ECON-UN 3211 - Intermediate Microeconomics

Recitation 7: Introduction to general equilibrium

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Plan for today

Midterm feedback

Practice questions for Problem Set 6

Introduction to general equilibrium

Practice questions for Problem Set 7

Midterm feedback

Q1. Find a utility function representing the following preferences
(a) Jesabelle spends all of her income on the good with the lowest price

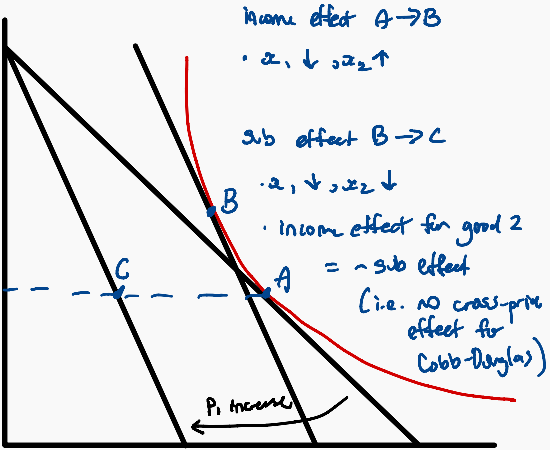
- $u(x) = x_1 + x_2$
- Also valid: symmetric concave preferences like $u(x) = \max\{x_1, x_2\}$
- Some people wrote $u(x) = \alpha x_1 + \beta x_2$ but this only works when $\alpha = \beta$

Q1. Find a utility function representing the following preferences
(b) Carly always buys an equal number of units of good 1 and 2

- $u(x) = \min\{x_1, x_2\}$ (or $\min\{f(x_1), f(x_2)\}$ for any positive increasing transformation $f(\cdot)$)
- Some people wrote $u(x) = \min\{\alpha x_1, \beta x_2\}$ but this only works when $\alpha = \beta$

Q2. With two budget lines, illustrate the income and substitution effects when the price of good 1 increases and preferences are Cobb-Douglas

- Draw the correct budget lines
- Show the correct direction of change: a price increase in good 1 means any substitution effect will involve consuming less of good 1 and more of good 2
- Label the effects properly: it's the change in x_1 and x_2
- Capturing the zero cross-price effect of the Cobb-Douglas



Q4. Derive the Marshallian demand for preferences $u(x) = 12\sqrt{x_1} + x_2$

- Recognize this is an example of quasi-linear utility
- Our approch for these: assume an interior solution and see where it is feasible
- If nowhere, then we only have corner solutions
- If only in some places, then we will have piecewise demand and at least two cases (which is the case here)

Practice questions for Problem Set 6

1. A firm faces cost function $c(q) = 10 + 2q^2$ and demand $q = 600 - \frac{p}{2}$

(a) What is the optimum supply choice?

$$\max_q \; p(q)\cdot q - c(q)$$

$$= \max_q \; (1200 - 2q)\cdot q - (10 + 2q^2)$$

$$= \max_q \; 1200q - 2q^2 - 10 - 2q^2$$

$$= \max_q \; \underline{1200q - 4q^2 - 10}$$

$$\frac{p}{2} = 600 - q$$

$$\Rightarrow \underline{p(q) = 1200 - 2q}$$

$$FOC_q : 0 = \underline{1200 - 8q}$$

$$\Rightarrow q^* = \frac{1200}{8} = 150$$

$SOC_q : -8 < 0 \Rightarrow \pi(q)$ is concave

and q^* is profit maximizing supply

1. A firm faces cost function $c(q) = 10 + 2q^2$ and demand $q = 600 - \frac{p}{2}$
(b) What is the resulting price?

$q^* = 150$

$$p(q^*) = 1200 - 2(150)$$
$$= 1200 - 300$$
$$= 900$$

$p^* = 900$

1. A firm faces cost function $c(q) = 10 + 2q^2$ and demand $q = 600 - \frac{p}{2}$
(c) What profit will the firm make?

$$\pi(q) = p(q)\cdot q - c(q)$$

$$= (1200 - 2q)\cdot q - 10 - 2q^2$$

$$\pi(q^*) = (1200 - 300)\cdot 150 - 10 - 2(300)^2$$

$$= 900 \cdot 150 - 10 - 2 \cdot 900$$

$$\boxed{= 89{,}990}$$

$$\pi(q^*) > \pi(0)$$

$\therefore q^*$ is profit-maximizing

$$\pi(0) = p(0)\cdot 0 - c(0)$$

$$= 10$$ (Boundary conditions

Two types of consumers

1. Type A demand: $q_A^D(p) = 100 - p$
2. Type B demand: $q_B^D(p) = 50 - 2p$

One type of firm

1. Supply function $q^S(p) = p$

Suppose the market features:

- There are 10 Type A consumers
- There are 20 Type B consumers
- There are 50 identical firms

(a) What is the aggregate demand in this market?

$q_A^D(p) = 0$ if $p > 100$

$q_B^D(p) = 0$ if $p > 25$

$$Q^D(p) = \begin{cases} 10q_A^D(p) + 20q_B^D(p) \quad \text{if } p \le 25 \\ = 10(100-p) + 20(50-2p) \\ = 1000 - 10p + 1000 - 40p \\ = 2000 - 50p \\ 10q_A^D(p) = 10(100-p) \quad \text{if } 25 < p \le 100 \\ = 1000 - 10p \\ 0 \quad \text{if } p > 100 \end{cases}$$

2. Competitive equilibrium

Two types of consumers

1. Type A demand: $q_A^D(p) = 100 - p$
2. Type B demand: $q_B^D(p) = 50 - 2p$

One type of firm

1. Supply function $q^S(p) = p$

Suppose the market features:

- There are 10 Type A consumers
- There are 20 Type B consumers
- There are 50 identical firms

(a) What is the aggregate demand in this market?

(Same as previous slide, just cleaner)

$$Q^D(p) = \begin{cases} 2000 - 50p & \text{if } p \leq 25 \\ 1000 - 10p & \text{if } 25 < p \leq 100 \\ 0 & \text{if } p > 100 \end{cases}$$

Two types of consumers

1. Type A demand: $q_A^D(p) = 100 - p$
2. Type B demand: $q_B^D(p) = 50 - 2p$

One type of firm

1. Supply function $q^S(p) = p$

Suppose the market features:

- There are 10 Type A consumers
- There are 20 Type B consumers
- There are 50 identical firms

(b) What is the aggregate supply in this market?

$$Q^S(p) = 50\, q^S(p)$$
$$= 50p$$

[In recitation, I mistakenly wrote 10 instead of 50]

Two types of consumers

1. Type A demand: $q_A^D(p) = 100 - p$
2. Type B demand: $q_B^D(p) = 50 - 2p$

One type of firm

1. Supply function $q^S(p) = p$

Suppose the market features:

- There are 10 Type A consumers
- There are 20 Type B consumers
- There are 50 identical firms

(c) Find the competitive equilibrium

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

$$\Rightarrow 2000 - 50p = 50p$$

$$\Rightarrow p^* = \frac{2000}{100} = 20$$

$$q^* = 50p^*$$
$$= 50(20)$$
$$= 1000$$

Two types of consumers

1. Type A demand: $q_A^D(p) = 100 - p$
2. Type B demand: $q_B^D(p) = 50 - 2p$

One type of firm

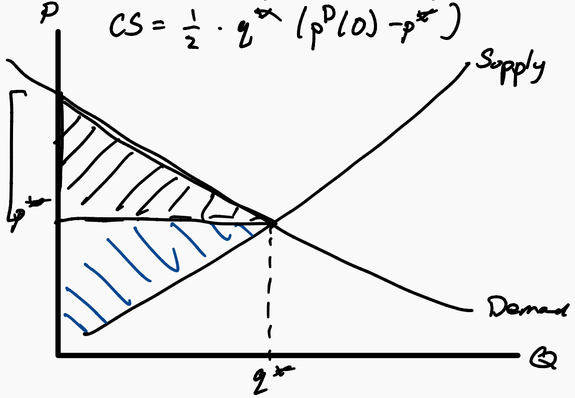
1. Supply function $q^S(p) = p$

Suppose the market features:

- There are 10 Type A consumers
- There are 20 Type B consumers
- There are 50 identical firms

(d) What is consumer/producer surplus?

$CS = \frac{1}{2} \cdot q^* (p^D(0) - p^*)$



Two types of consumers

1. Type A demand: $q_A^D(p) = 100 - p$
2. Type B demand: $q_B^D(p) = 50 - 2p$

One type of firm

1. Supply function $q^S(p) = p$

Suppose the market features:

- There are 10 Type A consumers
- There are 20 Type B consumers
- There are 50 identical firms

(d) What is consumer/producer surplus?

$CS = CS^A + CS^B$

CS^A : $Q_A^D(p) = 10 q_A^D(p)$

$= 1000 - 10p$

$Q_A^D(p^*) = 1000 - 10 \cdot 20 \underline{= 800}$

$CS^A = \frac{1}{2}(Q_A^D(p^*))(P_A^D(0) - p^*)$

$= \frac{1}{2}(800)(100 - 10(0) - 20)$

$= \frac{1}{2}(800) \times 80 = 32{,}000$

Two types of consumers

1. Type A demand: $q_A^D(p) = 100 - p$
2. Type B demand: $q_B^D(p) = 50 - 2p$

One type of firm

1. Supply function $q^S(p) = p$

Suppose the market features:

- There are 10 Type A consumers
- There are 20 Type B consumers
- There are 50 identical firms

(d) What is consumer/producer surplus?

$$CS^B = \frac{1}{2}\left(Q_B^D(p^*)\right)\left(p_B^D(0) - p^*\right)$$

$$= \frac{1}{2}(200)(25-20)$$

$$= 500$$

$$CS = CS^A + CS^B$$

$$= 32{,}000 + 500$$

$$= 32{,}500$$

Two types of consumers

1. Type A demand: $q_A^D(p) = 100 - p$
2. Type B demand: $q_B^D(p) = 50 - 2p$

One type of firm

1. Supply function $q^S(p) = p$

Suppose the market features:

- There are 10 Type A consumers
- There are 20 Type B consumers
- There are 50 identical firms

(d) What is consumer/producer surplus?

Producer Surplus

$\frac{1}{2}(p^* - 0)(q^*)$

$= (20 \times 1000) \cdot \frac{1}{2}$

$= (20{,}000) \cdot \frac{1}{2}$

$= 10{,}000$

Two types of consumers

1. Type A demand: $q_A^D(p) = 100 - p$
2. Type B demand: $q_B^D(p) = 50 - 2p$

One type of firm

1. Supply function $q^S(p) = p$

Suppose the market features:

- There are 10 Type A consumers
- There are 20 Type B consumers
- There are ~~50~~ **10** identical firms

(e) What is the new equilibrium?

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

First assume both Types A and B participate

$2000 - 50p = 10p$

$\Rightarrow p^* = \frac{2000}{60p} \approx 33$ $\Rightarrow$ Type B will not participate in equilibrium

Now solve assuming only Type A participates:

$\underline{1000 - 10p} = 10p$

$\Rightarrow p^* = \frac{1000}{20} = 50$

$\Rightarrow q^* = Q^S(p^*) = 10 \cdot 50 = 500$

Two types of consumers

1. Type A demand: $q_A^D(p) = 100 - p$
2. Type B demand: $q_B^D(p) = 50 - 2p$

One type of firm

1. Supply function $q^S(p) = p$

Suppose the market features:

- There are 10 Type A consumers
- There are 20 Type B consumers
- There are ~~50~~ 10 identical firms

(f) What is the new consumer/producer surplus?

$CS = \frac{1}{2}(1000 - 10p^{**})(p_A^D(0) - p^{**})$

$= 12,500$

$PS = \frac{1}{2}(q^{*})(p^{*})$

$= 12,500$

$\Delta CS = 12,500 - 32,500 = -20,000$

$\Delta PS = 12,500 - 10,000 = 2,500$

Consumer surplus $\downarrow$, producer surplus $\uparrow$

2. Competitive equilibrium

Two types of consumers

1. Type A demand: $q_A^D(p) = 100 - p$
2. Type B demand: $q_B^D(p) = 50 - 2p$

One type of firm

1. Supply function $q^S(p) = p$

Suppose the market features:

- There are 10 Type A consumers
- There are 20 Type B consumers
- There are ~~50~~ **10** identical firms

See recitation 6 for discussion of price and quantity effects

(g) Do these changes in surplus make sense?

- The consumer population has not changed but prices have increased quantity effect
- Thus, fewer consumers are being served so we should expect a decrease in CS
- There are fewer firms but prices have increased so effect on producer surprlus ambiguous price effect
- However, prices have increased more than the quantity has decreased so total producer surplus has increased
- Each individual firm experiences an even more significant increase in surplus

3. Taxes, subsidies, and deadweight loss

(a) Calculate the deadweight loss of a $300 tax per unit on consumers

$Q^{D+tax} = 12000 - 10(p+300)$

- $Q^D(p) = 12000 - 10p$
- $Q^S(p) = 15p$

$DWL = \frac{1}{2}(q^* - q^{**})(300)$

$= 270{,}000$

Pre-tax: $Q^D(p) = Q^S(p)$

$\Rightarrow 12000 - 10p = 15p$

$\Rightarrow 25p^* = 12000$

$\Rightarrow p^* = \frac{12000}{25} = 480$

$\Rightarrow q(p^*) = 15(480)$

$= 7200$

Post-tax: $12000 - 10p - 300 = 15p$

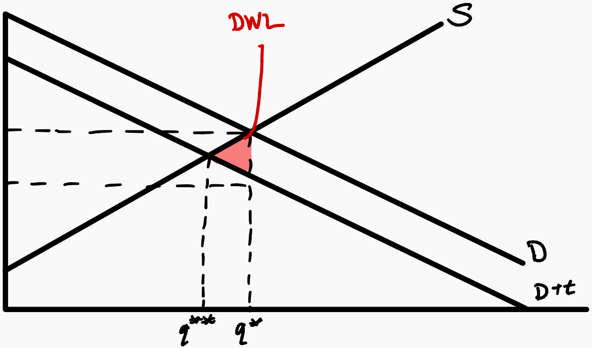
$\Rightarrow p^{**} = \frac{1}{25}(9000) = 360$

$\Rightarrow q(p^{**}) = 15 \cdot 360 = 5400$

3. Taxes, subsidies, and deadweight loss
(a) Calculate the deadweight loss of a $300 tax per unit on consumers

$Q^{D+t}(p) = 12000 - 10(p+300)$ $\quad p^{D+t}(q^*)$

- $Q^D(p) = 12000 - 10p$
- $Q^S(p) = 15p$



$$DWL = \frac{1}{2}(q^* - q^{**})((p+300) - p)$$
$$= \frac{1}{2}(7200 - 5400)(300)$$
$$= 270{,}000$$

Example 3: Taxes, subsidies, and deadweight loss
(b) Calculate the deadweight loss of a \$300 subsidy per unit to producers

- $Q^D(p) = 12000 - 10p$
- $Q^S(p) = 15p$

$\Downarrow$

$Q^S(p) = 15(p+300)$
$= 15p + 4500$

<u>Post-subsidy</u> : $12\,000 - 10p = 15(p+300)$

$\Rightarrow p^{**} = \frac{1}{25}(12\,000 - 4500)$

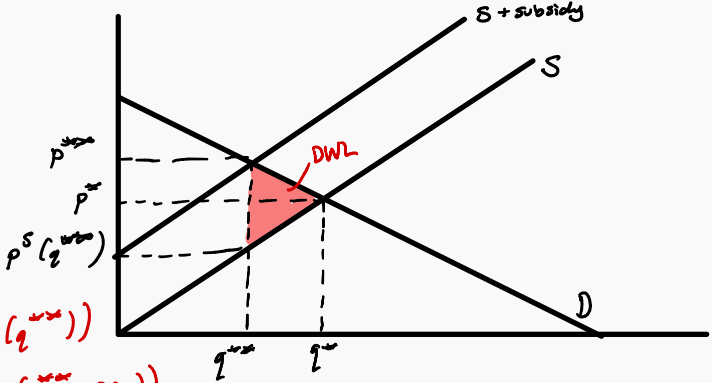
$= 300$

$\Rightarrow q^{**} = 15 \cdot 300 + 4500$

$= 9000$

Example 3: Taxes, subsidies, and deadweight loss
(b) Calculate the deadweight loss of a \$300 subsidy per unit to producers

- $Q^D(p) = 12\cancel{2}000 - 10p$
- $Q^S(p) = 15p$



$$DWL = \frac{1}{2}\left(q^* - q^{**}\right)\left(p^{**} - p^S(q^{**})\right)$$

$$= \frac{1}{2}\left(7200 - 9000\right)\left(p^{**} - (p^{**} + 300)\right)$$

$$= \frac{1}{2}(-1800)(-300)$$

$$= 270{,}000$$

∴ same welfare loss regardless of whether consumer gets taxed or producer subsidized

Introduction to general equilibrium

General equilibrium theory

General equilibrium the method

- Exogenous primitives (number of agents, number of goods, technologies, preferences, endowments)
- Simultaneous mutual resolution of agents behaviors as specified by primitives
- Result: "equilibrium" prices and quantities

General equilibrium the theory

- Assumptions: perfect competition
  1. Price-taking behavior
  2. Symmetric information
  3. Markets for all goods
- These strong assumptions buy us an elegant theory integrating consumer and producer theory
- Key result: the fundamental theorems of welfare economics

Pure exchange: the Edgeworth box

Three basic economic activities:

1. Consumption
2. Production
3. Exchange

The Edgeworth box is a very simplified general equilibrium model of a *pure* exchange economy

- No production, just endowments $w = (w^A, w^B)$
- Given initial endowments, preferences over the goods determine what exchange unfolds

Very simple and abstract

- Two agents exchange two goods according to initial endowments and the interaction of their preferences
- No production, firms, or mediums of exchange (i.e., money)

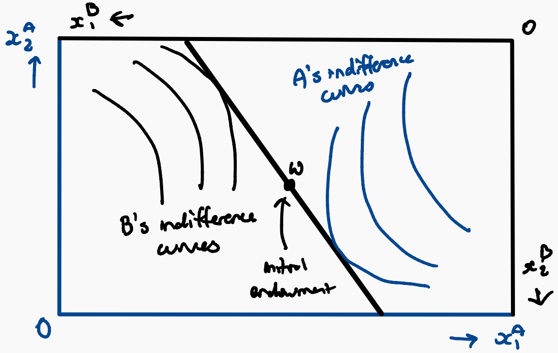
But rich in its insights

- Depicts how prices arise as a mechanism for clearing markets
- Depicts how preferences and endowments give rise to 'wealth'
- Depicts market efficiency and opportunities for mutual benefit

The Edgeworth box: capturing insights from consumer theory

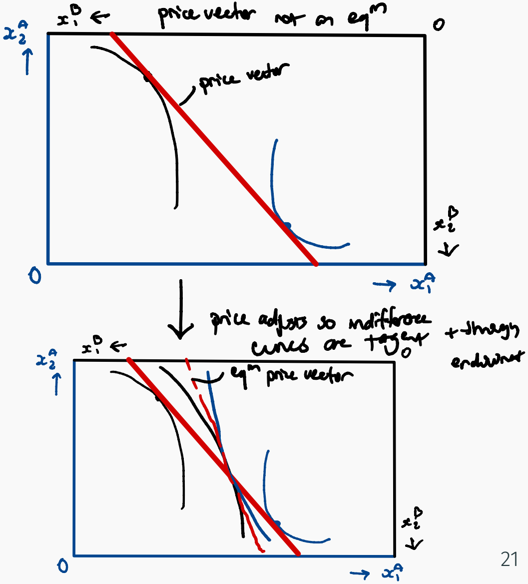
We can plot the familiar lines from consumer theory

- Wealth/income as the product $p \cdot q$
- Budget lines divide the two budget sets capture relative prices between two goods
- Indifference curves reflect the two consumers' preferences
- Tangency condition for well-behaved preferences depict optimal consumer behaviors
- Tracing these bundles as budget line changes gives us offer curves



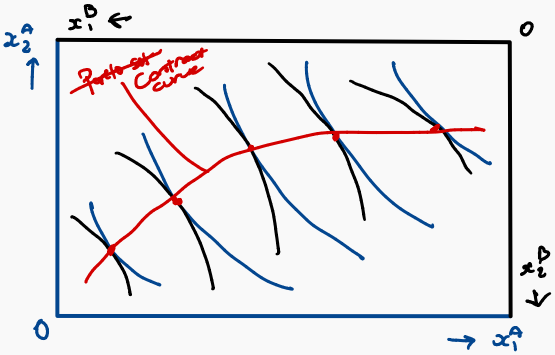
The Edgeworth box: equilibrium adjustments and prices as a rate of exchange

- Given a price vector, we see that the two tangent indifference curves may occur at different points
  - Consumer 1 is in net demand for good 2, consumer 2 in net supply
- Equilibrium adjustment: change the relative prices of the two goods so they are both tangent to the budget line at the same point
- In fact, the equilibrium budget line through initial endowments implies a price ratio where the two consumers' offer curves intersect



The Edgeworth box: Pareto optimality and contract curves

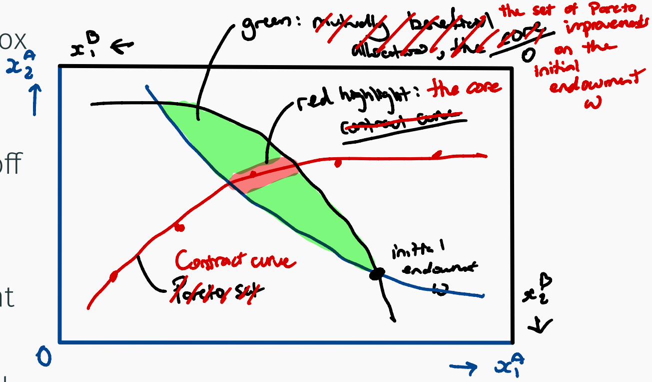
- An allocation x in the Edgeworth box is **Pareto optimal/efficient** if there is no other feasible allocation x' that makes one consumer better off without making another worse off
- Trace out the points where indifference curves are just tangent to one another: the ~~Pareto set~~ contract curve
- For a given initial endowments, only a subset of the ~~Pareto set~~ contract curve is a Pareto improvement: we call this the ~~contract curve~~ core



Pareto set given by $MRS^A = MRS^B$

The Edgeworth box: Pareto optimality and contract curves

- An allocation x in the Edgeworth box is **Pareto optimal/efficient** if there is no other feasible allocation x' that makes one consumer better off without making another worse off
- Trace out the points where indifference curves are just tangent to one another: the ~~Pareto set~~ contract curve
- For a given initial endowments, only a subset of the ~~Pareto set~~ contract curve is a Pareto improvement: we call this the ~~contract curve~~ core



Practice questions for Problem Set 7

1. Competitive equilibrium with negative externalities
(a) Find the competitive equilibrium

1. Demand: $Q^D(p) = 1200 - 8p$
2. Supply: $Q^S(p) = 2p$
3. Externalities: $E(q) = -\frac{1}{16}q^2$

$1200 - 8p = 2p$

$\Rightarrow p^* = 120$

$\Rightarrow q^* = Q^S(p^*)$

$= 2(120)$

$= 240$

$(p^*, q^*) = (120, 240)$

1. Competitive equilibrium with negative externalities
(b) Find the inverse demand function and inverse supply function

$8p = 1200 - q$

$\Rightarrow p^D(q) = \frac{1200 - q}{8}$

1. Demand: $Q^D(p) = 1200 - 8p$
2. Supply: $Q^S(p) = 2p$
3. Externalities: $E(q) = -\frac{1}{16}q^2$

$p^S(q) = \frac{q}{2}$

Results

- $(p^*, q^*) = (120, 240)$

1. Competitive equilibrium with negative externalities
(c) Find the marginal social value curve

$$MSV(q) = p^D(q) + ME(q)$$

$$= 150 - \frac{q}{8} - \frac{q}{8}$$

$$= 150 - \frac{q}{4}$$

1. Demand: $Q^D(p) = 1200 - 8p$
2. Supply: $Q^S(p) = 2p$
3. Externalities: $E(q) = -\frac{1}{16}q^2$

$\frac{dE(q)}{dq} = ME(q) = -\frac{1}{8}q$

Results

- $(p^*, q^*) = (120, 240)$
- $p^D(q) = 150 - \frac{q}{8}$
- $p^S(q) = \frac{q}{2}$

1. Competitive equilibrium with negative externalities
(d) Find the surplus-maximizing quantity

1. Demand: $Q^D(p) = 1200 - 8p$
2. Supply: $Q^S(p) = 2p$
3. Externalities: $E(q) = -\frac{1}{16}q^2$

Results

- $(p^*, q^*) = (120, 240)$
- $p^D(q) = 150 - \frac{q}{8}$
- $p^S(q) = \frac{q}{2}$
- $MSV(q) = 150 - \frac{q}{4}$

$$MSV(q) = p^S(q)$$

$$\Rightarrow 150 - \frac{q}{4} = \frac{q}{2}$$

$$\Rightarrow 150 = \frac{3q}{4}$$

$$\Rightarrow q^{\cancel{**}} = 150 \times \frac{4}{3}$$

$$= 200$$

1. Competitive equilibrium with negative externalities
(e) Calculate the deadweight loss of the competitive equilibrium

1. Demand: $Q^D(p) = 1200 - 8p$
2. Supply: $Q^S(p) = 2p$
3. Externalities: $E(q) = -\frac{1}{16}q^2$

Results

- $(p^*, q^*) = (120, 240)$
- $p^D(q) = 150 - \frac{q}{8}$
- $p^S(q) = \frac{q}{2}$
- $MSV(q) = 150 - \frac{q}{4}$

$$MSV(q^*) = 150 - \frac{q^*}{8}$$
$$= 150 - \frac{240}{8} = 120$$

$$DWL = \frac{1}{2}\left(p^* - MSV(q^*)\right)\left(q^* - q^{**}\right)$$
$$= \frac{1}{2}\left(120 - 150 + \frac{240}{4}\right)(240 - 200)$$
$$= \frac{1}{2}(-30 + 60)(40)$$
$$= \frac{1}{2}(30)(40) = 600$$

1. Competitive equilibrium with negative externalities
(f) Find the optimal per-unit tax for this market

$t^* = ME(q^*)$

$= -\frac{1}{8} \cdot 240$

$= -60$

1. Demand: $Q^D(p) = 1200 - 8p$
2. Supply: $Q^S(p) = 2p$
3. Externalities: $E(q) = -\frac{1}{16}q^2$

Results $ME(q) = -\frac{1}{8} \cdot q$

$t^* = MSV(q^*) - p^D(q^*)$

- $(p^*, q^*) = (120, \underline{240})$
- $p^D(q) = 150 - \frac{q}{8}$
- $p^S(q) = \frac{q}{2}$
- $MSV(q) = 150 - \frac{q}{4}$

$= ME(q^*)$

$= -60$

1. Competitive equilibrium with negative externalities

(g) Find the optimal price floor and optimal price ceiling for this market

1. Demand: $Q^D(p) = 1200 - 8p$
2. Supply: $Q^S(p) = 2p$
3. Externalities: $E(q) = -\frac{1}{16}q^2$

Results

- $(p^*, q^*) = (120, 240)$
- $p^D(q) = 150 - \frac{q}{8}$
- $p^S(q) = \frac{q}{2}$
- $MSV(q) = 150 - \frac{q}{4}$

Price floor: $p^D(q^{**})$

$= 150 - \frac{q^{**}}{8}$

$= 150 - \frac{200}{8}$

$= 125$

Price ceiling: $MSV(q^{**})$

$= 150 - \frac{200}{4}$

$= 100$

2. Competitive equilibrium with ~~negative~~ positive externalities
(c) Find the marginal social value curve

$MSV(q) = p^D(q) + ME(q)$

$= 150 - \frac{q}{8} + 30$

$= 180 - q/8$

1. Demand: $Q^D(p) = 1200 - 8p$
2. Supply: $Q^S(p) = 2p$
3. Externalities: $E(q) = 30q$

$ME(q) = 30$

Results

- $(p^*, q^*) = (120, 240)$
- $p^D(q) = 150 - \frac{q}{8}$
- $p^S(q) = \frac{q}{2}$

2. Competitive equilibrium with ~~negative~~ positive externalities

(d) Find the surplus-maximizing quantity

1. Demand: $Q^D(p) = 1200 - 8p$
2. Supply: $Q^S(p) = 2p$
3. Externalities: $E(q) = 30q$

Results

- $(p^*, q^*) = (120, 240)$
- $p^D(q) = 150 - \frac{q}{8}$
- $p^S(q) = \frac{q}{2}$
- $MSV(q) = 180 - \frac{q}{8}$

$MSV(q) = p^S(q)$

$\Rightarrow 180 - q/8 = q/2$

$\Rightarrow 180 = 5q/8$

$\Rightarrow q^{**} = \frac{180 \cdot 8}{5}$

$= 288$

$\Rightarrow p^{**} = \frac{q^{**}}{2} = 144$

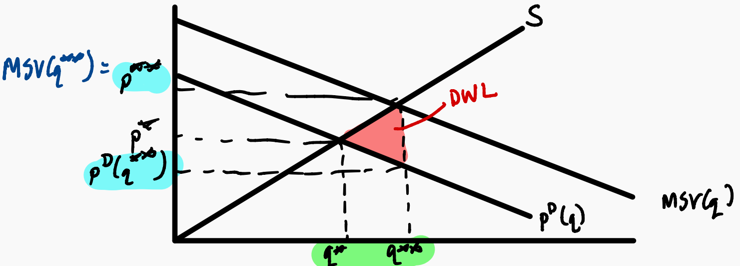
2. Competitive equilibrium with ~~negative~~ positive externalities
(e) Calculate the deadweight loss of the competitive equilibrium

1. Demand: $Q^D(p) = 1200 - 8p$
2. Supply: $Q^S(p) = 2p$
3. Externalities: $E(q) = 30q$

Results

- $(p^*, q^*) = (120, 240)$
- $p^D(q) = 150 - \frac{q}{8}$
- $p^S(q) = \frac{q}{2}$
- $MSV(q) = 180 - \frac{q}{8}$

$$DWL = \frac{1}{2}\left(MSV(q^{**}) - p^D(q^{**})\right)(q^{**} - q^*)$$
$$= \frac{1}{2}\left(144 - \left(150 - \frac{q^{**}}{8}\right)\right)(288 - 240)$$
$$= \frac{1}{2}\left(144 - \left(150 - \frac{288}{8}\right)\right)(48)$$
$$= \frac{1}{2}(144 - 150 + 36)(48) = 24 \cdot 30$$
$$= 720$$



2. Competitive equilibrium with ~~negative~~ positive externalities
(f) Find the optimal per-unit tax for this market

1. Demand: $Q^D(p) = 1200 - 8p$
2. Supply: $Q^S(p) = 2p$
3. Externalities: $E(q) = 30q$

Results $ME(q) = 30$

- $(p^*, q^*) = (120, 240)$
- $p^D(q) = 150 - \frac{q}{8}$
- $p^S(q) = \frac{q}{2}$
- $MSV(q) = 180 - \frac{q}{8}$

$t = ME(q^*)$

$= 30$

(positive number means subsidy of \$30/unit)

2. Competitive equilibrium with ~~negative~~ positive externalities
(g) Find the optimal price floor and optimal price ceiling for this market

1. Demand: $Q^D(p) = 1200 - 8p$
2. Supply: $Q^S(p) = 2p$
3. Externalities: $E(q) = 30q$

Results

- $(p^*, q^*) = (120, 240)$
- $p^D(q) = 150 - \frac{q}{8}$
- $p^S(q) = \frac{q}{2}$
- $MSV(q) = 180 - \frac{q}{8}$

Here, the market equilibrium quantity is lower than the socially optimal quantity.
Price floors and ceilings are only effective at reducing equilibrium quantities: they cannot induce increases in equilibrium quantities. Thus, there is no optimal price floor or ceiling.

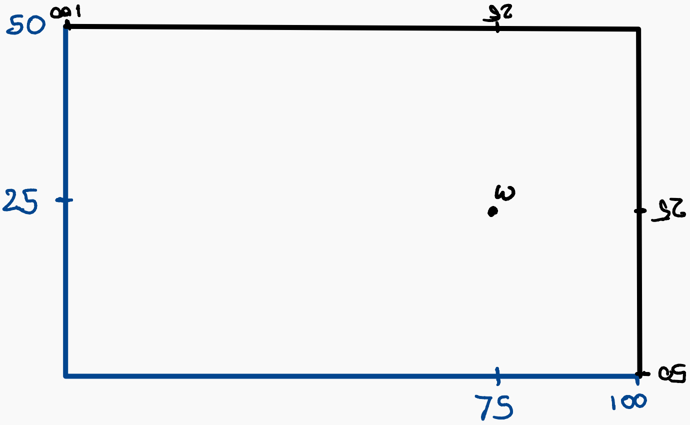
(a) Draw the Edgeworth box of this economy, depicting the initial endowment

Endowments w

1. $w^A = (75, 25)$
2. $w^B = (25, 25)$

Preferences

1. Cobb-Douglas: $u^A(x^A) = x_1^A x_2^A$
2. Perfect substitutes: $U^B(x^B) = x_1^B + x_2^B$



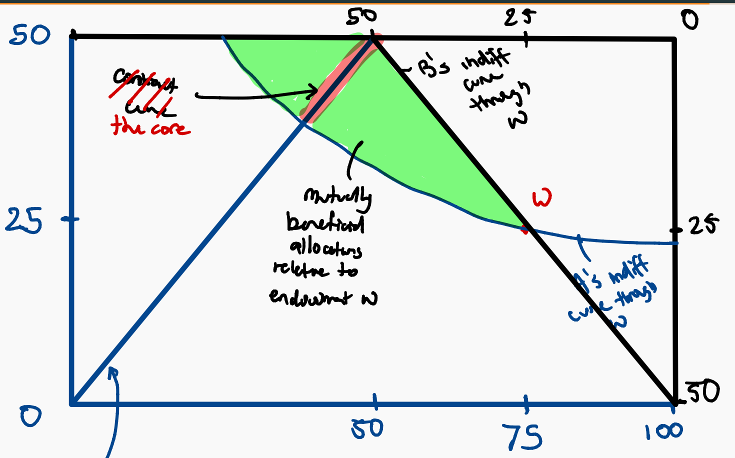
3. Exchange economies with an Edgeworth box
(b) Graph the contract curve, the set of Pareto improvements, and the core

Endowments w

1. $w^A = (75, 25)$
2. $w^B = (25, 25)$

Preferences

1. Cobb-Douglas: $u^A(x^A) = x_1^A x_2^A$
2. Perfect substitutes: $U^B(x^B) = x_1^B + x_2^B$



Contract curve: $MRS^A = MRS^B$

$\Rightarrow \dfrac{MU_1^A}{MU_2^A} = \dfrac{MU_1^B}{MU_2^B}$

$\Rightarrow x_2^A / x_1^A = 1/1 \Rightarrow x_2^A = x_1^A$

(c) Graph the contract curve, the set of Pareto improvements, and the core

The set of Pareto improvements is empty: empty core

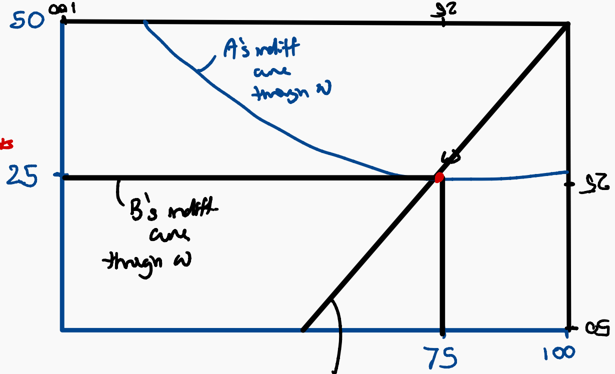
no ~~[illegible]~~ Pareto improvements available

Endowments w

1. $w^A = (75, 25)$
2. $w^B = (25, 25)$

Preferences

1. Cobb-Douglas: $u^A(x^A) = x_1^A x_2^A$
2. Perfect ~~substitutes~~ **complements**: $U^B(x^B) = \min\{x_1^B, x_2^B\}$



Complementarity ratio ($\alpha x_1 = \beta x_2$)

here, $\alpha = \beta = 1$ $\Rightarrow$ the ~~Pareto set~~ contract curve

Contract curve: $MRS^A = \dfrac{MU_1^A}{MU_2^A} = \dfrac{x_2^A}{x_1^A}$

MRS^B = undefined: optimal when $x_2^B = x_1^A$ (complementarity ratio) $\Rightarrow$ the Pareto set