The Global Economy

The Production Function

NYU STERN

Roadmap

- Discussion
- Problem Set #0
- Reminders
- Facts: GDP and GDP growth
- Theory: the production function
- Inputs: capital and labor
- Productivity

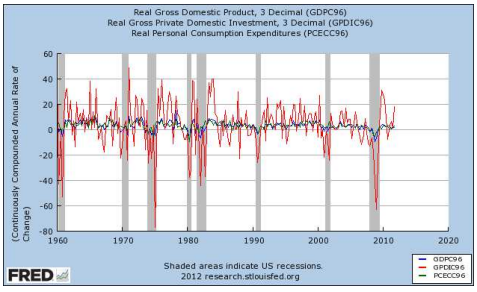
Discussion: inflation

- Linpei Zhang
  - My father in law just came from Beijing. His biggest complaint was inflation in China. Although overall inflation is not high, the price of the food has increased substantially.
- Questions
  - What is inflation?
  - Why are people concerned about it?
  - Where does it come from?

Problem Set #0

- Math and spreadsheet skills
  - Spreadsheets: essential life skill
  - Exponents and logarithms: used extensively in first half [LN]
  - Calculus: used sparingly, not on exams
- Answers will be posted Saturday afternoon
- 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)

Problem Set #0



Reminder: Problem Set #1

- Due next class
- Do in groups of one to five
- Send questions to me or TF
  (I'll post answers in announcements)
- Start with the data download step of Question 3
  (Any problems, let me know)

Reminder: Announcements/Discussion

- Links on course website
- Optional signups for email delivery

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Reminder: real and nominal GDP

- Real GDP ("quantity")
  - GDP in constant dollars
  - GDP in 2005 USD
  - GDP in 1990 international prices
  - GDP in LCU
  - GDP chain-weighted in 2010 USD
- Nominal GDP ("value = price times quantity")
  - GDP at current prices

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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?
- Our proposed answer (developed over several weeks)
  - Business opportunities and economic performance generally reflect effective markets backed by institutions that keep them honest.

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Facts: GDP per capita

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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.

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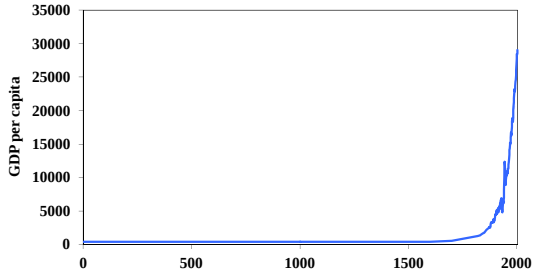
Economic history of the world



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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.

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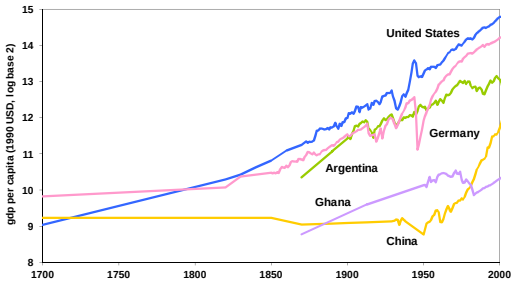
More history



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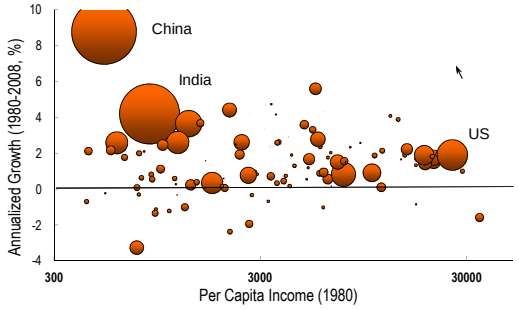
Recent history



Source: World Bank, World Development Indicators.

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Facts: 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

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Questions

- What separates successes from others?
  - What factors facilitate good performance?
  - What factors generate business opportunities?
- Why?
  - Why did Western Europe do so well?
  - Why not the Greeks and Romans?
  - Why not China, India, the Islamic World?
- Could the future be different?

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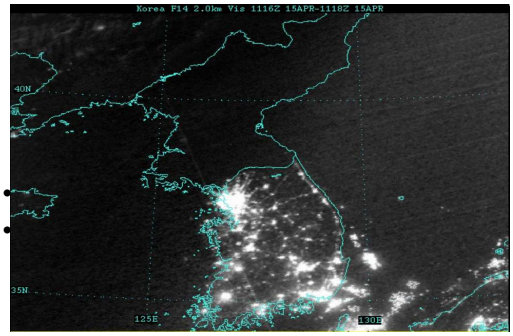
A controlled experiment



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Theory: The Production Function

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Why theory?

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

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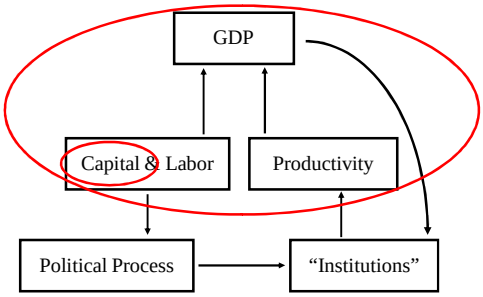
Theory: the picture



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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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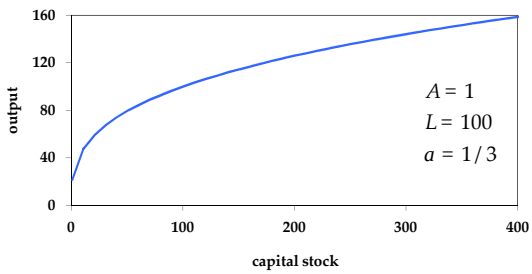
Production function properties



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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

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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?

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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"
  - Set $\delta = 0.06$ [ballpark number]
  - Example: $K_{2010} = 100$, $\delta = 0.06$, $I = 12$ → $K_{2011} = ??$

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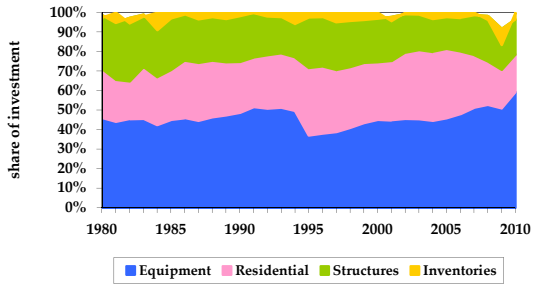
Investment composition



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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

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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

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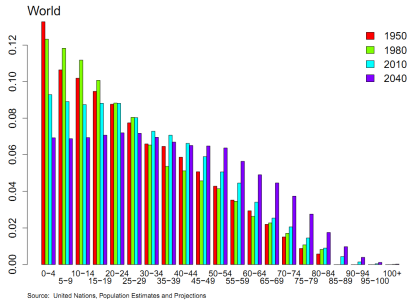
Population by age



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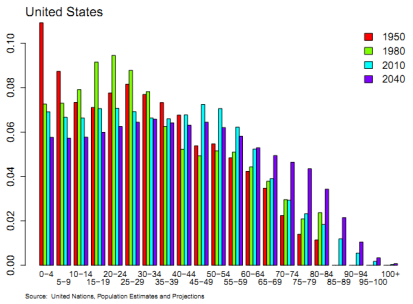
Population by age



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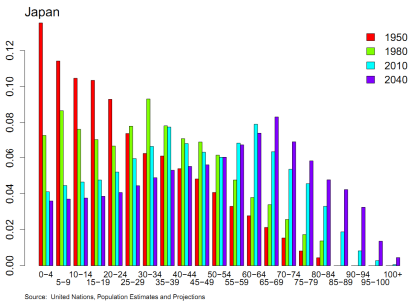

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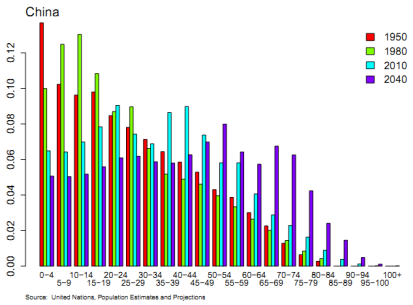

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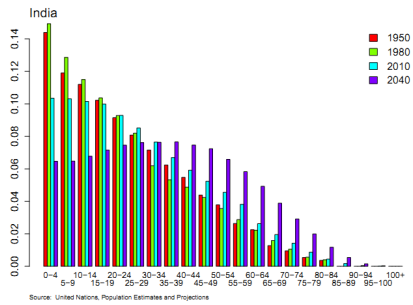
Population by age



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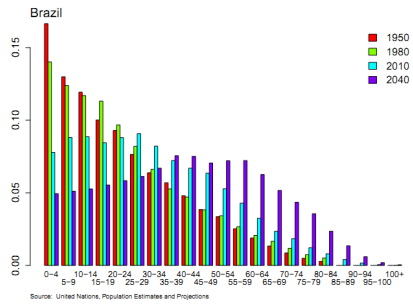
Population by age



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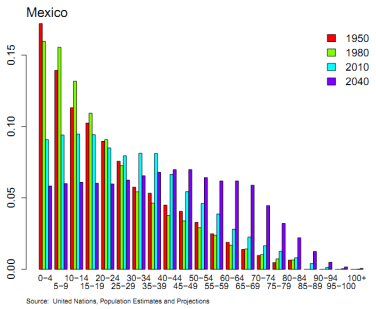
Population by age



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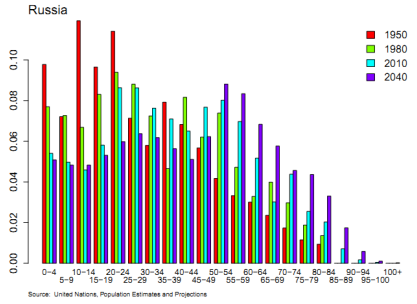

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Comparing China and Mexico

- Different "demographics"
  - China has had "one child" rule since 1979, low birth rate
  - Mexico has high birth rate
- How does that show up in (say) GDP per capita?
  - If kids don't work, then having lots of them reduces the ratio of workers to population
  - Ditto having lots of retired people

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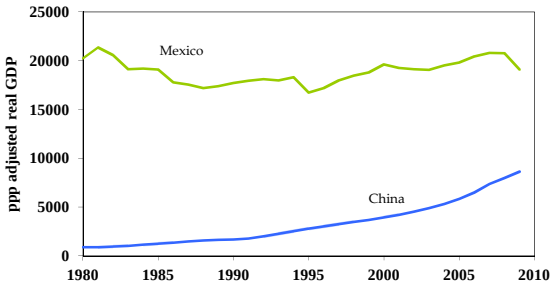
GDP per working age person



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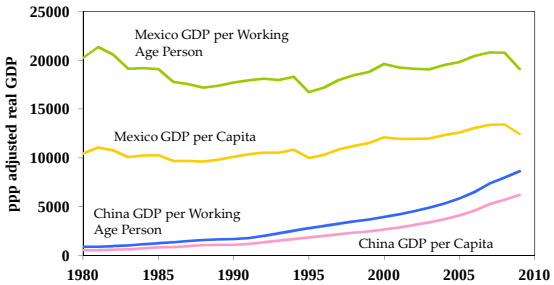
GDP



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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

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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 comparisons across time or countries are useful

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
  - **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

The Global Economy

Solow's Growth Model

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Roadmap

- In the news
- Saving and growth
- Solow's model and convergence
- India

In the news: Greece

- Joachim Fels, Morgan Stanley
  - Events around Greece underscored our concerns. Following the Eurogroup's ultimatum, the Greek government – hit by a slew of resignations – now has to pass the reform and austerity measures in Parliament. More uncertainties lie ahead, including whether the deal will be approved by German parliament and whether a sufficient number of investors participates in the debt swap.
- What is he saying?
- Do you agree?

In the news: inflation

- Joachim Fels, Morgan Stanley
  - With central banks around the world opening the monetary floodgates, it is only a question of time until markets start to worry about the consequences for inflation. Our Asia (ex-Japan) and Latin America teams are looking for inflation rates to creep higher after the middle of the year.
- What is he saying?
- Do you agree?

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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?

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Saving and growth

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

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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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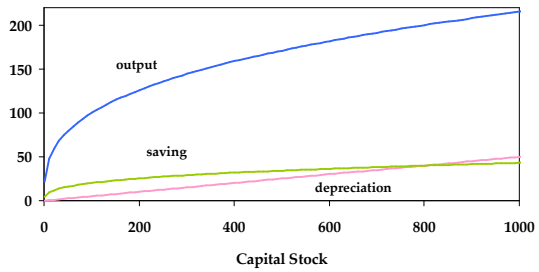
Solow model: dynamics



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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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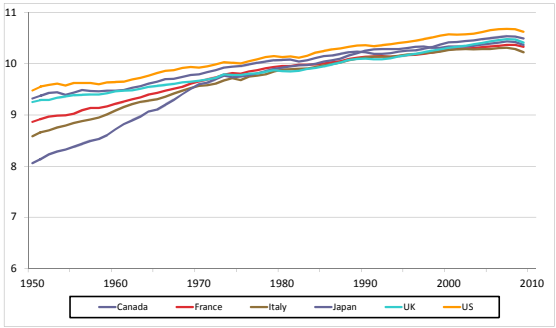
Convergence?

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



Source: Penn World Tables 7.0

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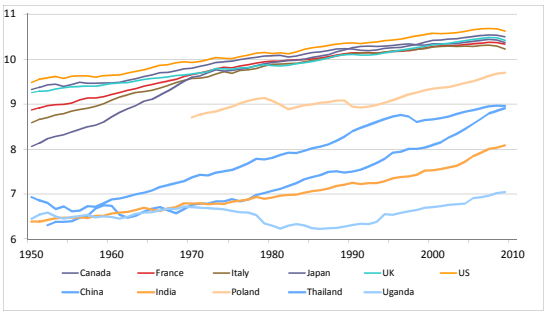
Convergence?

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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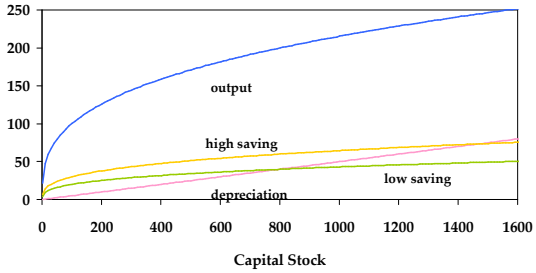
Level effects v. growth effects

- *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

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India

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

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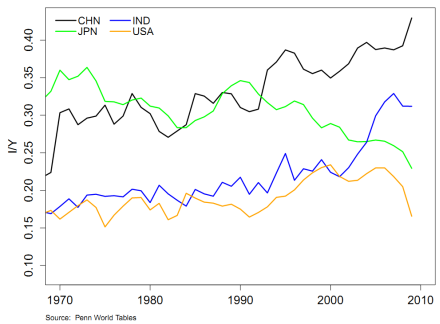
Investment rates



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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?

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India

- Solow model inputs (estimates for 2010)
  - Output Y=GDP: 3.87 trillion 2005 USD
  - Capital K: 5.78 trillion 2005 USD
  - Labor L: 0.450 billion people
  - 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

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India

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

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India

Scenario	GDP
2010	3.87
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	3.87
2050: no-growth benchmark	6.08
2050: higher saving (+5%)	6.61
2050: population growth (1%)	8.72
2050: TFP growth (2%)	18.02
2050: TFP growth (+1%)	31.09

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What have we learned?

- Solow model
  - Growth comes from saving and capital accumulation
  - 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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For the ride home

- US healthcare
  - What's the biggest problem you see?
  - How would you solve it?

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