ECON 30020: Intermediate Macroeconomics

Topic 2c: Cross-Country Income Differences

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Review: Solow Growth Model

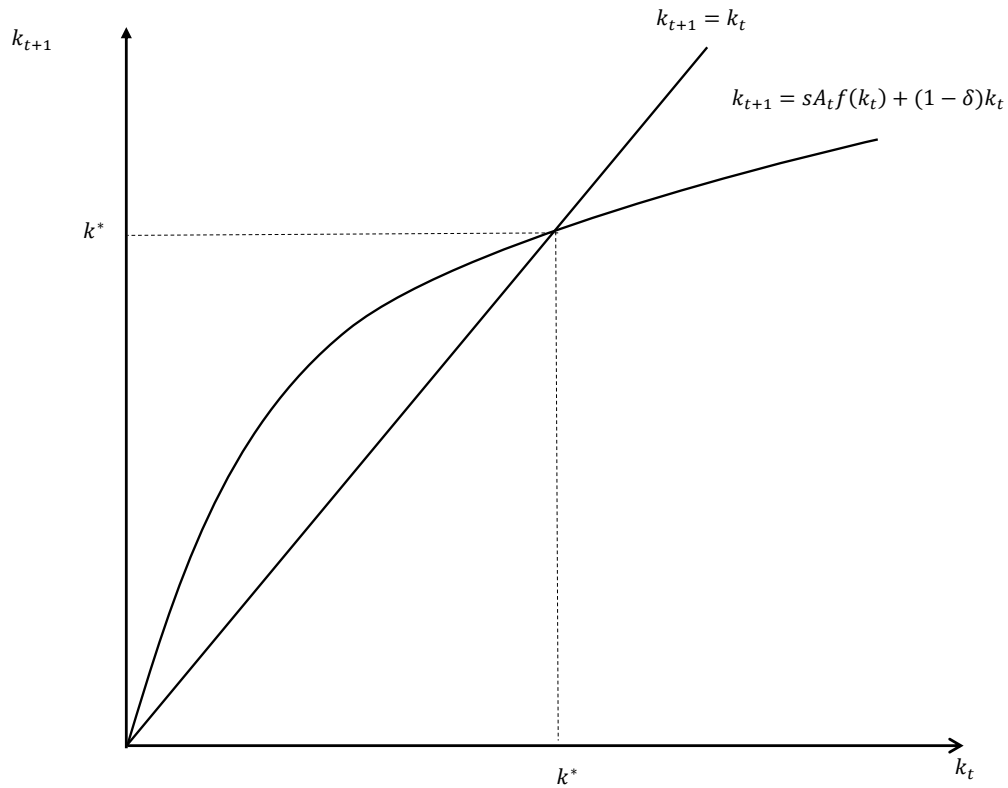
Six equations in Solow model

$$
\begin{aligned}
Y_t &= A_t F(K_t, N_t) \\
Y_t &= C_t + I_t \\
K_{t+1} &= I_t + (1-\delta)K_t \\
I_t &= sY_t \\
w_t &= A_t F_N(K_t, N_t) \\
R_t &= A_t F_K(K_t, N_t)
\end{aligned}
$$

Review: the Central Equation and Steady State

Central Equation for $k_t \equiv K_t / N_t$

$$k_{t+1} = sA_t f(k_t) + (1-\delta)k_t$$



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  1. Output per worker grows at a constant rate
  2. Capital per worker grows at a constant rate
  3. The capital to output ratio is constant
  4. Labor's share of income is constant
  5. The return to capital is constant
  6. The real wage grows at the same rate as output per worker

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  6. The real wage grows at the same rate as output per worker
- Implications of the model:
  - Productivity is key to sustained growth
  - Cannot simply save your way to faster growth

Cross-Section Stylized Facts

		GDP per Person
High income countries		
	Canada	$35,180
	Germany	$34,383
	Japan	$30,232
	Singapore	$59,149
	United Kingdom	$32,116
	United States	$42,426
Middle income countries		
	China	$8,640
	Dominican Republic	$8,694
	Mexico	$12,648
	South Africa	$10,831
	Thailand	$9,567
	Uruguay	$13,388
Low income countries		
	Cambodia	$2,607
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	India	$3,719
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1. There are large differences in income per capita across countries: Rich countries are 3-5 times richer than middle income or 10-20 times richer than poor countries

Cross-Section Stylized Facts

		Growth Miracles	
	1970 Income	2011 Income	% change
South Korea	$1918	$27,870	1353
China	$1,107	$8,851	700
Botswana	$721	$14,787	1951
		Growth Disasters	
Madagascar	$1,321	$937	-29
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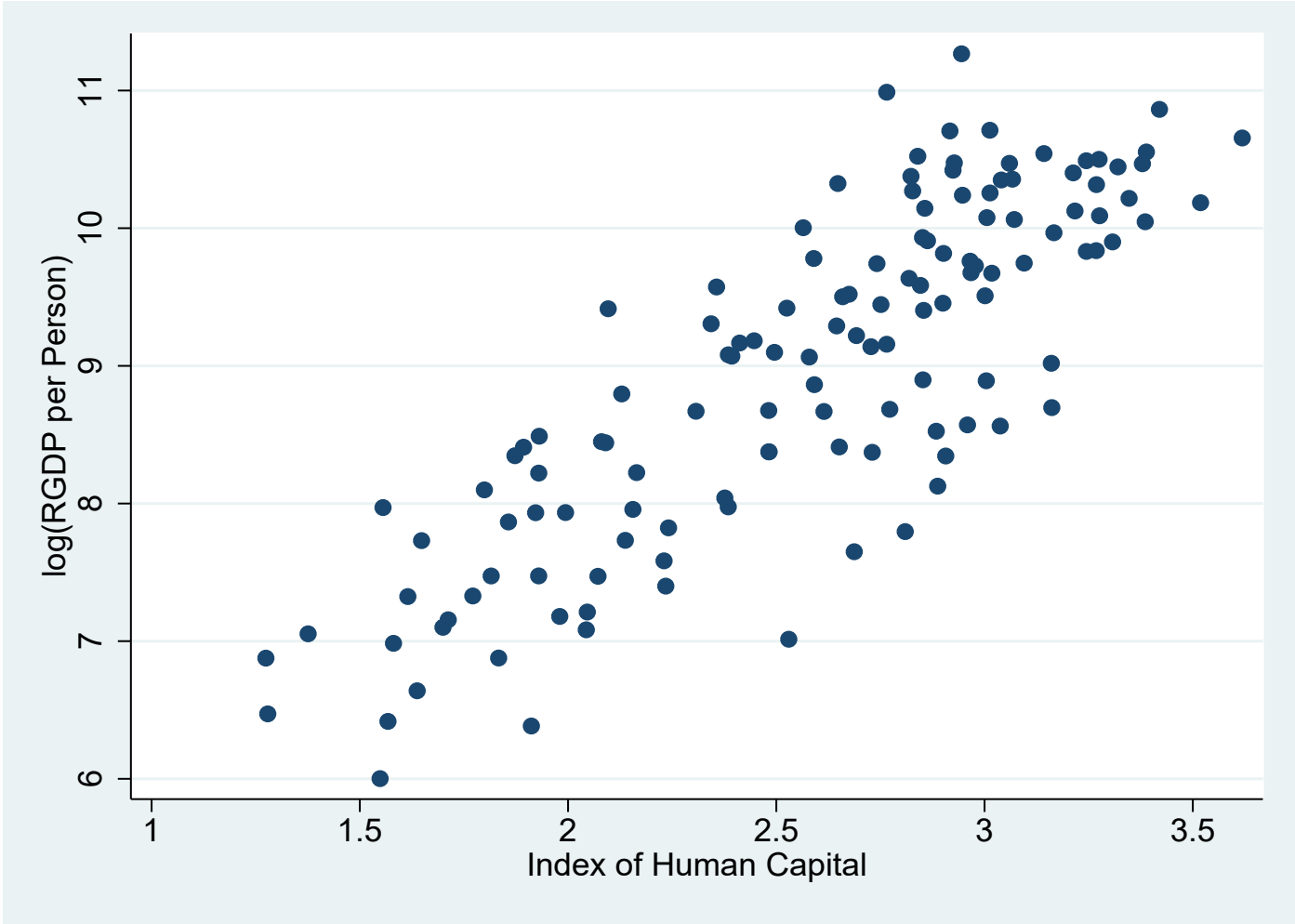
2. There are some examples where poor countries catch up (growth miracles), otherwise where they do not (growth disasters)

Cross-Section Stylized Facts



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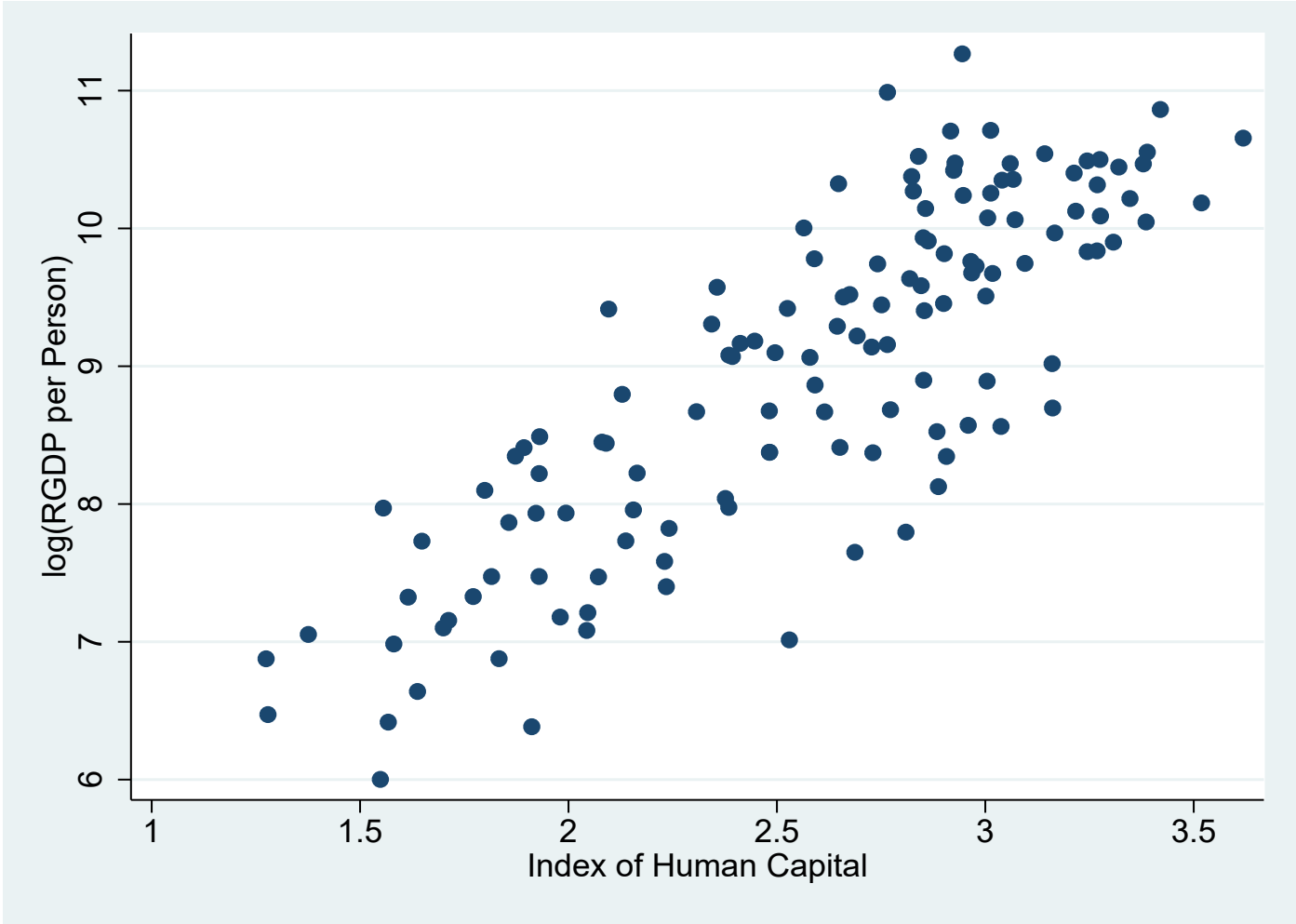

3. Human capital (e.g. education) strongly correlated with income per capita

What does the model say about cross-sectional facts?

- Wide dispersions in standards of living across countries
- Model explains time series facts successfully
- we want to use the model to study why some countries are very poor in comparison to others
- what policy makers should do about this

What does the model say about cross-sectional facts?

What explains these differences?

- Three hypotheses for why cross-country income differences exist:
  1. Countries initially endowed with different levels of capital
  2. Countries have different saving rates
  3. Countries have different productivity levels

  Your guess?

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  Your guess?
- Like sustained growth, most plausible explanation for cross-country income differences is productivity

Understanding Cross-Country Income Differences

- Consider standard Solow model
- Two countries, $j = 1, 2$.

$$y_{j,t} = A_{j,t} f(k_{j,t})$$

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$$y_{j,t} = A_{j,t} f(k_{j,t})$$

- Suppose that $j = 1$ is rich relative to $j = 2$

$$y_{1,t} > y_{2,t}$$

In the data, $y_{1,t}/y_{2,t} = 5$ or 10 is observed

Understanding Cross-Country Income Differences

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What accounts for $y_{1,t} > y_{2,t}$?

- Different k_t
  - $k_1^* = k_2^*$, but $k_{2,t} < k_{1,t}$: because of initial endowment
  - $k_2^* < k_1^*$: because of A or s
- Different A_t: which would result in different k

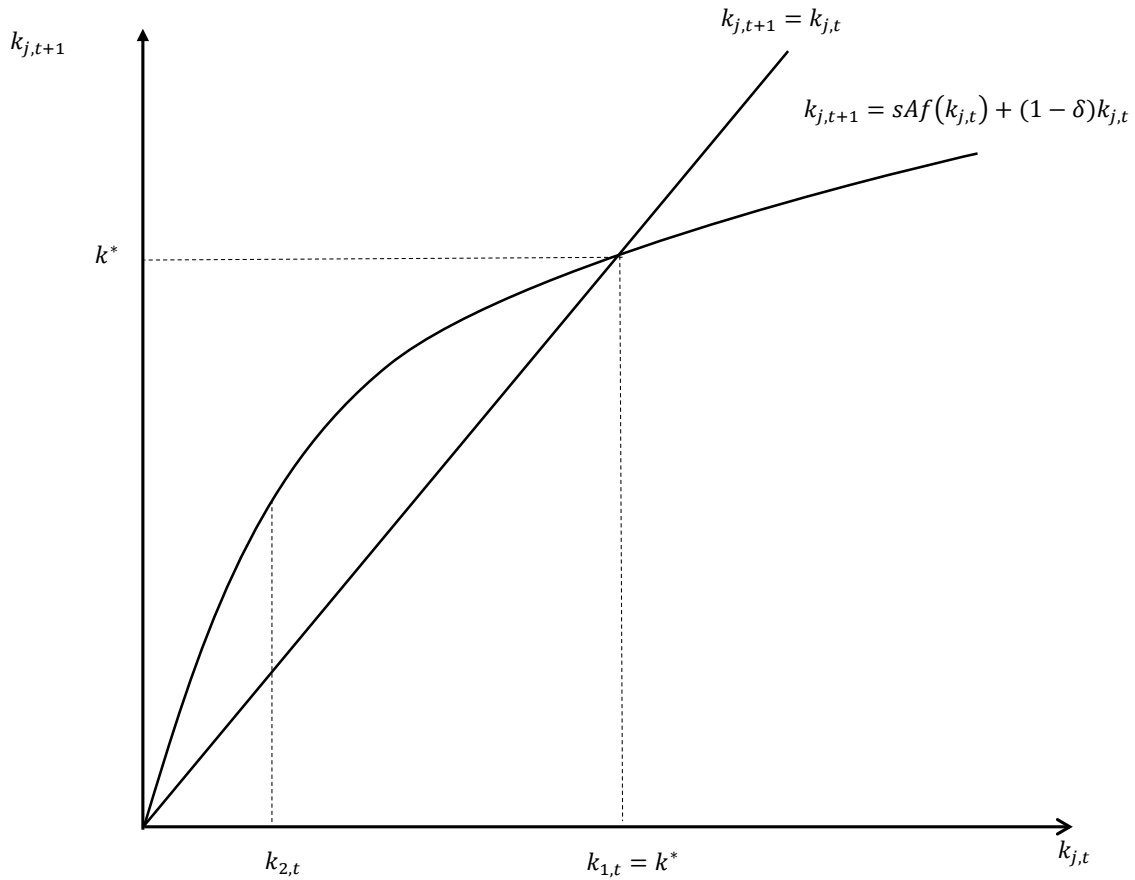
Will argue different A is most plausible

Convergence

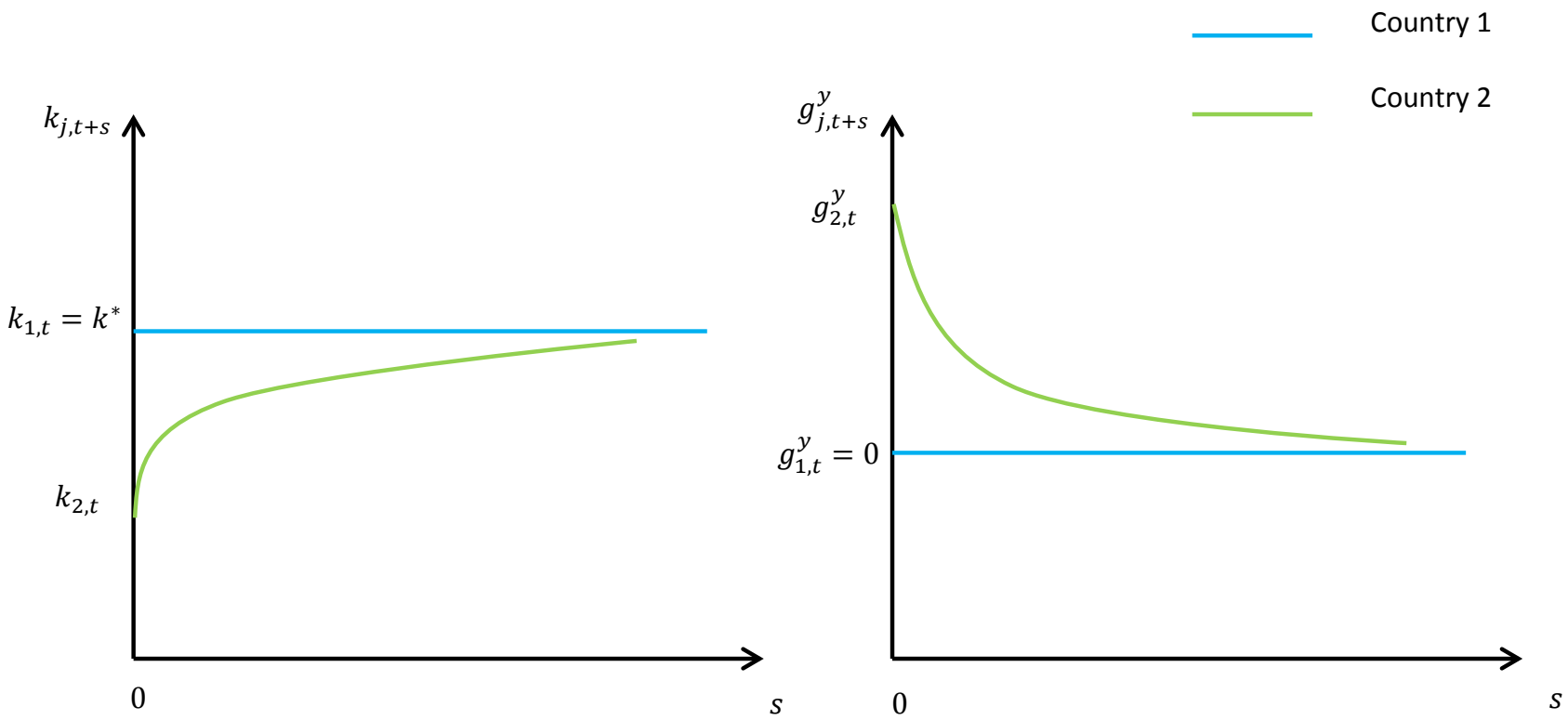
- Suppose two countries are otherwise identical ($A_1 = A_2, s_1 = s_2$), what happens to their central equation and steady state?

Convergence

- Suppose two countries are otherwise identical ($A_1 = A_2, s_1 = s_2$), what happens to their central equation and steady state?
- But suppose that country 2 is initially endowed with less capital: $k_{2,t} < k_{1,t} = k^*$, for historical reasons



Catch Up



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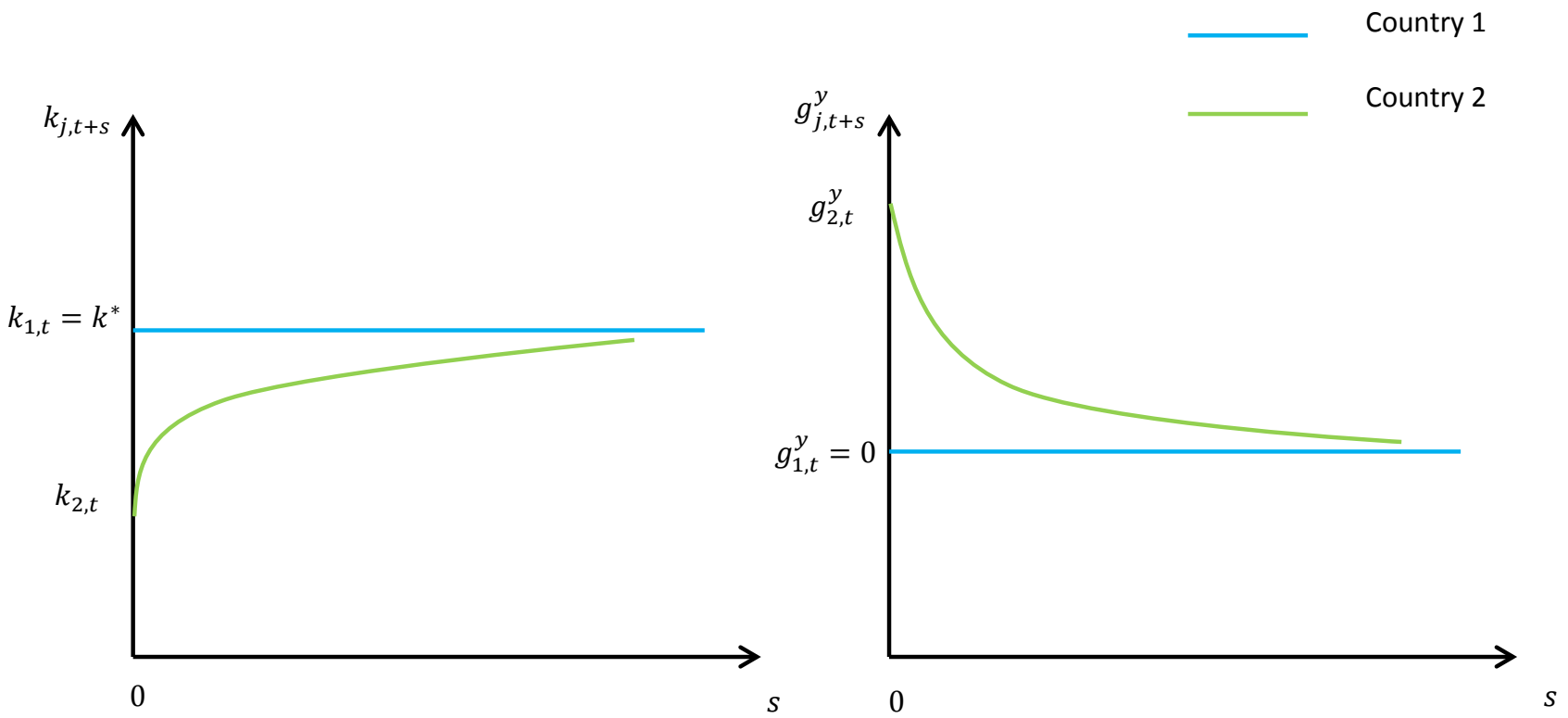
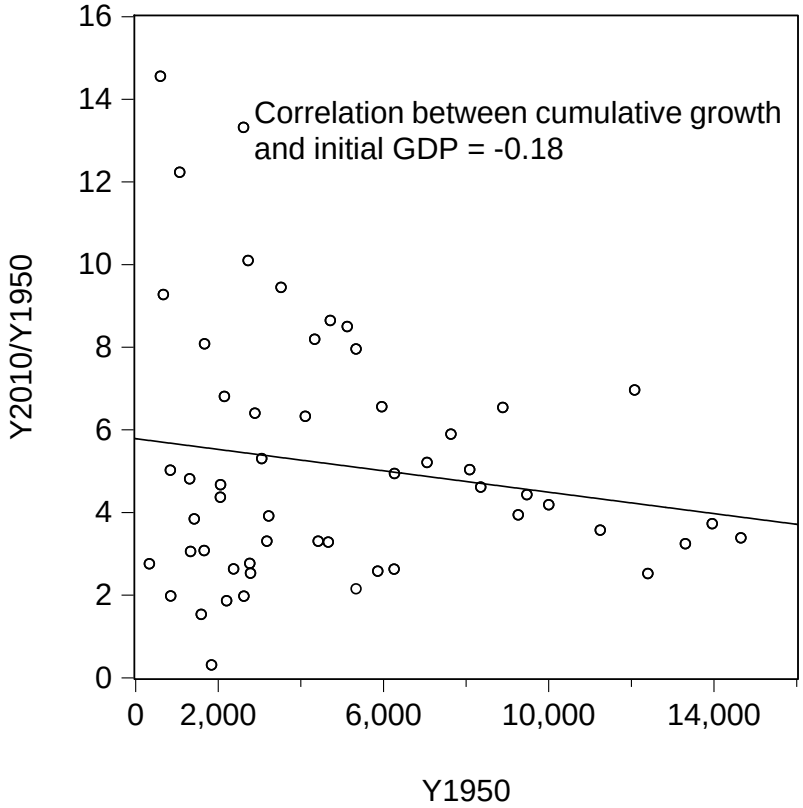


- Model predicts convergence
  - If country 2 is initially endowed with less capital
  - it should grow faster than country 1
  - eventually catching up with country 1

Is There Convergence in the Data?



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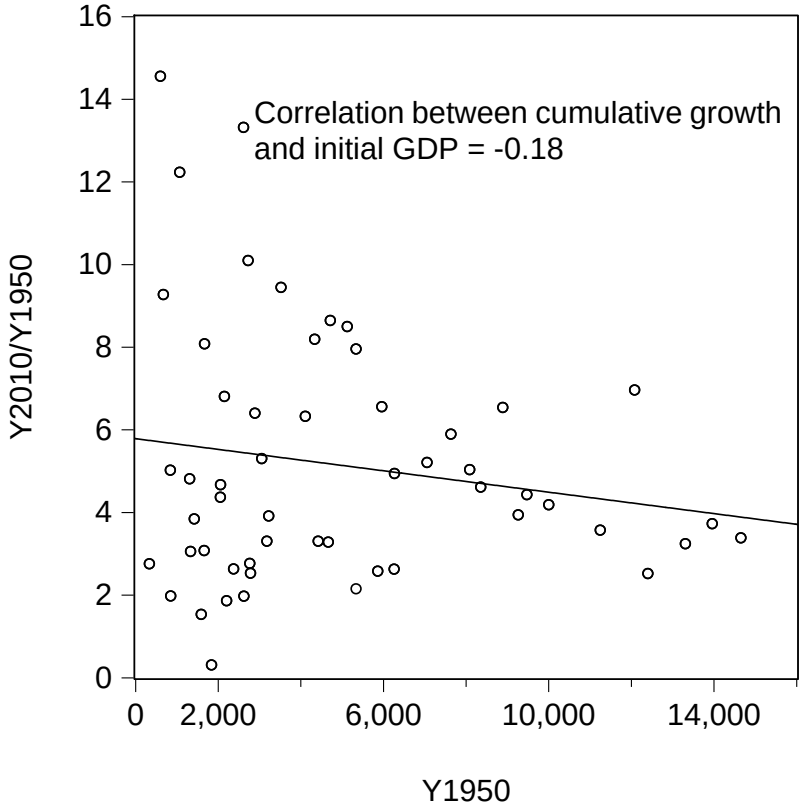

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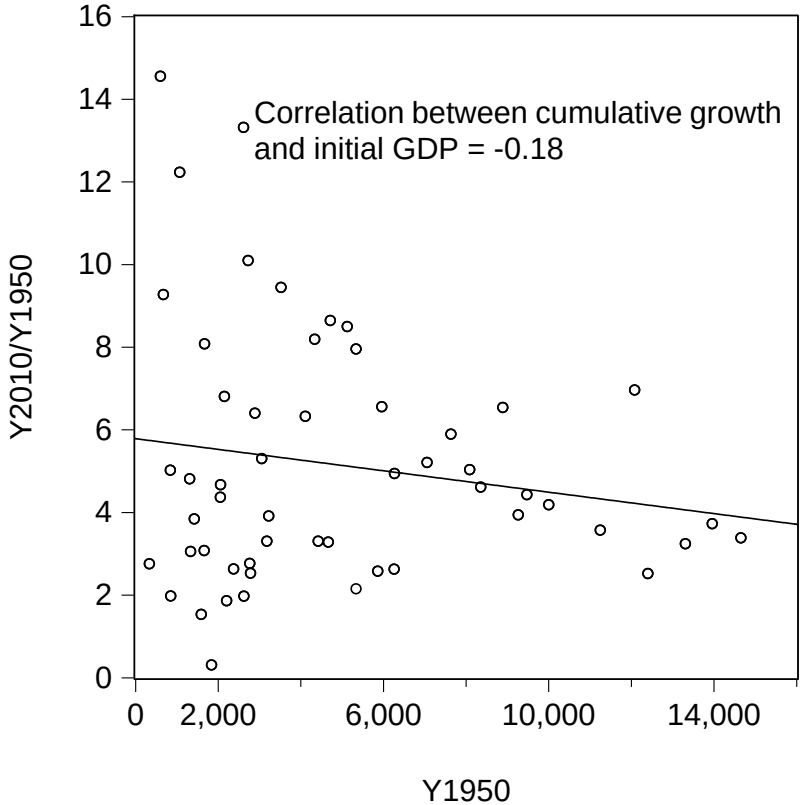

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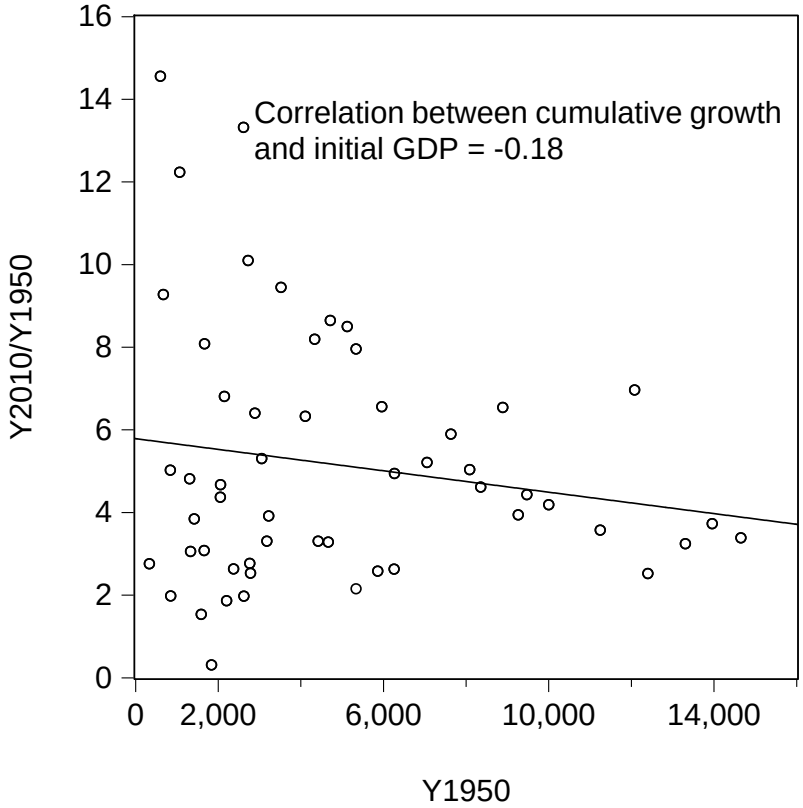
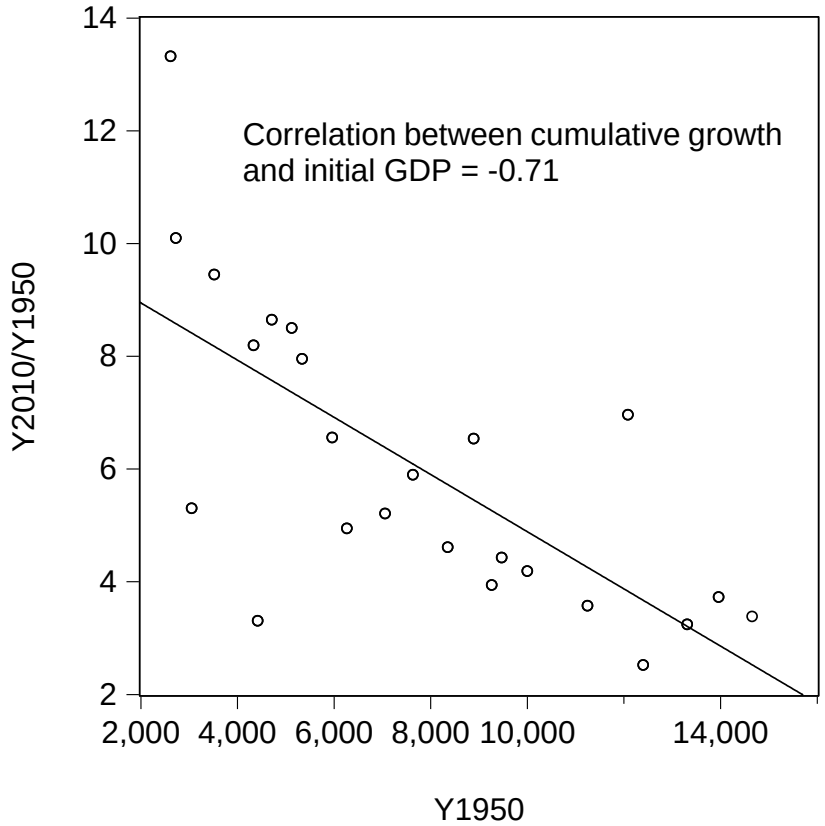


- Should there be a positive or negative correlation?
  Convergence predicts negative correlation: countries initially poorer would grow faster
- Is the correlation strong?
  Correlation between growth and initial GDP is negative, but not strong. Many countries were poor in 1950, didn't grow subsequently.

Focusing on OECD Countries



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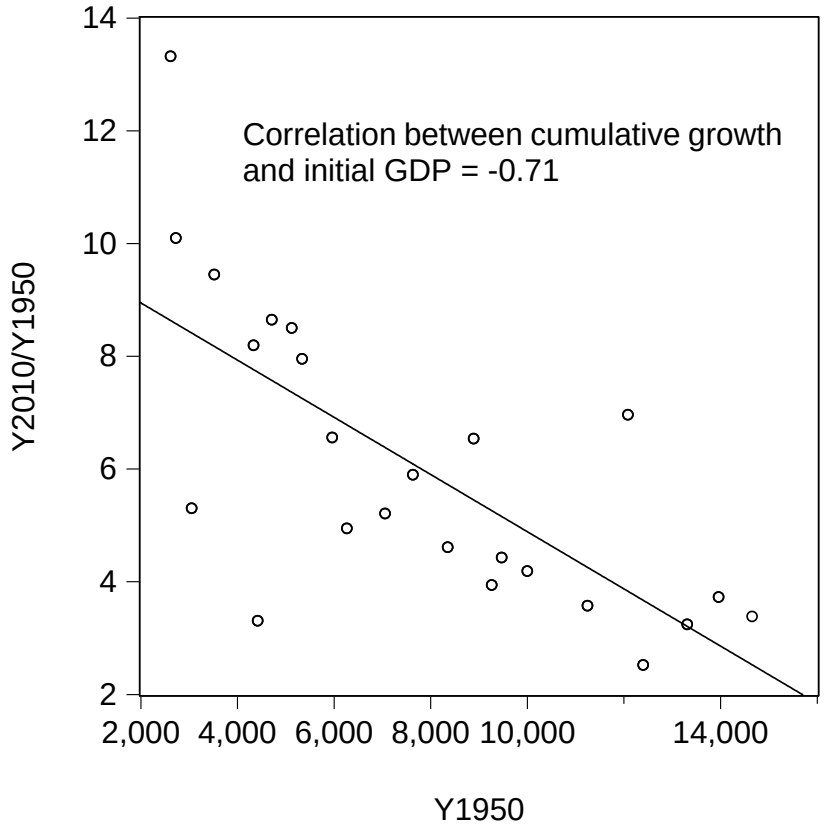
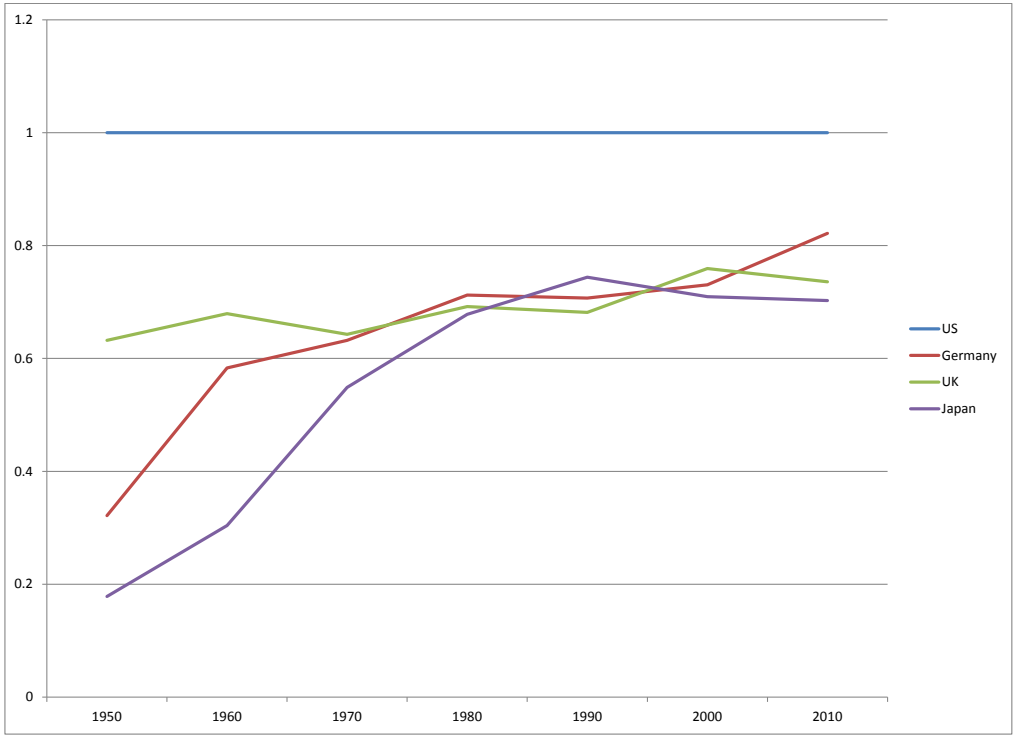


- Focusing only on OECD countries, story looks more promising for convergence
- Still, catch up seems too slow for initial low levels of capital to be the main story

Pseudo Natural Experiment: WWII



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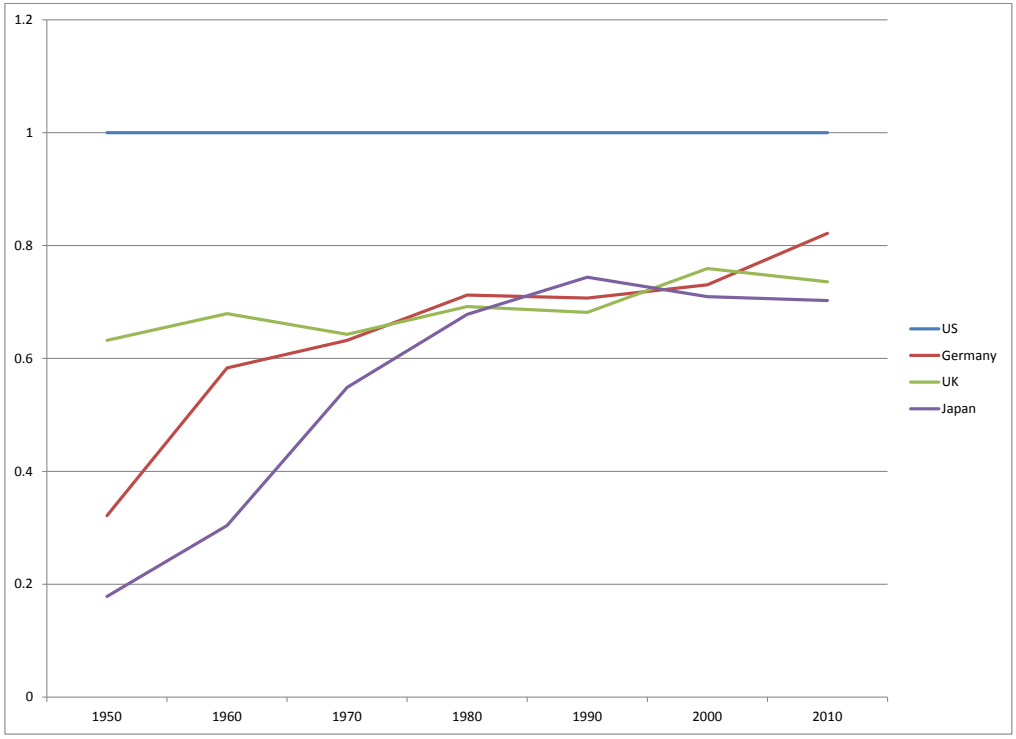

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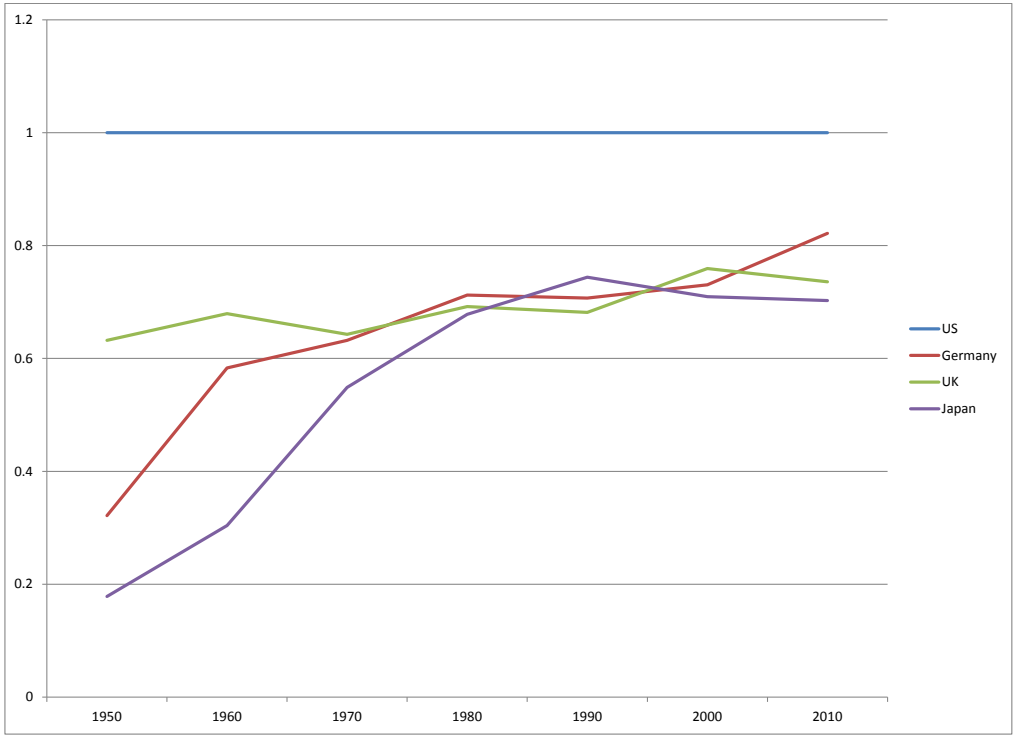

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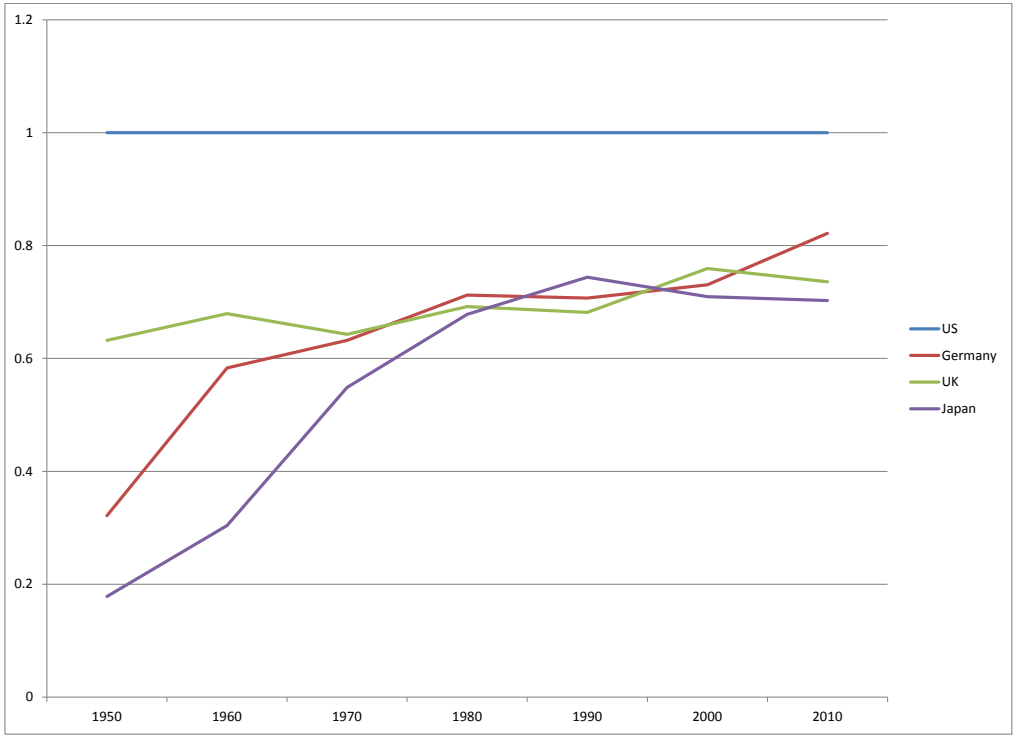

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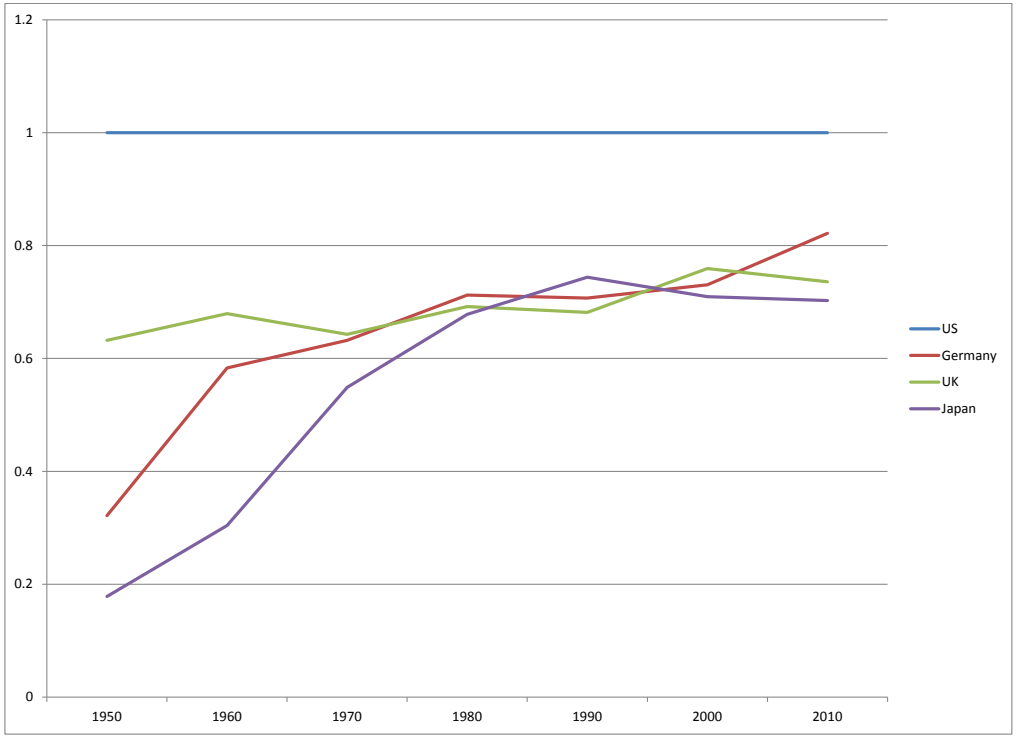

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- *Conditional convergence.* Countries have different steady states

Differences in Steady States

Most countries seem to have different steady states

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- For simple model with Cobb-Douglas production function,

$$k_j^* = \left(\frac{s_j A_j}{\delta} \right)^{\frac{1}{1-\alpha}}$$

The production function

$$y_{j,t} = A_{j,t} k_{j,t}^{\alpha}$$

The steady state output is

$$\begin{aligned} y_j^* &= A_j (k_j^*)^{\alpha} \\ &= A_j \left(\frac{s_j A_j}{\delta} \right)^{\frac{\alpha}{1-\alpha}} \\ &= A_j^{\frac{1}{1-\alpha}} \left(\frac{s_j}{\delta} \right)^{\frac{\alpha}{1-\alpha}} \end{aligned}$$

- What causes different steady state?

Differences in s and A^*

- Relative outputs:

$$\frac{y_1^*}{y_2^*} = \left(\frac{A_1}{A_2}\right)^{\frac{1}{1-\alpha}} \left(\frac{s_1}{s_2}\right)^{\frac{\alpha}{1-\alpha}}.$$

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- Where could $\frac{y_1^*}{y_2^*} > 1$ come from?
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- Answer: no

Differences in s

Question: can differences in s plausibly account for large income differences?

- Suppose A^* the same in both countries. Suppose country 1 is US, and country 2 is Mexico: $\frac{y_1^*}{y_2^*} = 4$. We have:

$$\begin{aligned} 4 &= \left(\frac{s_1}{s_2}\right)^{\frac{\alpha}{1-\alpha}} \\ 4^{\frac{1-\alpha}{\alpha}} &= \frac{s_1}{s_2} \\ s_2 &= 4^{\frac{\alpha-1}{\alpha}} s_1 \end{aligned}$$

Differences in s

$$s_2 = 4^{\frac{\alpha-1}{\alpha}} s_1$$

- Based on data, a plausible value of $\alpha = 1/3$. Means $\frac{\alpha-1}{\alpha} = -2$, and $4^{\frac{\alpha-1}{\alpha}} = 0.0625$
- Mexican saving rate would have to be 0.0625 times US saving rate
- If $s_1 = 0.2$, then $s_2 = 0.01$: This would be something like a saving rate of one percent
- Factor of 4 difference in income/capita requires factor of 20 difference in savings rates
- Not plausible, and we don't see nearly this much variations in savings rate across countries
- Becomes more plausible if α is much bigger

What Could It Be?

- If countries have different steady states and differences in s cannot plausibly account for this, must be differences in productivity
- How do we determine the empirical measure of A_t: total factor productivity (TFP)

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- If countries have different steady states and differences in s cannot plausibly account for this, must be differences in productivity
- How do we determine the empirical measure of A_t: total factor productivity (TFP)
- Assume

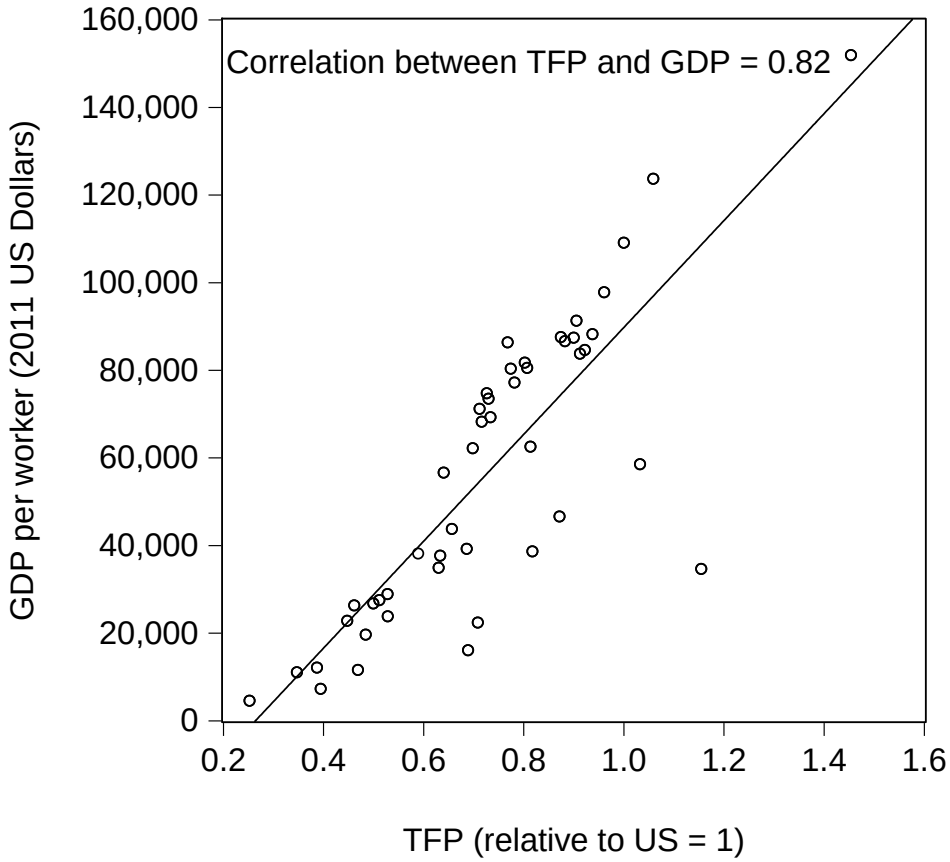
$$\begin{aligned} Y_t &= A_t K_t^{\alpha} N_t^{1-\alpha} \\ \ln Y_t &= \ln A_t + \alpha \ln K_t + (1-\alpha) \ln N_t \end{aligned}$$

- Define

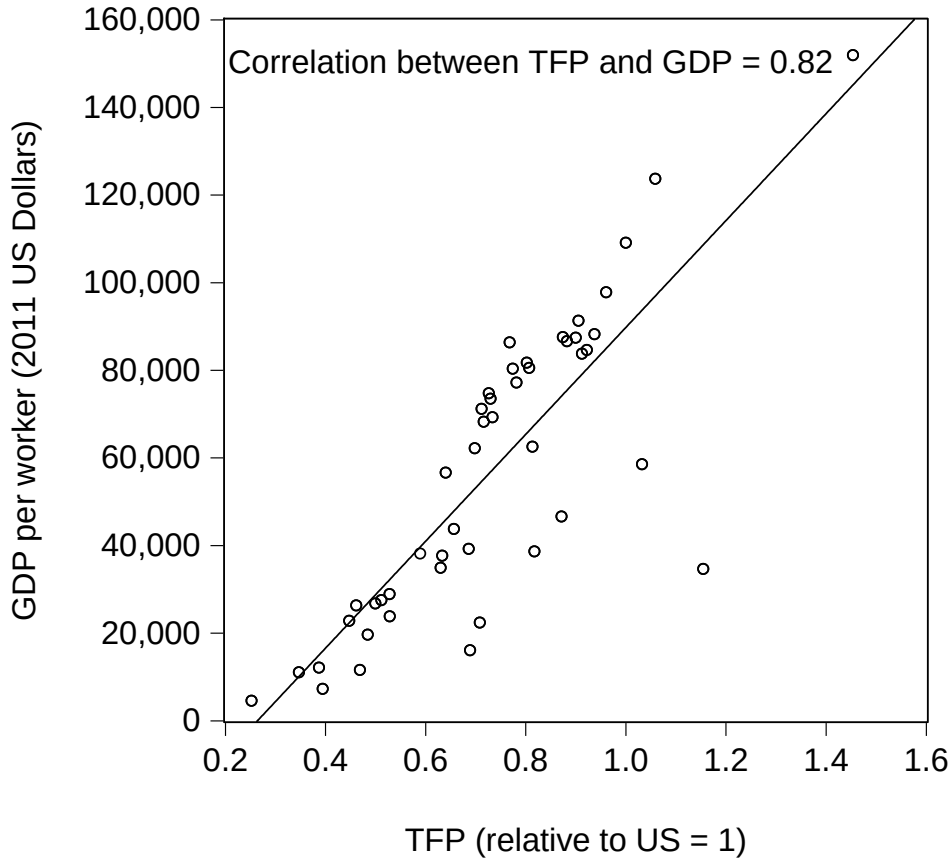
$$\begin{aligned} \ln TFP_t &= \ln A_t \\ &= \ln Y_t - \alpha \ln K_t - (1-\alpha) \ln N_t \end{aligned}$$

- Output minus share weighted capital and labor, or output you cannot explain by K_t or N_t

GDP and TFP


Correlation between TFP and GDP = 0.82
GDP per worker (2011 US Dollars)
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
TFP (relative to US = 1)

GDP and TFP



- Correlation is high!
- Rich countries are rich because they have high productivity
- They also have a lot of capital, but this is a consequence of high productivity

Productivity is King

- Productivity is what drives everything in the Solow model
- Sustained growth must come from productivity
- Large income differences must come from productivity
- But what is productivity? Solow model doesn't say

Factors Influencing Productivity

What is productivity? It's not as obvious as first appears. It encompasses much more than technology.

Factors Influencing Productivity

What is productivity? It's not as obvious as first appears. It encompasses much more than technology.

- Knowledge and education
- Climate: e.g., agricultural countries
- Geography: how easy is it to trade and specialize?
- Institutions: broadly defined, rule of law, legal systems
- Finance
- Degree of openness
- Infrastructure: airports, roads, bridges

Policy Implications

- If a country wants to become richer, need to focus on policies which promote productivity
- Example: would giving computers (capital) to people in Africa help them get rich?

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- Example: would giving computers (capital) to people in Africa help them get rich?
  Not without the infrastructure to connect to the internet, the knowledge of how to use the computer, and the institutions to protect property rights