The Global Economy

The Production Function

NYU | STERN

Saving and investment

- How important for economic performance?
- Examples?
- Why?

Roadmap

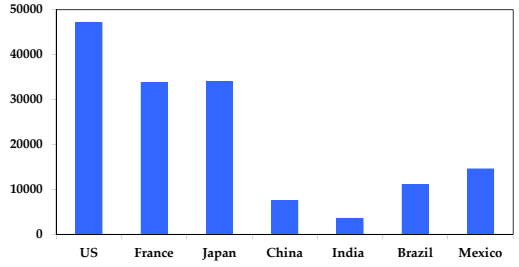
- Saving ✓
- Reminders
- Economic history of the world
- Theory: the production function
- Inputs: capital and labor
- Productivity

Reminders

Reminder: real and nominal GDP

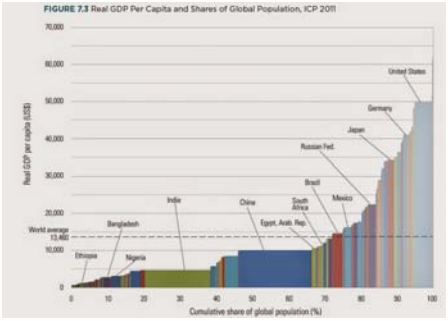
- Real GDP ("quantity")
  - GDP at 2010 prices
  - GDP in 2005 USD
  - GDP in USD, PPP adjusted
  - GDP chain-weighted in 2010 USD
- Nominal GDP ("value = price times quantity")
  - GDP at current prices
  - GDP in LCUs
- Both come from "NIPA":
  - National Income and Product Accounts

Reminder: GDP per capita (USD, PPP adj)



Source: World Bank, World Development Indicators

Reminder: GDP



Source: World Bank, International Comparisons Project, report.

Reminder: where are we headed?

- Module 1: long-term economic performance
  - Why are some countries rich, and others poor?
  - Where are the economic and business opportunities?
- Suggested answer (developed over several weeks)
  - Business opportunities and economic performance generally reflect **effective markets** backed by **institutions** that keep them honest
  - Effective markets, not "free" markets

Reminder: where are we headed?

- Where would you open a new Nike factory?
  - What factors are important to you?
  - How do Indonesia, Kazakhstan, Viet Nam compare? Others?
- Where should Four Seasons expand?
  - What factors are important to you?
  - How do Baku, Dublin, Guangzhou compare? Others?
- Where should Genpact open a new BPO operation?
  - What factors are important to you?
  - How do Ghana, India, Jamaica compare? Others?

Economic history of the world

Economic history of the world

- Until recently, life was "poor, nasty, brutish, and short"
- Thomas Hobbes, "Leviathan," 1651
  - [In the natural state of Man] there is no place for industry . … [There is] continual fear and danger of violent death, and the life of man [is] solitary, poor, nasty, brutish, and short."

Economic history of the world

- Nasty and short on Gapminder

  http://www.gapminder.org/world/

Economic history of the world

Statistic	Year			
	1	1000	1820	2008
Population (millions)	225	267	1,042	6,694
GDP Per Capita (1990 USD)	467	425	666	7,614
Life expectancy (years)	24	24	26	66

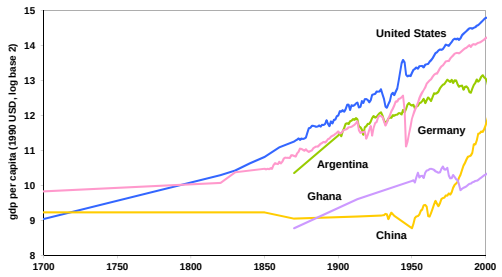
Source: Angus Maddison, Millenial Perspective.

GDP per capita (1990 international USD)

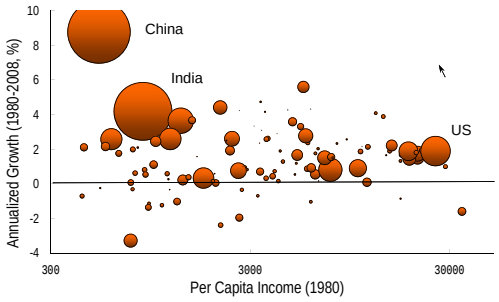
Region	Year			
	0	1000	1820	2008
Western Europe	599	425	1,218	21,672
Western "offshoots"	400	400	1,202	30,152
Japan	400	425	669	22,816
Latin America	400	400	691	6,973
Former USSR	400	400	688	7,904
China	450	466	600	6,725
Africa	472	425	420	1,760
World Average	467	453	666	7,614

Source: Angus Maddison, website.

Some examples



Growth



Source: World Bank, World Development Indicators.

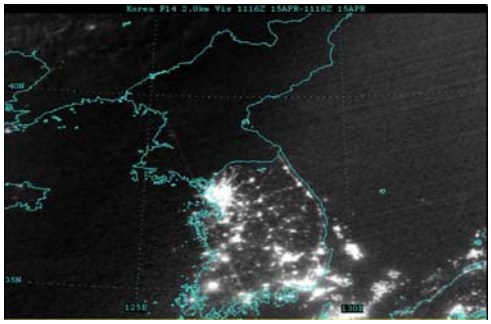
Summary

- Several centuries ago, we were all poor – and died young
- Now there's enormous variation across countries
- Also variation in growth rates
  - Modest variation among rich countries
  - Greater variation among poor countries
- Questions
  - Why?
  - What will the future bring?
  - Where are the opportunities?

Open questions

- Why did Western Europe do so well?
- Why not the Greeks and Romans?
- Why not China?
- Why not India?
- Why not the Islamic world?

A controlled experiment



19

Theory: The Production Function

20

Why theory?

- A tool to help us organize our thoughts
- What factors facilitate good performance?
- What factors offer attractive business opportunities?

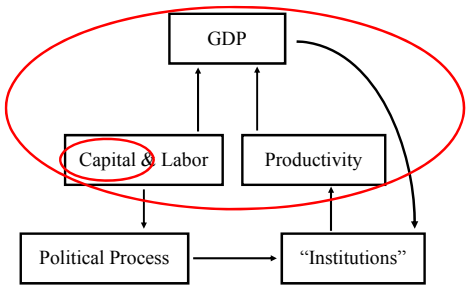
21

What kind of theory?

- Albert Einstein
  - "Make things as simple as possible – but not simpler."
- Georgia O'Keefe
  - "Nothing is less real than realism. Details are confusing. It is only by selection, by elimination, by emphasis that we get to the real meaning of things."
- Me
  - "Let's keep things simple."

22

Theory: the picture



23

Theory: the math

- The idea: relate output to inputs
- Mathematical version ("production function"):

$$Y = A\,F(K,L) = A\,K^{\alpha}\,L^{1-\alpha}$$

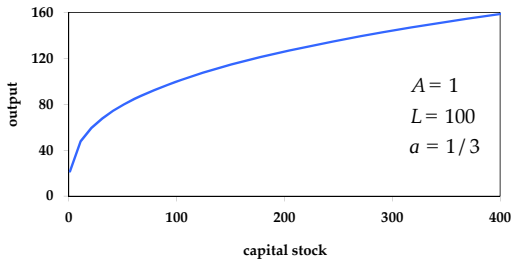
- A formula we can compute in a spreadsheet
- Definitions:
  - K = quantity of physical capital used in production (plant and equipment)
  - L = quantity of labor used in production
  - A = total factor productivity (everything else)
  - α = a parameter we set equal to 1/3 (more soon)

24

Production function properties

- More inputs lead to more output
  - Positive marginal products of capital and labor
- Diminishing marginal products
  - If we increase one input at a time, each increase leads to less additional output
  - Marginal product = partial derivative of production function
- Constant returns to scale
  - If we double **both** inputs, we double output (no inherent advantage or disadvantage to size)

Production function properties



Where does α come from?

- Capital's share of value-added
- If you know calculus, this is how we show it
  - Profit is

    $$\text{Profit} = pY - rK - wL = pAK^{\alpha}L^{1-\alpha} - rK - wL$$
  - Maximize profit by setting derivative wrt K equal to zero

    $$d\text{Profit}/dK = \alpha pAK^{\alpha-1}L^{1-\alpha} - r = 0$$
  - Multiply by K

    $$\alpha\, pAK^{\alpha}L^{1-\alpha} = rK$$

    $$\alpha = rK / pAK^{\alpha}L^{1-\alpha}$$
  - Evidence (last week): about 1/3

Capital (K)

- What we mean: plant and equipment, physical capital
- Why does it change?
  - Depreciation/destruction
  - New investment ("capex")
- Mathematical version:

  $$K_{t+1} = K_t - \delta_t K_t + I_t$$

  $$= (1 - \delta_t) K_t + I_t$$
- Adjustments for quality?

Measuring capital

- Option #1: direct surveys of plant and equipment
- Option #2: perpetual inventory method
  - Pick an initial value K_0
  - Pick a depreciation rate (or measure depreciation directly)
  - Measure K like this:

    $$K_{t+1} = (1 - \delta_t)K_t + I_t$$
- In practice, #2 is the norm:
  - Get I from "NIPA" ["real" investment]
  - Set $\delta = 0.06$ [ballpark number]
  - Example: $K_{2010} = 100$, $\delta = 0.06$, $I = 13 \rightarrow K_{2011} = ??$

Labor (L)

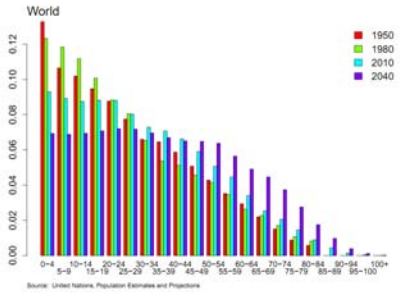
- What we mean: units of work effort
- Why does it change?
  - Population growth
  - Fraction of population employed (extensive margin)
  - Hours worked per worker (intensive margin)
- Our starting point: number of people working

Measuring labor

- Our starting point
  - L = number of people working
- Adjustments for hours worked
  - Replace L with hL (h = hours per worker)
- Adjustments for skill, education
  - Replace L with HL (H = "human capital")
  - H commonly connected to years of school

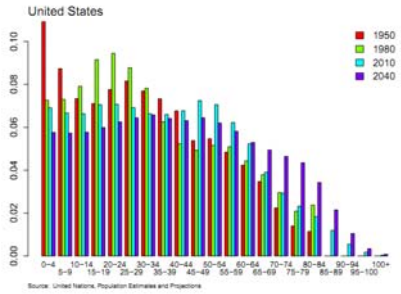
31

Population by age



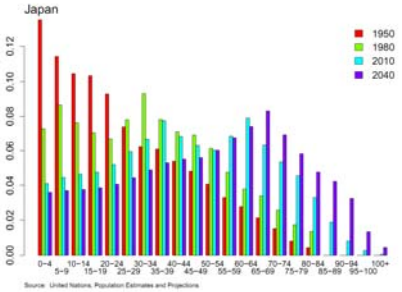
32

Population by age



33

Population by age



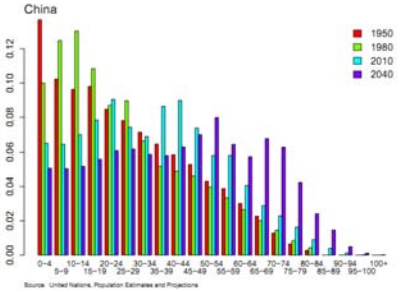
34

Population by age

- Business Week, Nov 2012:
  - Last year, for the first time, sales of adult diapers in Japan exceeded those for babies.
- Target markets in Japan? US?

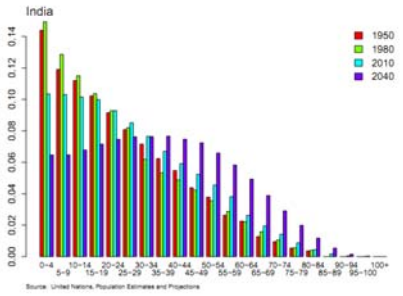
35

Population by age



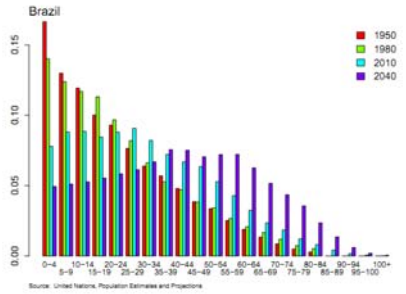
36

Population by age



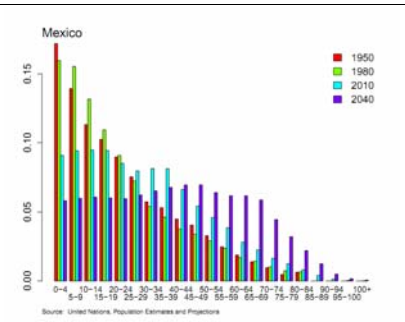
37

Population by age



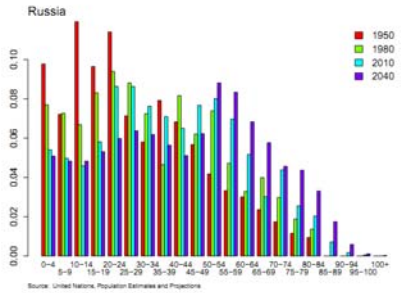
38

Population by age



39

Population by age



40

Productivity (A)

- Standard number
  - Average product of labor: Y/L
- How do we measure it?
  - Measure output and labor input, take the ratio
- Our number
  - Total Factor Productivity (TFP): A = Y/F(K,L)
- How do we measure it?
  - Same idea, but "input" combines capital and labor ("total")

41

Productivity

- Solve the production function for A

$$Y = A K^{\alpha} L^{1-\alpha}$$

$$A = Y/[K^{\alpha} L^{1-\alpha}] = (Y/L)/(K/L)^{\alpha}$$

- Example: Y/L = 33, K/L = 65,

$$A = 33/65^{1/3} = 8.21$$

- Note: units meaningless, but the same across time or countries

42

Production function review

- Remember: $Y = A\,F(K,L)$
- What changes **in this equation** if
  - **A firm builds a new factory?**
  - Fewer people retire at 65
  - **Spanish banks channel funds to unproductive firms**
  - Workers shift from agriculture to industry in Viet Nam?
  - **Competition drives inefficient firms out of business?**
  - Venture capital fund identifies good unfunded projects?
  - **Alaska builds a bridge to nowhere?**
  - China invests in massive infrastructure projects?

What have we learned?

- The production function links output to inputs and productivity:

$$Y = A\,K^{\alpha}\,L^{1-\alpha}$$

- Capital input (K)
  - Plant and equipment, a consequence of investment (I)
- Labor input (L)
  - Population growth, age distribution, participation, hours (h), skill (H)
- TFP (A) can be inferred from data on output and inputs

"Guard your manhood"

- What is this ad doing?
- Is it effective?

The Global Economy

Solow's Growth Model

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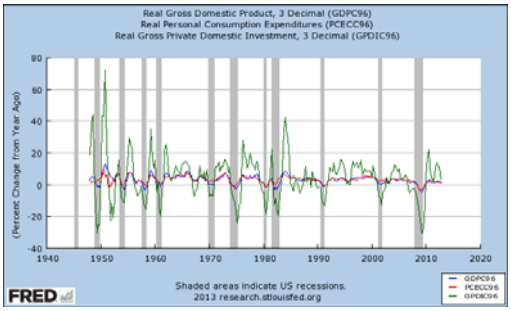
Problem Set #0

- Answers attached
- Question 3 makes two points that will come up later
  - C and I move up and down with GDP (correlations)
  - I moves a lot more than the others (standard deviations)

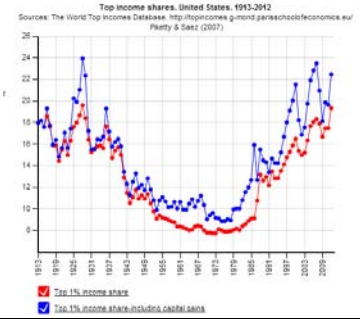
Problem Set #0



Problem Set #1

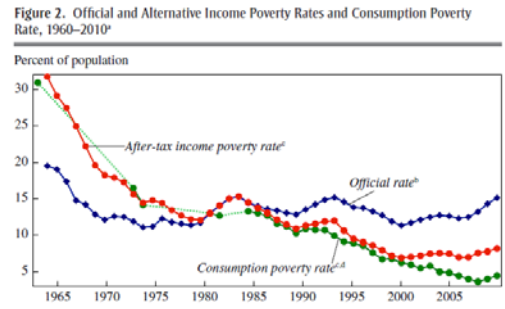
- Due at start of next class
- Do in groups, learn from each other
- Post questions on Discussion & Announcements (or email me and I'll do it)
- Note data link for Question 3 (also embedded in pdf)
- **Anyone need group members?**

What's happening?



Source: World Top Incomes.

What's happening?



Source: Meyer and Sullivan, Brookings.

Roadmap

- Problem Set #0 ✓
- What's happening? ✓
- Saving and growth
- Solow's model
- Does India need more saving?
- China less?

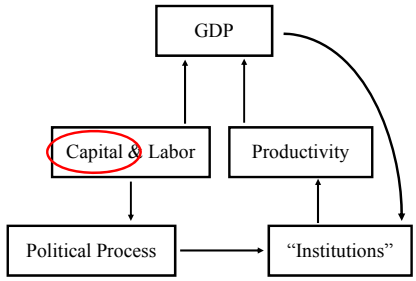
Saving and growth

- JFK in 1960, height of Cold War
  - Rapid growth in USSR, also high saving and investment rates
  - Cause and effect?
- US analysts in 1985
  - Rapid growth in Asian "tigers," lots of saving
  - Cause and effect?
- China in 2010
  - Rapid growth, saving close to 50% of GDP
  - Does India need to do the same?

Saving and growth

- How does saving generate growth?
- Critical to long-run performance?

Saving and growth



55

Solow's Model

56

Solow model

- How it works
  - Saving finances capital accumulation
  - More capital leads to greater output
  - Impact eventually tails off: diminishing marginal product of capital

57

Solow model: equations

- Production function:

$$Y = A K^{\alpha} L^{1-\alpha}$$

- Flow identity:

$$S = I$$

- Saving:

$$S = sY$$

- Capital stock:

$$K_{t+1} - K_t = \Delta K = I - \delta K$$

58

Solow model: analysis

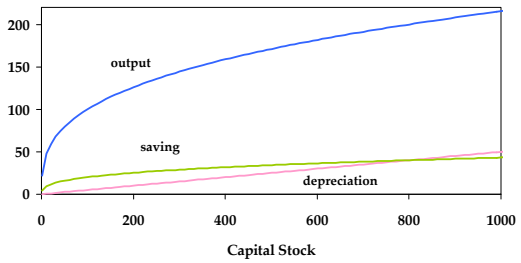
- "Analysis" here means we substitute like crazy

$$\Delta K = sY - \delta K$$
$$= sAK^{\alpha} L^{1-\alpha} - \delta K$$

- For the time being, A, L don't change
- Two competing forces on K
  - Depreciation drives K down
  - Saving drives K up
  - Which is stronger?
  - Where does diminishing returns show up?

59

Solow model: dynamics



60

Solow model: convergence

- Eventually the two forces balance
  - Capital stock eventually stops changing
  - Output does, too
- Solow's answer to JFK
  - USSR won't catch up through saving alone
  - Eventually the effects of higher saving/investment peter out

61

India

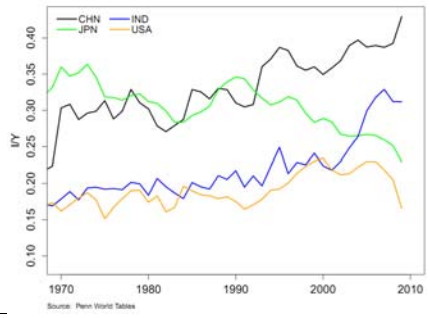
62

India

- Saving and investment rates well below China's
- How important is this to India's future?

63

Investment rates



64

India

- Experiments with Solow model
  - Benchmark: start model in 2010 and see what happens
  - Raise saving rate
  - Introduce productivity growth
- What has the biggest impact?

65

India

- Solow model inputs (estimates for 2010)
  - Output Y=GDP: 4.08 trillion USD
  - Capital K: 8.23 trillion USD
  - Labor L: 0.452 billion people
  - Source: Penn World Table
  - Productivity A: how do we compute this?
  - Saving/investment rate s: 0.25
  - Depreciation rate δ: 0.06
- Experiments
  - Raise saving rate
  - Add productivity growth

66

India

- Solow model experiments
  - Raise saving rate
  - Add labor force growth
  - Add productivity growth
  - Increase productivity growth

67

India

Scenario	GDP
2010	4.08
2050: no-growth benchmark	
2050: higher saving (+5%)	
2050: population growth (1%)	
2050: TFP growth (2%)	
2050: TFP growth (+1%)	

68

India

Scenario	GDP
2010	4.08
2050: no-growth benchmark	5.56
2050: higher saving (+5%)	6.03
2050: population growth (1%)	7.01
2050: TFP growth (2%)	15.49
2050: TFP growth (+1%)	25.94

69

China

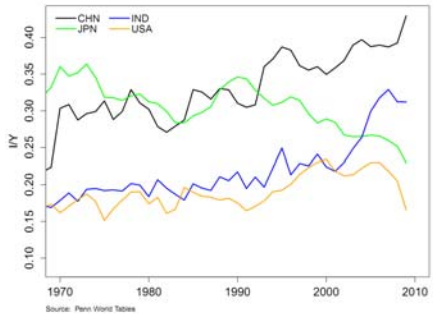
70

China

- Saving and investment are 40-50% of GDP?
- Is that too much?

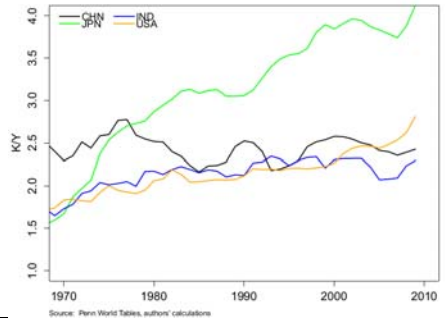
71

Investment rates



72

Capital intensity



73

China summary

- Quantity of capital not unusual
  - K/Y not much different from US
  - How can that be?
  - When you growth this fast, you need a lot of investment
- "Quality" of capital raises some questions
  - Has public infrastructure been overdone?
  - Are productive firms starved for resources?
  - Is the financial system a hindrance to future growth?

74

Almost done

75

What have we learned?

- Solow model
  - Saving and capital accumulation generate growth
  - But diminishing returns kills this off quickly
  - Conclusion: saving and capital formation can't be the keys to prosperity (in the US, in China, in India, etc)
  - Solow model still a useful forecasting tool
- If not capital, what?
  - Productivity growth

76

Something for the ride home

- Are natural resources critical to economic growth?
- Do countries that have a lot of them tend to do well?
- Examples?
- Why? Or why not?
- Add your thoughts on the discussion page

77