The economics of climate change

C 175 - Christian Traeger

Part 2: Efficiency, Public Goods, Externalities

Suggested background reading for emerging questions:

Kolstad, Charles D. (2000), “Environmental Economics”, Oxford University Press, New York.

Varian, Hal R. (any edition…), “Intermediate Microeconomics – a modern approach”, W. W. Norton & Company, New York.

A Brief Micro Review:

From Preferences to Efficiency

Preferences

Preferences, Indifference Curves, Budget Constraints, and Choice

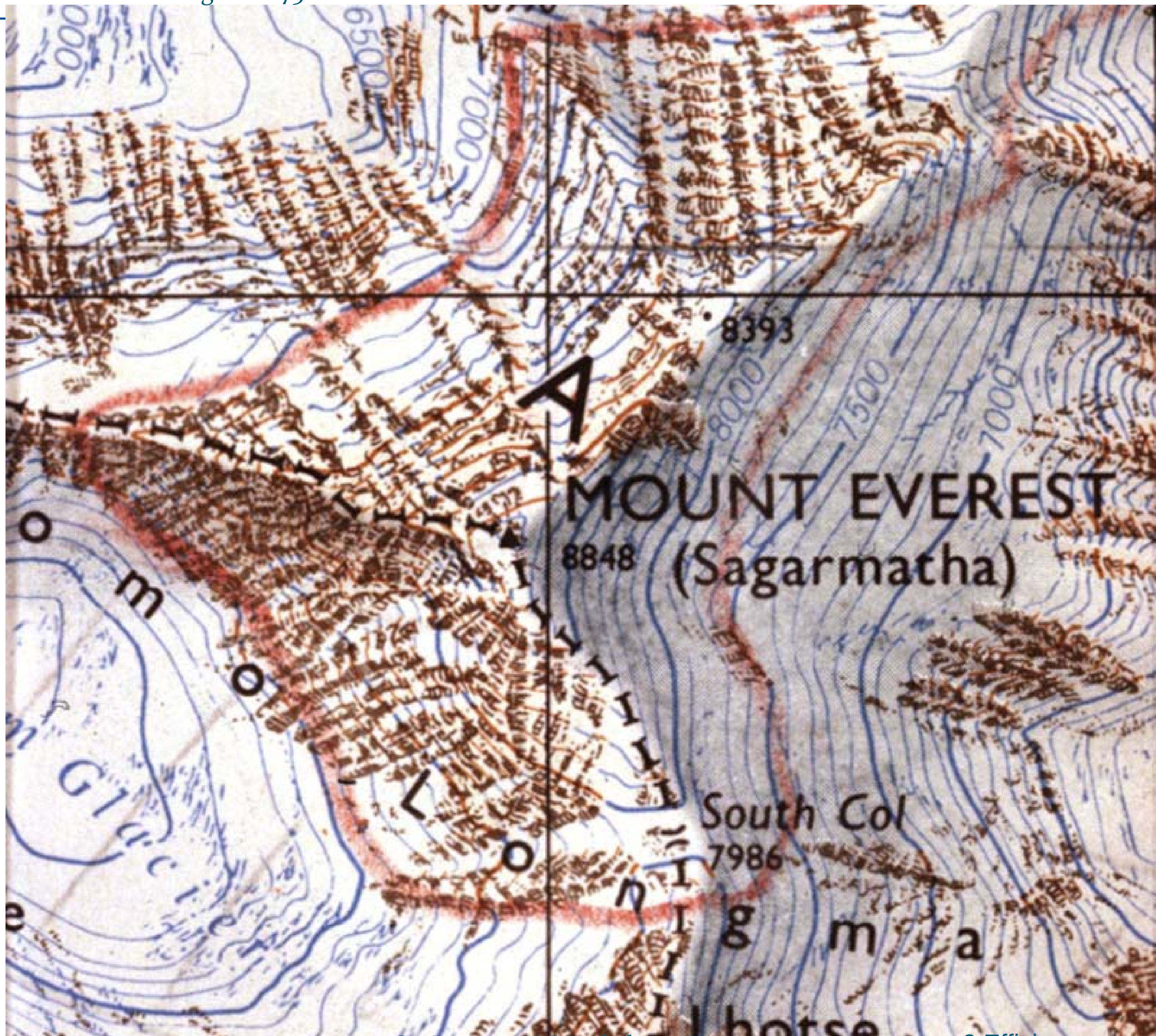
(Blackboard)

Utility

From (well behaved) preferences we can build

“Mountains of Pleasure”

(Blackboard? No, you have seen me drawing Antarctica and England…)


MOUNT EVEREST
(Sagarmatha)
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Utility

- Each bundle is associated with a utility level U(x,y)
- You can think of utility as a measure of pleasure, or happiness, or simply as representing preferences
- More utility = preferred
- Indifference curves are the topo lines or contour lines of the utility mountain
- While of a lot of the analysis that we will do could be done right away with preferences, utility functions are a very convenient tool to make things easier

Utility

- **Marginal utility (MU)** of good x: Change in utility (ΔU) associated with a small change in the amount of good x (Δx).
  (Note that good y is kept constant, MU depends on x-level)
  - Discrete change: $MU_x = \frac{\Delta U}{\Delta x} = \frac{U(x+\Delta x, y) - U(x,y)}{\Delta x}$
  - Infinitesimal change: $MU_x = \frac{\partial U}{\partial X} = \lim_{\Delta x \to 0} \frac{U(x+\Delta x, y) - U(x,y)}{\Delta x}$
  - Change in utility caused by a change Δx is then (approximately)

$$\Delta U = MU_x \ \Delta x$$

Utility

- More precisely marginal utility is itself a function of x and y:

$$MU_x = MU_x\,(x,y)$$

- Frequently met assumption:

  Diminishing Marginal Utility: The pleasure of an additional unit of consumption of good x decreases the more of good x I consume.

Aside on Cardinal vs Ordinal Utility:

- An ordinal measure/ An ordinal utility function:
  - (only) ranks alternatives
  - the value means nothing in absolute terms
  - e.g. grades, finishing position in race

- A cardinal measure / A cardinal utility function:
  - Absolute measure allowing ranking and absolute comparison
  - e.g. tons of carbon, income

- For describing market outcomes we only need ordinal utility
- To aggregate utility over different individual we need cardinal utility (necessary for most normative comparisons of market outcomes)

Marginal Rate of Substitution

- **Marginal rate of substitution (MRS)**
  = Rate at which a consumer is just willing to substitute one good for the other

  = Rate at which the consumer is just on the *margin* of being *willing* to 'pay' some of good x in order to buy some more of good y

  = Slope of indiffierence curve

  (Note: Generally negative, what does that mean?)

- Formally: $$MRS = \frac{\Delta Y}{\Delta X} = -\frac{MU_X}{MU_Y} = -\frac{\frac{\partial U}{\partial X}}{\frac{\partial U}{\partial Y}} \qquad = -\frac{p_X}{p_Y}$$

This side is all about the consumer

Here he hits the market

- Derive this from $\Delta U = MU_x\ \Delta x + MU_y\ \Delta y = 0$ (meaning U is constant)!

Marginal Rate of Substitution

- Remark: While MU is a cardinal measure,
  MRS is an ordinal measure!
- Frequently made assumption:

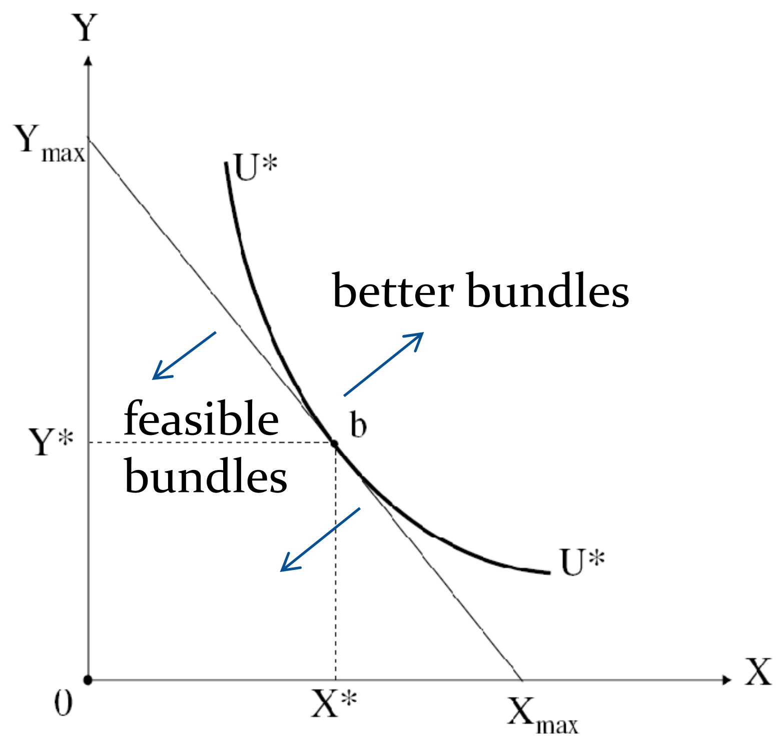
Diminishing marginal rate of substitution

is responsible for

convex indifference curves

'Different' perspective on convex indifference curves:

Averages are preferred



Efficiency in consumption: *X* vs *Y*

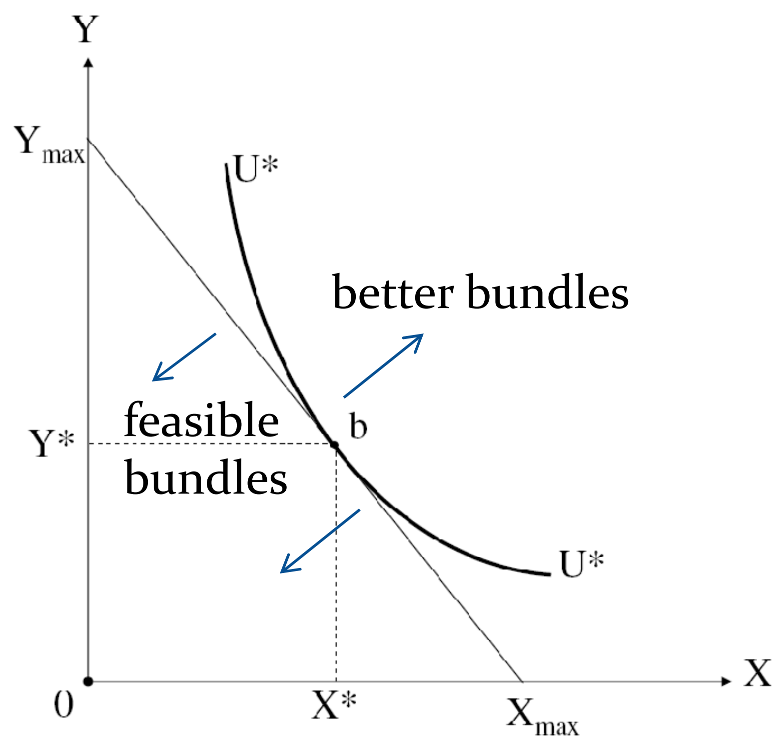
For some Individual A:

The necessary condition for utility maximizing

Max $U(X,Y)$
subject to: $p_x X + p_y Y = M$

given prices and income M are

$$MRS^A = -\frac{\frac{\partial U^A}{\partial X^A}}{\frac{\partial U^A}{\partial Y^A}} = -\frac{p_X}{p_Y}$$



and yield the generally **efficient** choices X* and Y*

Pareto Efficiency

- One of the most important economic concepts – named after the Italian economist Vilfredo Pareto (1848-1923).

Definition

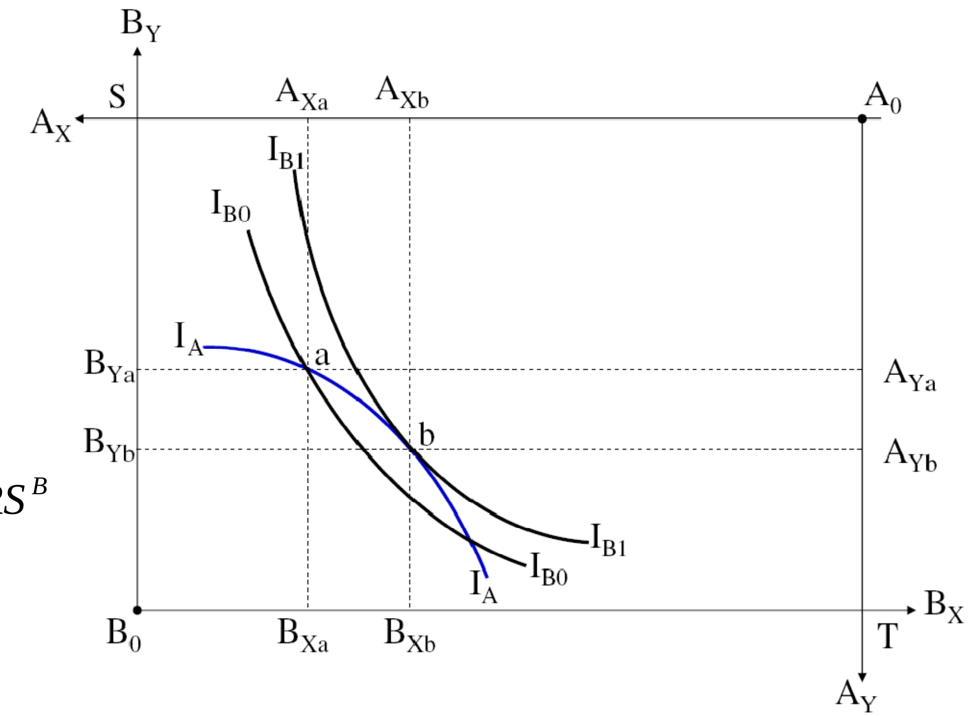
- An allocation is ***Pareto optimal or Pareto efficient***, if it is not possible to reallocate the resources of the economy in a way such that at least one person is better off without making any other person worse off.
- An allocation is ***inefficient*** if it is possible to make one member of the society better off without making any other member worse off. Such a movement is called ***Pareto improvement***.

Efficiency in consumption: X vs Y

- Take a second consumer B
- Both consumers face same market prices and take them as given
- Then efficiency requires

$$MRS^A = -\frac{\frac{\partial U^A}{\partial X^A}}{\frac{\partial U^A}{\partial Y^A}} = -\frac{p_X}{p_Y} = -\frac{\frac{\partial U^B}{\partial X^B}}{\frac{\partial U^B}{\partial Y^B}} = MRS^B$$

- What about the efficiency of points a and b ?



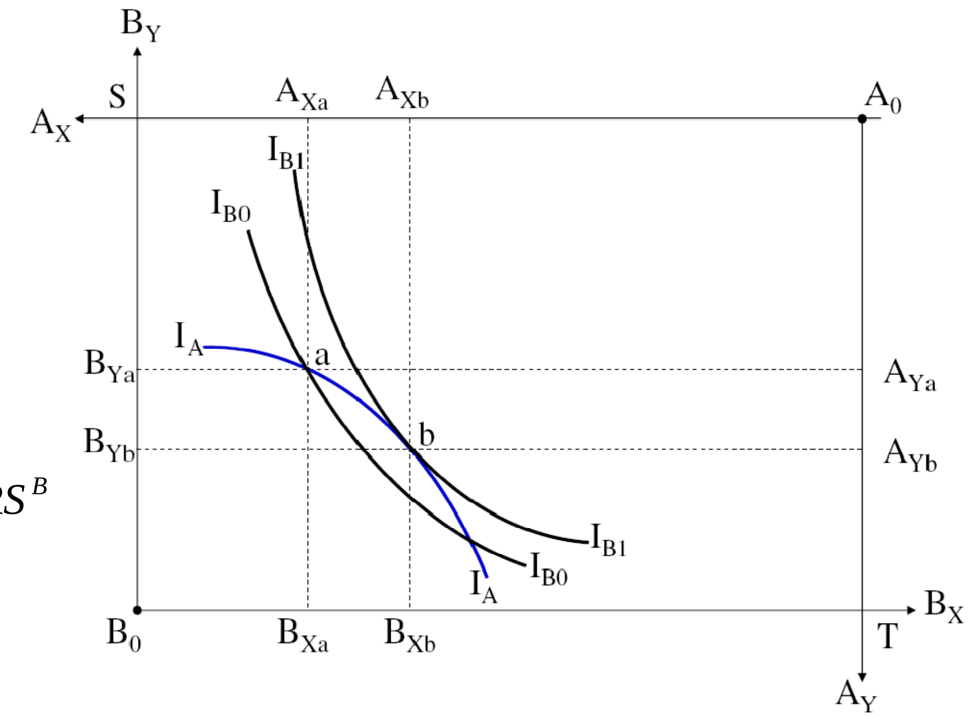
Edgeworth Box: Consumer A's origin is the upper right corner and his utility increases moving to the lower left (blue indifference curve)

Efficiency in consumption: X vs Y

- Take a second consumer B
- Both consumers face same market prices and take them as given
- Then efficiency requires

$$MRS^A = -\frac{\frac{\partial U^A}{\partial X^A}}{\frac{\partial U^A}{\partial Y^A}} = -\frac{p_X}{p_Y} = -\frac{\frac{\partial U^B}{\partial X^B}}{\frac{\partial U^B}{\partial Y^B}} = MRS^B$$

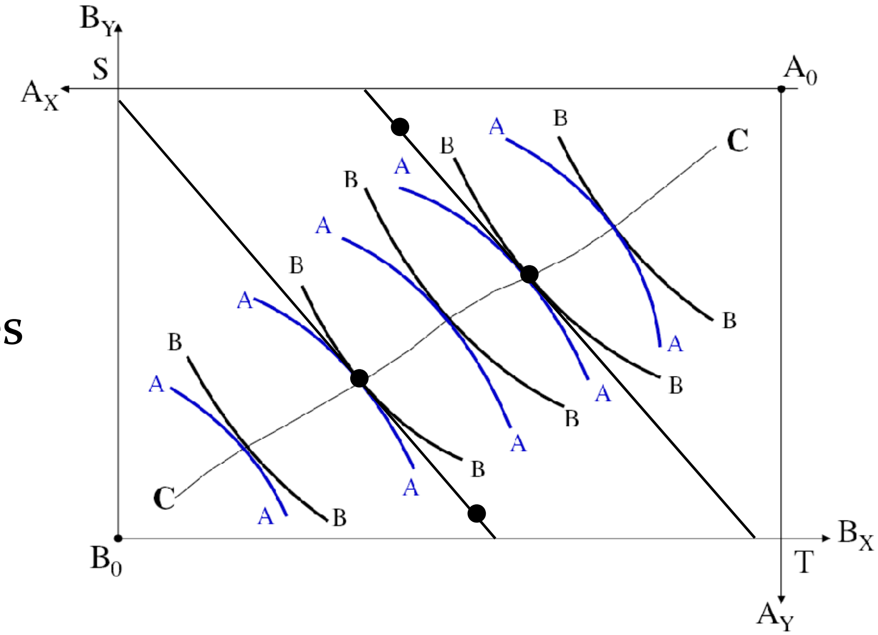
- Point a not Pareto efficient; point b is Pareto efficient



Edgeworth Box: Consumer A's origin is the upper right corner and his utility increases moving to the lower left (blue indifference curve)

Efficiency in consumption: X versus Y

- Note that there are infinitely many Pareto efficient allocations
- Which one will occur depends on initial allocation of resources



Production (please review these slides in more detail at home)

- Firm *i* produces *X* and maximizes profits:

$$\max \pi_i = p_X X_i\left(K_i^X, L_i^X\right) - p_K K_i^X - p_L L_i^X$$

Where $X_i\,(K_i^X, L_i^X)$ is the production function.
It uses the inputs capital K_i^X and labor L_i^X.

- Similarly some firms j produce Y and maximize:

$$\max \pi_j = p_Y Y_j\left(K_j^Y, L_j^Y\right) - p_K K_j^Y - p_L L_j^Y$$

A similar reasoning holds for production

- **Marginal Rate of Technical Substitution (MRTS)** or Technical Rate of Substitution
  = how much more of an *input* factor into production do we need if we give up a little bit of the other input factor while keeping the output constant
  Analogy: MRS
- **Isoquant** = set of all possible input combinations that are just sufficient to produce a given amount of the output
  Analogy: Indifference curve
- **Marginal Rate of Transformation (MRT)** = rate at which we can technically transform one *output* good into the other
  Analogy: Also MRS

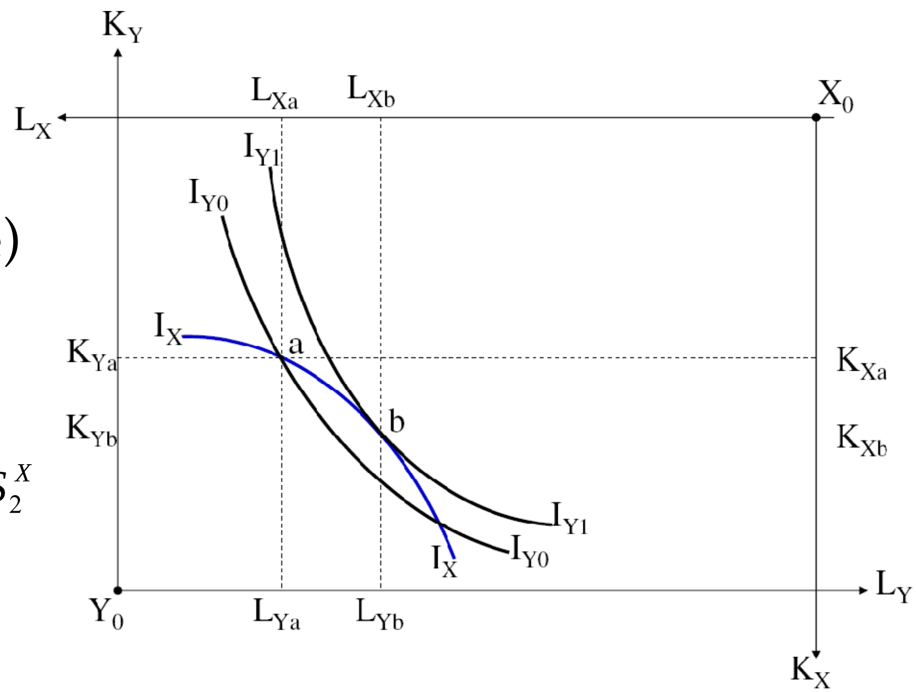
  (Note: we do not actually transform one output into the other, but switch inputs from one production to the other)

Efficiency in production: Capital K versus Labor L (inputs)

- All firms face the same factor prices and take them as given, say two X producers (first line) and two Y producer (second line)
  - Then efficiency requires:

$$MRTS_1^X = -\frac{\frac{\partial X_1}{\partial K_1^X}}{\frac{\partial X_1}{\partial L_1^X}} = -\frac{p_K}{p_L} = -\frac{\frac{\partial X_2}{\partial K_2^X}}{\frac{\partial X_2}{\partial L_2^X}} = MRTS_2^X$$

$$= MRTS_1^Y = -\frac{\frac{\partial Y_1}{\partial K_1^Y}}{\frac{\partial Y_1}{\partial L_1^Y}} = -\frac{p_K}{p_L} = -\frac{\frac{\partial Y_2}{\partial K_2^Y}}{\frac{\partial Y_2}{\partial L_2^Y}} = MRTS_2^Y$$



  - Point a not Pareto efficient; point b is Pareto efficient

Efficient product mix: output goods X versus Y (a tough one…)

- Profit maximization:

$$\max \pi_i^X = p_X X_i\left(K_i^X, L_i^X\right) - p_K K_i^X - p_L L_i^X$$

$$\frac{\partial \pi_i^X}{\partial K_i^X} = 0 \Leftrightarrow p_X \frac{\partial X_i}{\partial K_i^X} - p_K = 0$$

$$\frac{\partial \pi_i^X}{\partial L_i^X} = 0 \Leftrightarrow p_X \frac{\partial X_i}{\partial L_i^X} - p_L = 0$$

$$\max \pi_i^Y = p_Y Y_i\left(K_i^Y, L_i^Y\right) - p_K K_i^Y - p_L L_i^Y$$

$$\frac{\partial \pi_i^Y}{\partial K_i^Y} = 0 \Leftrightarrow p_Y \frac{\partial Y_i}{\partial K_i^Y} - p_K = 0$$

$$\frac{\partial \pi_i^Y}{\partial L_i^Y} = 0 \Leftrightarrow p_Y \frac{\partial Y_i}{\partial L_i^Y} - p_L = 0$$

$$\frac{p_X}{p_Y}\frac{\frac{\partial X_i}{\partial K_i^X}}{\frac{\partial Y_i}{\partial K_i^Y}} = 1 \Leftrightarrow \frac{p_X}{p_Y} = \frac{\frac{\partial Y_i}{\partial K_i^Y}}{\frac{\partial X_i}{\partial K_i^X}} = -\frac{dX_i}{dY_i} \equiv -MRT_K$$

$$\frac{p_X}{p_Y}\frac{\frac{\partial X_i}{\partial L_i^X}}{\frac{\partial Y_i}{\partial L_i^Y}} = 1 \Leftrightarrow \frac{p_X}{p_Y} = \frac{\frac{\partial Y_i}{\partial L_i^Y}}{\frac{\partial X_i}{\partial L_i^X}} = -\frac{dX_i}{dY_i} \equiv -MRT_L$$

Efficiency in consumption and product mix

- Utility maximization:

$$MRS^A = -\frac{\frac{\partial U^A}{\partial X^A}}{\frac{\partial U^A}{\partial Y^A}} = -\frac{p_X}{p_Y} = -\frac{\frac{\partial U^B}{\partial X^B}}{\frac{\partial U^B}{\partial Y^B}} = MRS^B$$

If not equal, then consumption mix should be changed.

- Profit maximization:

$$MRT_K = -\frac{\frac{\partial Y_i}{\partial K_i^Y}}{\frac{\partial X_i}{\partial K_i^X}} = -\frac{p_X}{p_Y} = -\frac{\frac{\partial Y_i}{\partial L_i^Y}}{\frac{\partial X_i}{\partial L_i^X}} = MRT_L$$

If not equal, then product mix should be changed.

- Efficiency of consumption and of product mix requires $MRS^A = MRS^B = MRT_K = MRT_L$

Competetive Equilibrium

- An allocation of goods and a set of prices constitute a **competitive** (or Walrasian) **equilibrium** if:
  - all firms maximize their profits,
  - all individuals maximize their utility (given the budget constraint),
  - and all markets clear (no leftovers).

Remark: The assumptions on slide 32 can also be considered as part of the definition of a (more narrowly defined) competitive equilibrium.

Theorems of Welfare Economics

First theorem of welfare economics:

In a competitive economy, a market equilibrium is Pareto optimal

Second theorem of welfare economics:

In a competitive economy, any Pareto optimum can be achieved as a market equilibrium, provided the resources of the economy are appropriately distributed before the market is allowed to operate.

But: Only hold under specific assumptions

Assumptions:

- **Complete property rights:** A well-defined, transferable, and secure set of property rights must exist for all goods and bads in the economy so that these commodities can be freely exchanged. All the benefits or costs must accrue to the agent holding the property right for the good or bad.
- **Atomistic agents:** Producers and consumers are small relative to the market and thus cannot influence prices. Instead, they maximize profits or utility taking the prices as given.
- **Complete Information:** Consumers and producers have full knowledge of current and future prices.
- **No transaction costs**
- **Technical assumption** on preferences/utility and production (in particular for the second welfare theorem)

The 'complete property rights assumption' includes:

- Complete markets (all goods are traded)
- Private goods (no public goods, to appear soon…)
- No externalities (to appear soon…)