Anna Xian Hansen
Microeconomics Fall 2024
BSc in IB

Microeconomics Notes

Table of Contents

Introduction & Supply Demand

1 Introduction

- Scarcity - Resources are limited, a choice must be made on how to use them.
- Opportunity cost of everything we do.
- Choices are deliberate - Maximization under constraints (Utility function)
- One market at a time.
- Use models as simple as possible
- Preferences are revealed from choices.
- Positive statement -> A testable hypothesis
- Normative statement -> What the world should be like.
- Assumption of completeness -> The consumer can rank all possible bundles
- The difference between the revenue received from sales and the explicit costs of producing its goods and services, as well as any opportunity costs

2 Supply and Demand

2.1 An Introduction to Supply and Demand

- Diamond-water puzzle: How can water which is so central to our life be so cheap, while diamonds be so expensive?
- Market - A collection of buyers and sellers of a good or service. Defined by geography and by product.
- Assumptions to describe market price and outcome with supply/demand curves. (Perfect competition)
    - Homogeneous product.
    - Many buyers and many sellers - each have no impact on the market price, meaning the act as price takers.

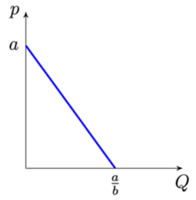
2.2 Demand

- Q^D = Quantity demanded
- p = price
- Market level demand = sum of demand from all buyers in the market.

$$E.g. Q^D = 10 - p$$

- Inverse demand function = Rewrite demand function so that price is dependent.

$$E.g. p = 10 - Q^D$$

- Determinants of demand: Taste, information, price of other goods, income, government actions.
- Linear direct demand is $Q^D = \frac{a}{b} - \frac{p}{b}$
- 

2.2.1 Effect on Demand of Changes in…

- Changes in the price of goods - movement along the demand curve
- Changes in income
    - Normal goods: Higher incomes associated with higher demand. (Outward shift)
    - Inferior goods: Higher income associated with lower demand. (Inward shift)
- Changes in the price of other goods
    - Substitute products increase (Outward shift)
    - Complement products increase (Inward shift)

2.2.2 Demand functions - Some Additional Aspects

- General form (Without exact numbers)

$$Example\ Q^D = f(p, T, p_r, I)$$

Where temp, substitute product and income are taken into account.

- Specific form (With numbers)

$$Example\ Q^D = 1 - p + T * 0.25 + p_r * 0.75 + I * 0.5$$

- Often - the demand curve flattens as quantity increases.

2.3 Supply

- The amount of the good that sellers are willing to sell at different prices.
- Price takers - Sellers do not set the price.
- Horizontal curve -> implies a comptitive market

- General linear form

$$Q^S = f(p)$$

- Example of specific form as well as inverse

$$Q^S = -2 + p \iff p = 2 + Q^S$$

2.3.1 Effect of Changes on the Supply Curve

- Changes in the price - movement along curve
- Changes in price of inputs
  - Higher price in input (producing costs) (Inward shift)
  - Visa versa.
- Other factors
  - Example opening to foreign suppliers - outward shift.
  - Disruptions like strikes, nature, new sellers etc. - inward shift.

2.4 Market Equilibrium

- Also called market clearing price.

$$Q^D = Q^S$$

- Excess demand
  - Upward pressure on prices as long as they are below equilibrium.
- Excess supply
  - Downward pressure on prices that are above the equilibrium.
- Both Supply and Demand Matter for the Equilibrium Price and Quantity

2.5 Shifts in the Equilibrium

- Guidelines for analyzing the effect of shocks on the market equilibrium.
  - Is primarily supply or demand affected. Can be muddy to include to too many factors. Ceteris Paribus (Other things equal)
  - To see direction. At a given price, do we expect a particular change to lead to higher or lower demand?
  - Don't jump straight to price and quantity, consider supply/demand first.

Producer Theory

3 From Technology to Costs

3.2 Key Concepts

- Firm = decisionmaker on what to produce and how.
- Factors of production = labour, capital, intellectual capital, land. Also called inputs. Could be e.g. raw materials and intermediate inputs.
- Technology - simply how they put together inputs and how well they do it.
- MC(q) = AVC(q) in the long run and MC(q) = AC(q) in the short run
  - if q is the output that minimizes AC/AVC

3.3 The Production Function

$$General: Q = f(K, L)$$

$$Specific\ e.g.(Cobb\ Douglas): Q = \sqrt{KL}$$

- Output Q = Number of goods and services, K= capital, L = Labour

Table 3.1: A representation of a simple production function

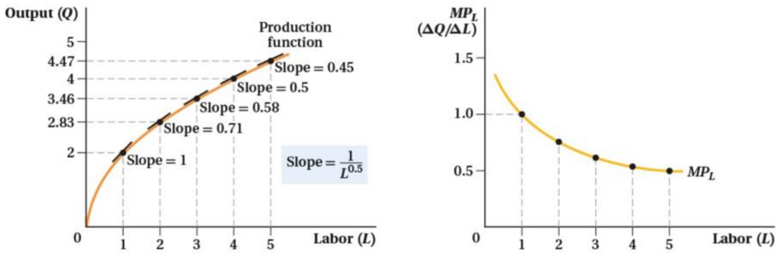
		L		
		1	2	3
K	1	10	14	16
	2	14	20	24
	3	16	24	30

3.3.1 Marginal product of an input

- $MP_L = marginal\ product\ of\ labour$ or $MP_K\ =\ for\ capital$
  - The change in output from a small change in the amount of labour/capital used, holding other inputs fixed.
- $\frac{\partial Q(KL)}{\partial L}$ in general - can be re-written below as
  - $MP_L\ for\ e.g.Q = \sqrt{K,L} : \frac{1}{2}\frac{\sqrt{KL}}{L} = \frac{1}{2}\frac{Q}{L}$
  - $MP_L\ for\ e.g.Q = LMK: \frac{Q}{L}$
  - $MP_L\ for\ e.g.Q = AK^aL^b : \frac{b}{L}Q$

- MP_L $for\ linear\ production\ function\ e.g. Q = aL + bK: a$
- MP_L $for\ e.g. Q = min\{aL + bK\}$ is a in the case of $aL < bK$ or 0.
- MP_K $for\ e.g. Q = AK^aL^b: \frac{a}{K}Q$
- $AP_L(Average\ product\ of\ labour) = \frac{q}{L}$

- Decreasing $MP_{L\ or\ K}$ -> often flatter at higher outputs, each additional worker increase output by less by than the previous (≠ decreasing product)



- Hire an extra unit of labour as long as $p * MP_L >$ wage
- $MC = \frac{w}{MP_L}$

3.3.2 Isoquant

- Isoquant/iso - different combinations of inputs that give the same output
- Different slopes for different outputs.
- MRTS - Marginal rate of technical substitution - Slope of the isoquant says something about how easy it is to substitute one input for another.
- Perfect substitutes - one can substitute one for the other and get the same.
- Perfect complements - cannot substitute - need each other.

Figure 3.4: Isoquants for perfect substitutes

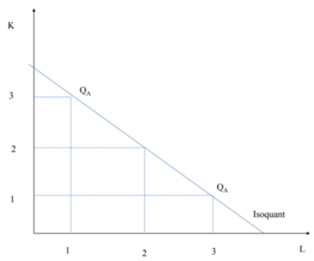


Figure 3.3: Different combinations of inputs that produce the same output

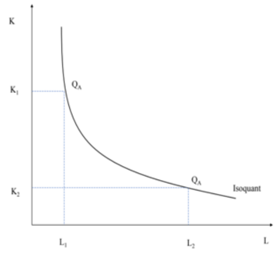
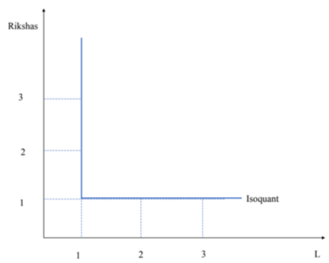
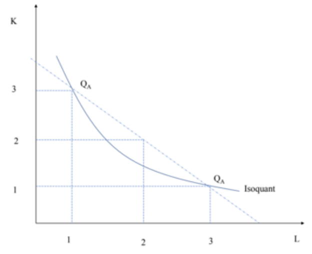


Figure 3.5: Isoquant for perfect complements



- Imperfect substitutes - Cases in between perfect complements and perfect substitutes. (Most common). Bow inwards = Strictly convex.

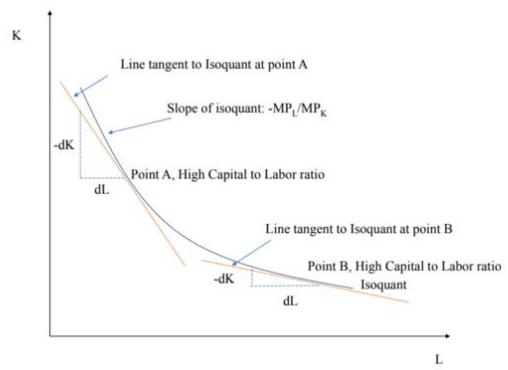
Figure 3.6: Isoquant for imperfect substitutes



3.3.2.1 Total Differentiation

- What happens if we change both inputs somewhat of $Q = f(K, L)$
- d = change
- Along the slope of the isoquant, $dQ = 0$

Figure 3.7: The slope of the isoquant



$$\text{Slope} = \text{MRTS} = -\frac{MP_L}{MP_K}$$

3.4 Productivity

- Parameter A can shift entire production function. (In same way per Hicks)

$$Q = Af(K, L)$$

- Increase in productivity can shift entire production curve upwards.
- Malthusian trap = gains in productivity neutralized by population increases.

3.5 Cost function

- Think of firm as renting the capital it needs.
- Cost will be

$$C = \omega L + rK$$

$$rK = C - \omega L$$

$$isocost \ = K = \frac{C}{r} - \frac{\omega}{r} L$$

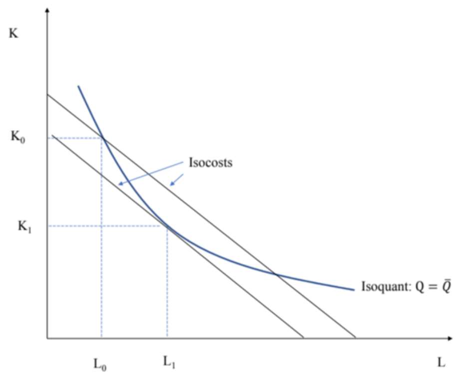
$$w = wage\ per\ hour, r = rental\ rate$$

- Isocost - combinations of L & K that give the same C
- Cost minimization problem subject to the constraint a certain $\bar{Q}$ is produced

$$\min_{K,L} \omega L + rK \ subject\ to\ f(K,L) = \bar{Q}$$

- Cost-minimizing choice
  - Lowest possible isocost at given isoquant = lowest cost.
  - Cost-minimizing point where isocost is tangent to isoquant.
  - Slope of isocost = $-\frac{w}{r}$ hence for an interior solution:
  - Optimal combination will be $\frac{w}{r} = \frac{MP_L}{MP_K}$ or rewritten $\frac{MP_L}{w} = \frac{MP_K}{r}$ Look at exercise 3.2.6 for how to.

Figure 3.14: The cost minimizing choice

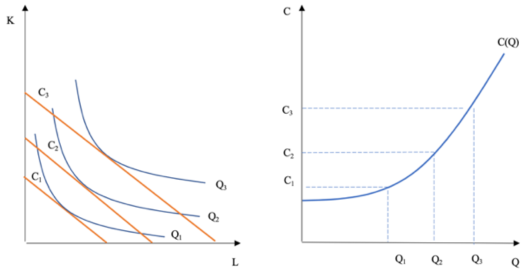


3.5.1 Changes in cost function and isocost

$$isocost \ = K = \frac{C}{r} - \frac{\omega}{r} L$$

- Changes in w will change slope of isocost
- A lower r flattens slope, and higher r makes it steeper.
- Higher cost, but unchanged r *and* w makes a parallel shift.
- Interior solution/combination -> at tangent
- Corner solution/combination -> in extremes/often perfect substitutes (where only input is used)
- The cost function describes the cost of producing a certain number of units.

$$C(Q)$$

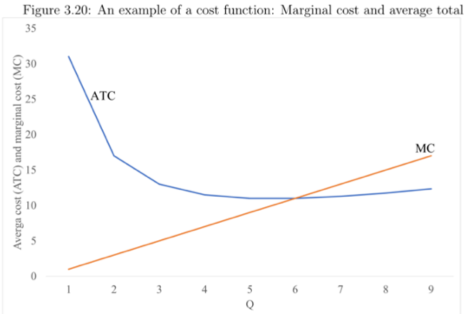


In words	Quantity	Total cost	Average total cost	Marginal cost	Variable cost	Fixed cost	Average fixed cost
Standard abbreviation			ATC	MC	VC	FC	AFC
General form	Q	C(Q)	C(Q)/Q	dC/dQ	C(Q)-F	F	F/Q
Specific form (example)	Q	$30+Q^2$	$(30+Q^2)/Q$	2Q	Q^2	30	30/Q

3.6.1 Average cost and marginal cost

- Total costs = fixed + variable
- Marginal cost = change in cost from producing slightly more
  - *C' or dC/dQ*
  - Derivative of cost function
  - Upwards sloping and depends on where we evaluate it.
- Take average as it's literal meaning.
  - $Average\ cost\ AC = \frac{C(q)}{q}$
  - $Average\ variable\ cost\ = \frac{Variable\ costs\ (those\ including\ q)}{q}$
- *To find the minimum values of MC, AVC, and AC, derive them and set equal to zero - then solve.*

Figure 3.20: An example of a cost function: Marginal cost and average total cost



3.7 Additional aspects of cost functions

3.7.1 Cost in long and short run

- Often in the short run capital is fixed. *MC(Q)=AC(Q)*
- Long-run flatter than short-run and there are no fixed costs. *MC(Q)=AVC(Q)*

3.7.2 Economies of Scale

- Economies of scale - long-run average costs decrease with more output.
    - Constant economies of scale = roughly same average costs
    - Diseconomies of scale = higher average cost with more output.
- Markets will often end up oligopolistic.
- Returns to scale = what happens to quantity produced if the number of inputs used change in the same proportion.
    - $\alpha = factor\ (often\ 2\ or\ 1.1)$
    - Constant returns to scale: α input = α output
    - Increasing returns to scale: α input = output > α
    - Decreasing returns to scale: α input = output < α
        - Example of increasing for $Q = 2L^{0.5}M^2K^{0.5}$
        - $Q = f(L, M, K) \rightarrow Q = f(2L, 2M, 2K)$
        - $2(2L)^{0.5}(2M)^{0.5}(2K)^2$ factoring out 2
        - $8 * (2L^{0.5}M^2K^{0.5})$ *or 8 times the production function.*
- Using Cobb-Douglas example $Q = \sqrt{KL}$ / $Q = K^{0.5}L^{0.5}$
    - In this case we can simply check what the exponents sum to.
        - 1 = constant returns
        - <1 decreasing
        - >1 increasing
    - Proof of 1: constant returns to scale and 2: increasing returns.

$$\alpha Q(K_0, L_0) \stackrel{?}{=} Q(\alpha K_0, \alpha L_0) \qquad \alpha Q(K_0, L_0) \stackrel{?}{=} Q(\alpha K_0, \alpha L_0)$$
$$\alpha Q(K_0, L_0) \stackrel{?}{=} (\alpha L_0)^{\frac{1}{2}}(\alpha K_0)^{\frac{1}{2}} \qquad \alpha Q(K_0, L_0) \stackrel{?}{=} (\alpha L_0)^{2}(\alpha K_0)^{2}$$
$$\alpha Q(K_0, L_0) \stackrel{?}{=} \alpha^{\frac{1}{2}+\frac{1}{2}}(L_0)^{\frac{1}{2}}(K_0)^{\frac{1}{2}} \qquad \alpha Q(K_0, L_0) \stackrel{?}{=} \alpha^{2+2}L_0^2K_0^2$$
$$\alpha Q(K_0, L_0) = \alpha \underbrace{(L_0)^{\frac{1}{2}}(K_0)^{\frac{1}{2}}}_{Q(K_0,L_0)} \qquad \alpha Q(K_0, L_0) < \alpha^4 \underbrace{L_0^2K_0^2}_{Q(K_0,L_0)}.$$

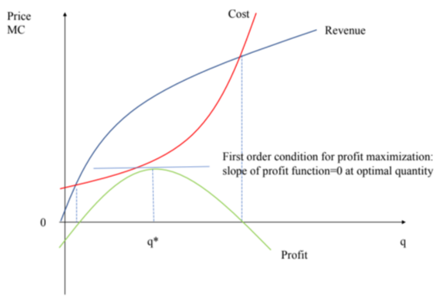
4 Supply by price taking firms

4.1 Maximizing profits - Introduction

- Standard assumption = firms want to maximize profits
- Profits denoted by π and quantity = q

$$\pi = Revenue(q) - costs(q)$$

Figure 4.1: Profit maximization in the general case



- <u>Find ATC' = 0 long run and π' = 0 depending on your information.</u>
- Find max profit where slope is zero

$$\frac{d\pi}{dq} = \frac{dRevenue}{dq} - \frac{dC(q)}{dq} = 0$$

$$or\ marginal\ revenue\ (MR) = marginal\ cost\ (MC)$$

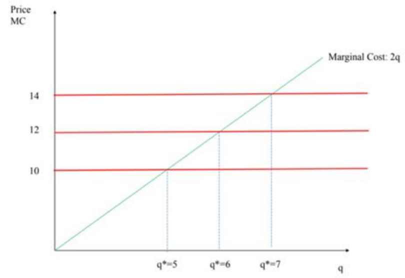
4.2 How much should be produced?

- Revenue of price taker is *price* times *quantity*.
- Condition for the optimal choice of quantity is

$$p = MC$$

- Use "*" to denote optimal quantity = q*

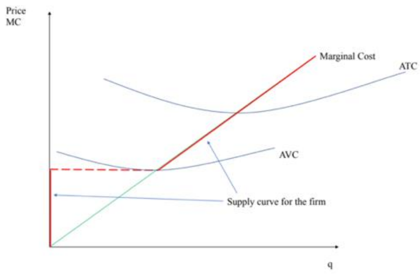
Figure 4.4: The supply of a price taking firm is given by its marginal cost curve



4.3 Should the good be produced?

- A firm's supply curve is given by its marginal cost curve as long as price is above the average variable cost.

Figure 4.10: The supply curve for an individual firm



- Profit in general form is written

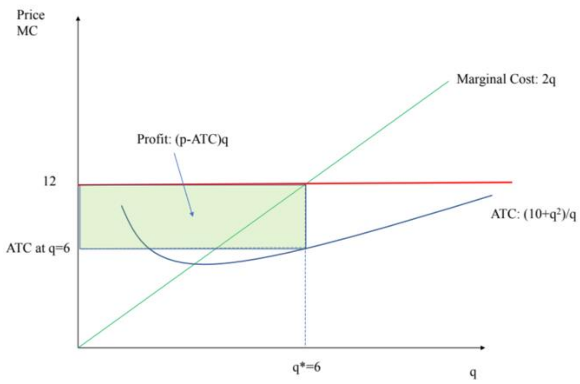
$$\pi = pq - C(q)$$

- Can be re-written to include average total cost times quantity

$$\pi = pq - C(q)\frac{q}{q}$$

$$\pi = (pq - \frac{C(q)}{q})q$$

Figure 4.6: Profit at the profit maximizing quantity



- $p = MC$ means that the firm produces up to the point where $p = MC$.

- As long as $p > MC$ the firm is increasing profit as it increases production.

4.4 Profits: Positive, negative or zero?

- Can produce at zero profit when $P=MC$

Figure 4.7: Zero profit

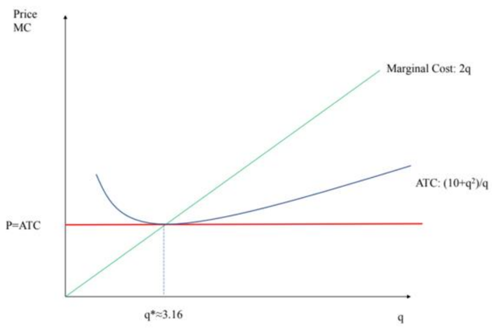
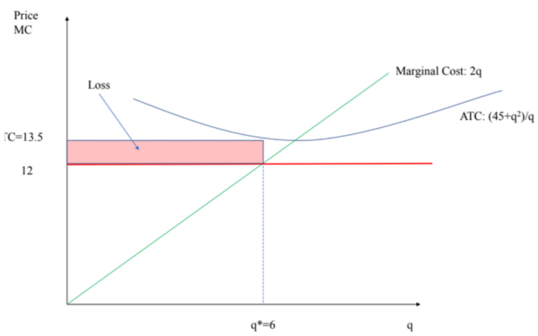


Figure 4.8: A loss



- Can produce at a loss, when it might be cheaper than not producing at all due to fixed costs.
  - If revenue is larger than *VC* it will be better than not producing at all and might be needed in short run.

Table 4.1: Why a firm may produce at a loss

	No production	**Production**
Revenue	0	$p \times q$
Cost	Fixed cost	Fixed cost + variable cost
Profit	-Fixed cost	- Fixed cost + ($p \times q$ - variable cost)

- If given the individual *TC* for a firm
  - $ATC' = 0$ is the individual q produced for a quadratic function (in the long run)
  - $MC(q) \;=\; price$ (Also in the short run)
  - Lowest price to get non-negative profits in the short run
    - AC = MC, solve for q
  - $Q^D(P) = Total\ Q\ in\ the\ market\ when\ price\ is\ known$
  - $\frac{Q^D(P)}{q} = \ Number\ of\ firms$

4.5 From firm supply to the market supply

- Market supply - at a given price, the sum of the quantities that all the firms together are willing to supply.

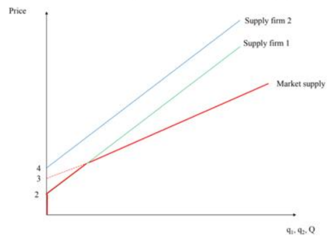
$$Q = q_1 + q_1 \ldots + q_n$$

- Can be written mathematically

$$Q(p) = \begin{cases} 0, & \text{if } p < 2 \\ -2 + p & \text{if } 2 \leq p < 4 \\ -6 + 2p & \text{if } p \geq 4 \end{cases}$$

- Easy to draw slope - be aware of different intercepts - setting constraints.

Figure 4.11: The market supply curve



Example from firm to market supply

- If given cost function per firm, market demand and number of firms in a competitive market. This is how you find equilibrium price, market output and economic profit per firm.
- *Know that MC = P, in that way you can solve for q*
- *You have to aggregate the total market supply given the q found before.*

Key Details:

1. **Cost Function per firm:** $C(q) = 500 + 3q^2$
2. **Market Demand Function:** $Q = 1200 - 2p$
3. **Number of firms:** 12

Steps:

1. **Find the Marginal Cost (MC):** Marginal cost is the derivative of the cost function:

$$MC = \frac{dC(q)}{dq} = 6q$$

2. **Determine Individual Firm's Supply Curve:** In a perfectly competitive market, $MC = P$, so:

$$P = 6q \quad \Rightarrow \quad q = \frac{P}{6}$$

3. **Aggregate Supply:** Total market supply Q_s is the sum of all firms' outputs:

$$Q_s = 12q = 12 \cdot \frac{P}{6} = 2P$$

4. **Market Equilibrium:** At equilibrium, market supply equals market demand:

$$Q_d = Q_s \quad \Rightarrow \quad 1200 - 2P = 2P$$

Solve for P:

$$1200 = 4P \quad \Rightarrow \quad P = 300$$

5. **Calculate Total Output:** Substitute $P = 300$ into the demand function:

$$Q = 1200 - 2(300) = 600$$

Since there are 12 firms, output per firm is:

$$q = \frac{600}{12} = 50$$

6. **Profit per Firm:** Profit is $\text{Total Revenue} - \text{Total Cost}$:

$$\text{Total Revenue} = P \cdot q = 300 \cdot 50 = 15000$$

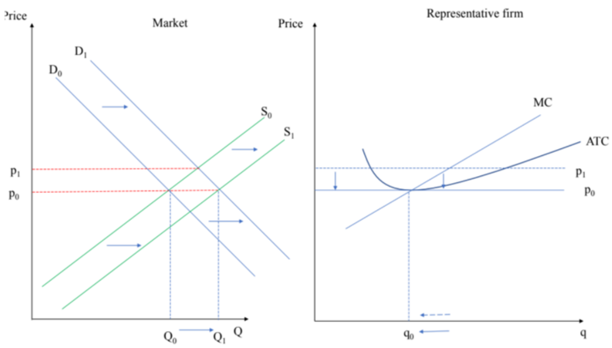
$$\text{Total Cost} = 500 + 3q^2 = 500 + 3(50)^2 = 500 + 7500 = 8000$$

$$\text{Profit} = 15000 - 8000 = 7000$$

4.6 Free entry and profits

- Perfect competitive market has free entry - meaning easy to enter and exit.
- If market demand were to increase, and in the short run increase prices and profit.
- However, as this is a market with perfect competition, a new entrant would simply come and push supply resulting in a long-run profit of 0.

Figure 4.15: The effect of entry on the market equlibrium



4.7 Types of cost and profits

- Accounting costs -> direct outlays (labour, materials etc.)
- Economic profit -> price minus average cost
- Opportunity costs
  - The cost of what you're giving up by using a resource.
  - Economic cost = opportunity costs + accounting costs
  - Economics rent -> Return to owning a scarce resource.
  - Sunk costs not included - as they are irretrievable.

4.8 Supply in the long run

- Theoretically in a free-market supply would be perfectly horizontal.
- In general, it is not and will instead be
  - Upwards sloping if it is harder for new entrant to enter or any scarce resources.
  - Downwards sloping if learning by doing - cheaper to produce the more is produced.

Consumer Theory

5 Consumer choice

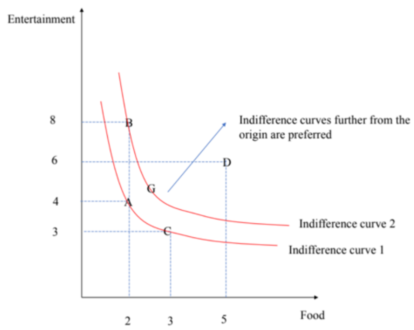
5.1 How can we model choice?

- We have preferences which are stable
- We have constraints e.g. time or money
- We try to be of as well as possible given constraints.

5.2 Preferences

- Bundles - a mix of goods of services (x_1, x_2)
- Preferences are complete - we can rank all bundles. Either A, B, C or them being indifferent.
- Preferences are transitive - They hold when in difference settings.
- More is preferred to less.

- Indifference curves - a more general look on bundles.
  - Connects all bundles that consumer views as equally attractive and she is indifferent about.
  - Indifference curves further from the origin are preferred to those closer to the origin.
- Perfect complements, perfect substitutes and imperfect substitutes just as with isoquants.



5.2.1 Utility

- Indifference curves closely related to utility functions.
  - Indifference curves further from origin has higher utility.
  - Use numbers from UC to rank but they have no other quantitative meaning (simply ordinal)
- Use utility function to assign value to different bundles

$$General\ form\ e.g.\ U = U(E, F)$$

$$Specific\ form\ eg.\ U = \sqrt{EF}$$

$$Leontief\ form\ eg.\ U = \min\{4E, F)$$

Will be a fixed consumption between the two meaning 4E = F

- Slope of indifference curve (MRS - Marginal Rate of Substitution)

$$dU = \frac{\partial U(E,F)}{\partial E} dE + \frac{\partial U(E,F)}{\partial F} dF$$

$$Which\ in\ the\ end\ becomes\ the\ ratio\ between\ the\ marginal\ utilities$$

$$-\frac{dE}{dF} = \frac{\frac{\partial U(E,F)}{\partial F}}{\frac{\partial U(E,F)}{\partial E}} = \frac{MU_F}{MU_E}$$

- MU = The change in utility from adding one more good. Assumed to be decreasing.

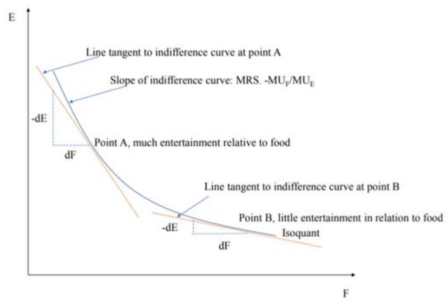
$$MU_F of\ e.g. U = A\sqrt{EF} = \frac{A\sqrt{E}}{(A-1)F}$$

Use examples of Marginal products in producer theory for calculations.

Meaning the MRS could in simpler terms be written $U = EF$ as

$$MRS = \frac{U_b}{U_c} = \frac{\frac{3\sqrt{c}}{2b}}{\frac{3\sqrt{b}}{2c}} = \frac{c}{b}\ and\ the\ same\ for\ U = EF$$

Figure 5.5: The slope of the indifference curve: Marginal rate of substitution (MRS)



5.3 Budget Constraints

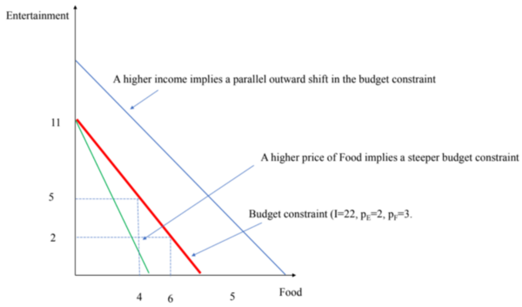
- How much we can buy depends on income and price.
  - Income denoted $I\ or\ Y$
  - Price of entertainment (E) e.g. peE

$$I = peE + pfF$$

To draw the income budget line

$$E = \frac{I}{P_E} - \frac{pf}{pe}F$$

- Changes in income - parallel shift in budget constraint
- Change in price of one good relative to the other changes steepness.



5.4 Maximization of utility subject to constraints

$$\max_{E,F} I(E,F) \text{ subject to } {}_{pe}E + {}_{pf}F \leq I$$

- Utility maximization reached at F*, E* so where indifference curve and utility function are tangent to another which will be:

$$\frac{MU_F}{MU_E} = \frac{pf}{pe} or \frac{MU_f}{pf} = \frac{MU_E}{pe}$$

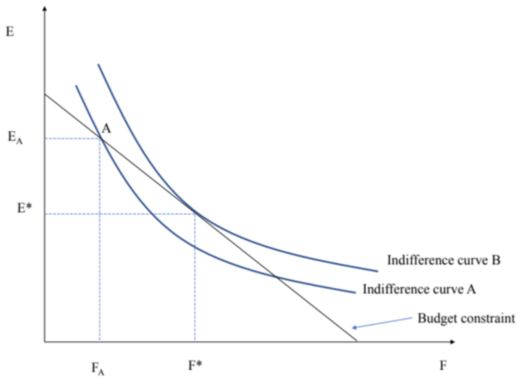
For an interior solution

Pf/Pe is simply the ratio between the prices, while MU/MF gives the preferences.

or sometimes written as the slopes

MRT -> marginal rate of transformation, trade off in production based on technology.

$$MRS = MRT$$



- People will consume less of something, even if preferred if the prices are higher. Income has an effect on choices.
- Utility in a Cobb-Douglas function with $U(x1, x2, x3) = x_1^2 x_2 x_3$, and p=20,10,10

Given a budget B and prices p_1, p_2, p_3, the optimal consumptions under a Cobb-Douglas utility function are

$$x_1 = \frac{2}{2+1+1}\frac{B}{p_1}, \quad x_2 = \frac{1}{2+1+1}\frac{B}{p_2}, \quad x_3 = \frac{1}{2+1+1}\frac{B}{p_3}.$$

(a) Letting $B = 400$, $p_1 = 20, p_2 = 10, p_3 = 10$, we have that the optimal bundle is (x_1, x_2, x_3) where

$$x_1 = \frac{2}{4}\frac{400}{20} = 10, \quad x_2 = \frac{1}{4}\frac{400}{10} = 10, \quad x_3 = \frac{1}{4}\frac{400}{10} = 10.$$

and the utility level is $U(x_1, x_2, x_3) = 10^2 \times 10 \times 10 = 10000$.

Example on deriving demand

Look at overhead "Utility maximization" in micro folder.

For $U(x) = Ax_1^{a_1}x_2^{a_2}x_3^{a_3}$: $MU_1 = \frac{a_1}{x_1}U(x)$

End with

$$Y = p_1 x_1 \frac{a_1 + a_2 + a_3}{a_1}$$

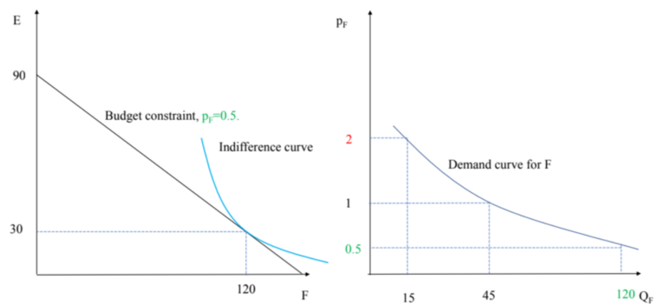
Flip around to get

$$x_1 = \frac{a_1}{a_1 + a_2 + a_3}\frac{Y}{p_1}$$

6 Demand curves and elasticities

6.1 From constrained optimization to demand curves

- Utility maximization links preferences, income and prices on the one hand, to demand for individual goods on the other hand.
- Optimal choice is a point on the demand curve.
- Meaning you derive demand from plotting tangents, while keeping other things fixed.



6.2 Effect of changes in income on demand

- Income has effect. Higher income -> outwards shift (vice versa)
- Normal goods -> higher income, higher demand
- Inferior goods -> higher income, lower demand
- Some can be normal at lower income and inferior at higher. (e.g. hostels)

6.3 From individual to market level demand

Market demand is the sum of the quantities that all consumers together are willing to demand at a given price.

- To add demand curves, you have to be cautious about whether they have positive demand at a particular price.
    - Create inverse functions and plot to counter.
- Market demand flatter than individuals.

6.4 Elasticities

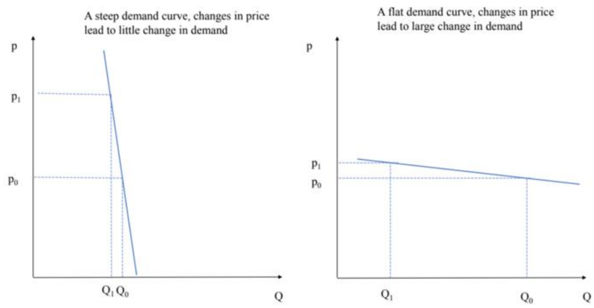
- Overhead on elasticities
- The elasticity is given at a specific price and quantity - how much does demand change.
- x and y in formula are the original values.
    - The elasticity of y with respect to x is

$$e_{y,x} = \frac{\%change\ in\ y}{\%\ change\ in\ x} = \frac{\frac{\Delta y}{y}}{\frac{\Delta x}{x}} = \frac{dy}{dx}\frac{x}{y}$$

"The percentage change in y given a very small/1% change in x"

    - Elasticities are negative given the law of demand.
    - The elasticity generally changes along the demand relation.
- Price elasticity of supply = $e_{Q^s,p}$ (Quantity supplies, price of good)
    - Elasticities are positive given the law of supply.

6.4.1 Price elasticity of demand



- Elastic demand -> price change decreases revenue
- Inelastic demand -> price change increases revenue
- Table 6.3: Elasticities, naming conventions

Name	Level of elasticity
Inelastic	$-1 < E^D < 0$
Unit elastic	$-1 = E^D$
Elastic	$E^D < -1$

- Price elasticity of demand
    - % change in quantity demanded in response to a % change in the price of the same good.

$$E^D = \frac{\frac{\Delta Q}{Q} * 100}{\frac{\Delta p}{p} * 100} \; or \frac{\Delta Q}{\Delta p} * \frac{p}{Q}$$

For a linear demand function also just $-\frac{1}{b}\frac{p}{Q^D}$

- Often more elastic for disaggregated product because they can substitute.
- Constant elastic demand curve

$$Q = ap^{-b} \; then \; E = -b$$

- Where e is the elasticity of demand (common in empirical estimation of demand functions)
- We can estimate the elasticity of demand from the following specification

$$\ln(Q) = \ln(a) + e * \ln(p) + error \; term$$

- Monopolist market relationship between price, mc and elasticity
    - $P = MC \cdot \left(\frac{E}{E+1}\right)$

6.4.2 Cross-price elasticity of demand

- Cross-price elasticity of demand = e_{Q,P_0} (Quantity demanded, price of another good)
- Example for $Q^D = 1 - p + .025T + 0.75p_r + .0.5I$ where pr = 2, $E = 0.75\frac{2}{Q^D}$
- If $E^{cross-price} = \begin{cases} \frac{\frac{\Delta Q_A}{Q_A}*100}{\frac{\Delta Q_B}{Q_B}*100} > 0, products\ are\ substitutes \\ \frac{\frac{\Delta Q_A}{Q_A}*100}{\frac{\Delta Q_B}{Q_B}*100} < 0, products\ are\ complements \end{cases}$

6.4.3 Income elasticity of demand

- Income elasticity of demand = $e_{Q,I}$ (Quantity demanded, income /sometimes Y)
- Example for $Q^D = 1 - p + .025T + 0.75p_r + .0.5I$ where I = 5, $E = 0.5\frac{5}{Q^D}$
- If $E^{income} = \begin{cases} \frac{\frac{\Delta Q}{Q}*100}{\frac{\Delta I}{I}*100} > 0, normal\ goods \\ \frac{\frac{\Delta Q}{Q}*100}{\frac{\Delta I}{I}*100} < 0, inferior\ goods \end{cases}$

6.5 Income and substitution effect

Income effect

- pF increases, it is as if the consumer's income has decreased. Will have to spend less on other products. Good for normal goods, bad for inferior.
- Reinforces lower demand for higher prices for normal goods, counteracts for inferior.

Substitution effect

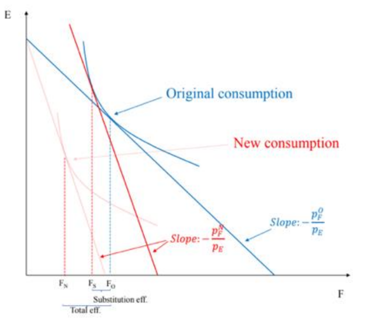
- If pF increases, F becomes more expensive relative to other goods – meaning they will substitute away.
- Is always negative (or zero)

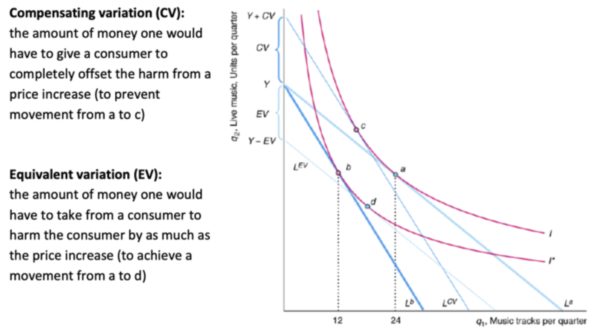
$$Total\ effect\ of\ of\ price\ change\ on\ demand = income + substitution\ effect$$

The compensating variation

- To make up for price increase when trying to change relative prices.

Figure 6.12: The substitution effect





Efficiency, Equilibrium and Welfare

7 Efficiency in partial equilibrium

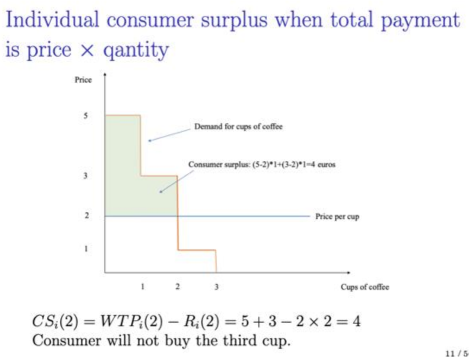
- Equilibrium in competitive markets (price-taking)
- Partial equilibrium - one market at a time

7.1 Efficiency

- Whether the market maximizes
- This can be achieved when individuals (consumers and producers) pursue own interests.
- Role of prices is what drives efficiency - implicit assumptions.

7.2 Consumer surplus

- WTP - willingness to pay for a q of a good.
    - For consumers 1, 2…n, consuming quantities $q_1, q_2 \ldots q_n$.
    - For market for a total quantity Q is denoted WTP(Q).
    - Marginal WTP - how much more will I pay for an extra unit.
    - If MC > MWTP always, then efficient output is 0
    - If MWTP > MC at some level, efficiency requires we increase output until MWTP is equal to MC (or just above)
- Welfare of consumers at a given amount.



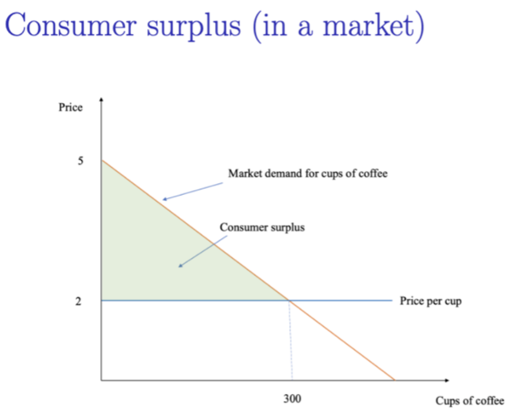
- The consumer surplus of an individual consumer for a quantity is, which is what they are willing to pay minus what they actually pay.

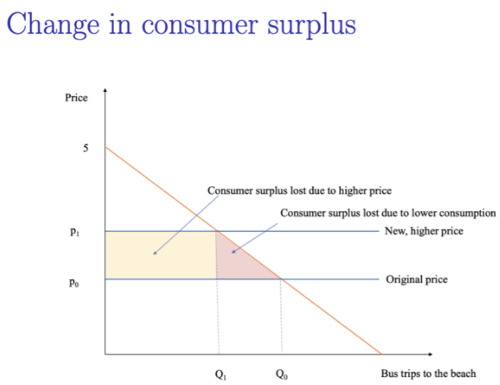
$$CS_i = WTP_i(q_i) - R_i(q_i)$$

- The consumer surplus of the market

$$CS(Q) = WTP(Q) - R(Q)$$

- For linear inverse demand curves
  - $P(q) = a - bq, where\ a\ and\ b\ are\ positive\ constants\ then\ q = \frac{a-p}{b}$
  - $CS(p) = (a-p)\frac{(a-p)}{b}\frac{1}{2} = \frac{(a-p)^2}{2b}$





7.3 Producer surplus

- Welfare of producer at a given amount.
- The difference between the revenue resulting from selling a quantity of a good and the minimum amount necessary for the producer to be willing to produce the quantity. Use marginal costs to calculate this.
- Producer surplus for an individual firm

$$Short\ run \rightarrow PS_i = R_i(q_i) - VC_i(q_i)$$

$$Long\ run \rightarrow PS_i = R_i(q_i) - C_i(q_i)$$

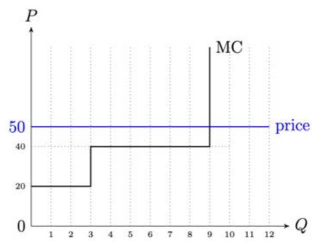
- Producer surplus for the market

$$Short\ run \rightarrow PS(Q) = R(Q) - C(Q)$$

$$Long\ run \rightarrow PS(Q) = R(Q) - C(Q)$$

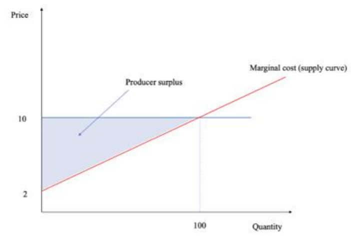
- For linear supply
  - $S(q) = c + dq, where\ c\ and\ d\ are\ positive\ constants, then\ q = \frac{p-c}{d}$
  - $PS(p) = (p-c)\frac{(p-c)}{d}\frac{1}{2} = \frac{(p-c)^2}{2d}$

PS for a firm if revenue is price × quantity and the firm is a price-taker



$PS_j(9) = (50 \times 9) - (3 \times 20 + 6 \times 40) = 150$

PS for a firm if revenue is price × quantity and the firm is a price-taker



This first photo is only for the variable costs.

7.4 Welfare and efficiency in partial equilibrium

- Studying efficiency and welfare in one market
- Social welfare - sum of producer and consumer surplus.
- Efficiency - when it maximizes welfare.
- In the short run, the welfare corresponding to a market output Q

$$CS(Q) + PS(Q) = [WTP(Q) - R(Q)] + [R(Q) - VC(Q)] = WTP(Q) - VC(Q)$$

- In the long run, the welfare corresponding to a market output Q

$$CS(Q) + PS(Q) = [WTP(Q) - R(Q)] + [R(Q) - C(Q)] = WTP(Q) - C(Q)$$

- Welfare maximization
  - A Q that maximizes welfare is such that (Both long and short run)

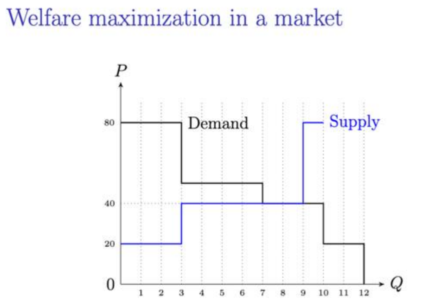
$$\frac{\Delta WTP(Q)}{\Delta Q} = MC(Q)$$

  - If P(Q) denotes the inverse demand function

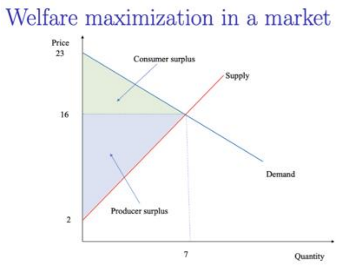
$$MWTP(Q) = \frac{\Delta WTP(Q)}{\Delta Q} = P(Q)$$

- Then the welfare will be maximized when Q is so that the competitive equilibrium price and quantity maximizes welfare.

$$P(Q) = MC(Q)$$



Welfare is maximized when the Q is between 7 and 9.

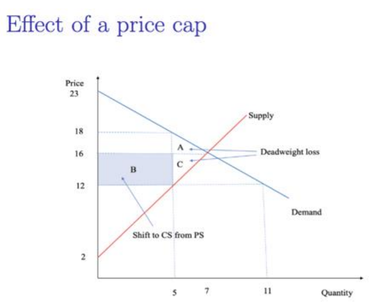


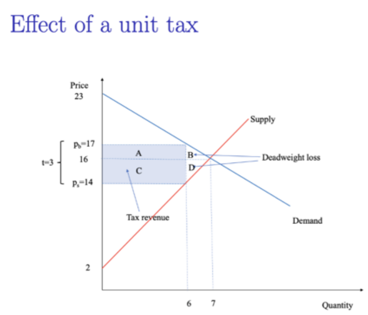
Welfare is maximized when $Q = 7$.

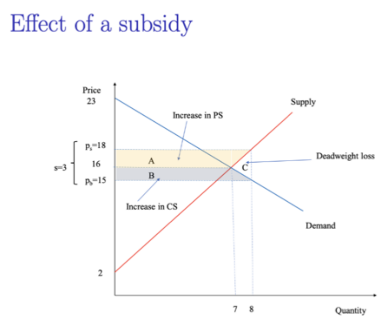
The competitive market equilibrium maximizes welfare.

7.5 Policy and deadweight loss

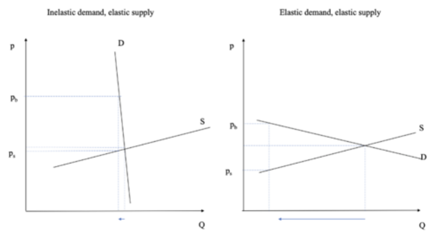
- Effects of market interventions
- Deadweight loss - The monetary loss of producing a quantity different than that maximizing welfare, different than the efficient quantity.
- Effect of a price cap, unit tax and subsidy
  - With a price cap they will both lose CS/PS, but some will also be moved from PS to CS. In the example, price cap at 12
  - Effect of tax dependent on shape of demand and supply. An inward shift in demand and deadweight loss from both, but also a revenue created.
    - Better to tax on inelastic demands - or be aware of it.
  - Effect of subsidy dependent on shape of demand and supply - more deadweight for elastic demand.



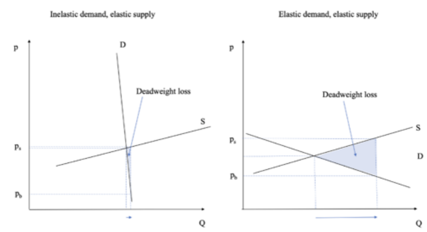




Effect of a tax depends on the shape of demand and supply

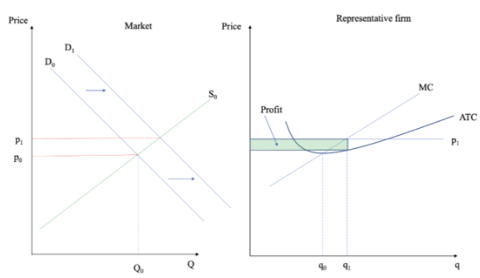


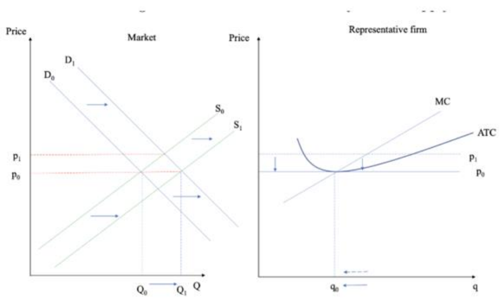
Effect of a subsidy depends on the shape of demand and supply



7.5.1 Drivers of efficiency: The role of prices

- When demand increases -> prices are pushed up -> leads to a profit -> leads to an increase in supply -> must push down prices again (thereby being more efficient)
- $MR = MC = P$ in perfect competition





8 Efficiency in general equilibrium

- General equilibrium - all markets interact.

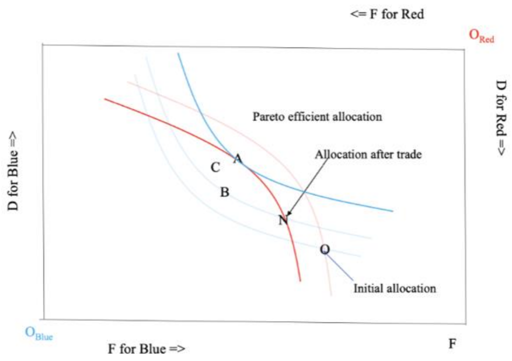
8.1 How resources are allocated in an economy

- An allocation is (Pareto) efficient if there is no alternative allocation making someone better-off without making someone else worse-off.
- Endowment - what you have initially

8.2 Efficiency in consumption

- Who should consume what
- At an efficient allocation

$$MRS_{Blue} = \frac{MU_F}{MU_D} = \frac{MU_F}{MU_D} = MRS_{Red}$$



- In equilibrium

$$MRS_{Blue} = \frac{MU_F}{MU_D} = \frac{pf}{pd} = \frac{MU_F}{MU_D} = MRS_{Red}$$

- First welfare theorem: The competitive equilibrium allocation is Pareto efficient.
- In an equilibrium allocation with equilibrium prices
    - Everyone maximizes utility given the same prices

$$\frac{MU_F}{pF} = \frac{MU_D}{pD}$$

$$\frac{MU_F}{pF} = \frac{MU_D}{pD}$$

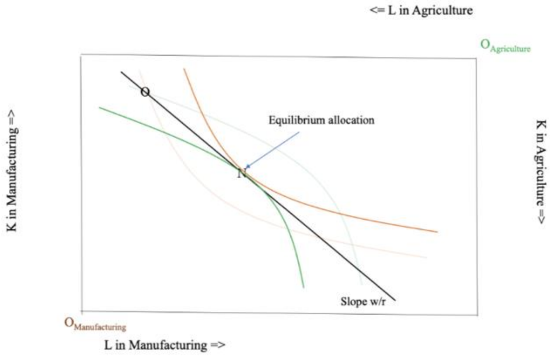
- Second welfare theorem: Every Pareto efficient allocation is a perfectly competitive equilibrium starting for some initial allocation of resources (endowments).

8.3 Efficient use of inputs

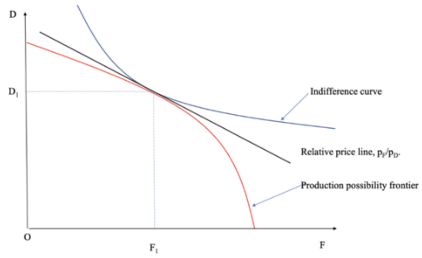
- At an efficient allocation of inputs (capital and labour) the prices of the inputs *(r, w)* will be such that each producer will choose to produce with a combination of outputs such that

$$MRTS = \frac{MP_L}{MP_K} = \frac{w}{r}$$

We are not taken w, r as given!



8.4 Efficient combination of goods



- The marginal rate of transformation (MRT) is the slope of the PPF

$$MRT_{D\ for\ F} = \frac{MC_F}{MC_D} = \frac{PF}{PD} = \frac{MU_F}{MU_D} = MRS_{D for\ F}$$

Imperfect Competition

9 Monopoly and monopolistic competition

- Imperfect competition - no price taking behaviour
- Market structure differs on - entry barriers, number of competitors, product differentiation.
- Duopoly (can be treated the same way)

9.1 Quantity set by a monopoly

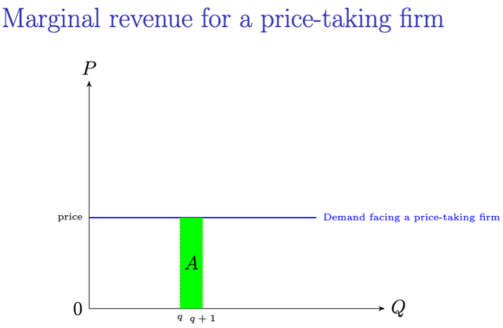
- One firm supplying, unique product and many entry barriers.

- no close substitutes.

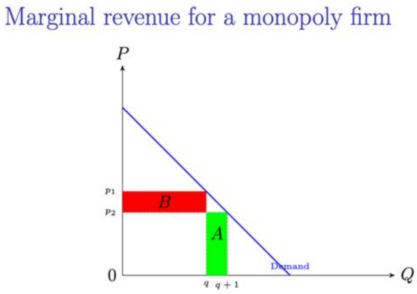
- Is not a price taker - it forecasts that its price will fall if it increases output.

9.1.1 Profit maximization of a monopoly

- Balance marginal cost with marginal revenue on whether to produce.



A is the marginal revenue of increasing output from q to $q+1$.



$A - B$ is the marginal revenue of increasing output from q to $q+1$. Depending on the demand, the marginal revenue may be positive or negative.

- Profit

$$\pi(Q) = R(Q) - C(Q)$$
$$R(Q) = p(Q)Q$$

- When having a linear demand function - the slope for the marginal revenue will be twice as steep $MR(Q) = \frac{dp(Q)}{dQ}Q + P = \frac{\Delta p}{\Delta Q}Q + p$ (Considering the decreasing price)
- If you instead have the inverse functions - insert price function into cost function and take derivative and set to zero.
- If marginal profit is positive - more should be produced

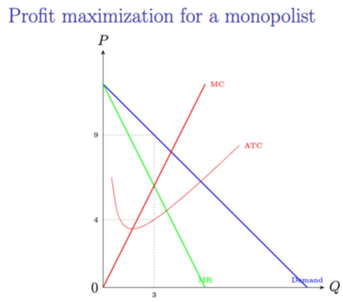
$$\frac{\Delta \pi}{\Delta Q} = MR(Q) - MC(Q) = 0$$
$$\leftrightarrow 0 = \frac{1}{e_Q, p} + \frac{p - MC(Q)}{p}$$
$$\leftrightarrow \frac{p - MC}{p} = -\frac{1}{e_{Q,P}} \rightarrow \textit{The more elastic, the lower market power}$$

i.e.

$$MR(Q) \geq MC(Q)$$

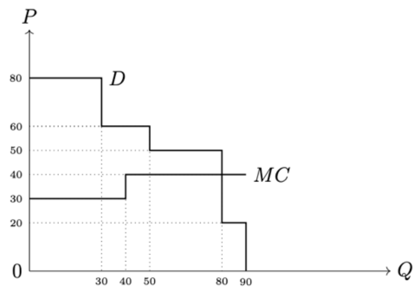
- In the case below, *Q=3 with p=9* (*Example in overhead week 47*)
- Monopolist market relationship between price, mc and elasticity

- $P = MC \cdot \left(\frac{E}{E+1}\right) or\ MC = P * \left(\frac{E+1}{E}\right)$



- Quantity and price choice are the same thing for a monopolist.
- *p-MC* -> The mark-up
- Lerner Index - measure of market power for a monopolist firm
  The ratio you get to keep from the mark-up.

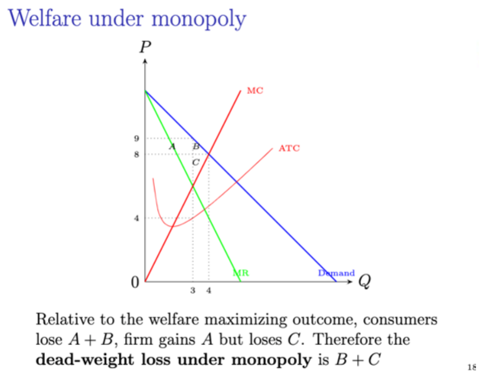
$$\frac{p - MC}{p}$$

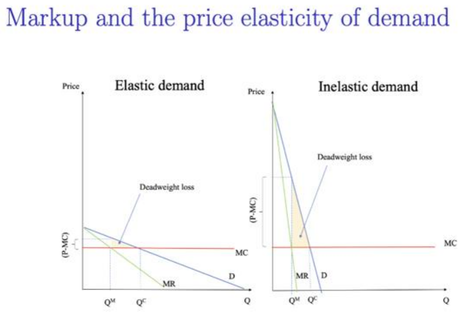
- To find the marginal revenue when you have it in stepped ladder (fixed)
- 

- $MR = \Delta TR/\Delta Q$, where $\Delta TR = P \cdot Q$(new total revenue) minus the previous TR
  - E.g. $For\ Q\ = 30\ to\ 50\ at\ P = 60$
  - $TR_{initial} =\ 80 * 30 = 2400\ and\ TR_{new} = 60 * 50$
  - $\Delta TR = 3000 - 2400 = 600, \Delta Q = 50 - 30 = 20$
  - $MR = \frac{600}{20} =\ 30$
  - Which is lower than MC, meaning monopoly would produce at 30.
  - If the MR goes up and down across MC, use the last time it is above - this way they maximize profits.

9.1.2 Deadweight loss of a monopoly

- Maximization of welfare happens where MC = Demand, but a monopolist will produce where MC = MR. There will be a deadweight-loss.



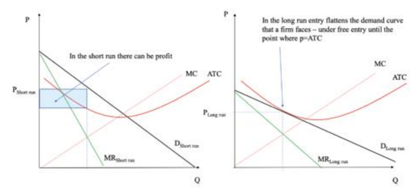


9.2 Why do monopolies exist?

- Entry barriers
    - High fixed cost (natural monopoly)
    - Control over important input
    - Regulation (legal barriers, copyrights, patents)
    - Product differentiation
    - Anticompetitive (Mafia, price-dumping)
    - Network effects
- Can make positive profits - also in the long-run.
- Natural monopoly - one firm can supply the whole market at lower AVC than multiple firms. (Railways, gas/electricity distribution etc.)

9.3 Monopolistic competition

- Many firms, different products
    - Downwards sloping demand of each firm (in the short run -> i.e. t is like a monopoly)
    - No significant entry barriers -> over time profits will be zero.



Like monopoly (in the short-run) but with no significant entry barriers.

10 Oligopoly

- Small number of competing firms and some barriers to entry.

10.1 Overview of oligopoly markets

In an oligopoly, price and quantity choices are ***strategically*** different.

Main models

- Cournot competition (quantity competition)
  - Cournot Nash Equilibrium
- Bertrand competition (price competition)
  - Bertrand Nash Equilibrium
  - Two firms can be enough to wipe out market power drive profits to zero if: (Bertrand paradox)
    - Prices are set once
    - Equal costs - no capacity constraints.
    - Homogenous.
    - Transparency.
  - Under the above assumptions - in equilibrium the prices are driven to marginal cost (For any demand function and number of firms)

10.2 Oligopoly with homogenous products

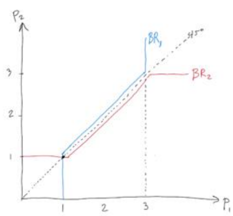
- Every firm sells the exact same thing

10.2.1 Bertrand Nash Equilibrium

A combination of prices (p1, p2) such that each firm is choosing its price to maximize its profit given the price of the competitor.

- e.g. the market is split into two lower prices instead of the higher price in the equilibrium. (E.g. 75, 75 instead of 100, 100 if firm 1 has chosen p=2.5)
    - Firm 2

		3	2.5
Firm 1	3	100, 100	0, 150
	2.5	150, 0	75, 75



The Bertrand Nash equilibrium is $(p_1, p_2) = (1, 1)$.

10.2.2 Cournot Nash Equilibrium

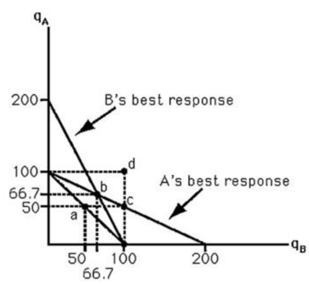
A combination of quantities (q1, q2… qn) such that each firm is choosing its quantities to maximize its profit given the quantities of its competitors.

- Firms 1, 2, 3 … n where Firm i = 1, 2…n, chooses output q_i
- Given $(q_1, q_2 \dots q_n)$ the profit of firm i = 1, 2 … n is

  $$\pi_i(q_1, q_2, \dots q_n) = q_i P(Q) - q_i m \; - \; F_i$$

  Where $Q = q_1 + q_1 + \cdots q_n$ and P(Q) is the inverse demand (As this is a homogenous market) (The P(Q) is where the strategic part comes in, as this is where it is dependent on the market) The first part is simply the revenue.

  m_i is the MC and F is the FC.
- NE for identical firms = $q = \frac{a-m}{(n+1)b}$



- Cournot at b (66.7/66.7)
- Example. Even though inputs are the same for π1 and π2 the profit is different as the firms are different.

  - Two firms: Firm 1 and Firm 2.
  - Demand $P(Q) = 339 - Q$
  - Marginal costs $m_1 = m_2 = 147$, and $F_1 = F_1 = 0$.
  - Can calculate profit (in thousands) for each firm for each combination of quantities:
    - $\pi_1(96, 96) = (339 - [96 + 96])(96) - 147(96) = 0$
    - $\pi_2(96, 96) = (339 - [96 + 96])(96) - 147(96) = 0$
    - $\pi_1(96, 64) = (339 - [96 + 64])(96) - 147(96) \approx 3.1$
    - $\pi_2(96, 64) = (339 - [96 + 64])(64) - 147(64) \approx 2.0$

    ⋮

  Firm 1 is American Airlines, Firm 2 is United Airlines

  Suppose a firm can only choose quantities 48, 64, or 96.

United Airlines / American Airlines	$q_A = 96$	$q_A = 64$	$q_A = 48$
$q_U = 96$	0, 0	3.1, 2.0	4.6, 2.3
$q_U = 64$	2.0, 3.1	4.1, 4.1	5.1, 3.8
$q_U = 48$	2.3, 4.6	3.8, 5.1	4.6, 4.6

- Using the Cournot model *(See overhead from week 47)*

  Lets solve the model with two firms (firm 1 and firm 2), where demand is linear demand $P(Q) = a - bQ$, $m_1, m_2 < a$, and the firms can choose any quantity.

  Step 1: The payoffs/profits are

  $$\pi_1(q_1, q_2) = q_1[a - b(q_1 + q_2)] - q_1 m_1 - F_1$$

  $$\pi_2(q_1, q_2) = q_2[a - b(q_1 + q_2)] - q_2 m_2 - F_2$$

Step 2: Obtain the best responses.

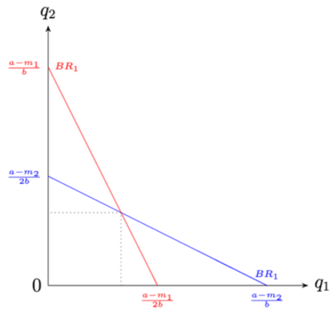
Given $\pi_1(q_1, q_2) = q_1[a - b(q_1 + q_2)] - q_1 m_1 - F_1$,

$$\frac{\partial \pi_1(q_1, q_2)}{\partial q_1} = [a - b(q_1 + q_2)] + q_1(-b) - m_1 = 0$$

$$q_1 = \frac{a - m_1}{2b} - \frac{q_2}{2}$$

Similarly,

$$q_2 = \frac{a - m_2}{2b} - \frac{q_1}{2}$$



q2 is 0, this will be the monopoly output (The first part of the equation is monopoly output)

Step 3: Combine the best responses to find the Cournot Nash equilibrium:

$$q_1 = \frac{a - m_1}{2b} - \frac{q_2}{2}$$

implies

$$q_1 = \frac{a - m_1}{2b} - \frac{\frac{a-m_2}{2b} - \frac{q_1}{2}}{2}$$

Solving, the the Cournot Nash equilibrium is

$$q_1 = \frac{a - 2m_1 + m_2}{3b}$$

$$q_2 = \frac{a - 2m_2 + m_1}{3b}$$

$$q_1 = \frac{a - 2m_1 + m_2}{3b}$$

$$q_2 = \frac{a - 2m_2 + m_1}{3b}$$

The combined profit of the whole market is the same as the monopoly profit.

$$For\ Q = q_1 + q_2$$

$$Profit\ = [P(q_1 + q_2) - m](q_1 + q_2) = [P(Q) - m]Q = \pi^m(Q)$$

- The best possible outcome for the firms is the production that produces the same amount combined as a monopoly would (which is not necessarily an equilibrium)

10.2.3 Stackelberg Model

Close to the Cournot model - but here into profit instead of BR.

- Insert the best response of F2 into the profit function of F1.
- Derive and set to 0. Isolate for q1/p1 and use this to find the value of F2.
- *See exercises 7.3 + 7.4*

More on game theory

- First firm 1 chooses q and THEN firm 2 chooses q
- Best response of $q_2 = \frac{a-m_2}{2b} - \frac{q_1}{2}$ or vice versa (This is the SPNE or Stackelberg Equilibrium) while $q_1 = \frac{a-\frac{a-m_2}{2}-m_1}{b}$ (Not sure it works)
- There can occur first or second mover advantages.
- If there are more firms, you write e.g. $q_3 = \frac{a-m_3}{2(b)} - \frac{q_1+q_2}{2}$
- When there are no marginal costs then Stackelberg leader -> $q_1 = \frac{a-2bq_2}{2b}$

10.3 Oligopoly with differentiated products

- Firms sell somewhat different products or more than one product
- Each firm has its own demand function (Which can depend on price/output of others in the market.
- Can compete on price or quantity

10.3.1 Price competition

- Even though products are substitutes, the lower price of one will not mean an immediate stop of the other.
- Find payoffs (same as profits), take partial derivative, set equal to 0 and find inverse demand function. (See overhead week 47 for example).
- Find equilibrium (Insert payoff into the other payoff (not in profit as in Stackelberg) and insert amount into the Bertrand Nash Equilibrium.
  Pay-offs/profits can be written as

$$\pi_1(p_1, p_2) = (p_1 - mc)(demand\ function)$$

10.3.2 Quantity competition

- Do as in Cournot Nash for homogenous but make the derivatives etc. yourself.

Game theory

11 Games and Strategies

11.1 Overview

- Strategic situation - where the outcomes are determined by are than one decision-maker.
- A game - a model of a strategic situation
  - Specified by the players (Decision-makers)
  - Strategies of a player (Actions possible)
  - Payoffs of a player (Benefits, utilities, profits of chosen strategy)
- Best response = what maximizes my payoff given strategies chosen by other players
  - Dominant strategy - best response is the same no matter what others have chosen.
  - Dominant strategy equilibrium - each player is playing a dominant strategy (therefore unable able to move)
  - Nash equilibrium (NE) - combination of strategies such that each player has the best response to the strategy of other players.
    - When writing it down - down write the actions, not profits

11.2 Simultaneous games

- Timing of action not important
- Static or normal-form games
- Bertrand and Cournot competition for homogenous products.
  - Cournot for more than two firms - found in week 48 slides
    - $q = \frac{a-m}{(n+1)b}$ and $P = \frac{a}{n+1} + \frac{nm}{n+1}$ (for large n, equilibrium close to m)
- Bertrand competition differentiated products.
- Pay-off matrix - possible payoffs for each combination of strategies.

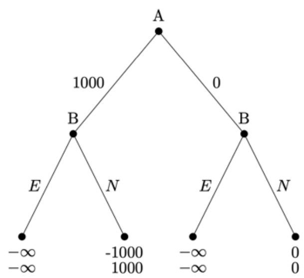
		Rebecca	
		P	V
Ethan	P	4, 3	1, 1
	V	0, 0	3, 4

- There are no dominant strategy equilibria.
  The NE are (P, P) and (V, V).

11.3 Sequential games

- Timing of action important - choose at given moment and possible again many more times later.
- Extensive form games.
  - Specifies players
  - When each player has the move
  - What each player can at each move
  - What each player knows when she gets the move
  - The payoffs.
- Game-trees to represent extent of choices (Where it branches out it becomes a subgame)

Game tree for the bomb game



SPNE: A chooses 0, B chooses (N, N).
Equilibrium payoffs will be 0 for A and 0 for B.

- Subgame - extensive game within the extensive form game
  - Begins at decision node *n*
  - Includes all nodes following node n but not nodes that do not follow node n.

Subgame Perfect Nash Equilibrium (SPNE)

  - The strategy is NE of the game

- For each subgame the restriction of the strategy profile to that subgame is itself a NE of the subgame.
- Strategy of each player in a SPNE must be a best-response each time she gets to move, given the strategies of other players
- It rules out equilibria that rely on incredible threats in a dynamic environment
- All SPNE are identified by backward induction.
- More than one SPNE dependent on who chooses first.

Examples

- In an example with vaccines, a person only participates at the NE of $\frac{1}{N}B \geq c$ Which can be problematic as many will choose not to participate.
- In an example with public goods put into a game, the equilibrium will be a prisoners dilemma at low/low effort. Which means no one will contribute anyhow. Solution - make direct regulations (or threat of it)
    - If giving subsidies instead. The tax must be added to the player as well. I.e. only the people who contribute get the subsidy as well.

Externalities

13 Third part externalities

- Many actions taken by individuals and firms affect others - even if such features don't directly benefit or cost them
- Negative externalities will always be more costly to society than to the firm?
- Negative externalities - have a negative welfare effect on others
    - Pollution, reckless behaviour, noise people
- Positive
    - Vaccines, education, healthy lifestyle
- Generally, an efficient (welfare maximizing) output will occur when the marginal social benefit equals the marginal social cost. Other output levels will generate dead-weight losses.
- Taxes and subsidies can be used to reach the efficient outcome or reduce the dead-weight losses

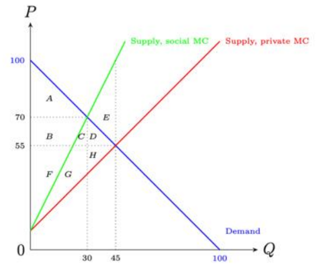
- In a "sense" monopolies could be better in terms of this as they produce less than the social optimum.

13.1 Negative production externalities in a competitive market

Look at week 48 slides for an example.

- Competitive markets produce too much, when there are negative externalities.
- Social producer surplus - measures the total cost to society of producing a given number of units.
- When given the damage - take derivate to get marginal external cost.
- The marginal social cost will be marginal external cost + marginal cost

Negative production externality in a competitive market



optimum output $\rightarrow$ competitive output

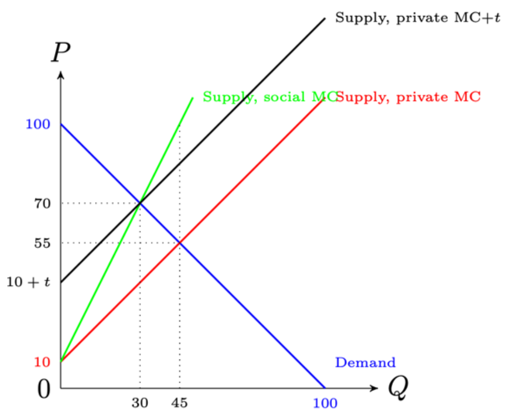
	Social optimum	Private	Change
CS	A	$A+B+C+D$	$B+C+D$
private PS	$B+C+F+G$	$F+G+H$	$H-B-C$
Externality	$C+G$	$C+D+E+G+H$	$D+E+H$
social PS	$B+F$	$F-C-D-E$	$-B-C-D-E$
Welfare	$A+B+F$	$A+B+F-E$	$-E$

where welfare is CS + social PS. The DWL is E

- Area between the two curves is the externality
- Benefit to society will simply be inverse demand curve.

13.1.1 Pigouvian tax

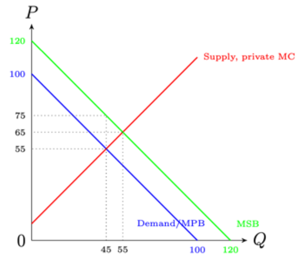
A per unit tax of t paid by sellers can correct for the externality, leading suppliers to internalize it.



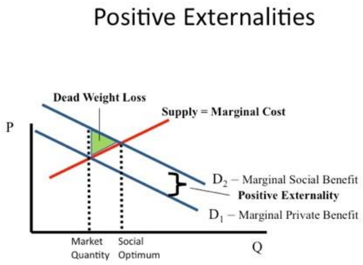
13.2 Positive consumption externality in a competitive market

- Occurs when consumption has benefits not captured solely by the consumer.
    - Positive - vaccines, education
    - Negative - drugs, ugly stuff
- The marginal social benefit (MSB) is $Q^D + benefit\ per\ unit$
- Social consumer surplus - measures the total benefit given to society of consuming a number of units.

Positive consumption externality in a competitive market



The DWL is 10(75 − 55)/2.



13.3 Types of Goods (Or Resources)

- Rival - one person's consumption means that another person cannot consume that same good.
- Non-rival - things like software, knowledge etc.
- Excludable - if you can exclude people from consuming it.
- Non-excludable - like national defence, light house, clean environment

	Excludable	Non-excludable
Rival	Private goods	Common goods
Non-rival	Club goods	Public goods

13.3.1 Common Good

- Rival and non-excludable
- Example (using Cournot competition)

Fishermen $1, 2, \dots, n$ share a lake.

Fishermen $i = 1, 2, \dots, n$ spends h_i hours fishing

$H = h_1 + h_2 + \cdots + h_n$

The number of fish caught by a fisherman per hour is $100 - H$ and each fish can be sold for 5 euro. The cost of each hour fishing is 100 euro.

Given $(h_1, h_2, \cdots, h_n)$, the profit of fisherman $i = 1, 2, \dots, n$ is

$$\begin{aligned} \pi_i &= h_i 5[100 - (h_1 + \cdots + h_n)] - h_i 100 \\ &= h_i(500 - 5H) - h_i 100 \end{aligned}$$

The NE is $(h_1, \dots, h_n) = (h, \dots, h)$ where

$$h = \frac{500 - 100}{(n+1)5} = \frac{80}{n+1}$$

Suppose from here on that $n = 9$. Then, $h = 8$ and the profit of each fisherman is

$$8(500 - 5[8 \times 9]) - 8 \times 100 = 320$$

The total profit is $9 \times 320 = 2880$.

Suppose that the fishermen acted in their common interest, maximizing

$$\pi(H) = H5(100 - H) - H100 = H(500 - 5H) - H100$$

Then,

$$\pi'(H) = 500 - 10H - 100 = 0$$

implies $H = 40$.

$$\pi(H) = 40(500 - 5 \times 40) - 40 \times 100 = 8000$$

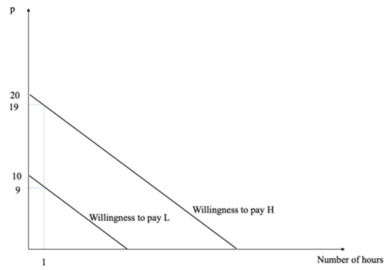
- The fishermen fish too much in the NE!
- Would be even worse if more fishermen (free entry) could start fishing in the lake!

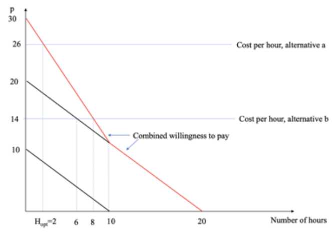
- The negative externality could be them inducing the externality on others instead of internalizing it. Solutions could be
    - Quantity restrictions
    - Increase the cost (license fee)
    - Local rules and social norms.

13.3.2 Public good

- Whoever provides an amount of a public good creates positive externalities.
- Free-rider problem: When people can benefit when they do not contribute, the amount provided will be too low.

The marginal benefit of person L is $p_L = 10 - h$ and that of person H is $p_H = 20 - h$





$$p = \begin{cases} 20 - h & \text{if} \quad 10 < h \leq 20 \\ 30 - 2h & \text{if} \quad h \leq 10 \end{cases}$$

Optimum would be (8,14) but due to free-rider problem it will be the one person with highest WTP who pays.

Risk and Asymmetry Information

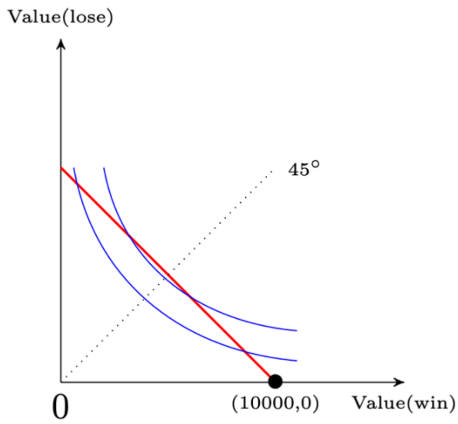
Risk

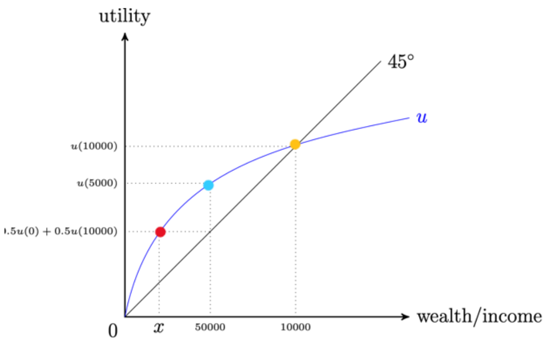
Risk Preferences

Overhead on risk

- Expected value - the probability-weighted average of the possible values.
- $\Pr(s_1)\text{Value}(s_1) + \Pr(s_2)\text{Value}(s_2) + \cdots + \Pr(s_n)\text{Value}(s_n)$

- Indifference curve



- Compute in a utility function with selling vs. keeping in the example.
- Marginal utility of income.
- 

Diminishing marginal utility
- Red - expected utility for taking the risk
- Blue - For sure getting 5000 - has a higher utility than taking the risk.
- Yellow - Utility when winning the 10.000

Risk Attitudes

- Risk neutral - if she chooses the option that maximizes expected value.
- Risk averse - if she prefers to have the expected value amount in every possible state rather than face the probabilities of the various states and the resulting values. (Would be like an L shape (perfect complements)
    - I.e. the slope of u gets flatter
    - For bundle $U(w_1, w_2)$ it would be saying there is a diminishing marginal utility for w_1 and w_2.

14 Information

Symmetric information - Everyone is equally knowledgeable or equally ignorant about prices, product quality, and other factors relevant to a transaction.

14.1 Asymmetric information

Overhead week 49 with examples

One party to a transaction has relevant information that another party lacks.

- Hidden information - An attribute of a person or thing that is known to one party but unknown to others.
- Hidden action - An act by one party to a transaction that is not observed by the other party.
- Asymmetric information leads to two problems
  - Adverse selection - occurs when one party to a transaction possesses information about a hidden information that is unknown to other parties and takes economic advantage of this information.
    - Examples: Insurance, credit, ethical production, difficult to judge quality for buyer (dentists, carpentry, car repair)
    - Solutions: Group policies, government regulations, certifications, ability to return, signaling by the party with more information
  - Moral hazard - occurs when an informed party takes an action that the other party cannot observe and that harms the less-informed party.
- Signaling - The more informed party can successfully signal high quality if it is less costly to signal for high quality products than what it is for low quality products to signal.
  - If having high quality car - set out warranty to reveal information.
  - Education easier and thus less costly if you're ambitious and smart ⇒ value of going to tough university even assuming you wouldn't learn anything useful.