

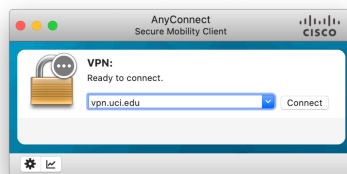
# HANDOUT 1

## About Your TA

- **Haoche (Howard) Hsu**
- Discussion Section: All sections conduct asynchronously via *YouTube*.
- Office Hour: Wed. 4:00-5:30pm only by appointment via Calendly: <https://calendly.com/howardhsu/econ-13-office-hour-summer-ii>
- My Website: <http://www.haochehsu.com> (Handout is located at the *Teaching* section)
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## 1 Logistics

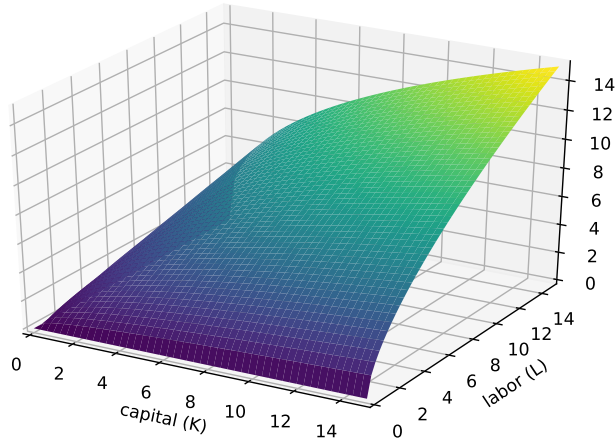
- Any comments feel free to use the anonymous *Feedback Survey* (on my website under *Teaching*)
- UCI VPN: <https://www.oit.uci.edu/help/vpn/>
  1. Choose (click) you platform: Windows/Mac or mobile devices and log in with your UCI ID.
  2. Download *Cisco AnyConnect Secure Mobility Client* from the website. For mobile devices, download *Cisco* from *App Store* or *Google Play*.
  3. Connect with your UCI credentials (instructions available on website after logging in).



## 2 Growth

1. **Production function:**  $Y = A \cdot F(L, K, H, N)$  (1)
  - Y: output, real GDP (the quantity of output produced)
  - A: technology (innovation)
  - L: number of labor (number of people in the work force)
  - K: physical capital (equipment, machines)
  - H: human capital (knowledge and skills, acquire through education, training, experience)
  - N: natural resources (used in production e.g. land, oil)
2. Factors of input in **per worker** terms:  $\frac{Y}{L}, \frac{K}{L}, \frac{H}{L}, \frac{N}{L}$ .
  - Divide the production function by "number of workers." Going from aggregate level to individual level.

### 3 Graphical Representation



### 4 Productivity

Productivity, measuring by the level of GDP per worker/hour, is the primary determination of long-term economics growth.

We will derive the level of productivity from equation 1. Noticed that there is an essential assumption regarding the production function. We assume that the technology ( $A$ ) is fixed, the production function exhibit **constant returns to scale (CRS)**<sup>1</sup>, then we can rewrite the production function

$$\begin{aligned}
 Y &= A \cdot F(L, K, H, N) \\
 &= A \cdot L \cdot F\left(\frac{L}{L}, \frac{K}{L}, \frac{H}{L}, \frac{N}{L}\right) \\
 &= AL \cdot F\left(1, \frac{K}{L}, \frac{H}{L}, \frac{N}{L}\right). \\
 \xrightarrow{\text{divide both sides by } L} \frac{Y}{L} &\equiv y = A \cdot F\left(1, \frac{K}{L}, \frac{H}{L}, \frac{N}{L}\right) \\
 &= A \cdot F(1, k, h, n).
 \end{aligned}$$

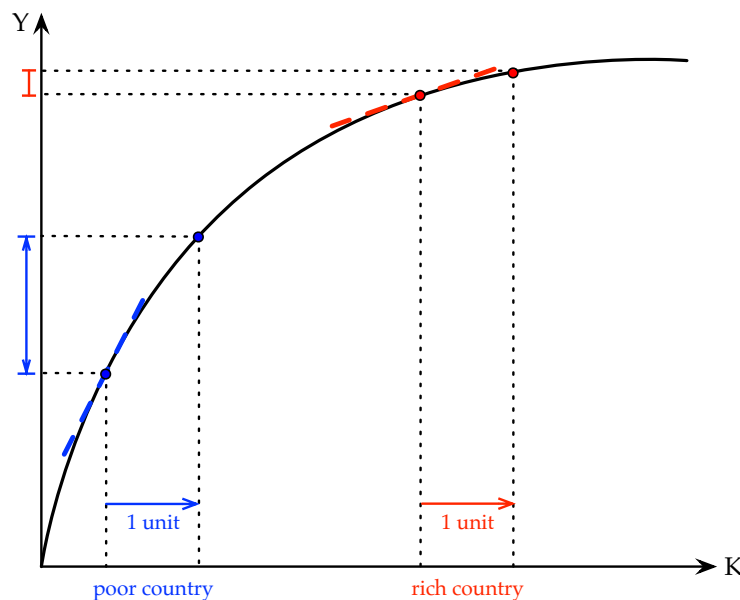
Here we define the output ( $Y$ ) per worker:  $\frac{Y}{L}$  as *productivity* ( $y$ ). Interpret directly from the productivity function, we can conclude that productivity is determined by:

1. Technology innovation ( $A \uparrow \implies y \uparrow$ )
2. Capital per worker ( $\frac{K}{L} \uparrow \implies y \uparrow$ ,  $L \uparrow \implies \frac{K}{L} \downarrow \implies y \downarrow$ )
3. Human capital per worker ( $\frac{H}{L} \uparrow \implies y \uparrow$ ,  $H \uparrow \implies \frac{H}{L} \uparrow \implies y \uparrow$ )
4. Natural resources per worker ( $\frac{N}{L} \uparrow \implies y \uparrow$ ,  $N \downarrow \implies \frac{N}{L} \downarrow \implies y \downarrow$ )
  - (a)  $A \uparrow$ : production process becomes more resource-efficient.
  - (b) Since natural resources is limited, the supply of resources is decreasing but the demand is decreasing (new technology, R&D, resources substitution) just as fast or even more rapidly.

<sup>1</sup>In mathematical term, the production function is homogeneous of degree 1.

## 5 Diminishing Marginal Returns and Convergence

1. Diminishing returns refers to property whereby the benefit (output/outcome) from an extra unit of input declines as the quantity of the input increases.
2. *Catch-up Effect (convergence)*: countries that start off poor tend to grow more rapidly than countries that start off rich.



The production function is a concave function (in both two or high dimensions).

3. Countries with lower levels of per capita GDP will catch up to those with higher levels due to those with higher levels experience *diminishing returns to capital*.

### Key Equations

- Let  $g$  denote the **growth rate**:
  - $x_{t+1} = (1 + g) \times x_t$
  - $g = \frac{x_{t+1} - x_t}{x_t}$
  - Percentage growth rate:  $(g \times 100)\%$

## 6 Exercises

1. In one day *Alpha Cabinet Company* made 40 cabinets with 320 hours of labor. What was their productivity?
  - (a) 8 hours per cabinet
  - (b) 40 cabinets
  - (c)  $\frac{1}{8}$  cabinet per hour
  - (d) None of the above is correct.

2. Suppose that there are diminishing returns to capital. Suppose also that two countries are the same except one has more capital per worker and so it has more real GDP per worker than the other. Finally, suppose that the saving rate in both countries increases from 4 percent to 7 percent. Over the next ten years we would expect that
  - (a) both countries will grow and at the same rate.
  - (b) the country that started with more capital per worker will grow faster.
  - (c) the country that started with less capital per worker will grow faster.
  - (d) the growth rate will not change in either country.
3. Last year the imaginary nation of *Freedonia* had a population of 2,700 and real GDP of 16,200,000. This year it had a population of 2,500 and real GDP of 14,640,000. What was the growth rate of real GDP per person between last year and this year?
  - (a) 4.4%
  - (b) -2.4 %
  - (c) 5.2 %
  - (d) -0.7%
4. An increase in capital will increase real GDP per person
  - (a) more in a poor country than a rich country.
  - (b) less in a poor country than a rich country.
  - (c) in both the poor and rich countries, but the magnitude can't be determined.
  - (d) An increase in capital doesn't impact the level of real GDP per person.
5. Which of the following would be considered physical capital?
  - (a) a taxi-cab driver's knowledge of the fastest routes to take
  - (b) the available knowledge on how to make semiconductors
  - (c) bulldozers, backhoes and other construction equipment
  - (d) All of the above are correct
6. Which of the following is an example of the "brain drain?"
  - (a) A country steals patented technology from another country.
  - (b) A country has such a poor educational system that human capital falls over time.
  - (c) The population of a country grows so fast that the educational system can't keep up.
  - (d) A country's most highly educated workers emigrate to rich countries.
7. Which of the following is correct?
  - (a) If developing countries limit career and educational opportunities for women, birth rates are likely to be lower.
  - (b) Historically, in periods where the rate of population growth was high, the rate of growth in real GDP per person is low.
  - (c) Growth rates in developed and developing countries are nearly the same.
  - (d) None of the above is correct.