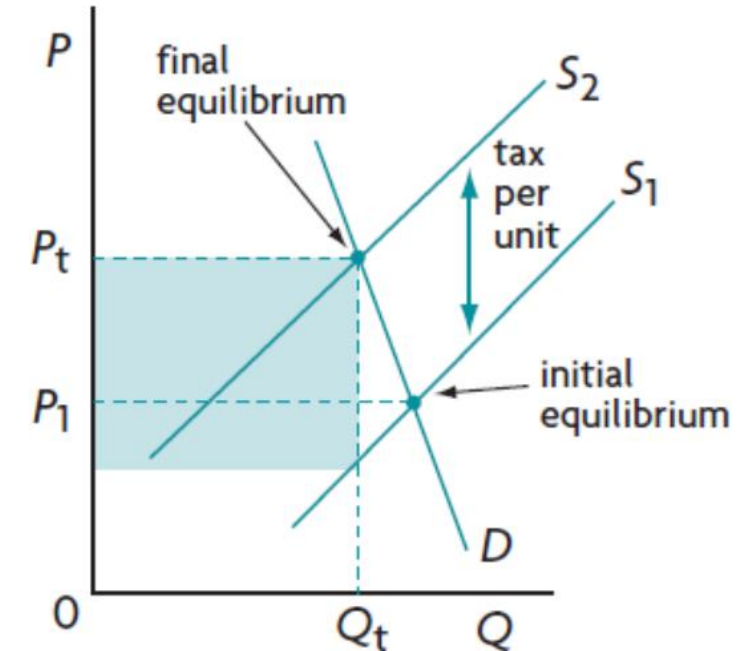
PED and indirect taxes

- In order to receive higher tax revenue, we need to choose the company with higher total revenue. It is the tax base.
 - Tax adds up cost to the product, thus it will increase the price. To maximize the TR, (with smaller decrease in Q) we need to **choose the product with inelastic demand**.
 - The lower the price elasticity of demand for the taxed good, the greater the government tax revenues.
- We decide to impose indirect tax on those products with lower PED, such as cigarettes, alcohol, etc.

b Elastic demand



a Inelastic demand



Primary commodities

V.s. Manufactured products

Primary commodities are goods arising directly from the use of natural resources (factor of production “land”)

- Agricultural products (food, cotton, rubber, etc.)
 - fishing and forestry products
 - Extractive industries products (oil, coal, minerals, etc.)
- * PED of food is estimated to be between 0.20-0.25 in developed countries.

**Relatively
low PED**

Necessity
Less substitutes

Manufactured products are goods produced by labour usually working together with capital as well as raw materials. E.g. TV, computer, cell phone, etc.

**Relatively
high PED**

more substitutes.

Compare these two types of product

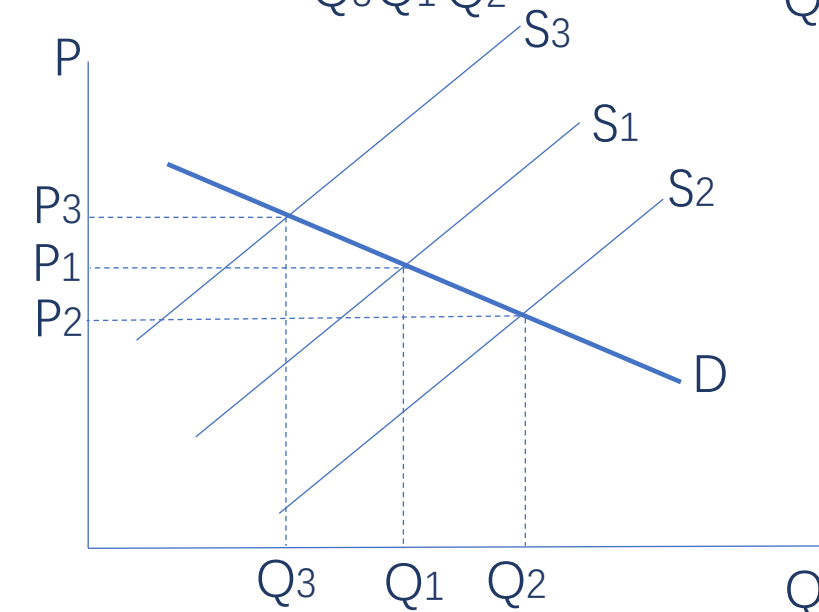
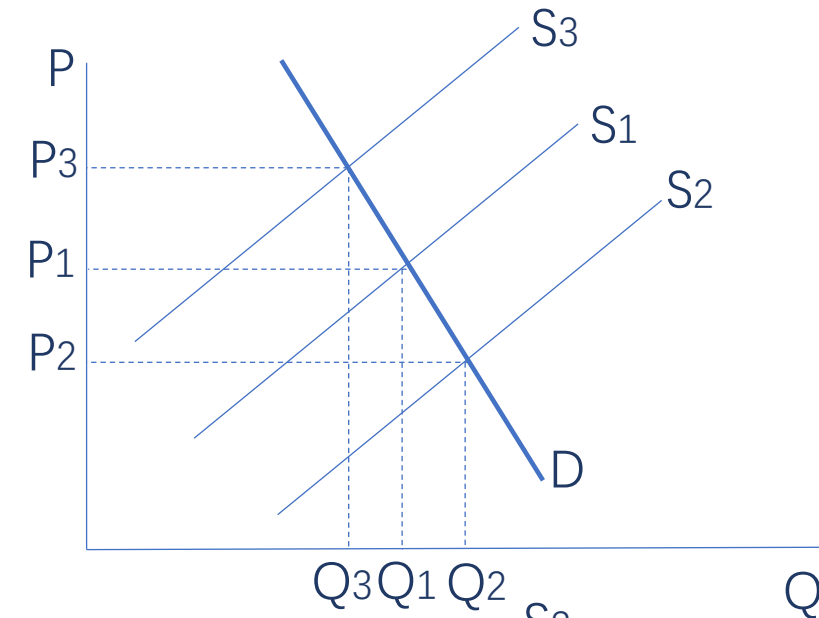
	Commodity goods	Manufactured goods
Nature	Production uncertainty	Production certainty
PED	Inelastic demand	Elastic demand
When supply shift leftwards		
When supply shift rightwards		

Low price elasticity of demand of primary commodities, together with fluctuations in supply over short periods of time, creates serious problems for primary commodity producers. Because they result in large fluctuations in primary commodity prices and producer's incomes.

Compare these two types of product

	Commodity goods	Manufactured goods
Nature	Production uncertainty	Production certainty
PED	Inelastic demand	Elastic demand
When supply shift leftwards	<ul style="list-style-type: none"> $\% \Delta \text{ of } Q < \% \Delta \text{ of } P$ Large price increase TR(producer's income) increase 	<ul style="list-style-type: none"> $\% \Delta \text{ of } Q > \% \Delta \text{ of } P$ Small price increase TR(producer's income) decrease
When supply shift rightwards	<ul style="list-style-type: none"> $\% \Delta \text{ of } Q < \% \Delta \text{ of } P$ Large price decrease TR(producer's income) decrease 	<ul style="list-style-type: none"> $\% \Delta \text{ of } Q > \% \Delta \text{ of } P$ Small price decrease TR(producer's income) increase

**Price
volatility!**



Dilemma for farmers

- Inelastic demand for their goods

In good harvest year, increased quantity will lead to relatively bigger price drop, and the total revenue(farmer's income) will decrease.

In bad harvest year, decreased quantity and bigger impact on price increase will ironically increase the total revenue.



Income elasticity of demand (YED)

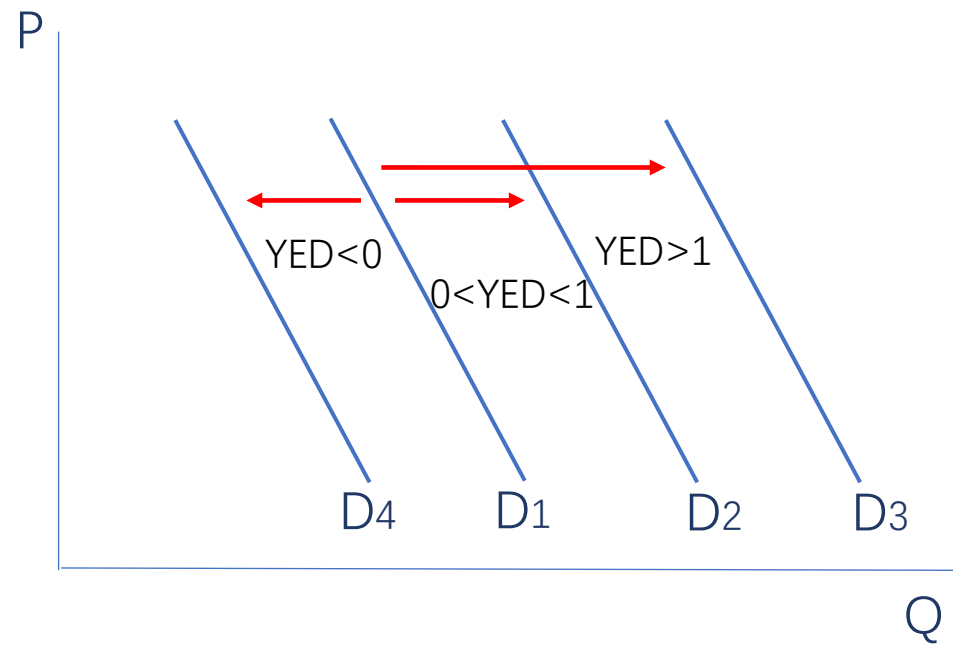
Income elasticity of demand (YED)

Income elasticity of demand is a measure of the responsiveness of demand to changes in income, and involves demand curve shifts. It provides information on the direction of change of demand given a change in income and the size of the change.

$$\begin{array}{c} \boxed{\text{Income elasticity of demand (YED)}} = \frac{\boxed{\begin{array}{c} \% \text{ change in quantity demanded} \\ \text{of good x} \end{array}}}{\boxed{\% \text{ change in income}}} = \frac{\boxed{\% \Delta Q}}{\boxed{\% \Delta Y}} \end{array}$$

The Sign of YED

- YED can be positive or negative
- The sign of YED tells us whether a good is normal or inferior good.
- **When $YED > 0$: normal good.** An increase in income lead to increase in demand. Demand for the good and income change in the same direction.
 - ✓ $0 < YED < 1$ Necessities (Income inelastic demand)
 - ✓ $YED > 1$ Luxuries and services (Income elastic demand)
- **When $YED < 0$: inferior good.** Demand for the good and income move in opposite directions. (bus, second-hand goods, inferior goods in supermarket)



Normal Good			
↑	An increase in income...	↑	increases demand.
↓	A decrease in income...	↓	decreases demand.
Inferior Good			
↑	An increase in income...	↓	decreases demand.
↓	A decrease in income...	↑	increases demand.

Calculation of YED

As a popular psychological therapist, my weekly income increased from 8000 to 12000 RMB. My purchasing habit have the following changes.

- 1) my taxi travel increased from 5 times to 10 times.
- 2) My bus travel decreased from 25 times to 20 times.
- 3) My fruit expenditure increased from 28 to 30 units.

$$\begin{aligned} \text{1) YED of taxi} &= \frac{\% \text{ change of } Q}{\% \text{ change of income}} = \frac{(10-5)/5}{(12000-8000)/8000} = \frac{1}{0.5} = 2 \\ \text{Service (elastic)} \end{aligned}$$

$$\begin{aligned} \text{2) YED of bus} &= \frac{\% \text{ change of } Q}{\% \text{ change of income}} = \frac{(20-25)/25}{(12000-8000)/8000} = \frac{-0.2}{0.5} = -0.4 \\ \text{Inferior goods} \end{aligned}$$

$$\begin{aligned} \text{3) YED of fruit} &= \frac{\% \text{ change of } Q}{\% \text{ change of income}} = \frac{(30-28)/28}{(12000-8000)/8000} = \frac{0.07}{0.5} = 0.14 \\ \text{Necessities (inelastic)} \end{aligned}$$

YED in real world application

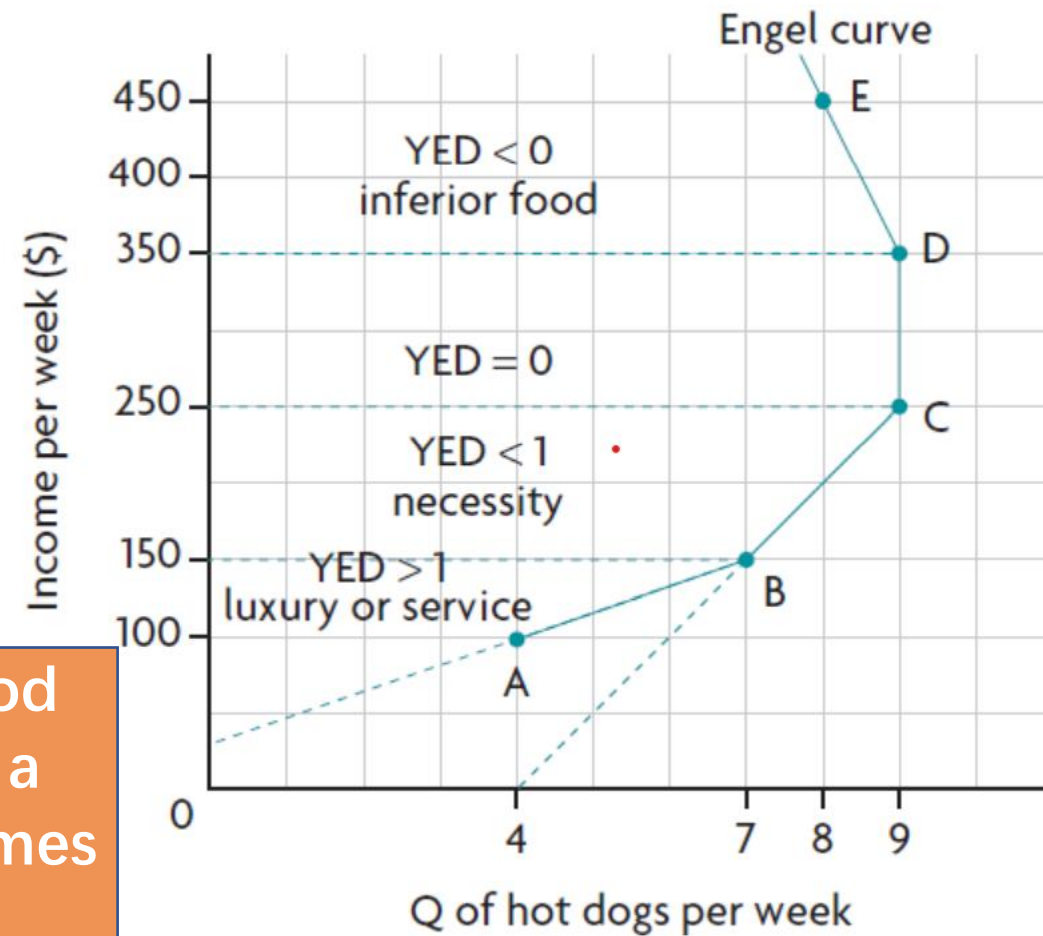
What is a necessity and what is a luxury depends on income levels.

- People in extremely poor country, even food and clothing are luxury goods.
 - Coffee and desert is necessity for western countries while it is luxury goods in poor countries.
 - Education is necessity in most countries, but it maybe luxuries for poor countries and those countries in war.
 - For super stars, maybe luxury brand goods are necessity because it is part of their daily appearance in TV.
-
- As income increases, certain items that used to be luxuries become necessities.
 - YED of food in Developed countries: 0.15-0.2 → This means that a 1% increase in income produces a 0.15% to 0.2% increase in spending on food.
 - YED of food in poor countries: 0.8 → For an increase in income of 1%, spending on food increases by 0.8% in poor countries

The Engel curve *(by Ernst Engel)*

Study the relationship between one's weekly income and quantity demand for hotdogs. It shows the relationship between income and quantity or consumption.

- Point A → B: When income rise from 100 to 150, hotdog increase from 4 to 7. ($YED > 1$, luxury or services)
- Point B → D: When income rise from 150 to 350, hotdog only increase 2 unit. ($YED < 1$ or $YED = 0$, necessity)
- Point D → E, When income goes above 350, hotdog demand start to decrease. ($YED < 0$ inferior good)



The Engel curve shows at very low incomes a good maybe a luxury; as income increases it becomes a necessity and finally at high income levels it becomes inferior good.

YED and producers:

The rate of expansion of industries (AO3)

If you are a investor with huge amount of money, which industry would you invest?

You can use the YED as a important indicator.

At times of economic growth:

- **For goods/services** $YED > 1$, demands for them grows at a higher rate than average rate. (e.g. restaurants, movies, health care, travel, etc.)
 - Higher growing and expanding speed than the whole economy.
- **For goods/services** $YED < 1$, demand for these grows at a rate below average rate. (food, clothing, other necessities)
 - Lower growing and expanding speed than the whole economy.

YED and producers:

The rate of expansion of industries (AO3)

At times of recession:

- For goods/services $YED > 1$, largest declines in sales.
- For goods/services $YED < 1$, smaller loss in sales.
- For goods/services $YED < 0$: Increase in sales.