Economic growth

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1 Class 2: about growth

Thinking about the Solow model

- What does it tell us?
- 1. If countries are alike
  - in terms of $s, n, A_0, \alpha, \delta, \theta$
  - note that this includes technology
  - then poorer countries will grow faster than richer
    - poorer countries have less capital
  - Idea of convergence
- let $\alpha = 0$, with the same $s, n, A_0, \delta, \theta$, all have the same stationary state

$$k^* = \left(\frac{sA}{n+\delta}\right)^{\frac{1}{1-\theta}}$$

- Growth rate, for a country wiht capital k_t, is equal to

$$\kappa_t = \frac{k_{t+1}}{k_t} = \frac{1-\delta}{1+n} + \frac{sA_0}{1+n}k_t^{\theta-1}$$

Solow model: capital and growth rates

- We can find out how fast a country grows as a function of the capital stock from

$$\frac{\partial \kappa_t}{\partial k_t} = (\theta - 1)\frac{sA_0}{1+n}k_t^{\theta-2}$$

- Since $\theta - 1 < 0$, countries with higher capital stocks grow slower

Solow models: countries with the same capital stock

- Growth rates depend on the values of $s, n, A_0, \alpha, \delta, \theta$
- Growth rate (with $\alpha = 0$) is

$$\kappa_t = \frac{1-\delta}{1+n} + \frac{sA_0}{1+n} k_t^{\theta-1}$$

- If s or A_0 is bigger, so is κ_t
- If δ or n is bigger, κ_t is smaller
- Notice how these values are related to the stationary state

$$k^* = \left(\frac{sA_0}{n+\delta}\right)^{\frac{1}{1-\theta}}$$

- So for countries with the same capital stock, those with the higher stationary state will grow faster
- These results hold true for economies with the same technology growth

Solow model with international capital flows

- What happens if we allow capital to flow between countries
- what is the rate of return on capital
- in a competitive economy = marginal product of capital

$$r = mpk = \frac{\partial y}{\partial k} = \theta A k^{\theta-1} = \frac{\theta A}{k^{1-\theta}}$$

- If $k^1 > k^2$, then $mpk^1 < mpk^2$ and $r^1 < r^2$
- Then citizens of country 1 will want to invest in country 2 until the returns are equal
- this will happen in just one period
- then all the world is the same: if $s, n, A_0, \alpha, \delta, \theta$ are the same
- Question: what happens if $s, n, A_0, \alpha, \delta, \theta$ are different in different countries?

What has human history been like?

- GDP per capital in the long run
- Show "long term graphs"
- What does this suggest about human history?

- How is now so different?
- Note that the recent growth has occurred (at different rates and times) in all parts of the world
- Lucas on long term growth
- One of the major constraints through history was the source of energy
  - slaves and animals (to be rich in ancient times meant you had many slaves)
  - wind and water
  - carbon based fuels: coal, oil, gas
    - steam
    - internal compustion
    - jet
  - electricity: water based, carbon based, nuclear based, solar based

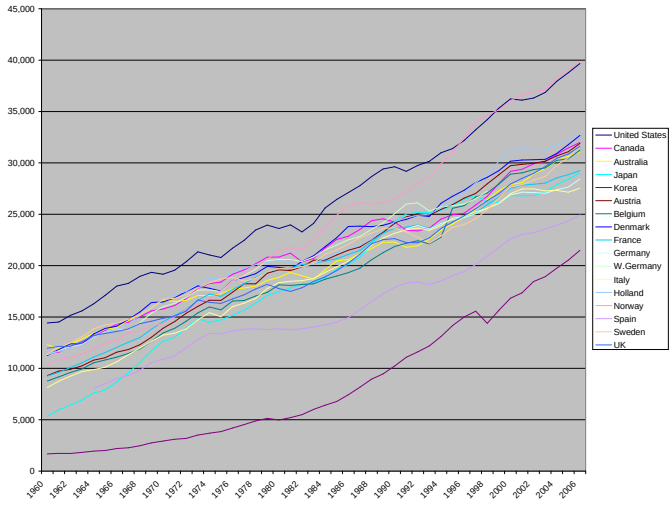
Long term graphs

- Graph 1: subsistance level for most of human history
  - different estimates of what subsistance level is
- Graph 2: more recent estimates
- Graph 3: how different parts of the world are doing
  - Europe and western offshoots (US, Australia, New Zealand)
  - Even africa is growing but very slowly
  - Some new books about growth (or lack of it)
  - "The Bottom Billion"
  - How "democracy" works in very poor countries
  - Institutions

Maddison on stages of growth

- Determinants of production potential in six economic epochs

	epoch	output function
1	$pre-agrarian$ $hunter,\ gatherer$	$F_1(N, L)$
2	*Agrarianism*	$F_2(N', L', K)$
3	*Ancient imperialism*	$F_3(N', L'', K^*) + p$
	Reversion to agrarianism	$F_2(N', L', K)$
4	*Advanced Agrarianism*	$F_4(N', L', K')$
5	*Merchant capitalism*	$F_5(N', L'', K'')^s + p'$
6	*Capitalism*	$F_6(N'', L''', K''')^s + p''$



- p = plunder, p' = plunder and monopolist trade, p'' = residual or negative plunder
- s = economies of scale and specialization present

Maddison on stages of growth
N = natural resources
N' = natural resources taken and maintained
N'' = natural resources developed and augmented
L = raw labor
L' = labor force - simple skills, defense oriented elite
L'' = labor force - skills, bureaucratic military elite
L''' = labor force - formal education, scientific, technical, military elite
K = moderate stock of working capital, replacement investment
K^* = as K with roads and urban facilities
K' = as K with gradual expansion of fixed capital
K'' = as K' with capital deepening more important
K''' = moderate working capital with greater fixed capital, investment major form of transmitting technology, tangible technological progress
Slides from last class

- Note Japan, Korea: other than that, common growth path

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- China!!!

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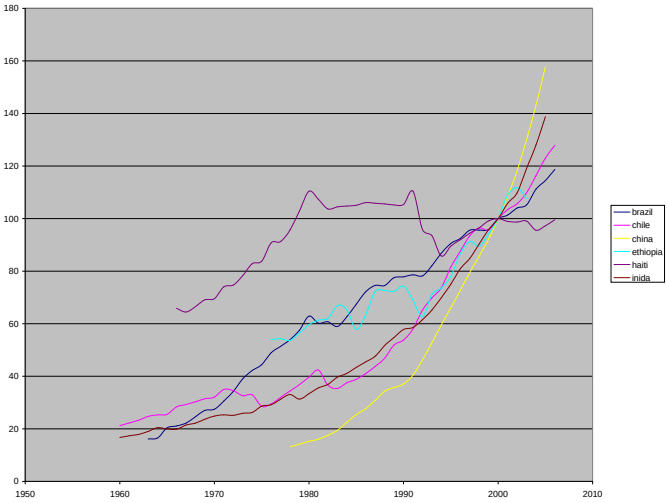
Maddison Tables on output (at factor costs)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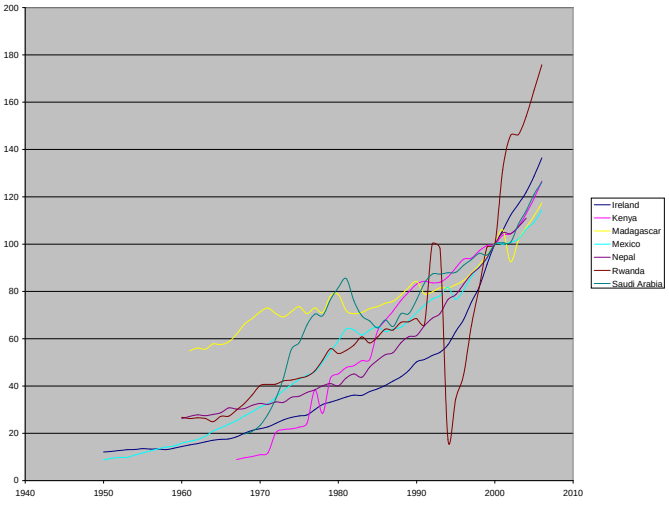
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Madagascar
Mexico
Nepal
Rwanda
Saudi Arabia

- What do these tables tell us?
- What does "at factor cost" mean
  - trying to correct for difference in exchange rates and tariff policy
- longer view than the OECD graphs
- Look at how the world was
  - relative income levels at different dates of poorer countries
  - asis, africa, south america, poor european (and Turkey)
  - developed countries

.Growth regressions

- Barro
- Barro and Sali-Martin
- Sali-Martin (I did one million regressions)
- Regressed growth rate per capita on other variables (will explain details in a bit)
- coefficients measure marginal effects of each variable
- Log(GDP) is the starting date GDP
  - higher initial GDP implies slower growth rate
  - this is somewhat complicated to interpret since many "independent" variables are correlated
    - GDP<=> fertility rate, GDP <=> schooling, GDP <=> life expectancy
- These regressions are an attempt to measure the effects in spite of these correlations
- They show only the variable that turned out to be significant in the regressions

.Dependent variable: per capita growth rate

Independent variable	(1)	(2)
log(GDP)	-.0254 (.0031)	-.0225 (.0032)
male>= secondary schooling	.0118 (.0025)	.0098 (.0025)
log(life expectancy)	.0423 (.0137)	.0418 (.0139)
log(GDP*male schooling)	-.0062(.0017)	-.0052 (.0017)
log(fertility rate)	-.0161 (.0053)	-.0135 (.0053)
Gov Consumption ratio	-.1360 (.0260)	-.1150 (.0270)
Rule of law index	.0293 (.0054)	.0262 (.0055)
Terms of trade change	.1370 (.0300)	.1270 (.0300)
Democracy index	.0900 (.0270)	.0940 (.0270)
Democracy index squared	-.0880 (.0240)	-.0910 (.0240)
Inflation rate	-.0430 (.0080)	-.0390 (.0080)
Sub/Sahara dummy		-.0042 (.0043)
Latin American dummy		-.0054 (.0032)
East Asia dummy		.0050 (.0041)
R^2	.58, .52, .42	.60, .52, .47
Number of observations	80,87,84	80,87,84

Barro's interpretations of the estimations

- If you just take the data: initial GDP <=> growth rates and graph them
  - You get a cloud without any special trend
- Uses panal data (across countries)
- How the estimations worked for the table
  - For example: with log(GDP)
  - have a set of countries with values for all variables
  - ran regression leaving out log(GDP) (set to zero), but with all the other variables included
  - find the residual growth rate (that not explained in the estimation without log(GDP)
  - run a regression of the residual on log(GDP)
  - coefficient gives how log(GDP) explains residual (part not explained by other variables)
  - the coefficient is slope of line of log(GDP) against residuals

Barro's interpretations of the estimations

- The fact that log(GDP) is negative is Barro's reason for claiming "conditional convergence"
- coefficient is -.025 which implies a 2.5% rate of congergence of per capita gdp

- These imply=> 27 years to get 1/2 way to stationary state
- 89 years to get 90% to stationary state

How important is human capital?

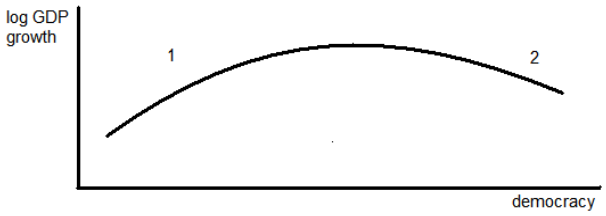
- Human capital (knowledge) is not in the simple Solow model
- Two variables in Barro's regressions are related to human capital
  - Average years of educational achivement in secondary school of men 25 and older
  - Life expectancy at birth (at the start of the period)
    - Why is life expectancy a human capital variable (time over which you can get a return to education)
- Regression says that extra year of over 25 secondary schooling increasing growth 1.2%
  - Primary schooling was insignificant (but of course necessary for secondary schooling)

How important is human capital?

- Women's schooling was insignificant (neither primary or secondary)
  - there is evidence that women's schooling matters indirectly
  - increased education implies reduced fertility
  - reduced fertility implies reduced infant mortaligy
  - reduced infant mortality increases life expectancy (which is a significant variable)
- Cross term: log(GDP)*schooling (coefficient is negative): how to interpret it
  - for same schooling, lower starting GDP will have higher growth rate
- Why might higher life expectancy mean higher growth
  - higher life expectancy implies healther implies more productive
  - higher life expectancy implies β closer to 1 (so future is discounted less and future expected consumption is more important (so higher savings)

Government

- Higher government consumption (minus education and defense) implies lower growth rate



  - perhaps government spending is less productive
  - can imply something about tax rates => higher spending implies higher taxes implies lower growth rate

- Rule of law (in 1980) index between 1 and 6 from other studies
  - part of study of institutions
  - higher rule of law => higher growth rate
  - with higher rule of law, capital is safer => more willingness to invest domestically

Democracy

- Democracy and democracy squared
  - relationship has this shape
- How to interpret
  - region 1: worst dictatorship => low property rights => low private investment => low growth
  - region 2: usually implies more equality in income *distribution* and not necessarily growth
    * highest political income correlated with highest incomes
    * high initial income implies lower growth because they are on the technology frontier

How to look at Barro's regressions

- Barro tells us about the things that matter
- Those that are in Solow's model
- Those that are NOT in Solow's model and perhaps should be in a good model of growth
  - He suggests how to account for these

Parente and Prescott: Barriers to Riches

- Average world income level relative to the US (which is the leader)

year	percent
1952	13.0
1962	13.3
1972	13.0
1982	13.8
1992	15.1
1996	17.7

- Notice that the average world income level is increasing in the last part of the period

Parente and Prescott: What they see as facts

- Before 1800, living standards differed little across countries and time
- After 1800, per capita GDP of leading country doubled every 40 years
- Differences in living standards grew dramatically from 1800 to 1950
  - as west grew rapidly
  - and the rest stagnated or grew slowly
- Difference between the west and the rest declined after 1950
  - most countries of the east grew rapidly
  - most grew faster than the west
- World differences in income have declined after 1960
  - modern economic growth is reaching almost every country in the world
- Growth miracles have occurred
  - but only in countries well behind the leader when miracle began
- Countries reaching a given level of income later tend to double in shorter time

Do rich countries save more than poor ones?

- If the numbers are done correctly
- Fraction of gdp invested

year	industrialized	developing	Africa
1966	22.7	17.6	19.0
1970	23.7	17.5	22.0
1975	21.6	25.5	29.2
1980	23.2	25.5	28.0
1985	21.3	22.3	20.3
1990	21.5	24.3	19.6
1993	19.4	23.3	18.8

- Recall that 1975 and 1980 were years around the first oil price increase

.Total Factor Productivity (TFP) and development
Implied TFP differences (1988) from Hall and Jones 1999

Country	per worker output
USA	1.00
West Germany	.82
France	.82
UK	.73
Japan	.59
South Korea	.38
Protugal	.37
Malaysia	.27
Thailand	.16
Philippines	.13
India	.09
Kenya	.06

.Total Factor Productivity

- Parente and prescott believe that TFP is what makes the difference in output and output growth
- Education (human capital) is related to the ability to increase TFP
- Economic miracles are caused by countries rapidly increasing their TFP (Japan, South Korea)
- Countries that stay poor have systems that go against increasing TFP
- This can come from monopoly rights of domestic producers and unions
- More open economies usually have higher TFP
- In open economies firms are not protected from world TFP levels (and goods and prices)