ME2720 Macroeconomics for Business

Lecture 2

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Outline

On the Importance of (Economic) Growth

"Once one starts to think about them [the consequences of economic growth], it is hard to think about anything else" ∼ Robert E. Lucas

"The history of economic growth is the history of people making more with less and shifting into new jobs that were unheard of in the previous generation" ∼ David R. Henderson

"Technological innovation is indeed important to economic growth and the enhancement of human possibilities" ∼ Leon Kass

Definition 1 (Economic Growth).

Economic growth is the increase in productive capacity of goods and services for an economy over a certain period of time.

It is often measured as the percentage increase in:

- *real* gross domestic product (GDP): adjusts for inflation
- *real* GDP per capita: adjusts for inflation & population size

The (*geometric*) growth formula:

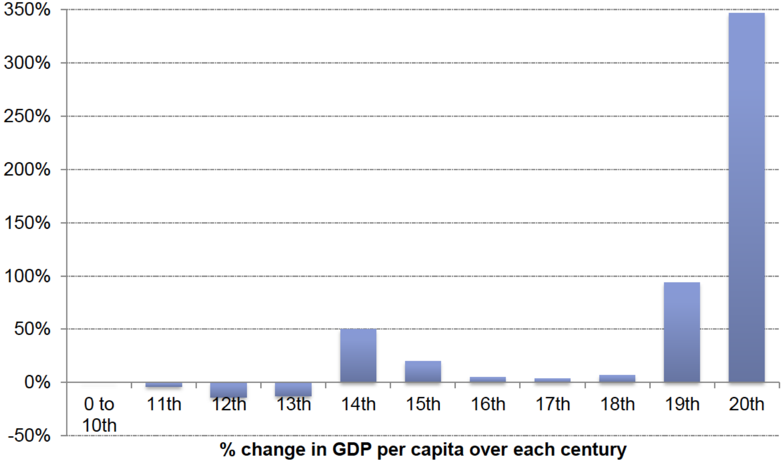
$$g = \left[\left(\frac{GDP_t}{GDP_{t-p}} \right)^{1/(p+1)} - 1 \right] \times 100$$

The Power of Compounding

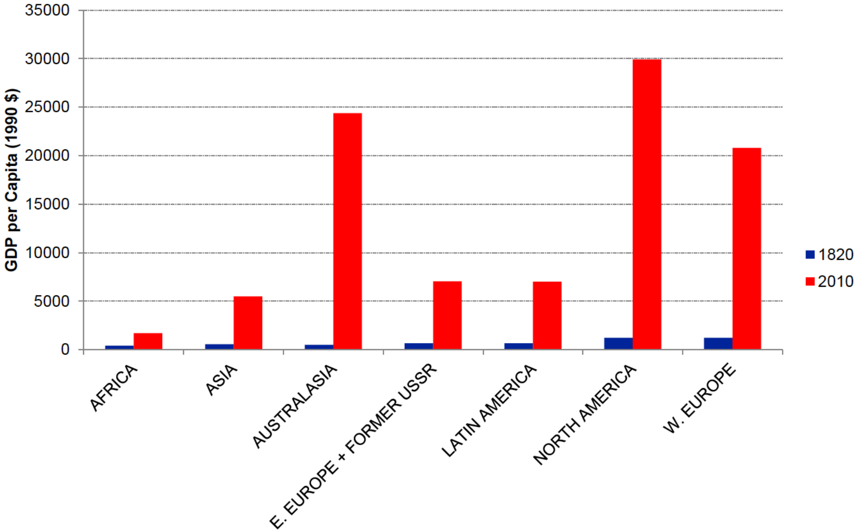
Table: Years to attain US 1999 GDP per capital level ($30,600)

Country	1999 GDP per capita	1%	3%	6%	9%	Actual (avg.) growth 1990-99
Germany	$25,350	20 yrs	7 yrs	4 yrs	3 yrs	1.5%
UK	$22,640	32 yrs	11 yrs	6 yrs	4 yrs	2.1%
Brazil	$4,420	196 yrs	66 yrs	34 yrs	23 yrs	1.7%
China	$780	370 yrs	145 yrs	64 yrs	44 yrs	9.8%
Ethiopia	$100	577 yrs	194 yrs	99 yrs	67 yrs	2.2%

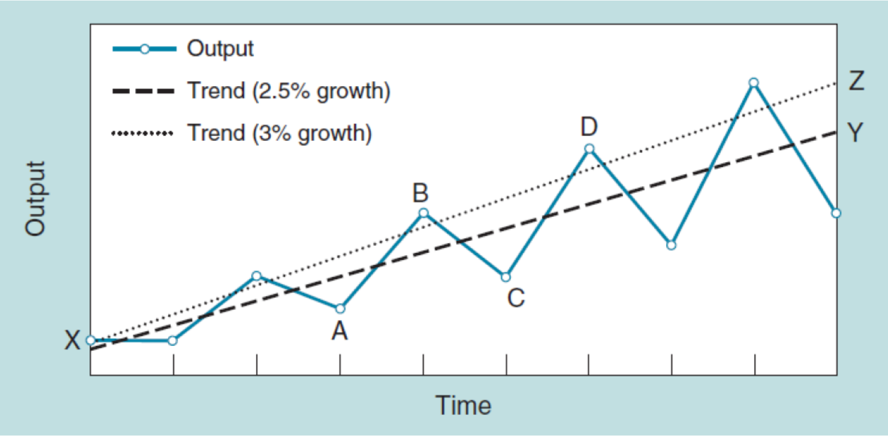
World GDP Growth, by Century



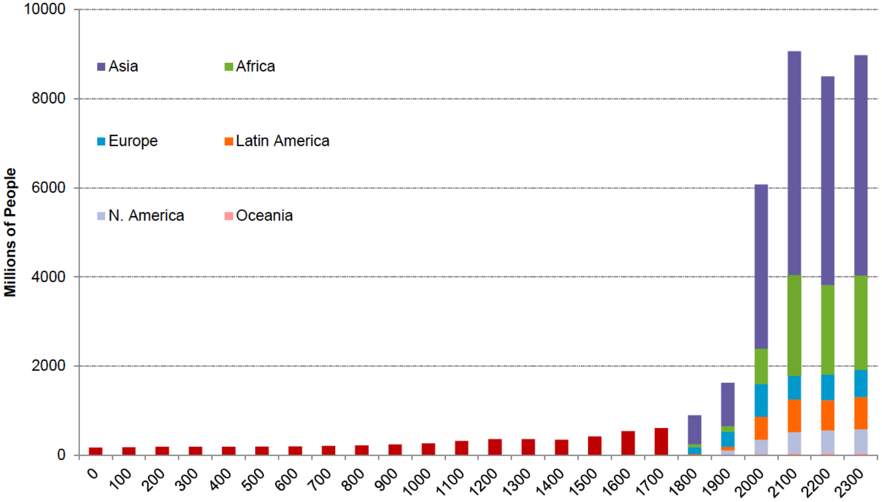
GDP per capita, by Region



Growth Rates & Business Cycles

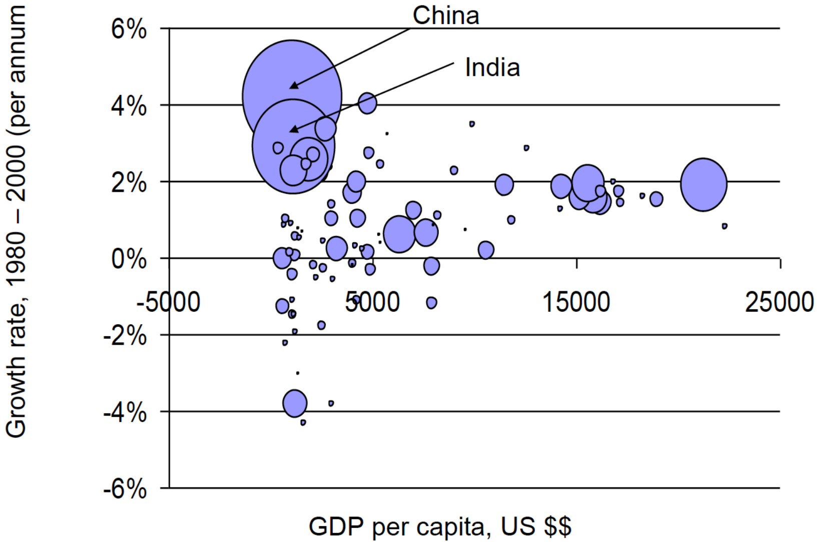


Population Growth

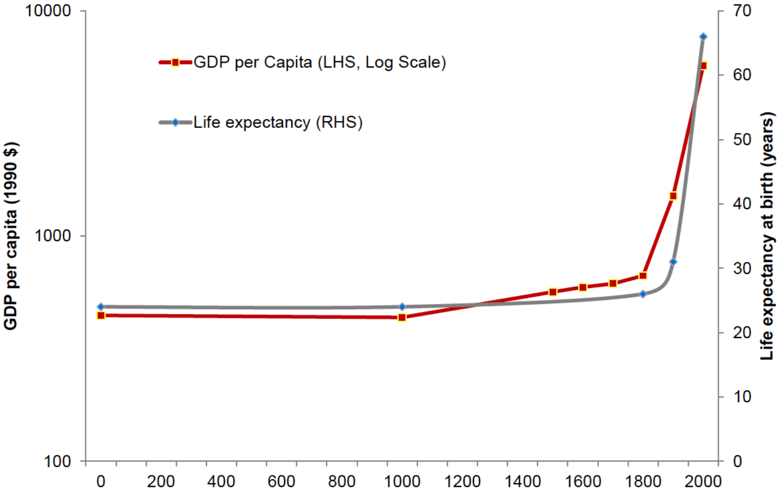


GDP and Population

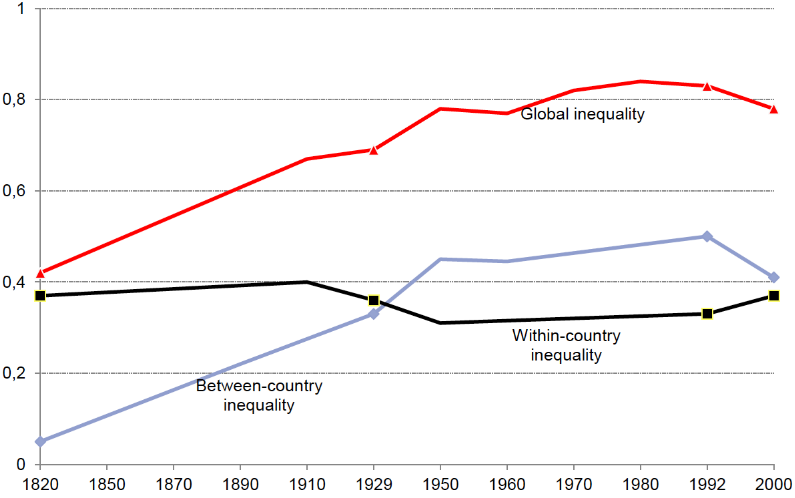
* dots weighted by population size (in 1980)



GDP and Life Expectancy

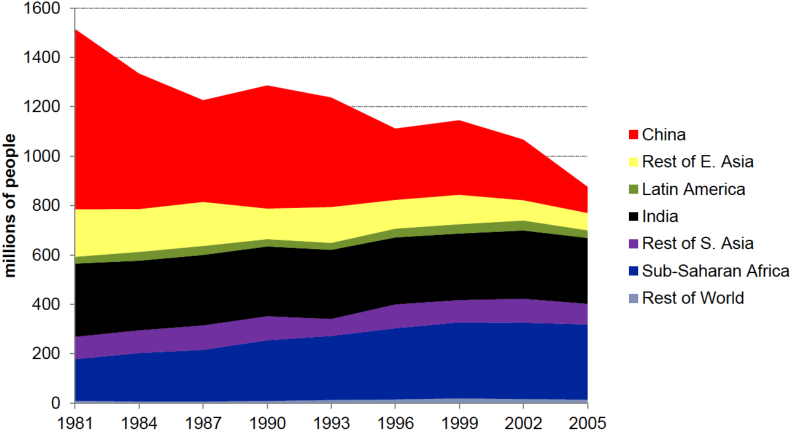


Trends in Global Inequality



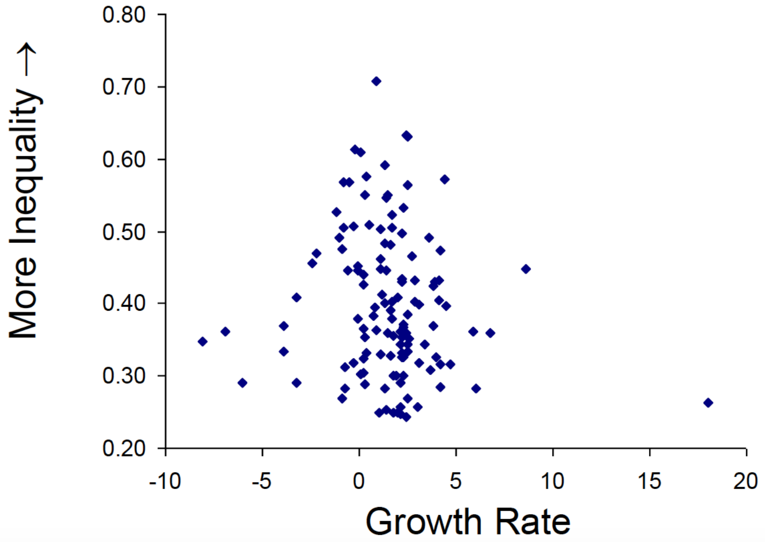
Trends in Global Poverty

Population with less than $1 income/day

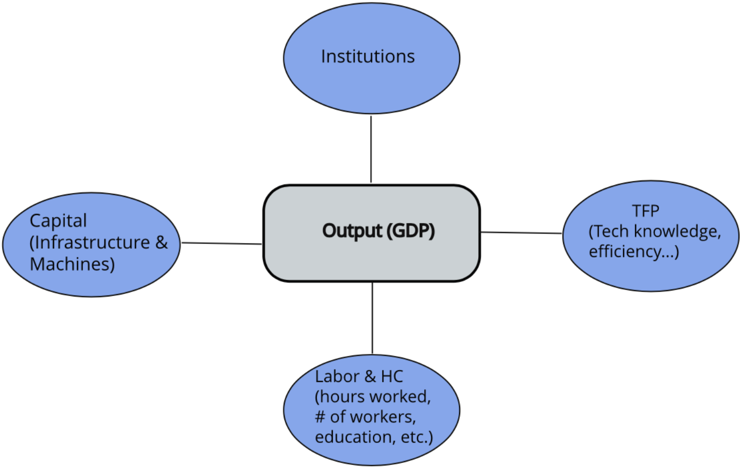


...but, if inequality is increasing, how's poverty being reduced?

The Inequality-Growth Relationship



Growth in a nutshell



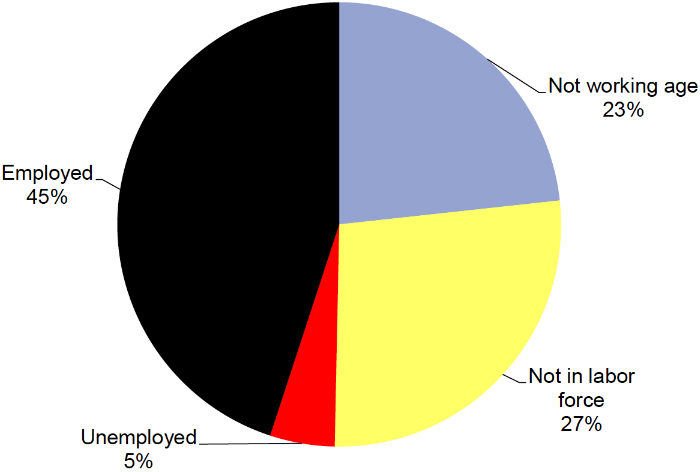
GDP per capita Decomposition

$$\text{GDP pc} = \frac{GDP}{Population}$$
$$= \underbrace{\frac{\text{GDP}}{\text{Hours}}}_{\text{Labor Productivity}} \times \underbrace{\frac{\text{Hours}}{\#\text{ Employed}}}_{\text{Avg. Hours Worked}} \times \underbrace{\frac{\#\text{ Employed}}{\text{Labor Force}}}_{\text{Employment Rate}} \times \underbrace{\frac{\text{Labor Force}}{\text{Population}}}_{\text{LF Participation Rate}}$$

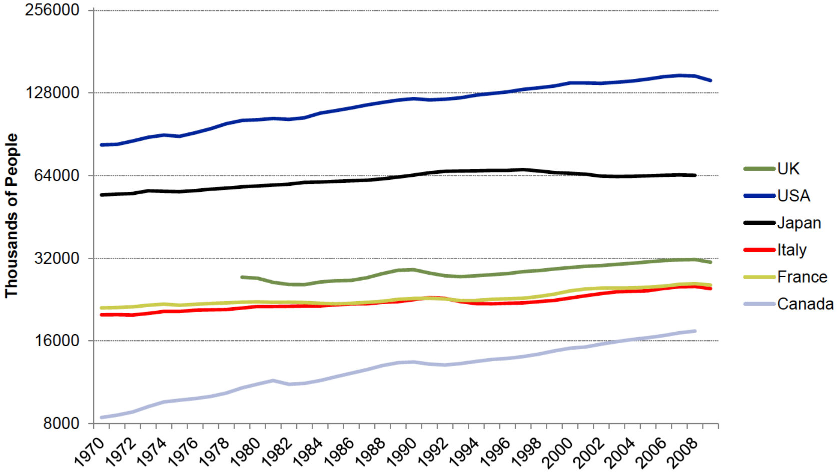
GDP per capita Decomposition

	GDP per Capita ($PPP)	Hourly Productivity ($PPP)	Average Annual Hours Worked	Employment Rate	Participation Rate
Australia	37 302	46.43	1718	0.940	0.50
Canada	38 941	44.83	1727	0.965	0.52
Denmark	38 566	49.72	1570	0.920	0.54
France	34 620	60.50	1560	0.909	0.40
Germany	36 922	57.47	1430	0.916	0.49
Greece	30 285	36.62	2116	0.933	0.42
Italy	32 695	44.55	1807	0.962	0.42
Japan	33 799	39.01	1772	0.971	0.50
Korea	26 875	25.52	2256	0.963	0.48
Mexico	15 313	20.58	1893	0.955	0.41
Netherlands	43 022	59.73	1389	0.976	0.53
Sweden	39 435	51.42	1625	0.955	0.49
UK	37 317	46.49	1652	0.946	0.51
US	47 209	56.83	1796	0.954	0.48

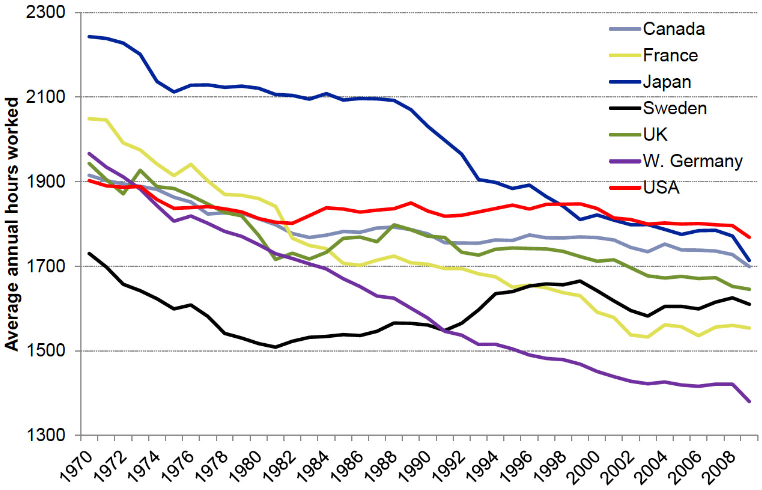
A Quick Look at the US Labor Market Composition, 2011



A Quick Look at Employment Levels



A Quick Look at Average Annual Hours Worked



The Production Function

- $Y = f(A, K, L)$, i.e. output depends on TFP, capital and labor
- Cobb-Douglas production function:

$$Y = AK^{\alpha}L^{1-\alpha}$$

where $0 < \alpha < 1 \Rightarrow$ decreasing returns to scale (DRS)

Definition 2.

Marginal product of capital (labor) is the increase in output when the capital (labor) stock increases by 1 unit but TFP and labor (capital) remain unchanged.

$$MPK = \frac{\partial Y}{\partial K} = \alpha A \left(\frac{L}{K}\right)^{1-\alpha}$$

$$MPL = \frac{\partial Y}{\partial L} = (1-\alpha) A \left(\frac{K}{L}\right)^{\alpha}$$

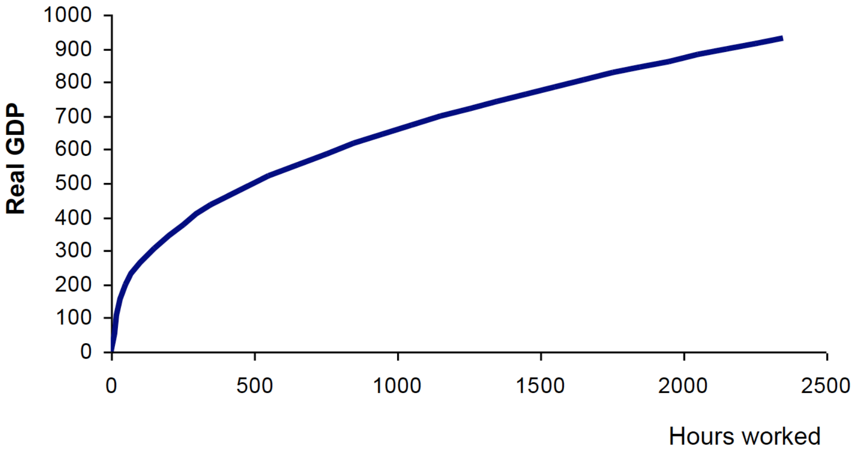
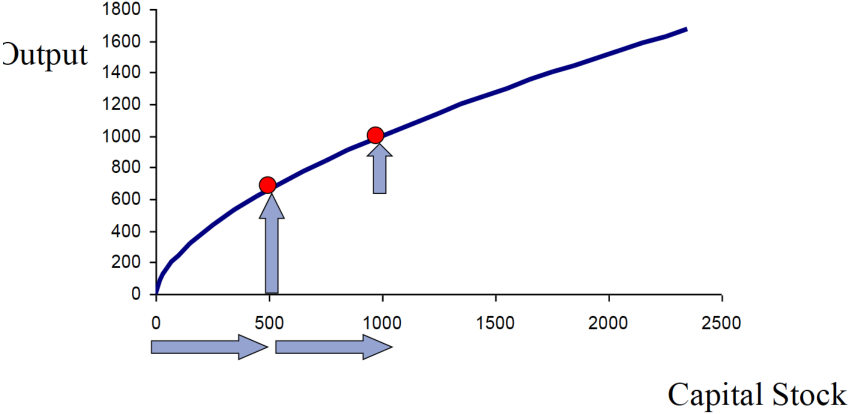


Figure: $Y = K^{0.6}L^{0.4}$

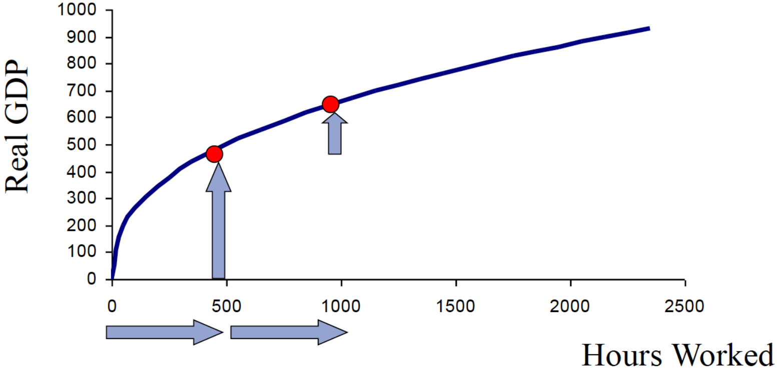
Diminishing returns to **capital**:

Figure: $Y = K^{0.6}1000^{0.4}$



Diminishing returns to **labor**:

Figure: $Y = 500^{0.6} L^{0.4}$



Recall:

$$Y = AK^{\alpha}L^{1-\alpha}$$

Substituting for **labor productivity**:

$$\frac{Y}{L} = A\left(\frac{K}{L}\right)^{\alpha}$$

Thus, changes in labor productivity caused by:

- A, i.e. TFP
- K/L, i.e. capital per labor hour

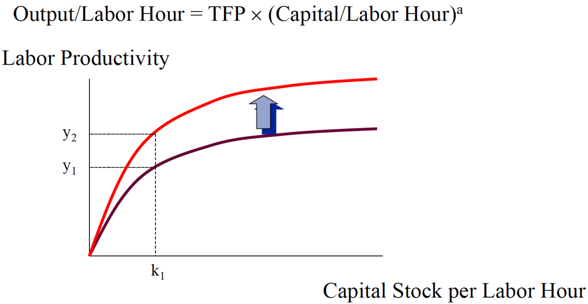
The Production Function

Output Growth

$$\%\Delta \text{GDP per capita} = \%\Delta \text{Labor productivity}$$

$$\%\Delta \text{Labor productivity} = \%\Delta A + \alpha \times \%\Delta \left(\frac{K}{L} \right)$$

- Changes in TFP shift the production function!



Growth in output may come from:

1. **Increases in labor supply**, L
   - May have no impact on GDP pc
   - NOT SUSTAINABLE!
2. **Increases in capital stock**, K
   - K must increase at a faster rate than L
3. **Increases in TFP**, A
   - No DRS in TFP... boundless possibilities?

Growth Accounting I

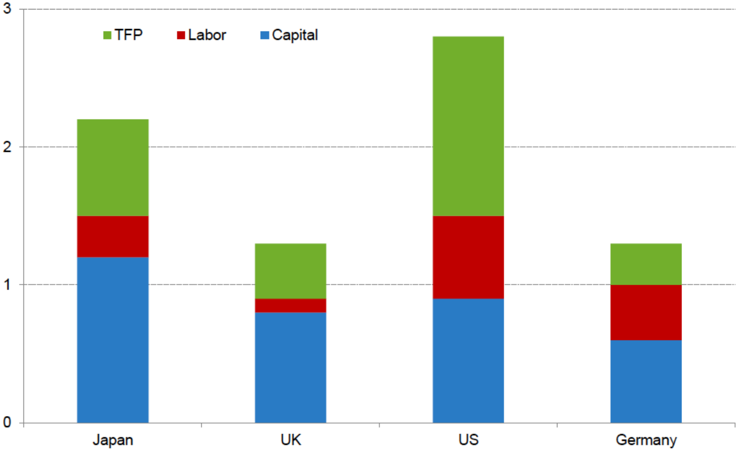
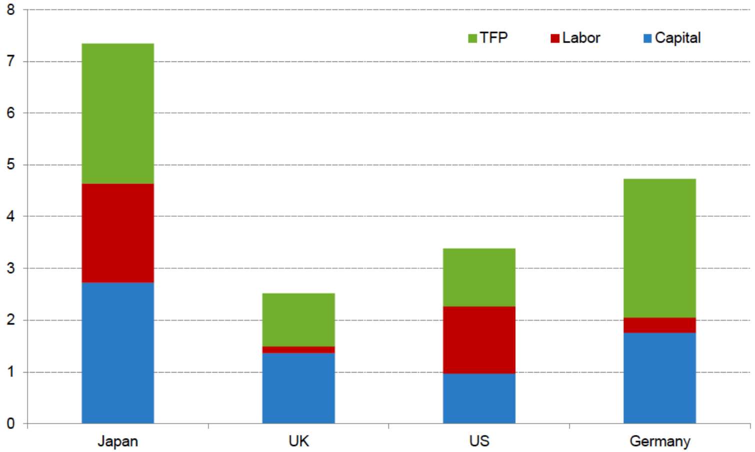


Figure: Growth accounting 1913-1950

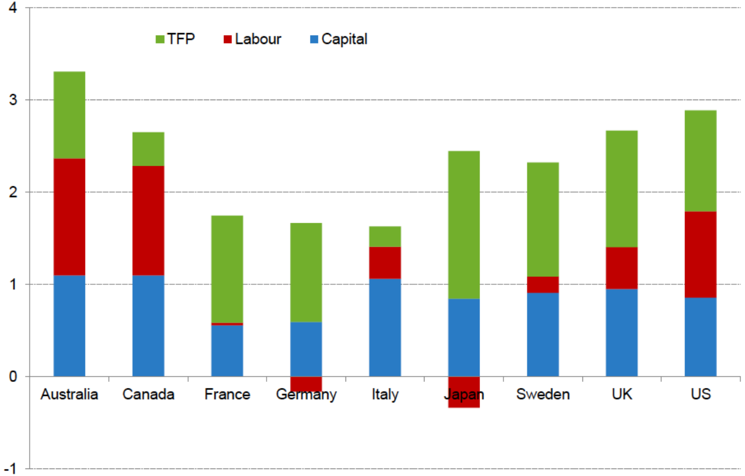
Growth Accounting II

Figure: Growth accounting 1950-1985



Growth Accounting III

Figure: Growth accounting 1985-2008



Growth Accounting IV

Evidence from Japan, US, UK and Germany (1913-2008)

- **Japan**
  - ⋆ Capital- and TFP- growth important throughout
  - ⋆ Labor importance declined recently
- **US**
  - ⋆ All 3 factors sustain output growth
- **UK** and **Germany** mainly rely on TFP and capital. Labor has a much less important role!

Growth Transitions

Usually, a country's growth process first relies on labor, and later on capital and TFP, with an increasing importance of the latter over time.

Capital Accumulation

Basic Understanding of Capital

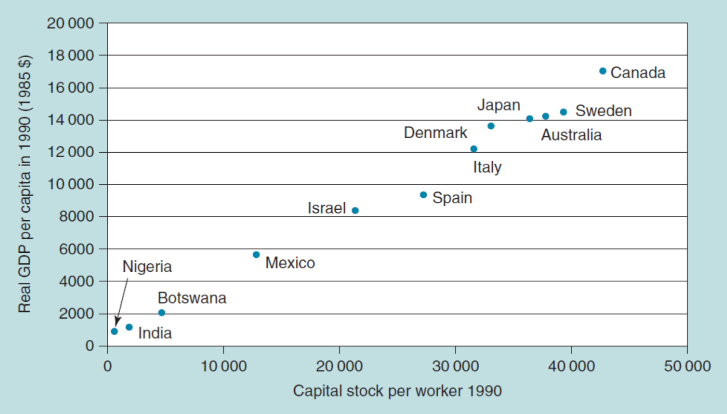
Capital, K, amounts to the total value of machines and buildings used for production.

- Capital depreciates/wears out
  - ⋆ Simplest case: capital depreciates **linearly**, i.e. assume a constant rate of depreciation δ, where $0 < \delta < 1$
- Depreciation as a fraction of the capital stock K

$$\text{Depreciation} = \delta K$$

Capital accumulation is important for standards of living and growth rates

Figure: GDP per capita vs. capital stock per worker



Can capital accumulation maintain output growth forever?

- Increasing returns to scale (IRS) $\Rightarrow$ YES!
- Constant Returns to Scale (CRS) $\Rightarrow$ YES!
- Decreasing Returns to Scale (DRS) $\Rightarrow$ NO

In general:

- Rapid growth when capital increases and the initial stock is low!
- Growth slows down as capital accumulates
- Eventually, firms stop adding capital and just replace depreciated capital $\rightarrow$ the economy reaches the **steady state**

- Extra revenue, ER, added by new capital:

$$ER = MPK \times p$$

- Cost of new capital, r^0

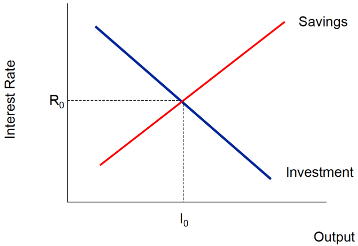
- Profitable to invest only if

$$MPK \times p > r^0 \;\Leftrightarrow\; MPK > \frac{r^0}{p}$$

Exercise (2 min). Adding 1 more machine increases output by 4 units. If the cost of the machine is $2000, in which range must the selling price of the produced units oscillate in order for the investment to be profitable?

- IRs determined by the interaction of savings and investments

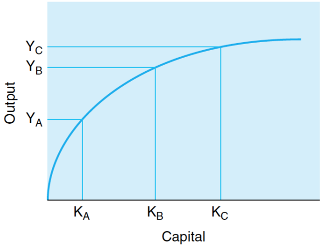
Figure: Interest rates and output



- Effects of changes in IRs:
  - ⋆ High IRs economy is a low-capital economy
  - ⋆ Low IRs economy is a high-capital economy

- **Crucial role of DRS**

Figure: Same production function, different capital stock levels

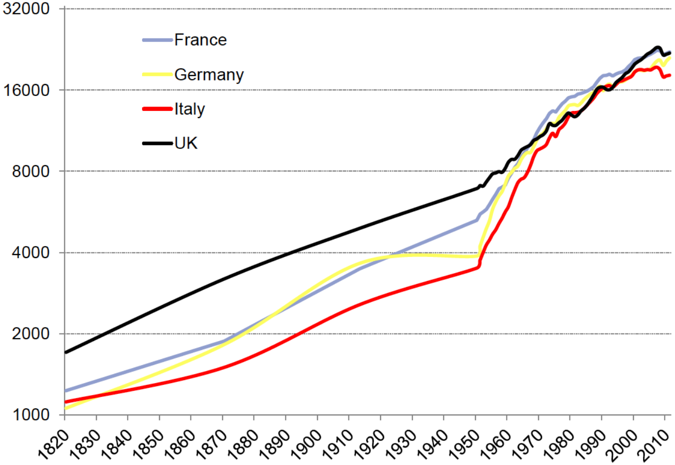


- Low-income country (K_A) vs. high-income country (K_B)
- Same investment brings bigger increases in output in the poorer economy

Capital Accumulation

. . . and Catching-Up Economies

Figure: Convergence in real GDP pc, 1820-2010

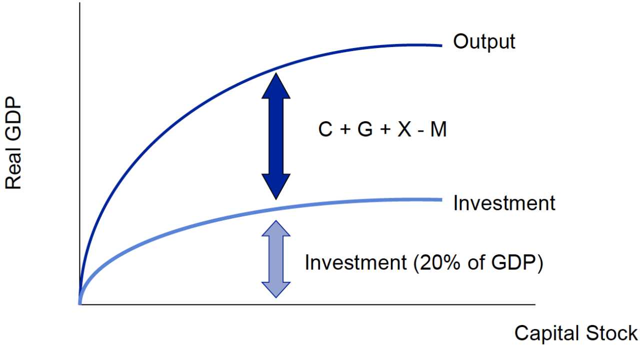


The Steady State

Steady State

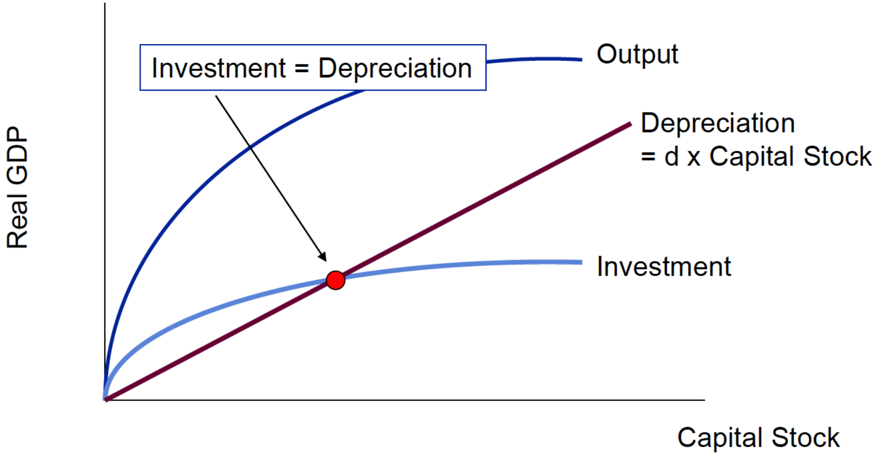
An **steady-state** economy has a constant stock of capital and a constant population size, i.e. such an economy does not grow[a].

[a] See *Herman Daly*'s definition for a more technical approach.



The Steady State

Figure: The steady state, when $I = \delta K$

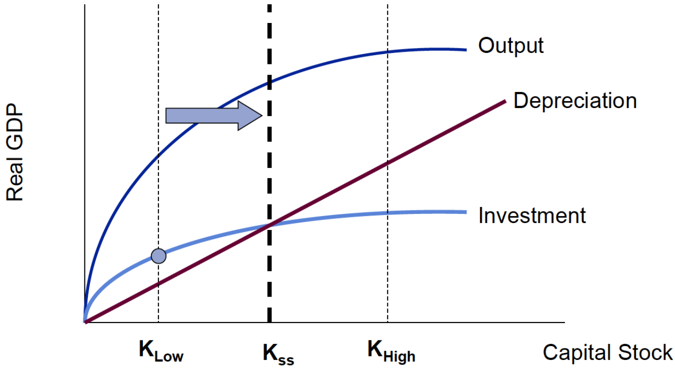


The Steady State

. . . and Transition Dynamics

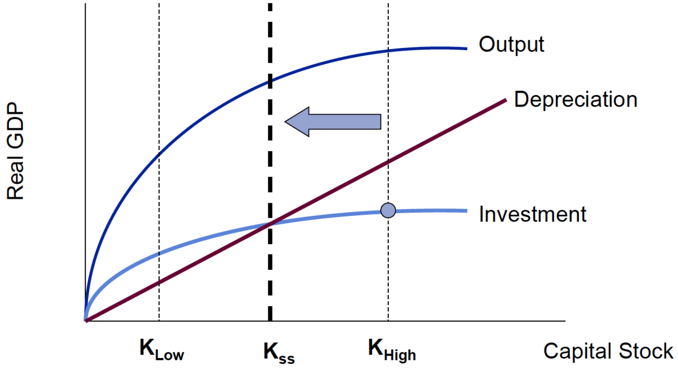
If investment (I) exceeds depreciation (δK) then the capital stock (K_{low}) increases towards K_{ss}, the **steady state**

Figure: Transition Dynamics: $I > \delta K$



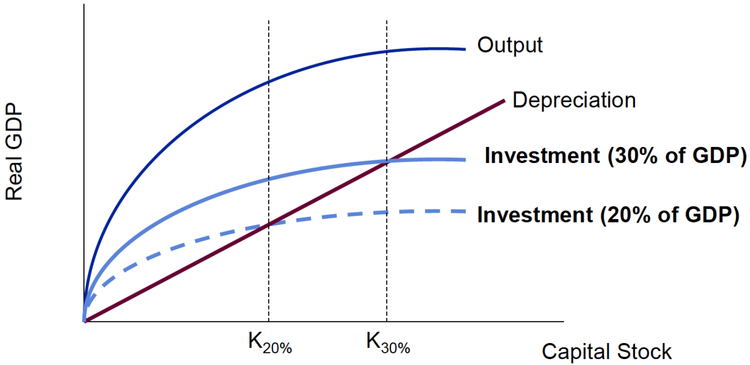
If depreciation (δK) exceeds investment (I) then the capital stock (K_{high}) declines towards K_{ss}, the **steady state**

Figure: Transition Dynamics: $\delta K > I$



The **higher** the investment rate of a country, the **greater** the steady state capital stock and its output level, *ceteris paribus*.

Figure: Steady state of an economy with $s = 0.2$ vs. $s = 0.3$



The Golden Rule (of Capital)

Things to recall:

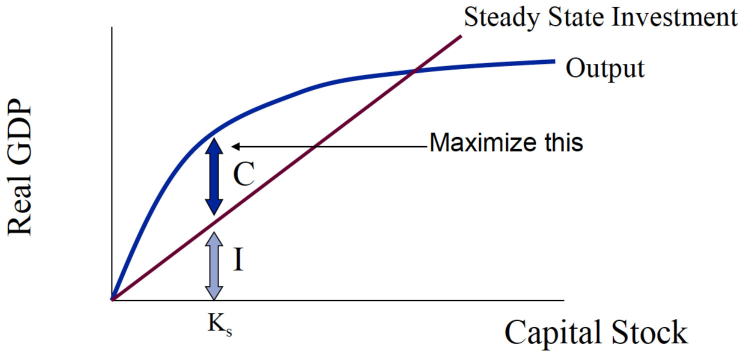
- Depreciation $= \delta K$
  - ⋆ δ is a technological parameter
- New Capital $=$ Investment $-\delta K$
- The **steady state**, i.e. when Investment$= \delta K$,
  - ⋆ will reach a point where increases in capital do not pay off any longer because of DRS!

The Golden Rule of Capital

The golden rule of capital is the steady-state level of capital, K_{ss}, which maximizes consumption per worker.

- Assume, for simplicity, we are in a closed economy, i.e. $Y = I + C$
- **Goal**: to maximize consumption per worker

Figure: The golden rule of capital



Consumption decreases when we get get closer to K_1

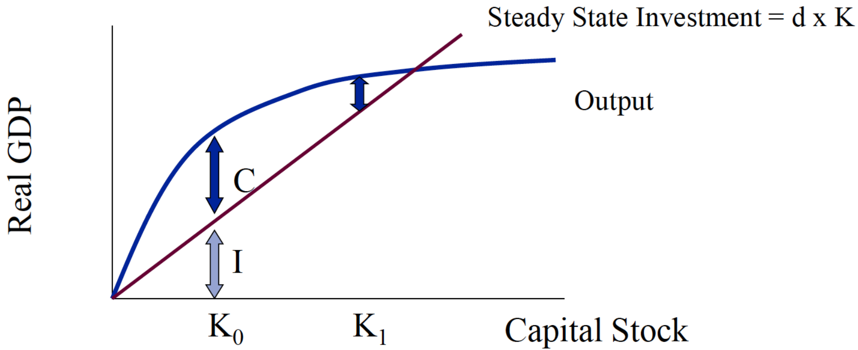


Figure: The golden rule of capital, moving from K_0 to K_1

Consumption also **decreases** if we move away from K_0 towards K_2

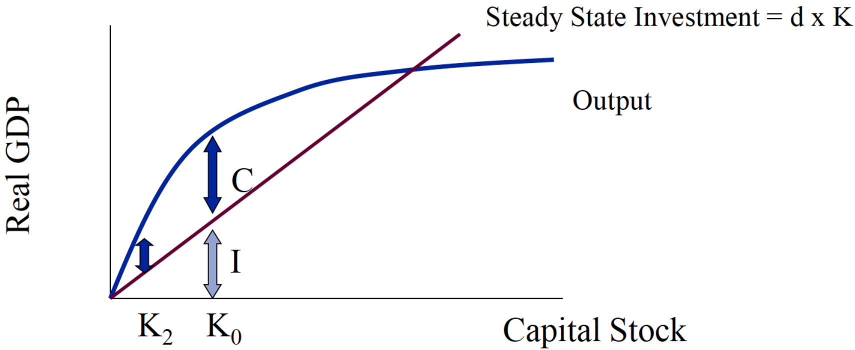


Figure: The golden rule of capital, moving from K_0 to K_2

The Golden Rule

When the **capital stock** K is **too high**:

- Output used to maintain an overly-large capital stock
- Consumption is low. . . what about welfare?

When the **capital stock** K is **too low**:

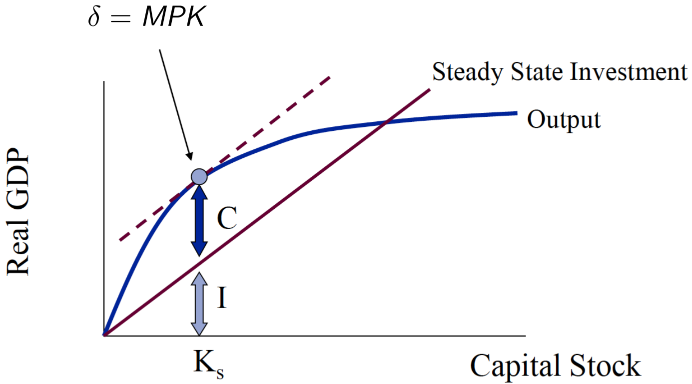
- Output used to support consumption
- Capital is too low to produce sufficient output

The Golden Rule

The Golden Rule Condition

At the Golden Rule level of capital K_{ss}, the production function and the line of depreciation have the same slope, i.e.:

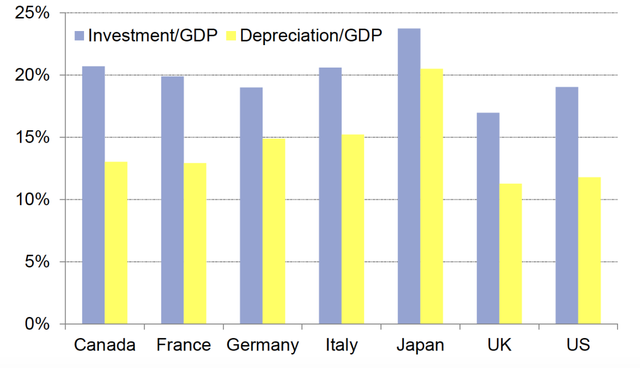
$$MPK = \delta$$



The Golden Rule in Practice

- The Golden Rule of Capital Accumulation suggests that in the steady state, investment should equal depreciation
- So, have countries already reached the steady state?

Figure: Investment and Depreciation



The Golden Rule in Practice

Optimal Investment Rates

Investment rates in the range 30-35% of GDP lead to steady states with high levels of consumption. Investment rates above or below this range, lead to lower levels of steady-state consumption.

Figure: Investment rates, 1980-2009

Country	Investment Rate	Country	Investment Rate	Country	Investment Rate
Argentina	19.0	Germany	20.9	Spain	24.1
Australia	24.5	India	23.8	Sweden	18.8
Brazil	22.5	Israel	20.5	U.K.	17.4
Canada	20.6	Italy	21.1	U.S.	18.5
Chile	20.8	Japan	27.1	Zambia	15.4
China	33.7	Mexico	19.9	Low Income	17.9
Congo	11.3	Russia	20.5	Middle Income	24.0
Egypt	22.0	Singapore	33.9	High Income	21.2
France	19.9	S. Africa	19.0	World	21.7

Recap!

- **Economic growth** and its importance
- The (Cobb-Douglas) **production function** and the role of **returns to scale**
- **Growth transitions**: initial reliance on labor and latter stronger dependence on capital and TFP
- **Capital accumulation** and **convergence**
- The **steady state** (i.e. when $I = \delta K$), **transition dynamics** and **investment rates**
- The **golden rule**, i.e. the steady-state level of capital that maximizes consumption per worker, and **the golden rule condition**

Thank you for your attention!