Economic Growth

Lecture 4: Population and Human Capital

İlhan Güner

University of Kent | EC569

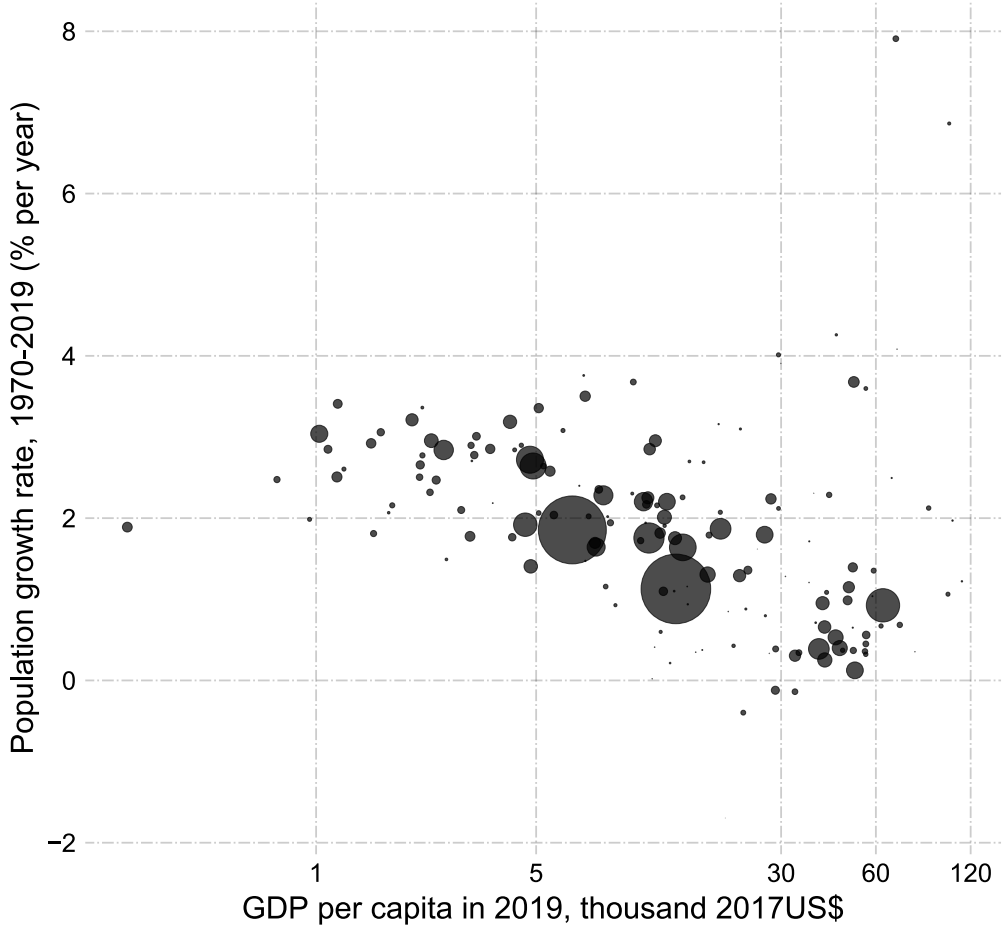
Questions

- What's the role of population growth on income differences across countries?
- What's the role of human capital on economic growth?

Population

Population growth rate and GDP per capita

- There is a negative correlation between population growth rate and GDP per capita

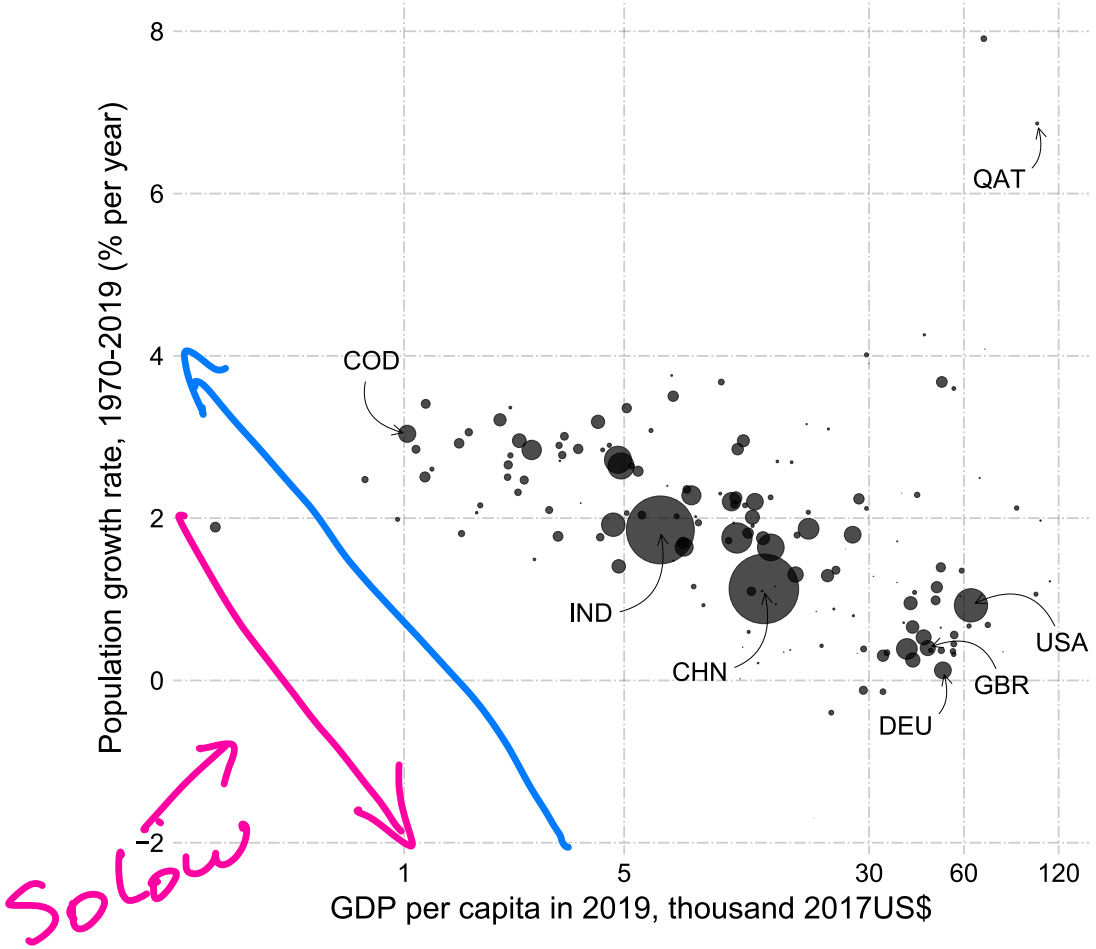


Data source:Penn World Tables (10.0)

Population growth rate and GDP per capita

Endogenous

- There is a negative correlation between population growth rate and GDP per capita
- Countries like The Democratic Republic of the Congo (COD) have high population growth rate and very low GDP per capita
- India and China how moderate population growth rate and middle income per capita
- Germany, the US, the UK have low population growth rates but high income per capita
- How about Qatar (QAT)?
    - Immigration?



Data source: Penn World Tables (10.0)

Population growth in the Solow model

- Law of motion for capital per worker

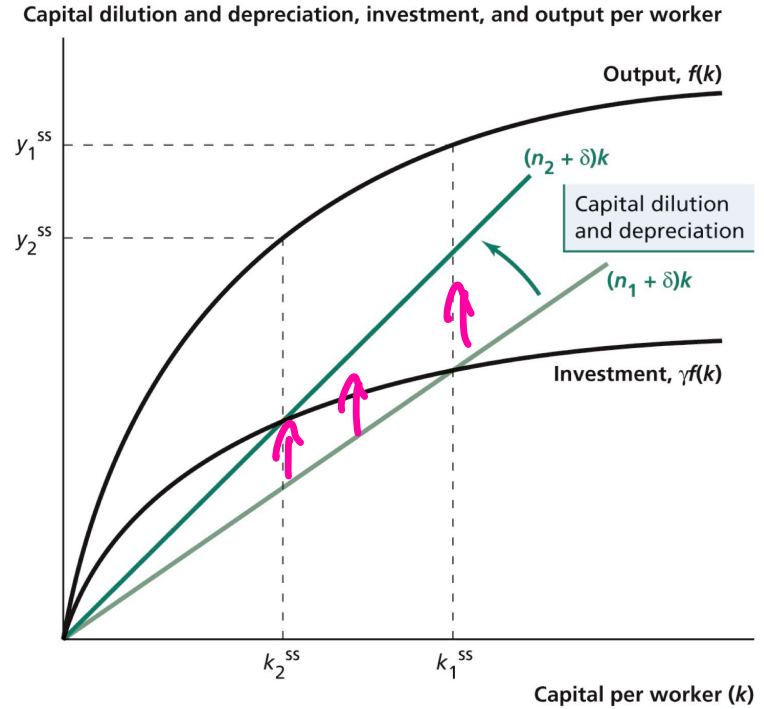
$$\dot{k} = \gamma f(k) - (\delta + n)k,$$

  where n is the population growth rate.

- At the steady state

$$\gamma f(k^*) = (\delta + n)k^*$$

- As $n \uparrow$, $k^* \downarrow$ (from k_1^{ss} to k_2^{ss})
  - Notice that both k^* and k^{ss} mean steady-state capital per worker.
- Countries with high population growth are poorer.
- Higher population growth dilutes per-worker capital stock more quickly
- Lower steady state level of output per worker

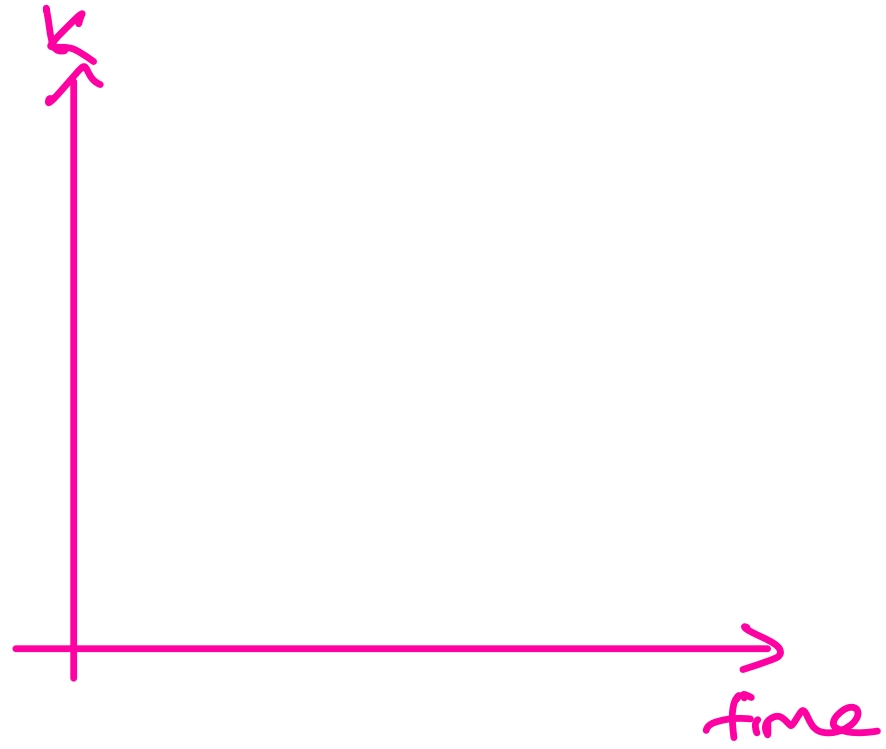


The figure shows how raising the population growth rate from n_1 to n_2 affects the steady-state level of capital per worker (k) and the steady-state level of output per worker (y).

Diagram from: Weil (2013)

Exercise

- Sketch a graph of (log of) capital per worker and output per worker over time with and without a decrease in the population growth rate.



Solow model's predictions of income differences

- Recall income per worker of country i relative to the country j,

$$\frac{y_i^*}{y_j^*} = \left(\frac{A_i}{A_j}\right)^{1/(1-\alpha)} \left(\frac{\gamma_i}{\gamma_j}\right)^{\alpha/(1-\alpha)} \left(\frac{\delta_j + n_j}{\delta_i + n_i}\right)^{\alpha/(1-\alpha)} \left(\frac{h_i}{h_j}\right)$$

- Remember that in the Solow model income per worker ratio is equal to income per capita ratio as everyone works.
- Suppose country i and country j differ only with respect to their population growth rates and $\alpha = 1/3$.

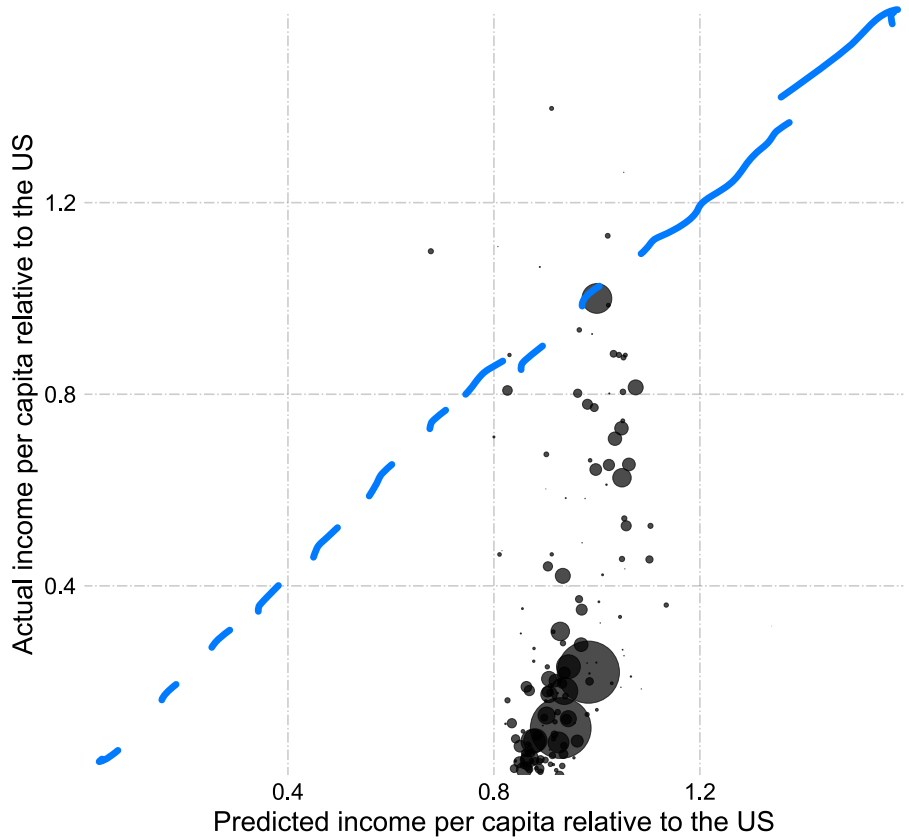
  $A_i = A_j = A$, $\delta_i = \delta_j = \delta = 0.05$, $h_i = h_j = h$, and $\gamma_i = \gamma_j = \gamma$.

- Then,

$$\frac{y_i^*}{y_j^*} = \left(\frac{0.05 + n_j}{0.05 + n_i}\right)^{\alpha/(1-\alpha)}$$

Solow model's predictions vs data

- If country i and j differ only with respect to their population growth rates
- Substitute in average population growth rates from 1970 and 2019, and calculate actual and predicted income per capita ratios relative to the US.
- There is still a positive correlation but not very strong.
- We did not take into account:
  - Differences in investment rates
  - Differences in human capital
  - Differences in productivity
  - Employment growth rate is not equal to population growth rate in the data in cotrast to the model

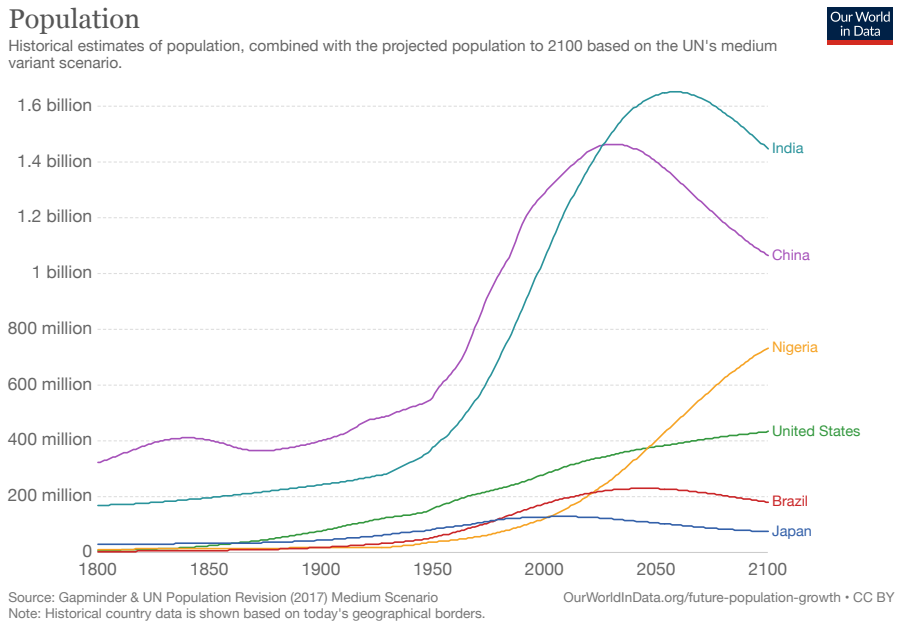


Data source: Penn World Tables (10.0)

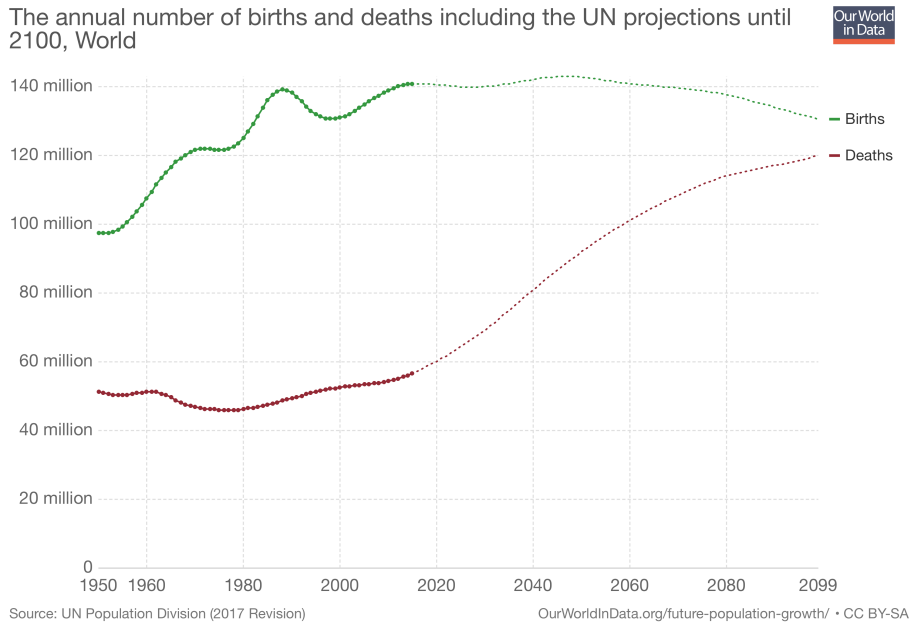
Correlation of predicted vs actual values = 0.22

What's the unrealistic critical assumption of the Solow model in regards to population growth rate?

- Constant population growth rate assumption of the model
- Population growth rate is decreasing throughout the world
    - As countries get richer, fertility rate tends to decrease.

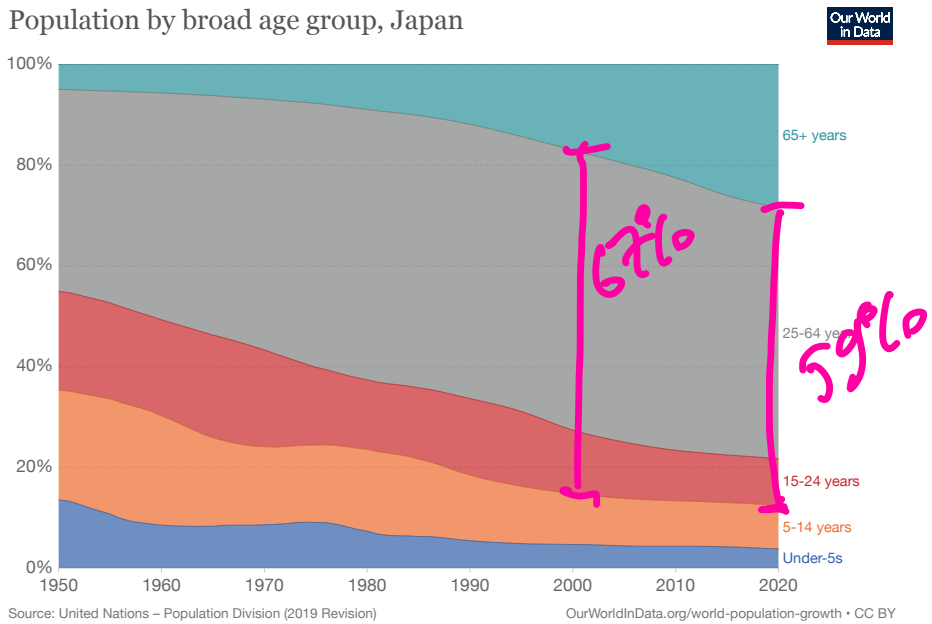


Graph from: Our World in Data



Graph from: Our World in Data

Why does lower population growth have negative impacts on the economy?



Graph from: Our World in Data

- Lower population growth rate leads to aging of the society
- Working age population/total population goes down
- GDP per capita = GDP per worker × $\frac{Employment}{Population}$
- A reduction in $\frac{Employment}{Population}$ pushes down GDP per capita growth.
- The second factor, which is very important, is assumed away in the Solow model.

Summary

Solow Model

- Accounts for the negative correlation of population growth rate and income per capita
    - higher population growth rate dilutes capital quickly, and hence countries cannot accumulate as much capital per worker
- Population growth rate is exogenous
- Cannot account for the reduction in population growth rate as countries get richer

Reduction in the population growth push down GDP per capita growth.

Human capital

Quality of labor

- So far, we have mostly treated quality of labor as same across countries and over time.
- Quality of labor that a worker supplies depends on whether the worker is
  - weak or strong
  - ill or healthy
  - ignorant or educated

Human Capital

Human capital: Qualities of labor that

- are productive (characteristics that enable workers to produce more),
- are produced (investment in human capital),
- earns a return (higher wage for owners of human capital),
- depreciates.

Human capital can be

- in the form of health,
- in the form of education.

How do human capital in the form health and in the form education affect per capita income of countries?

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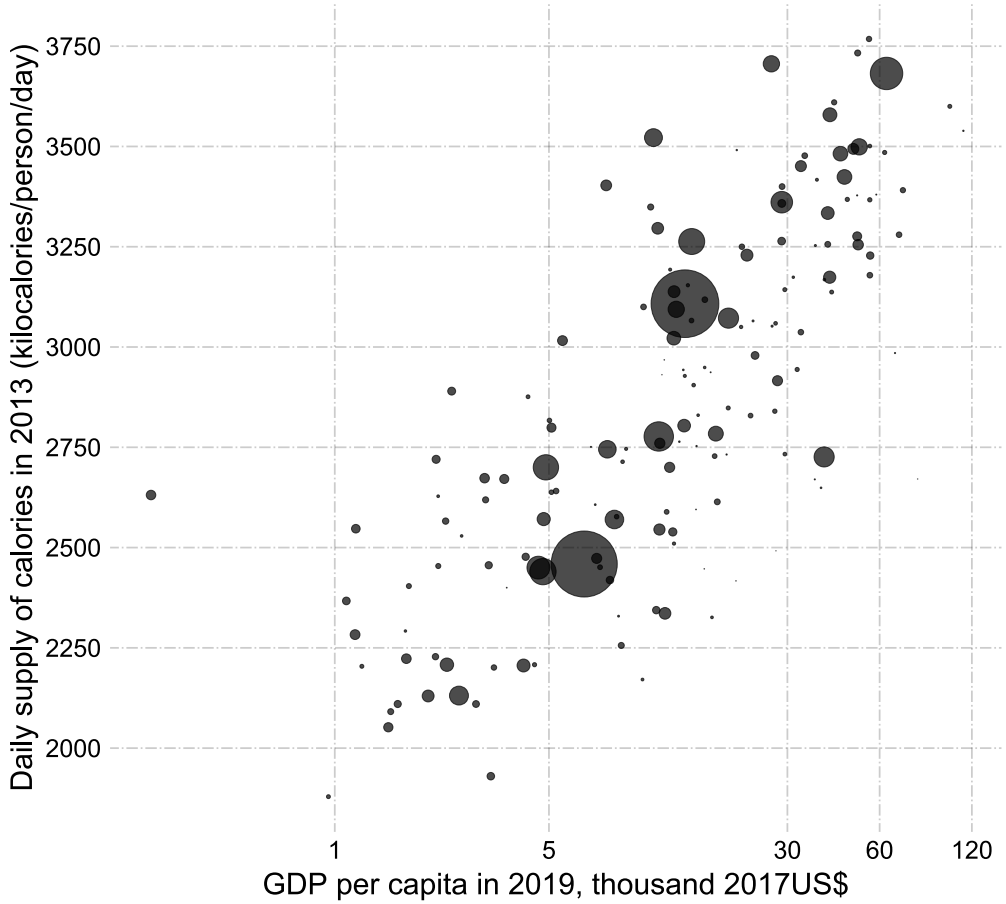
How do human capital in the form health and in the form education affect per capita income of countries?

'LeBron James Spends About $1.5 Million Per Year To Maintain His Body' (from CBS Cleveland)

Link to the tweet in the html file: twitter

Calorie intake

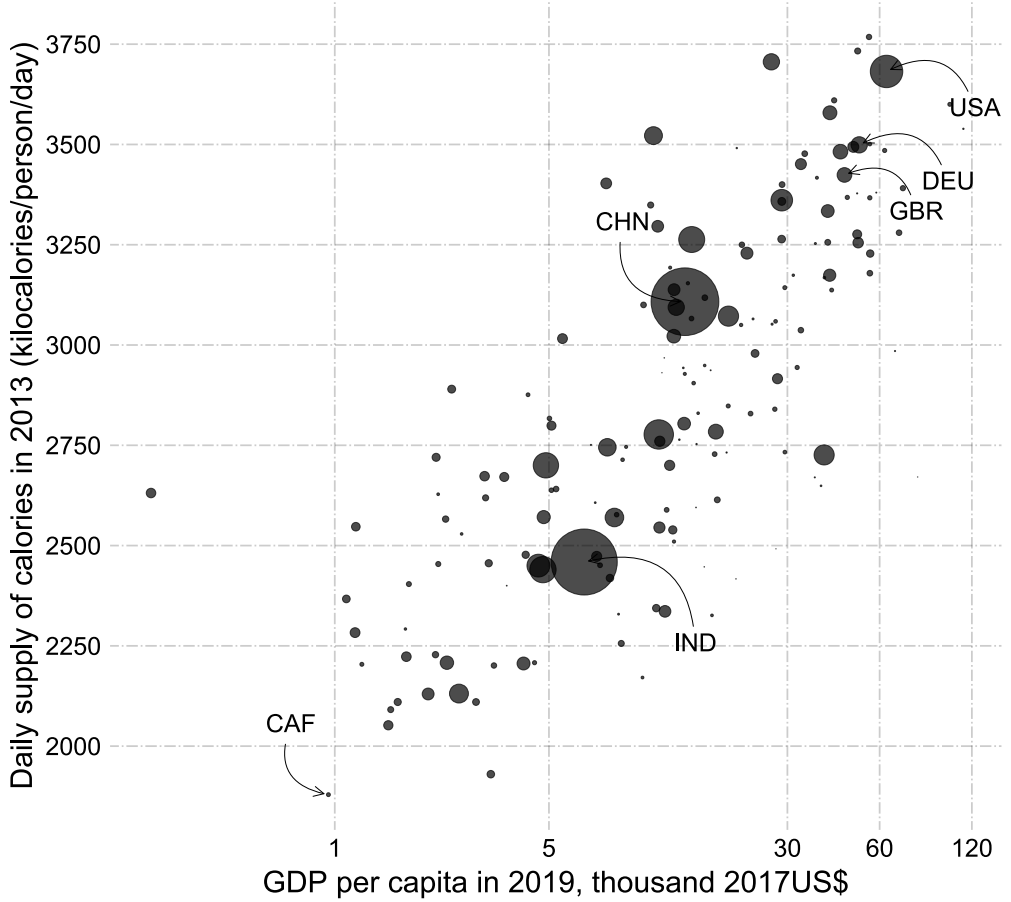
- Calorie intake is a determinant of human capital in the form health
- There is a positive correlation between calorie intake per person and income per capita



Data source: Penn World Tables (10.0) and FAO (via Our World in Data)

Calorie intake

- Calorie intake is a determinant of human capital in the form health
- There is a positive correlation between calorie intake per person and income per capita
- In richer countries like the UK, Germany and the US daily calorie intake per person is greater than 3250
- In a poor country like Central African Republic (CAF) daily calorie intake per person is less than 2000
    - Half of calorie intake of Americans



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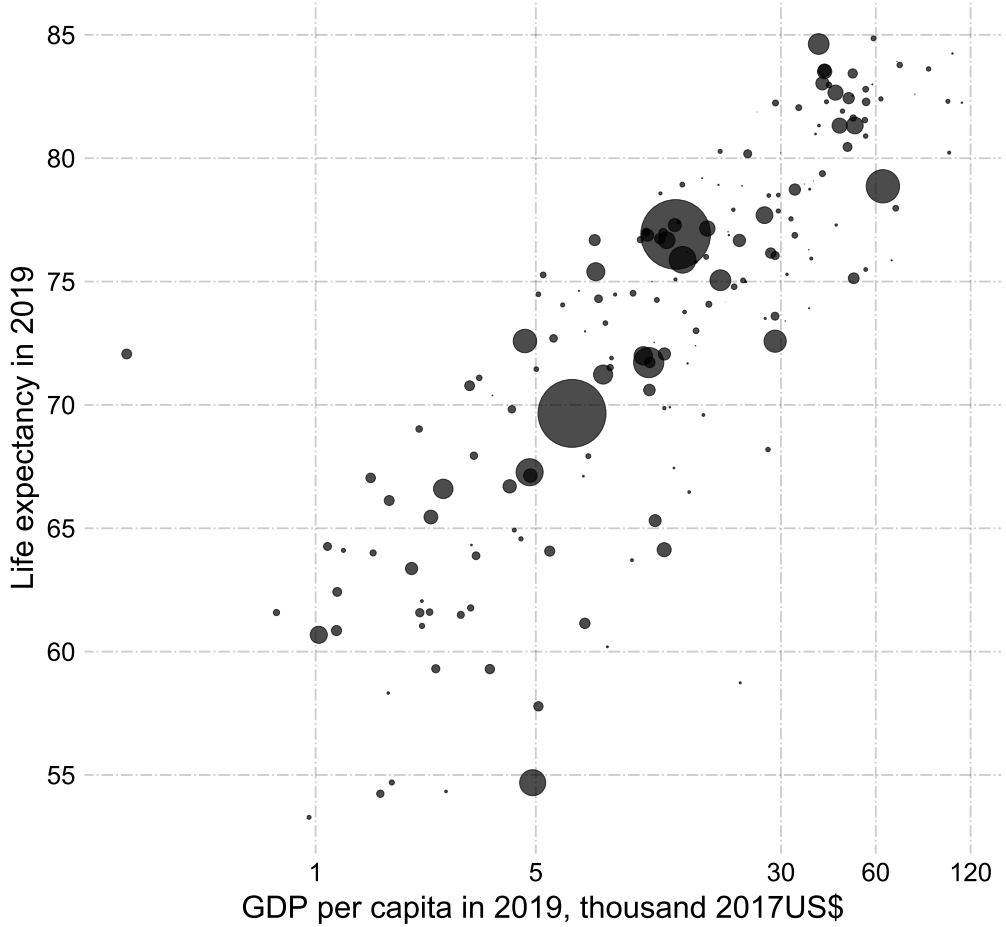
Life expectancy at birth

> "Life expectancy at birth indicates the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life." – the World Bank

- Life expectancy is a critical measure of health
- People in richer countries are expected to live longer



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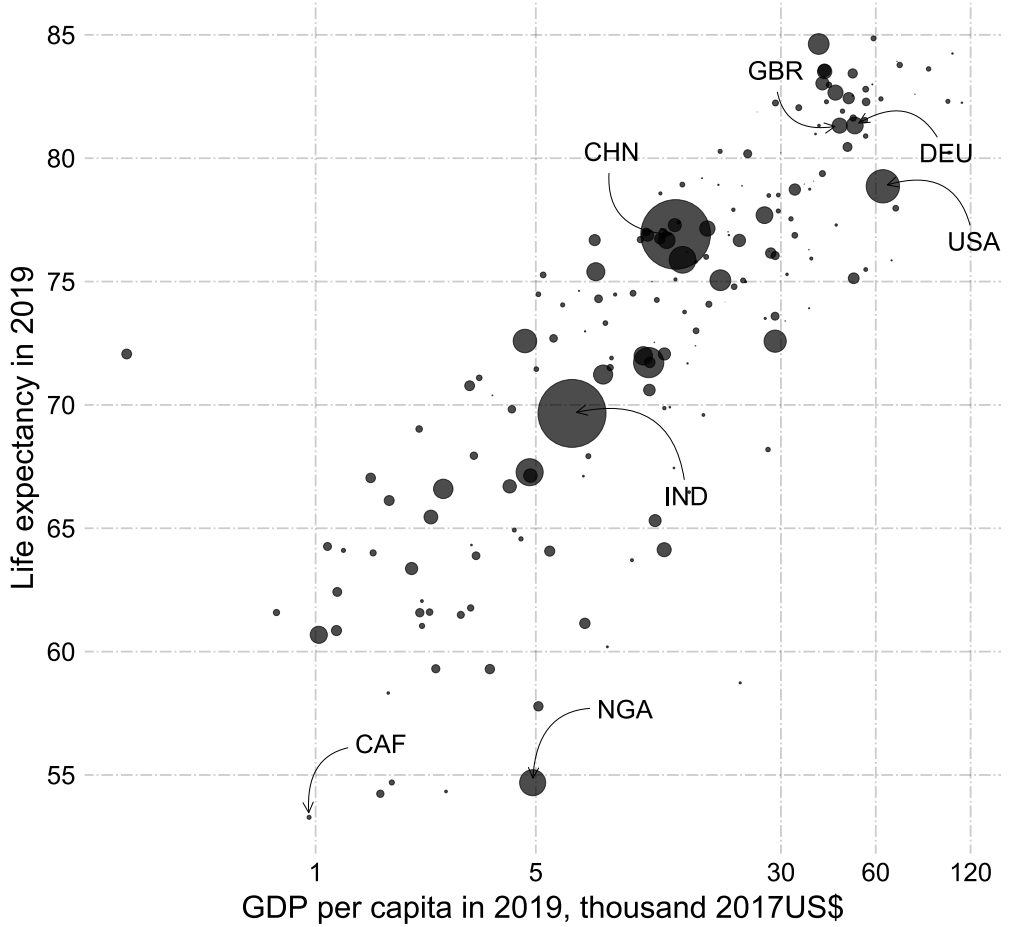
- Life expectancy is a critical measure of health
- People in richer countries are expected to live longer
- A new born in richer countries is expected to live about 80 years
- Whereas, a new born in Nigeria is expected to live about 55 years.

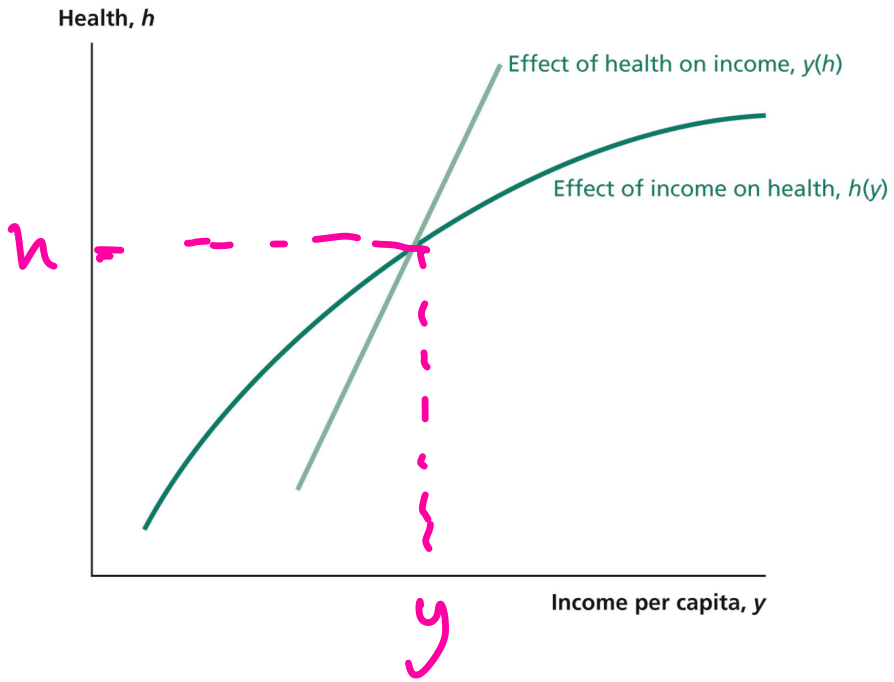
Why the life expectancy in the US is lower than othe reach countries? Read Deaths of despair and the future of capitalism by Anne Case and Angus Deaton



Data source: Penn World Tables (10.0) and World Bank (via Our World in Data)

Human Capital in the form of health

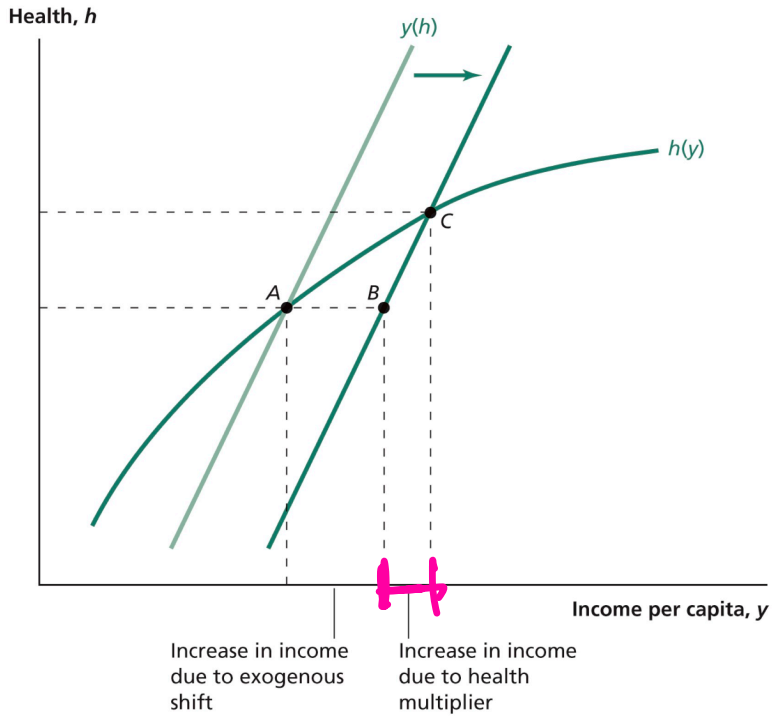
- Better nutrition, healthier workers ⇒ Higher income
    - healthier workers can work harder and longer
    - healthier people can think more clearly
- Higher income ⇒ better nutrition, healthier workers
    - United Nations Development Program (2000):
    - richer OECD countries: 2.2 doctors per thousand people
    - developing countries: .8 doctors per thousand people
    - sub-Saharan Africa: .3 doctors per thousand people
- Health and income are endogenous



Graph from Weil (2013)

Impact of an exogenous increase in income on the economy

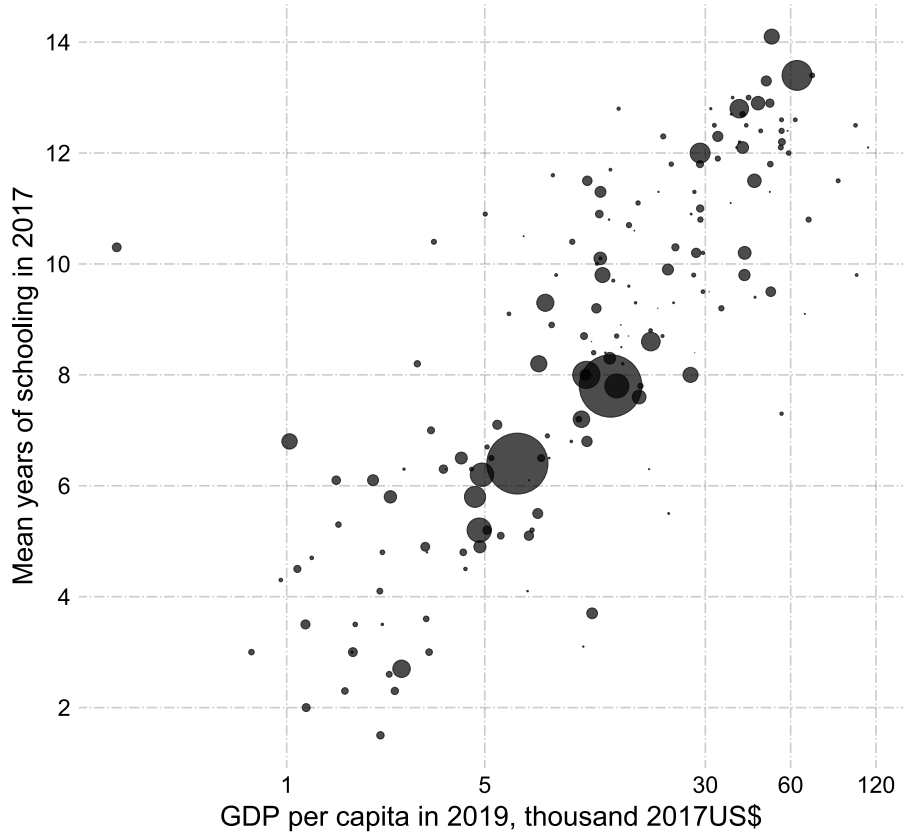
- Exogenous increase in income leads to increase in health outcomes
- Increase in health leads to further increase in income



Graph from Weil (2013)

Human Capital in the form of education

- Intellectual ability is as important as health in determining a person's human capital
- People invest in human capital through education
- People in richer countries get educated longer than people in poorer countries



Data from Penn World Tables (10.0); Lee-Lee (2016); Barro-Lee (2018) and UNDP HDR (2018) via Our World In Data

Human Capital in the form of education

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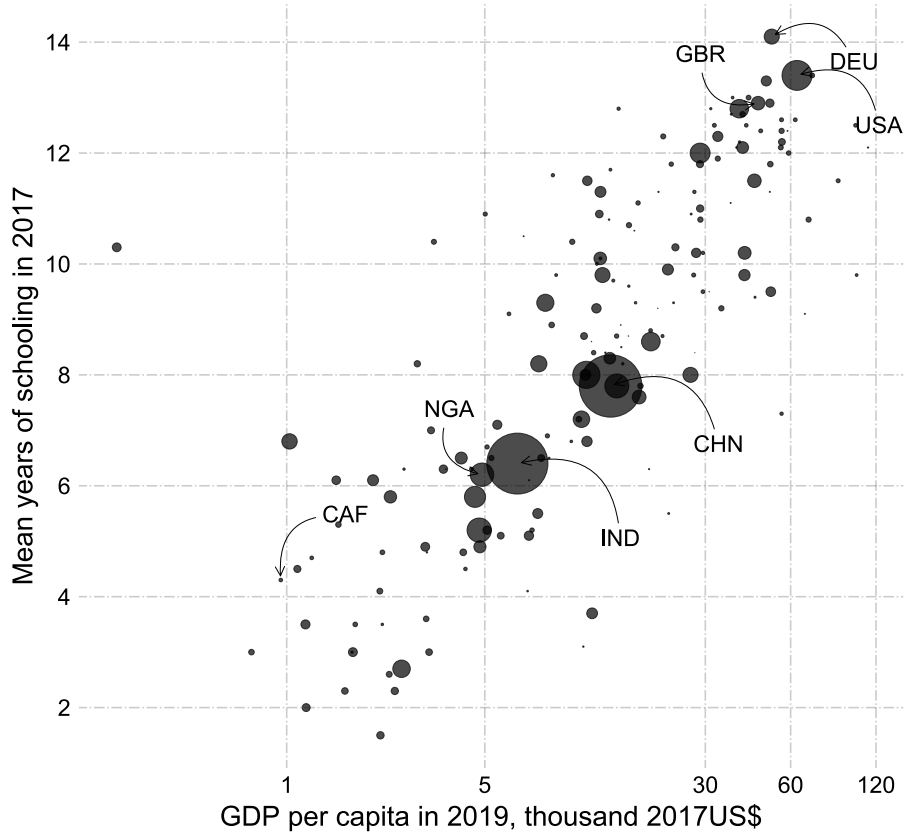
- People invest in human capital through education
- People in richer countries get educated longer than people in poorer countries
- Chinese spend about 8 years in school
- Whereas, Germans spend on average 14 years in school



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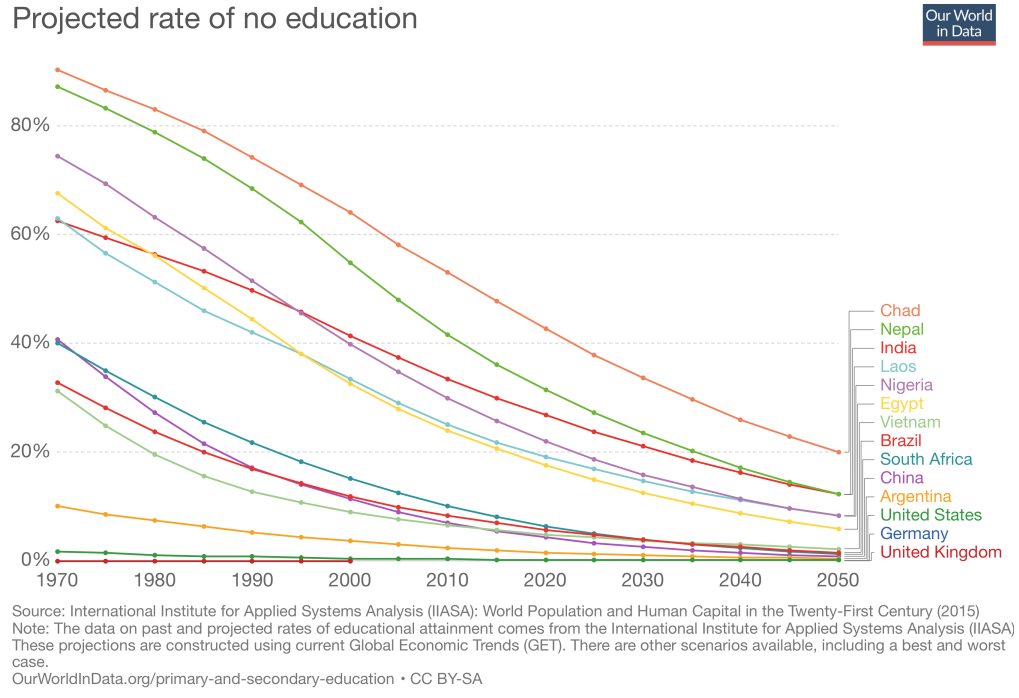
People are more educated than before

- In almost everywhere in the World, people are more educated than before
- The number of people with no educated has declined substantially, and projected to decline even further



Graph from Our World In Data

Measuring human capital

How do we put a value on h in the production fucntion $y = Ak^{\alpha}h^{1-\alpha}$?

Human capital =

- A weighted average years of education
    - returns to education in each year of schooling are used as weights
- Click for details

Quantitative analysis

- Recall income per worker of country i relative to the country j,

$$\frac{y_i^*}{y_j^*} = \left(\frac{A_i}{A_j}\right)^{1/(1-\alpha)} \left(\frac{\gamma_i}{\gamma_j}\right)^{\alpha/(1-\alpha)} \left(\frac{\delta_j + n_j}{\delta_i + n_i}\right)^{\alpha/(1-\alpha)} \left(\frac{h_i}{h_j}\right)$$

- Suppose country i and country j differ only with respect to their human capital

$$A_i = A_j = A,\ \delta_i = \delta_j = \delta,\ n_i = n_j = n,\ \text{and}\ \gamma_i = \gamma_j = \gamma$$

.

- Then

$$\frac{y_i^*}{y_j^*} = \frac{h_i}{h_j}$$

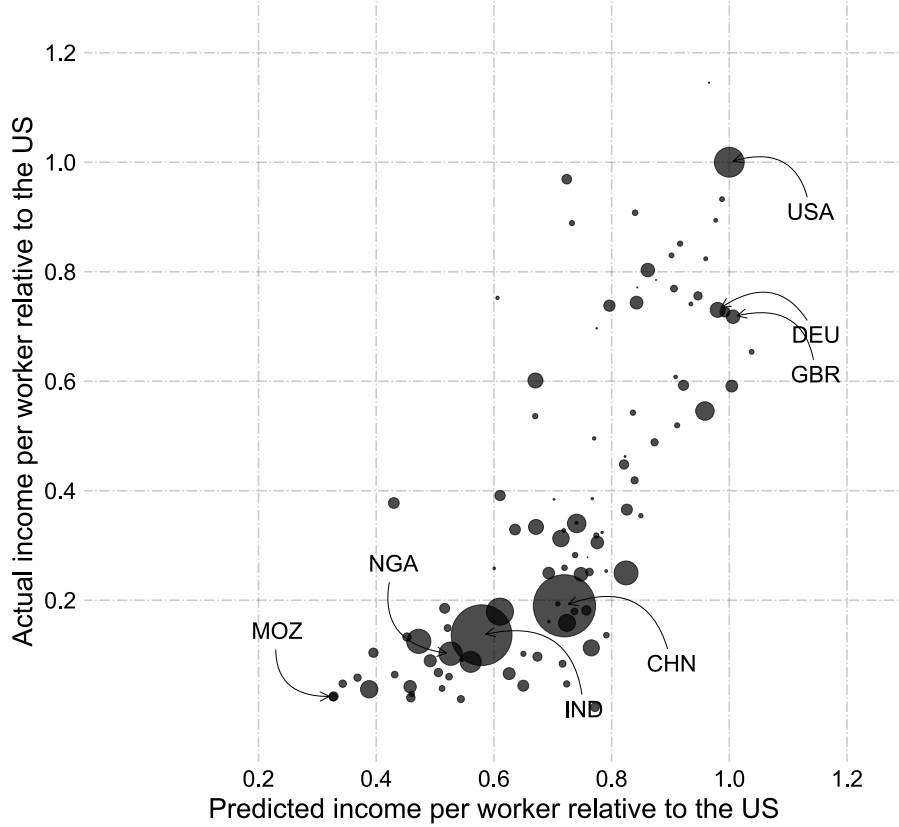
- If we measure human capital, we can calculate income differences predicted by human capital differences using the above equation

Solow model's predictions vs data

- Substitute in human capital levels in 2019 into

$$\frac{y_i^*}{y_j^*} = \frac{h_i}{h_j}$$

- Compute predicted income per worker ratio relative to the US for each country
- Compare predicted values with actual values from data
    - There is a strong and positive correlation (0.71) between the two
- Human capital is a strong predictor of income differences across countries



Data source: Penn World Tables (10.0)

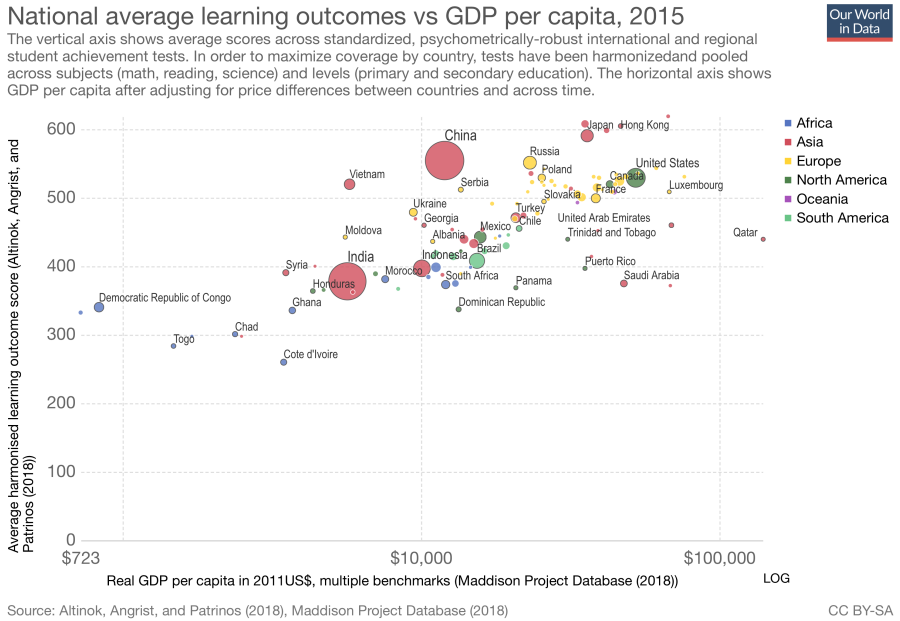
Correlation of predicted vs actual values = 0.71

Exercise

Analyze the impact of an increase in human capital level in the Solow economy using a Solow diagram. Also, sketch a graph of (log of) capital per worker and output per worker over time with and without an increase in the human capital.

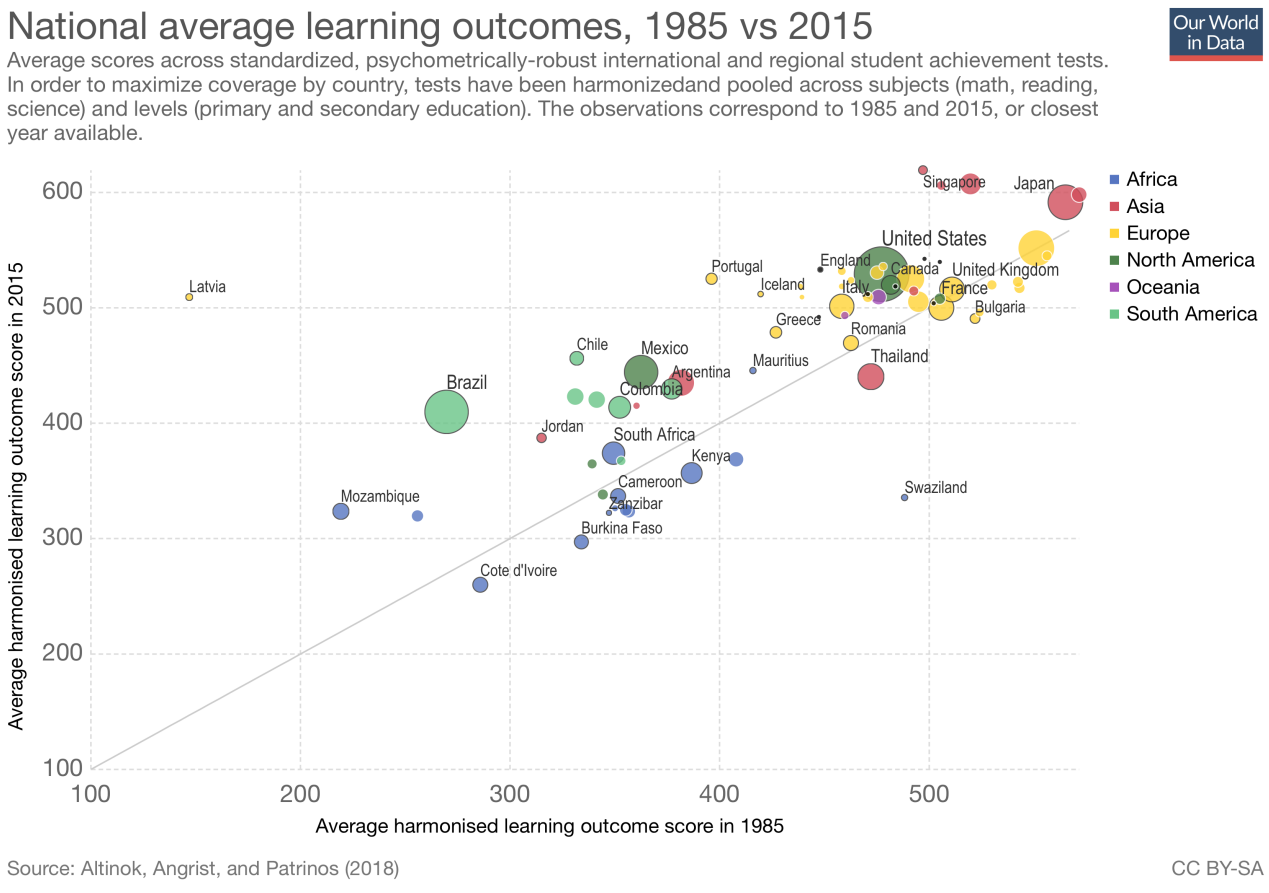
Problems in comparing education levels across countries

- quality of schooling might be different across countries
  - high income countries tend to have "better" schooling
  - average years of schooling understates the difference in human capital
- externalities
  - human capital could affect technology and efficiency levels
  - private return vs social return of education



Graph from Our World in Data

Quality of schooling over time



Graph from Our World in Data

Summary

- Human capital in the form of health and education have positive effects on income.
- High income countries have higher years of schooling, and higher schooling quality.
- Years of schooling and quality of schooling have been improving all around the world.

Suggested readings for this lecture

- From Jones and Vollrath, read Chapter 3.1
- From Weil, read Chapter 6
- From Weil, introduction of Chapter 4 and Chapter 4.2.

Suggested readings for the next lecture

- From Jones and Vollrath read Chapter 3.2 (Convergence of countries)
- From Jones and Vollrath rad Chapter 2.2 (The Solow model with technology)

Appendix

Measuring human capital

$Y = F(K, hL)$

$Y = AK^{\alpha}(hL)^{1-\alpha}$

↳ how do we put a numerical value for h?

How can we measure human capital in a country?

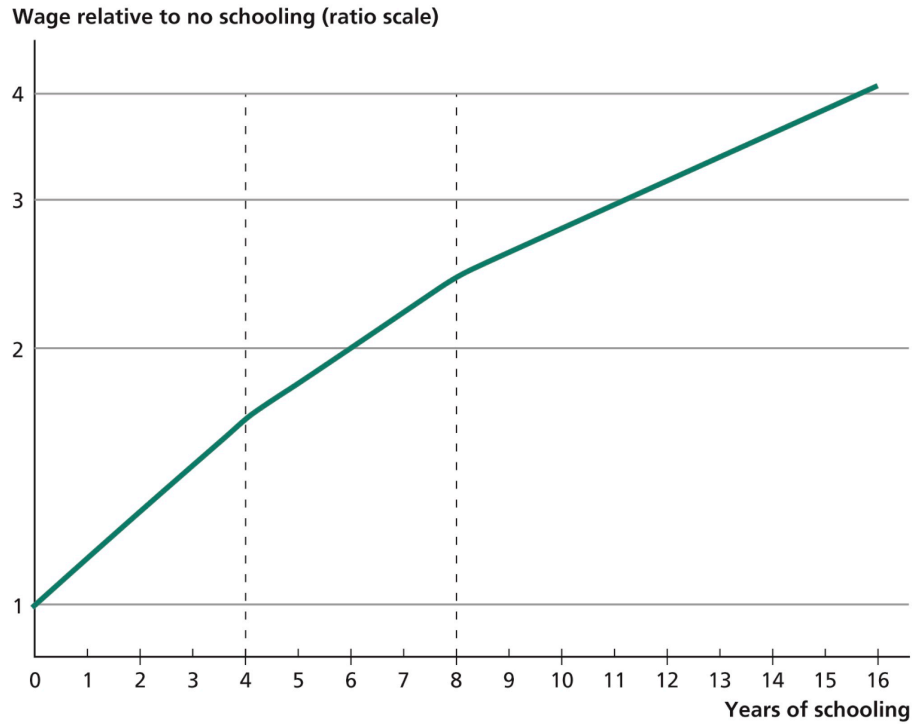
1. Measure the value of spending one more year in school in different education levels
2. Characterize the distribution of years of schooling people have in a country
3. Find human capital for different education levels using step 1
4. Combining the 2nd and 3rd steps, generate a human capital index
    - Human capital index is a measure of average human capital in a country

↑ weighted

(Private) returns to education

Step 1 in measuring human capital

- Returns to education: Increase in wages that a worker would receive if she had one more year of schooling.
    - a measure of spending one more year in school
- Estimates from Hall and Jones (1999)
    - First 4 years (grades 1 – 4): 13.4%
    - Next four years (grades 5 – 8): 10.1%
    - Beyond eight years: 6.8%



Breakdown of the population by schooling and wages

Step 2 in measuring human capital

Highest Level of Education	Years of schooling	Wage Relative to No Schooling	Percentage of the Population	
			Developing Countries	Advanced Countries
No Schooling	0	1.00	20.8	2.5
Incomplete Primary	4	1.65	10.4	3.4
Complete Primary	8	2.43	18.0	12.3
Incomplete Secondary	10	2.77	19.3	17.8
Complete Secondary	12	3.16	23.2	37.4
Incomplete Higher	14	3.61	2.9	9.9
Complete Higher	16	4.11	5.3	16.6

Source: Barro and Lee (2010).

Table from Weil (2013)

Measuring human capital

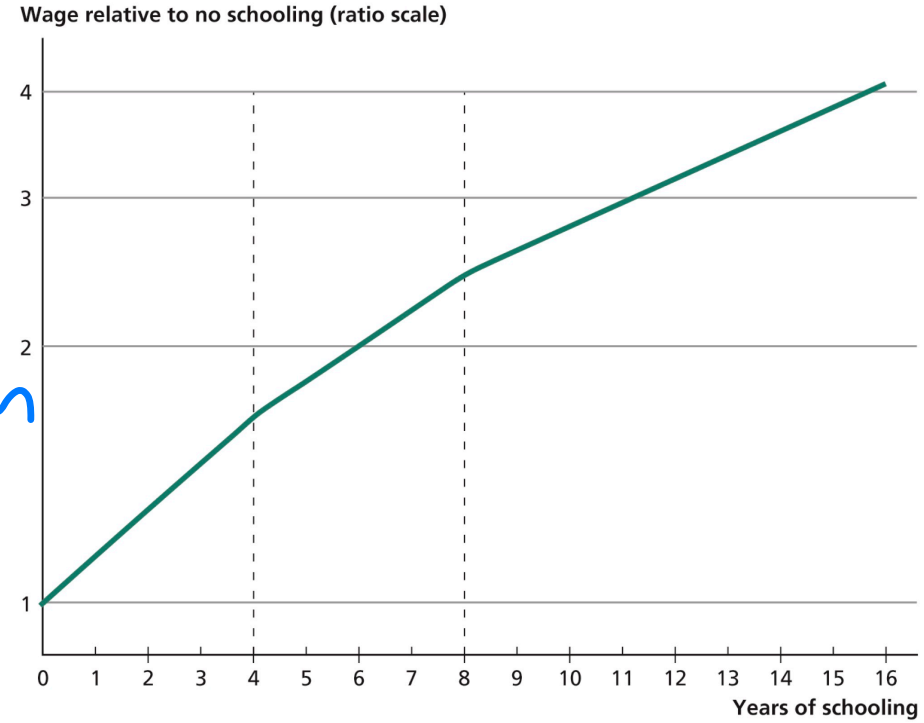
Steps 3 and 4 in measuring human capital

How can we measure human capital in the form of education?

$$h = h_0 \times \left(\left(\frac{w_1}{w_0} \right)^{t_1} \times \left(\frac{w_2}{w_1} \right)^{t_2} \times \dots \right)$$

- h_0 : level of labor input per worker with no schooling
- $\frac{w_i}{w_{i-1}}$: annual wage premium paid to education level i (primary, secondary, higher)
- t_i : years spend in education level i

Then take a weighted mean of worker specific human capital to mesure average human capital in a country:



Example: Percentage of people with primary education times human capital of a worker with primary education, plus percentage of people with high school education times human capital of a worker with high school degree, and so on.

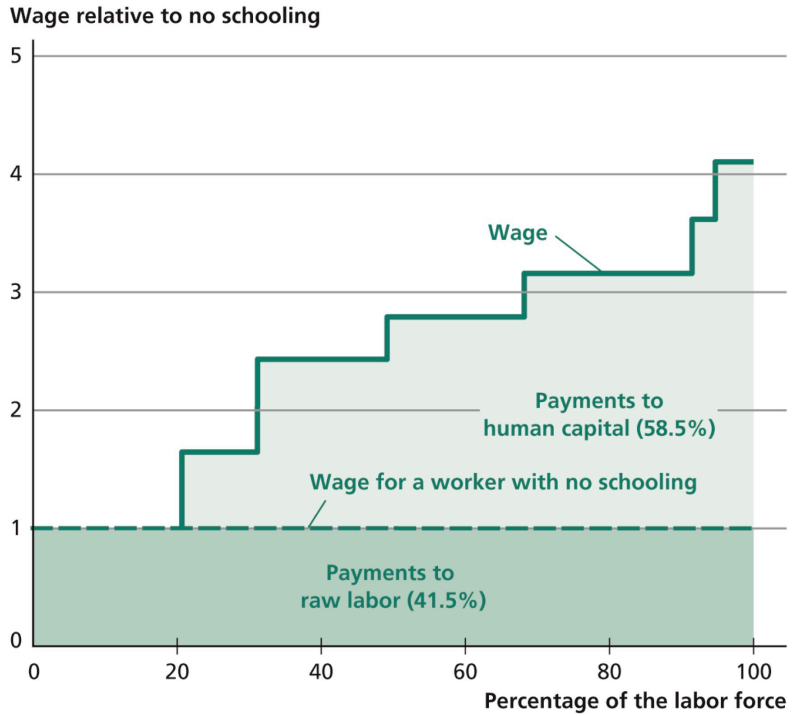
Human capital's share of wages

- Wage is paid to the combination of the hours worked (raw labor) and their quality (human capital)
- How much is paid to raw labor?
- How much is paid to human capital?
- Suppose a worker has five years of education.
- His wage would be $1.1344^4 \times 1.101 = 1.82$ times wage of a worker with no education
- $0.82/1.82 = 45\%$ to human capital, 55% to raw labor
- Now, apply this method to entire labor force

$1 \times 1.1344^4 \times 1.101 = 1.82$

Share of human capital in wages

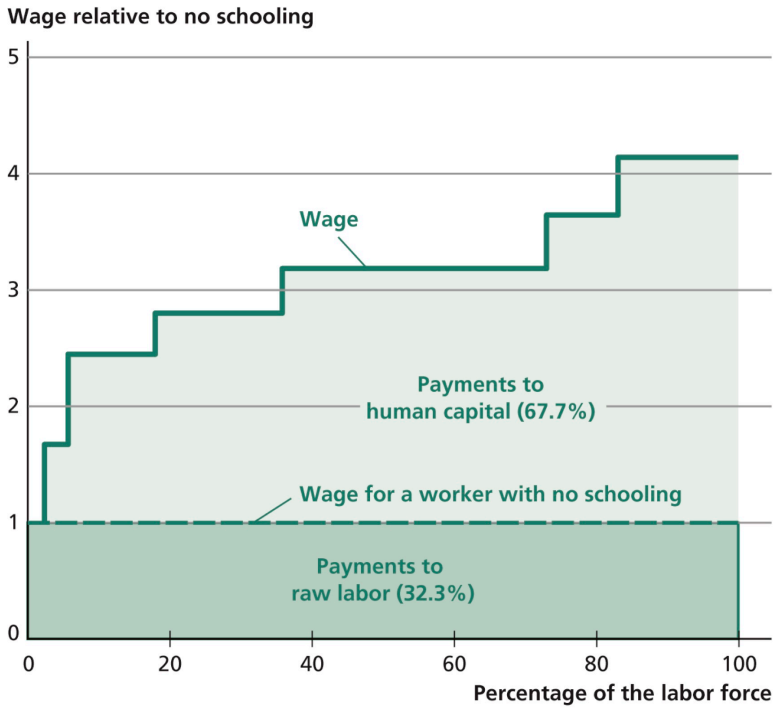
Developing countries



human capital's share of national income in developing countries = $2/3 \times 58.5\% = 40\%$

Charts from Weil (2013)

Developed countries



human capital's share of national income in developed countries = $2/3 \times 67.7\% = 45\%$