The Global Economy

The Production Function

NYU STERN

What's happening?

- Zeeshan Haider, Sara Bitteti*, and Shiyue Cheng weighed in on taxes, including this from Bloomberg:
  - Amazon.com was among three U.S. companies singled out by U.K. lawmakers last year for not paying enough tax in Britain. Members of Parliament's Public Accounts Committee criticized the online retailer, Starbucks Inc. and Google Inc. for using complex accounting methods to reduce their tax liabilities in the U.K.
- What would you do if you were Amazon? If you were the UK?

What's happening?

- Questions about tax policy
  - If you're a CEO, how important are taxes to your location decision?
  - If you're Mayor Bloomberg, are tax breaks for firms good for the NYC economy?
  - Is competition between localities good for economic performance overall?
  - Should we tax firms directly, or collect the same revenue with income and sales taxes?

What's happening?

- An old joke:
  - Opinion polls show that 100% of voters think other people should pay more tax.

Roadmap

- What's happening? ✓
- 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 in constant dollars
  - 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

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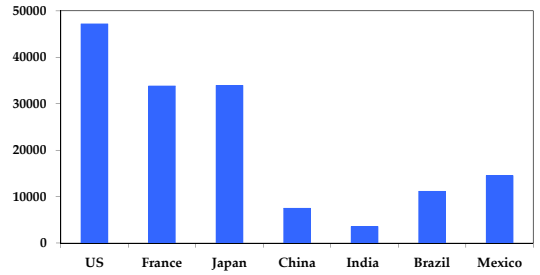
Reminder: GDP per capita (USD, PPP adj)



Source: World Bank, World Development Indicators

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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
  - More bluntly: low price is good, not messed up also good

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Reminder: where are we headed?

- Where should Genpact open a new BPO operation?
  - What factors are important to you?
  - How do Ghana, India, Jamaica compare? Others?
- 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?

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Economic history of the world

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Economic history of the world

- Until recently, life was "poor, nasty, brutish, and short"
- 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."

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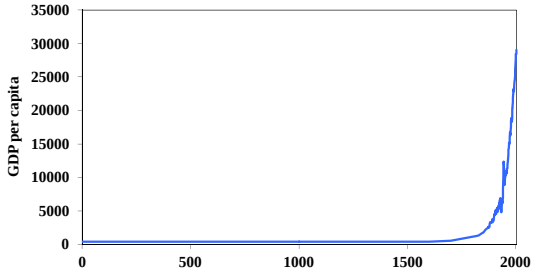
Economic history of the world

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.

Economic history of the world

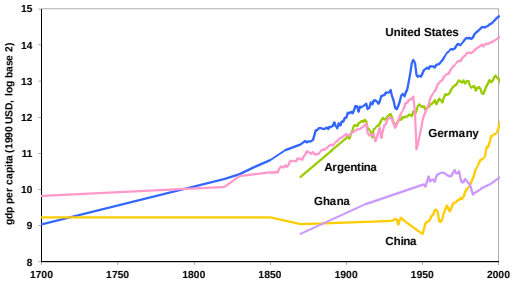


GDP per capita (1990 international USD)

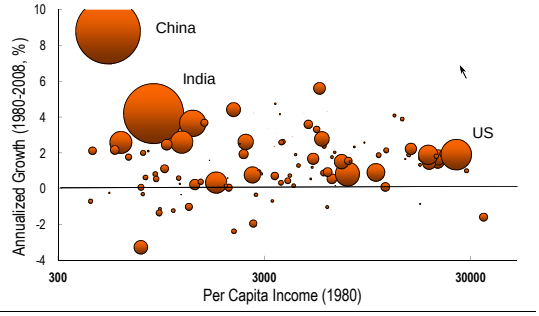
Region	Year			
	0	1000	1820	2008
Western Europe	599	425	1,218	21,672
Western "offshoots"	400	400	1,202	30,152
Japan	400	425	669	22,816
Latin America	400	400	691	6,973
Former USSR	400	400	688	7,904
China	450	466	600	6,725
Africa	472	425	420	1,760
World Average	467	453	666	7,614

Source: Angus Maddison, website.

Some examples



Growth

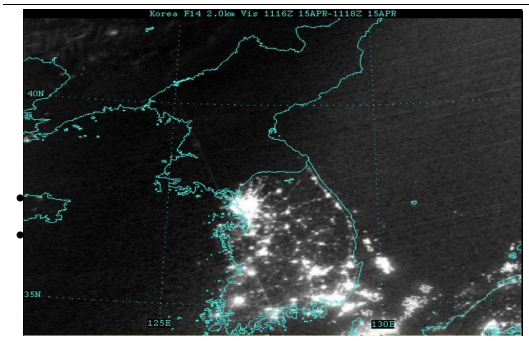


Source: World Bank, World Development Indicators.

Summary

- Several centuries ago, we were all poor
- 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?

A controlled experiment



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Theory: The Production Function

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Why theory?

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

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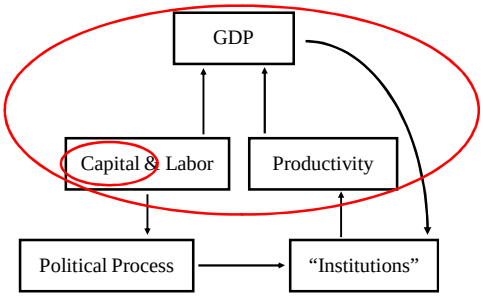
Theory: the picture



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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)

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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)

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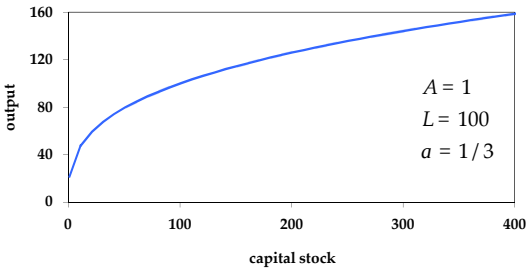
Production function properties



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: $K_{2010} = 100$, $\delta = 0.06$, $I = 13 \rightarrow K_{2011} = ??$

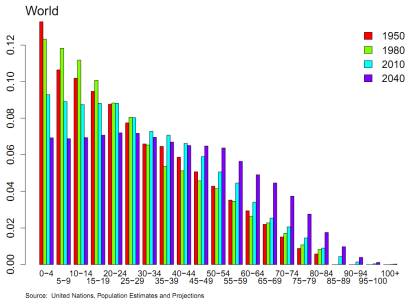
Labor (L)

- 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

Population by age



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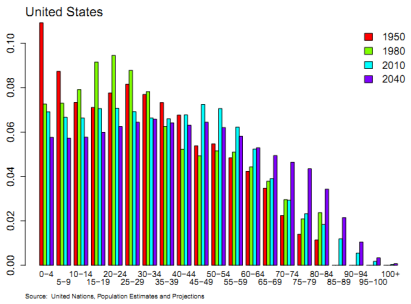

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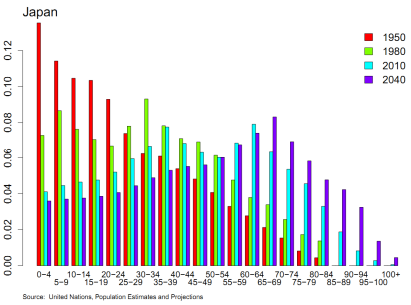
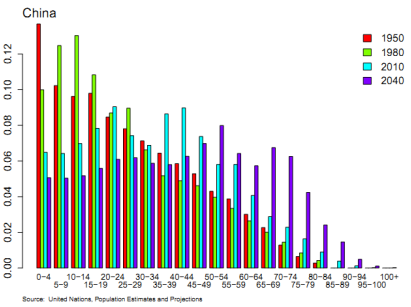


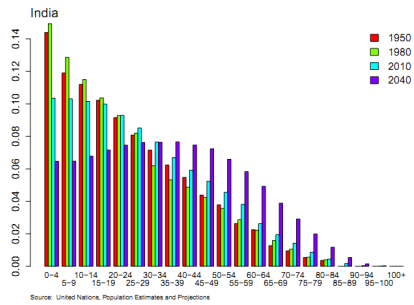
Population by age

- Business Week, Nov 2012:
  - Last year, for the first time, sales of adult diapers in Japan exceeded those for babies.
- We'll come back to this.

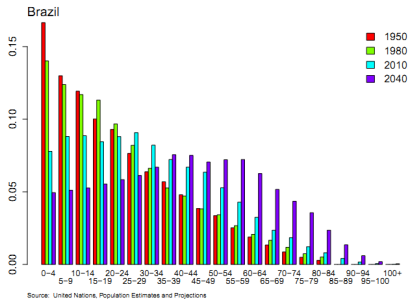
Population by age



Population by age



Population by age



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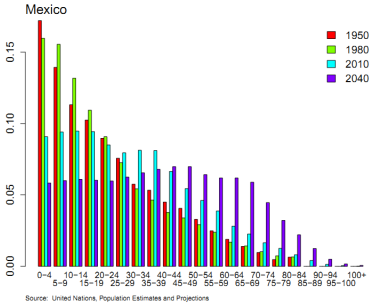
Population by age



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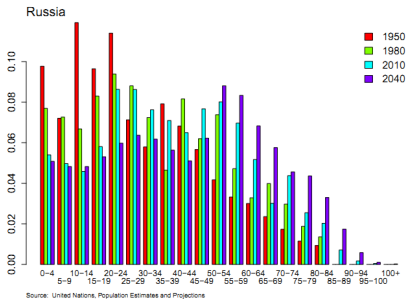
Population by age



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Productivity (A)

- Standard number
  - Average product of labor: Y/L
- How do we measure it?
  - Measure output and 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")

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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

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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?

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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

After the break

- Come back ready to discuss: "Diapers in Japan"
- Business Week, Nov 2012:
  - Last year, for the first time, sales of adult diapers in Japan exceeded those for babies.
- What are the market opportunities of an aging population? Design challenges? Other ideas?

The Global Economy

Solow's Growth Model

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Diapers in Japan

- What are the market opportunities of an aging population? Design challenges? Other ideas?

Wages

- Would you like to live in a high- or low-wage country?
  - Why? Why not?
- Would you open an office or factory in a high- or low-wage country?
  - Why? Why not?

What's happening?

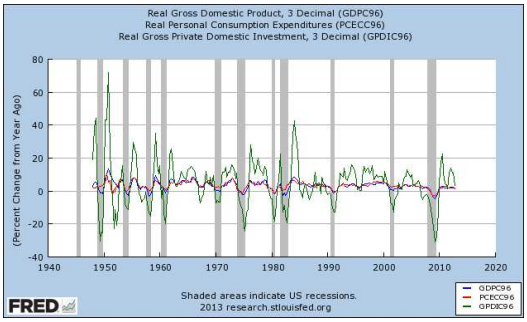
- "Trickle-up economics," The Economist, Feb 16, 2013:
  - On February 12th, Obama proposed raising the federal minimum wage by 24% to $9. Labour and liberal groups said it would reduce poverty, while businesses and Republicans said it would cost low-skilled workers jobs.
- What's the likely effect? Who wins? Who loses?

What's happening?

Problem Set #0

- Answers will be posted Monday night or Tuesday
- Question 3 makes two points that will come up later
  - GDP, C, and I move up and down together (correlations)
  - I moves a lot more than the others (standard deviation)
  - Picture of year-on-year growth rates (next page)

Problem Set #0



Roadmap

- Diapers in Japan, wages
- Saving and growth
- Solow's model and convergence
- India

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?

Solow's Model

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Solow model

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

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Solow model: equations

- Production function:

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

- Flow identity:

$$I = S$$

- Saving:

$$S = sY$$

- Capital stock:

$$\Delta K = I - \delta K$$

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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?

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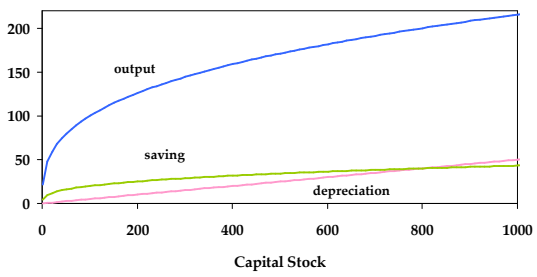
Solow model: dynamics



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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
- Do we see convergence in the data?

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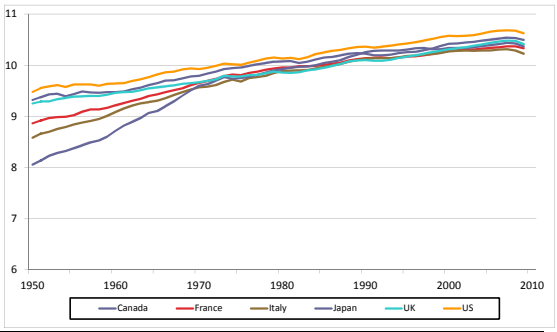
Convergence?

Log of Real Per Capita GDP (PPP, 2005 Chained US$)



Source: Penn World Tables 7.0

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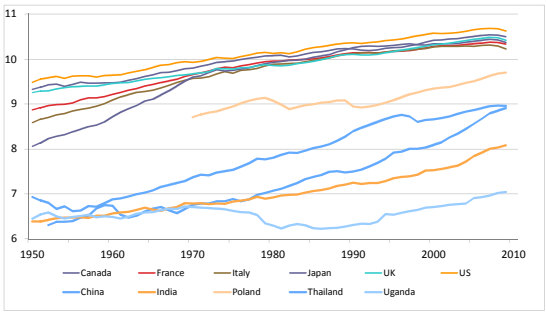
Convergence?

Log of Real Per Capita GDP (PPP, 2005 Chained US$)



Source: Penn World Tables 7.0

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Convergence summary

- Worked reasonably well for rich countries after WW II
  - Countries bounced back from the destruction of capital
- Not so well for other countries
  - Something else must be going on
  - But what?

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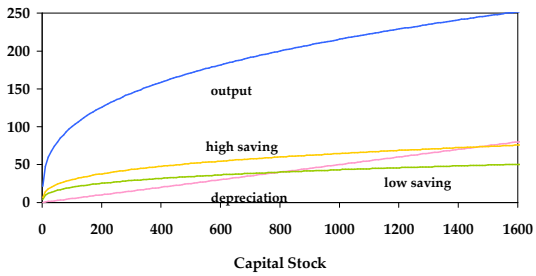
Level effects v. growth effects

- *Level effect*: change in GDP level
  - Temporary change in growth rate
- *Growth effect:* permanent change in growth rate
- Level or growth effect?
  - Saving rate
  - Population growth

Saving?



Population growth?

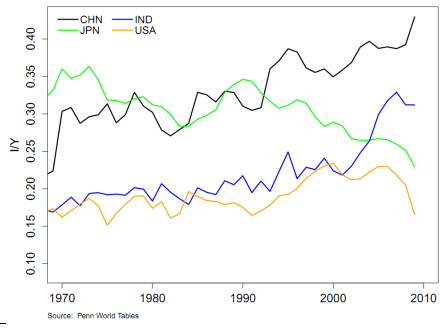
- How does it work?
- Increases GDP
- Decreases GDP per capita if K is fixed
  - Capital per worker falls
  - Increases share of young, who don't work
- Doesn't vary enough to account for growth experiences

India & China

India

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

Investment rates



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?

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 Tables (see link)
  - Productivity A: how do we compute this?
  - Saving/investment rate s: 0.25
  - Depreciation rate delta: 0.06
- Experiments
  - Raise saving rate
  - Add productivity growth

India

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

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%)	

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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

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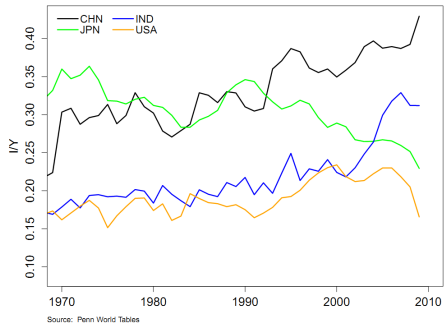
Investment rates



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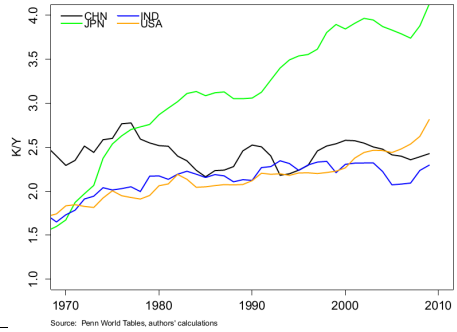
Capital intensity



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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?

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Almost done

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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)
  - Still a useful forecasting tool
- If not capital, what?
  - TFP growth

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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

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For the ride home

- US healthcare
  - How might it affect US output and productivity?
  - What's the problem policy is trying to solve?
  - How would you suggest we solve it?

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