Health and Economic Growth

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Econ 2840

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Notes to self (students can ignore)

add: bleakley on worms (do I have his slides?)

one or more of the malaria papers (Cutler et al., Lucas, Bleakley)

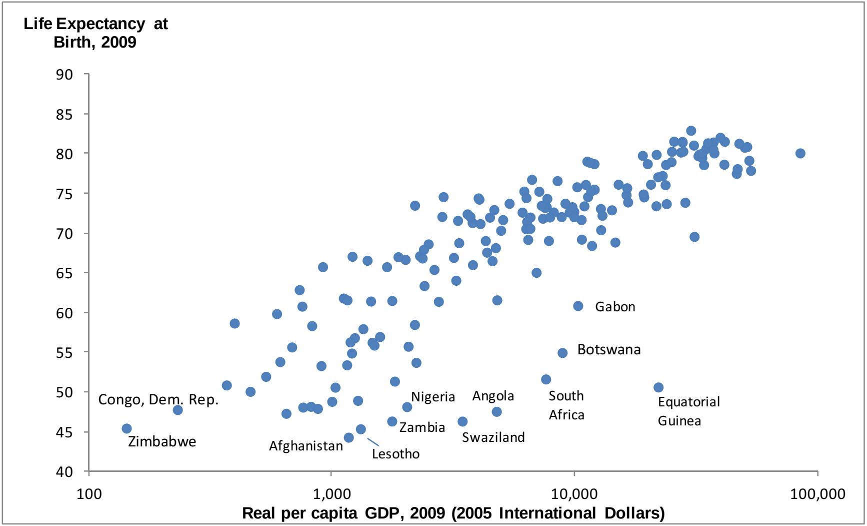
should I just do my own slides for Accounting?

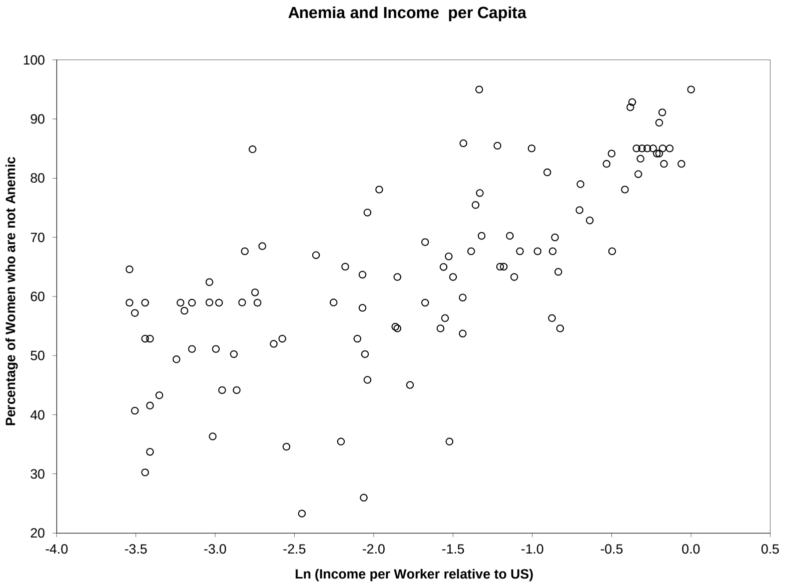
statistical exercise

iodine???

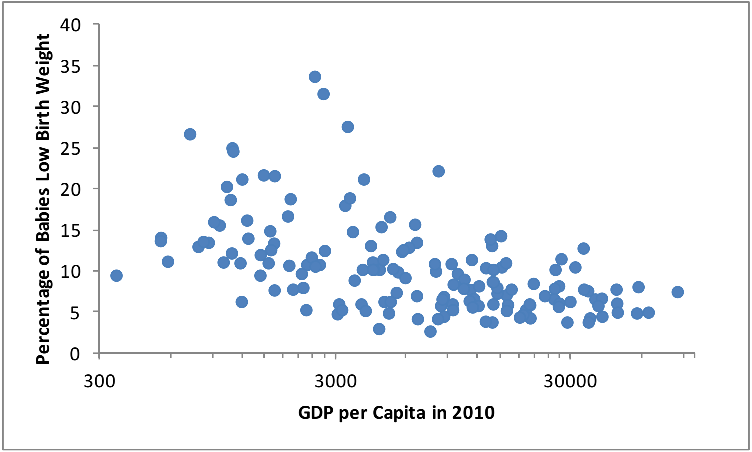
alw?

Life Expectancy and Income





Anemia and Income per Capita
Percentage of Women who are not Anemic
100
90
80
70
60
50
40
30
20
-4.0
-3.5
-3.0
-2.5
-2.0
-1.5
-1.0
-0.5
0.0
0.5
Ln (Income per Worker relative to US)



Percentage of Babies Low Birth Weight
40
35
30
25
20
15
10
5
0
300
3000
30000
GDP per Capita in 2010

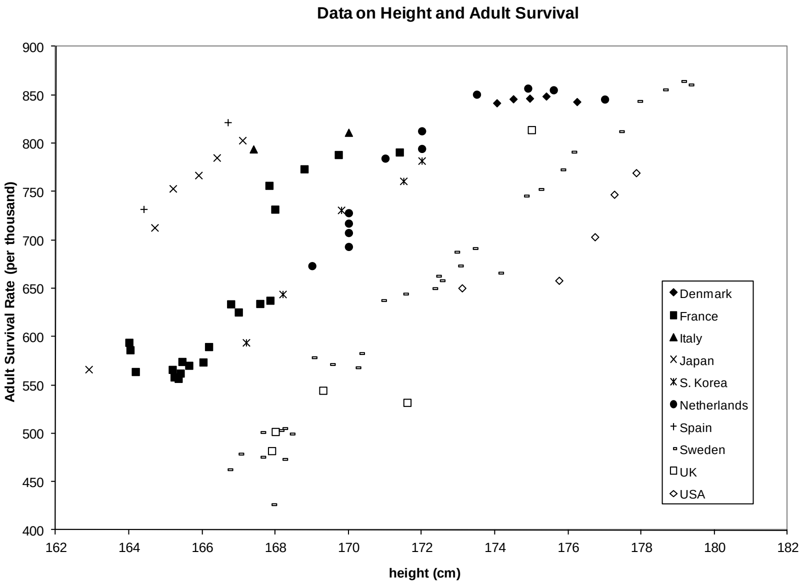
Within-Country Covariation of Health and Income

- In the US, mortality hazard declines with income or education, but hard to differentiate between them (Deaton and Paxson, 2001).
- In the US, life expectancy gap between rich and poor is growing:
  - gap in life expectancy at age 65 between highest and lowest deciles grew from 0.3 years to 1.6 years between 1980 and 2000.
- In developing countries, the relationship between income and health is stronger
  - Under five mortality almost twice as high in bottom quintile as in top quintile.

Historical Data on Health

Pattern very similar to Lucas (2000) facts from first lecture:

1. Prior to the Industrial Revolution, there was little long-term change in average health, though with considerable short-run variation.
2. Prior to the Industrial Revolution, cross-sectional differences in health were small.
3. In the 19th century, there was a takeoff of health in Europe and its offshoots, with little change elsewhere
4. Starting in the middle of the 20th century, health improvements in trailing countries began to exceed those in leaders.
    - "Health convergence" in last 50 years much stronger than income convergence



Data on Height and Adult Survival
Adult Survival Rate (per thousand)
height (cm)
900
850
800
750
700
650
600
550
500
450
400
162
164
166
168
170
172
174
176
178
180
182
Denmark
France
Italy
Japan
S. Korea
Netherlands
Spain
Sweden
UK
USA

The Flynn Effect

- Measured intelligence is affected by both education (formal and informal) and health
- "Flynn effect" is rise in measured IQ by 2-3 points per decade for last 50 years in developed countries
- Effect shows up in measures of "fluid intelligence," which is not supposed to be affected by schooling and also at young ages
- Consistent with the observed effects of low birthweight, malnutrition, micronutrient deficiency, and infectious diseases on IQ.
- Coming "IQ convergence" as a result of health convergence?

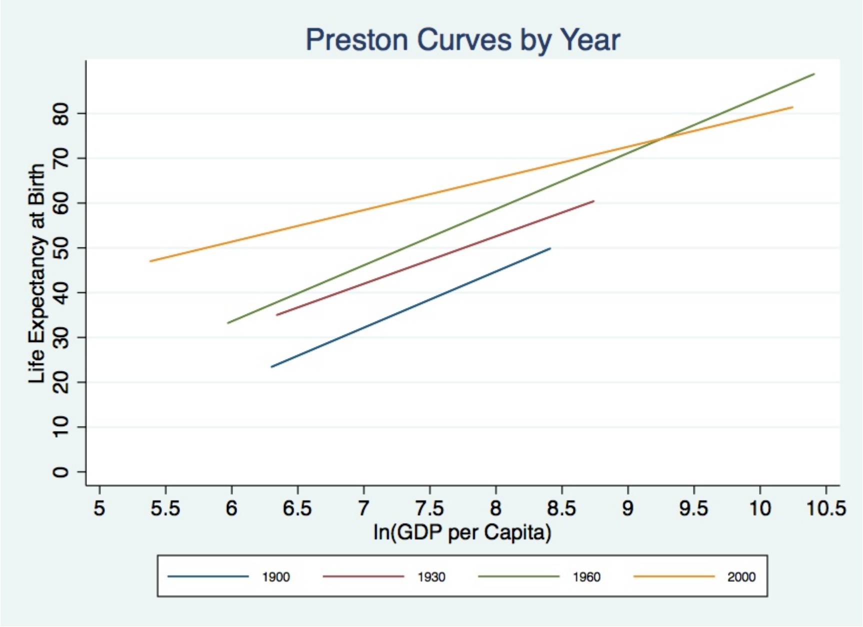
Health Improvement and Income Growth: Questions Raised

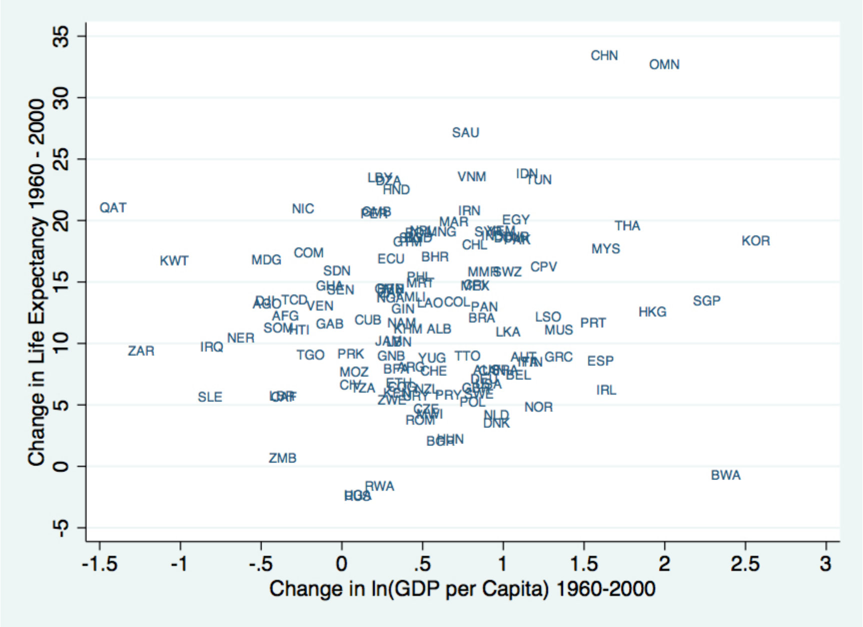
1. How are they related?
   1. how did the health improvement affect output growth
   2. how did output growth affect health improvement?
2. Comparison of their importance
   1. Which is bigger?
   2. Which is a better target for policy?

Co-Movement of Income and Health

Show the Gapminder video!

Co-Movement of Income and Health

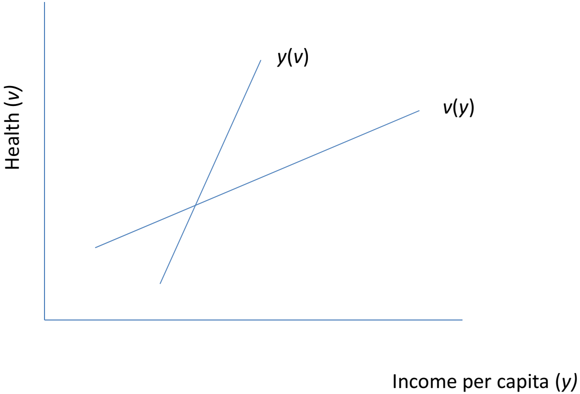




R^2 is 0.50 when countries weighted by population

Theory

The Interaction of Health with Income



Positive Observed Correlation of v and y

Theory #1: variation in $y(v)$, holding $v(y)$ fixed

This could be due to

- (across countries): differences in productive technology, institutions, natural resources
- (across individuals): differences in non-health aspects of human capital

These variations will trace out the $v(y)$ curve, so to match the observed data, $v(y)$ must be upward sloping, i.e. income has big effect on health

Positive Observed Correlation of v and y

Theory #2: variation in $v(y)$ curve, holding $y(v)$ fixed

This could be due to

- (across countries): differences in "health environment," e.g. tropical diseases
- (across individuals): variation in idiosyncratic health

These variations will trace out the $y(v)$ curve, so to match the observed data, $y(v)$ must be upward sloping (in its reflected form), i.e. health has a big impact on income.

Positive Observed Correlation of v and y

Theory #3: correlated shifts in $v(y)$ and $y(v)$ curves

Due to common factor(s) that shift both curves

These could be

- (over time): "technology" that allows for more output and better health
- (across countries): institutional quality
- (across individuals): education

Does not require either $y(v)$ or $v(y)$ to be sloped.

Complications of the Simple Theory: Timing!

- Delays in the productive impact of health gains
  - Adult health very sensitive to conditions during gestation and early life
    - malnutrition, micronutrient deficiency, smoking, Spanish Influenza, etc.in utero
    - malaria and nutrition in early life
  - Thus gains in health do not show up in adult productivity for a generation

Complications of the Simple Theory: Timing!

- Negative short-run effects of income growth on health
  - urbanization and inter-regional migration expose people to new pools of pathogens
  - pollution (environmental Kuznets curve)
  - increases in income not always well spent (tobacco, processed foods)
    - obesity/diabetes rising in developing countries
    - mis-match with fetal programming
  - public health spending rises with income, but often there is a lag in implementation
    - Cutler and Miller (2005): 43% of decline in mortality in 13 big US cities 1900-1936 due to water quality improvements

Complications of the Simple Theory: Timing!

- Entanglement of health improvements with population growth
  - When life expectancy rises, most of the lives saved are infants and young children
  - holding fertility constant, this raises population growth
  - Due to standard Solow/Malthus effects, this will lower income per capita
  - Acemoglu and Johnson (discussed below) point to this channel as explanation for their empirical finding

The Effect of Income Growth on Health: $v(y)$

- Improvements in health resulted from three sources:

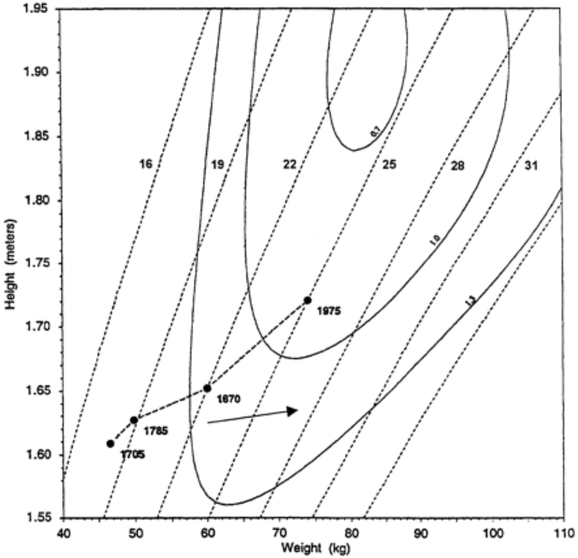
1. Improved standard of living, especially nutrition
2. public health – clean water, sanitation
    1. includes health behavior modifications like boiling water and washing hands
3. medical interventions (antibiotics, other drugs, surgery, etc.)

- In the early-developing countries, these happened roughly in the order listed
- in catch-up countries, the order was more chaotic
- Key point: particular conditions (most notably infectious diseases) can be addressed by different channels

The McKeown / Fogel View

- Much of the decline in mortality that took place over the last two centuries in rich countries was due to standard of living rather than public health or medical interventions.
- McKeown: large declines in infectious disease deaths took place before public health or medical interventions
  - For example, death rate from tuberculosis declined 80% between 1848 and the development of effective treatments in the 1940s.
- Fogel: large increases in caloric consumption, body size
  - UK: calories per adult rose 20% between 1800 and 1913
  - France: 65% between 1800 and 1960
- More food produced bigger, healthier people (who could also do more work)

A Waaler Surface



Criticism of the McKeown/Fogel View

- Shifts up in the Preston Curve dominate movements along the curve
  - but this is for the period after 1900
- Bigger bodies are not only a result of better standard of living (more food), but also better health
- Many dramatic episodes of mortality reduction not associated with income growth
  - Almost all of China's remarkable improvement in infant mortality took place before economic growth took off in 1980.
  - Acceleration in economic growth in India following economic reforms in the early 1990s was accompanied by a slowdown in the rate of decline in infant mortality.

If Higher Income did not Raise Life Expectancy, What Did?

Caldwell (1986), “mortality breakthroughs” associated with political and social will to address health issues rather than availability of economic resources.

Cutler, Deaton, and Lleras-Muney (2006): Key is application of knowledge

- Germ theory of disease (empirically validated in the 1880)
  - allowed for the introduction of effective public health infrastructure, particularly clean water
  - allowed for better *private* health behavior, such as hand washing, boiling water
    - example: children of doctors and teachers had mortality slightly lower than average at the end of the 19th century, but 1/3 lower than average by 1925
- Similar example: smoking
  - At time of Surgeon General's report (1964), little variation by education. By 1987, 17% for college grads vs. 41% for high school dropouts

The Knowledge Story

Note that CDL-M story posits a different mechanism generating the correlation between income and health in cross section and time series:

- In time series (for rich countries): "health knowledge" and "productive knowledge" developed in parallel, driving a parallel evolution of health and income
- Across countries today, gaps in health are due to differential application of available knowledge. Institutional quality can explain why this is correlated with income.
  - Why are institutions relevant for the diffusion of ideas? Evidently, it is not just knowledge, but knowledge applied through institutions.
- Given the high R^2 of the health-income relationship, these institutions must be the dominant explanation for variation in both.

Effect of Income on Health: The Bottom Line

- For poor countries with poor health, income growth neither necessary, nor sufficient for health improvement. Further, it is not the best way to achieve health improvement.
  - all that is required is application of available knowledge.
- Even for rich countries (like the US), there are large gains in health available through the application of existing knowledge.
- *However*, the idea that the evolution of health knowledge is independent from the evolution of productive knowledge is silly.

The Effect of Health Improvement on Economic Growth

- Why we expect one:
  - Healthier people can work harder, think better
  - Healthier people learn more in school
  - If children likely to survive, have fewer and invest more in each
  - People who expect to live longer save more capital, build better institutions, etc.
- Three approaches to finding the magnitude
  - Poorly identified cross country regressions
  - Better identified cross-country regressions
  - simulation / calibration

Better Identified Regressions

- Look for plausible exogenous variation in health, look for its effect on income
- Ahuja, Wendell, and Werker (2006): Impact of HIV/AIDS in sub-Saharan Africa.
  - Identifying variation comes from male circumcision rate, which is strong predictor of HIV prevalence
  - Use ethnographic data to classify the fraction of the population that practices male circumcision
    - three categories: 0-20%, 20-80%, 80-100%
- Theory is that circumcision is only relevant for growth once HIV becomes present
- Note: time series data on HIV is completely unreliable, because definititions change. UNAIDS cautions never to use it. So authors only use HIV cross section from 1997.

Cross-section regresssion for HIV prevalence

Table 1 Predicting HIV/AIDS rates with male circumcision

	Dependent Variable: % of adults 15-49 living with HIV/AIDS in 1997				
	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) OLS
H/B circumcision 20%-80%	-8.156	-5.167	-6.08	-5.253	-5.443
	[2.481]***	[3.622]	[4.079]	[3.254]	[3.618]
H/B circumcision 80%-100%	-14.151	-11.264	-9.565	-11.051	-8.826
	[2.167]***	[3.119]***	[3.167]***	[3.544]***	[3.347]**
ln(GDP per capita, PPP, Int. $2000), 1980		-0.187	1.853	2.041	2.589
		[1.486]	[1.616]	[1.826]	[1.638]

- Matches RCT evidence on protective effect of circumcision

Predicting Mortality

- depednent variable is mortality relative to 1980-85 baseline
- includes country and year fixed effects

	OLS	IV
HIV/AIDS Rate in 1997 * 1990	0.141 [0.062]**	0.228 [0.129]*
HIV/AIDS Rate in 1997 * 1995	0.289 [0.066]***	0.374 [0.116]***
HIV/AIDS Rate in 1997 * 2000	0.508 [0.074]***	0.555 [0.102]***
HIV/AIDS Rate in 1997 * 2005	0.642 [0.106]***	0.694 [0.145]***
F Statistic on AIDS-year interactions P (>F)	15.08 0	9.38 0
F Statistic on first stage instrument P (>F)		22.61 0

Effect on Output per Capita

	(1) OLS	(2) IV
HIV/AIDS Rate in 1997 * 1990	0.001	0.003
	[0.007]	[0.007]
HIV/AIDS Rate in 1997 * 1995	0.001	0.004
	[0.008]	[0.009]
HIV/AIDS Rate in 1997 * 2000	0.002	0.006
	[0.011]	[0.012]
HIV/AIDS Rate in 1997 * 2005	-0.001	0.003
	[0.013]	[0.013]
F Statistic on AIDS-year interactions	0.78	0.48
P (>F)	0.5436	0.7493
F Statistic on first stage instrument		22.84
P (>F)		0

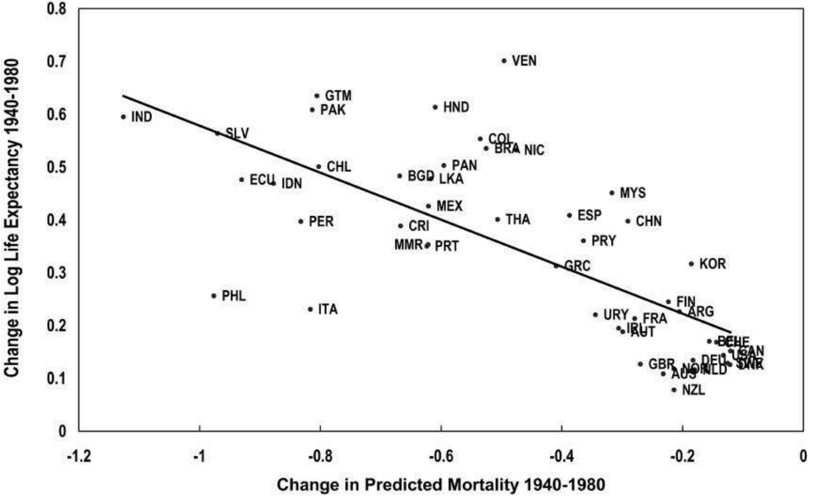
- No effect on income per capita

Acemoglu and Johnson (2007)

- "international epidemiological transition" starting in the 1940s
  - rapid transfer of health knowledge to developing world, driven by humanitarian impulses and the cold war
  - public health knowledge, antibiotics, vaccines, DDT, etc.
  - This is what caused the catch-up in health that we saw earlier
- AJ proceed in three steps

1. Look at cross-country data on disease specific death rates prior to the transition
2. Look at world data on progress against different diseases (based on discoveries or simply worldwide declines)
3. Construct predicted mortality change for every country

Acemoglu and Johnson



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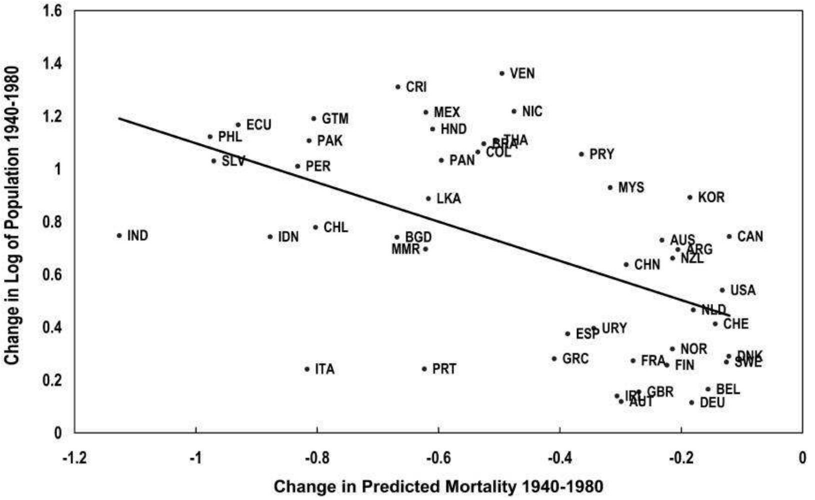
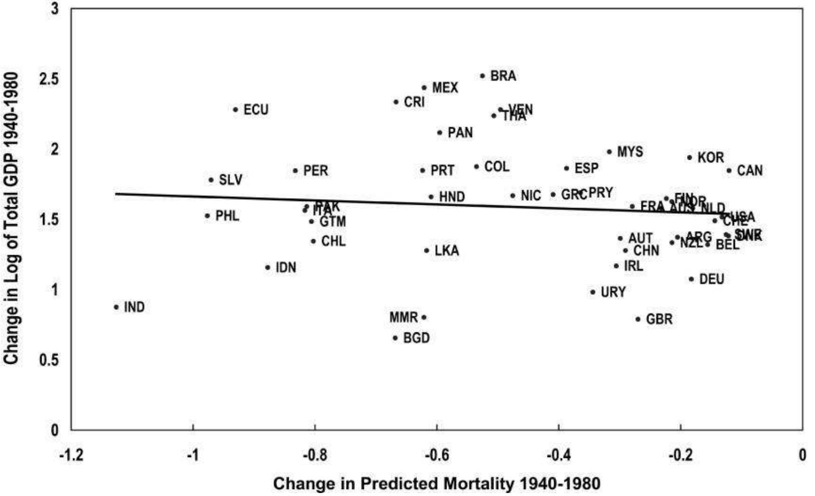




Change in Log of Total GDP 1940-1980
Change in Predicted Mortality 1940-1980
3
2.5
2
1.5
1
0.5
0
-1.2
-1
-0.8
-0.6
-0.4
-0.2
0
BRA
MEX
CRI
ECU
VEN
THA
PAN
MYS
KOR
CAN
PER
PRT
COL
ESP
SLV
HND
NIC
GRC
PRY
FIN
NOR
FRA
AUS
NLD
PAK
ITA
USA
CHE
PHL
GTM
AUT
ARG
SWE
DNK
NZL
BEL
CHL
LKA
CHN
IDN
IRL
DEU
IND
URY
MMR
GBR
BGD

Acemoglu and Johnson

- Their interpretation of their finding: This is exactly the entanglement of health with population discussed above.
- Big reductions in mortality triggered rapid population growth, which reduced income per capita via Solow/Malthus/dependency channel
- This does *not* mean that epidemiological transition was a bad thing! Big welfare gain from lives saved, suffering avoided.

Problems with Acemoglu and Johnson

- The instrument (change in predicted mortality) is highly correlated with initial life expectancy
  - so countries that got a big "treatment" were systematically different from those that didn't
  - See Bloom, Canning, and Fink (2013) as well as AJ's reply.
- Change in population resulting from reduced mortality, as predicted by their regression model, is too large compared to a demographic simulation
  - They regress change in log population size 1940-1980 on change in log life expectancy (instrumented with predicted mortality. Coefficient is 1.67.
  - Rise in life expectancy from 40 to 60 –> change in log life expectancy of 0.405
  - implies rise in log population of 0.676
  - implies rise in population by factor of 1.97 – Is that reasonable?

Ashraf, Lester, and Weil: Mortality Decline and Population Growth

- Demographic simulation model
- start with age specific fertility Sri Lanka 1953
- Change life expectancy from 40 to 60 using UN model life table
- allow for fertility adjustment to new mortaility environment

Figure 1: Survivorship Functions, UN Model Life Table, South Asia

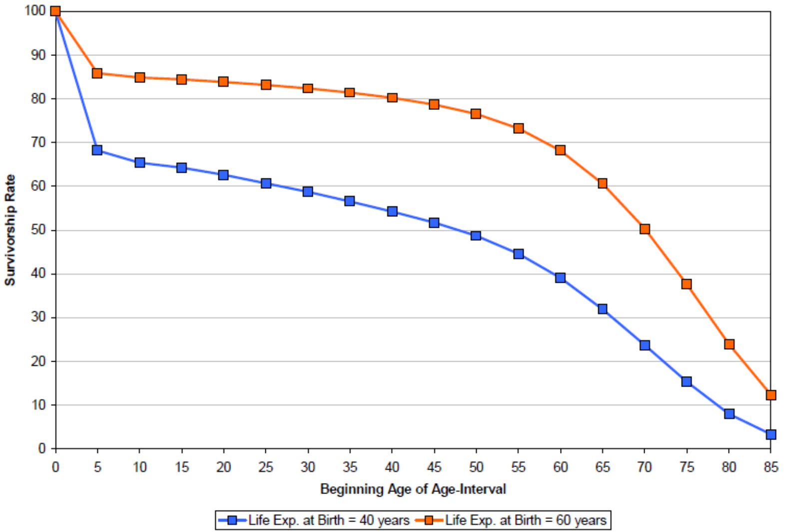


Figure 2: Fertility Schedule, Sri Lanka, 1953

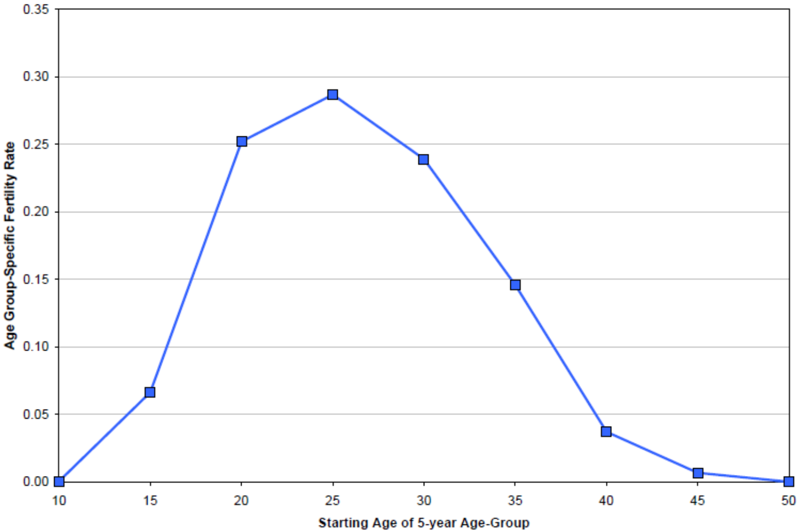
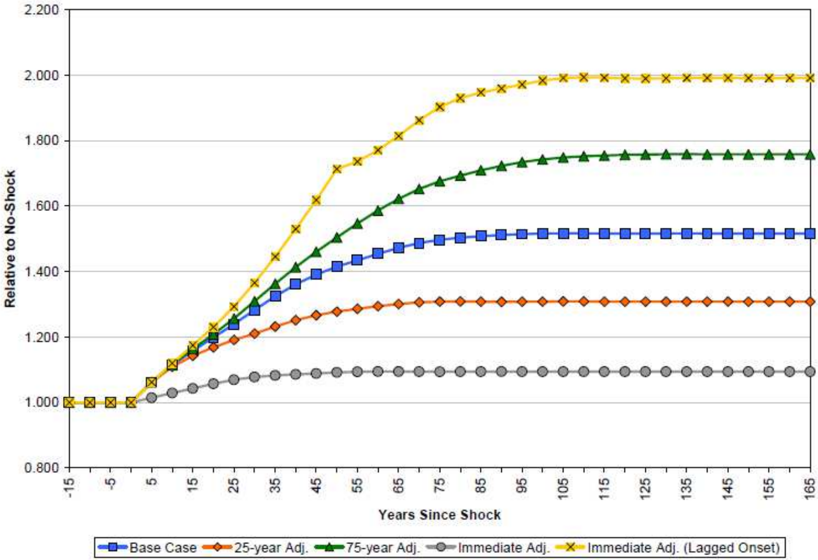


FIGURE 10: EFFECT OF ADJUSTMENT SPEED ON POPULATION SIZE



Health ==> Income, Calibration Approach

- Maybe this is not a question that can be answered with aggregate regressions
  - identification is too hard, especially with lags
- Alternative is to use theory, accounting for as many channels as possible
  - effect of health on productivity
  - population channel
  - improved schooling
  - etc.
- Weil (2007) estimates the productivity effect of improved health
- Ashraf, Lester, and Weil (2009) combine all the different channels in a simulation model
- Young (2005) does a similar analysis focused on HIV

Weil (2007): Productivity Increase from Better Health

- Framework similar to Mincerian approach to education.

Aggregate Production: $Y_i = A_i K_i^{\alpha} H_i^{1-\alpha}$

Human Capital Aggregate: $H_i = \sum_{j=1}^{L} h_{i,j} v_{i,j}$

where i indexes countries and j indexes individuals

Return to one unit of human capital: $w_i = \frac{dY_i}{dH_i} = (1-\alpha) A_i \left(\frac{K_i}{H_i}\right)^{\alpha}$

Wages for individual: $ln(w_{i,j}) = ln(w_i) + ln(h_{i,j}) + ln(v_{i,j}) + \eta_{i,j}$

Human capital from education and schooling:
$ln(h_{i,j}) = \phi(s_{i,j}) = \beta s_{i,j}$

- We need a way to map some health measure into units of v
- This would be the health equivalent of the “Mincer coefficient”

Framework for Estimating Return to Health

X = a vector of intputs into individual health

I = any observable health indicator (such as height)

v = human capital in the form of health

z = latent health (scalar!)

$$z = z(X)$$

$$I = I(z)$$

$$v = v(z)$$

Relationship Between Latent Health and Health Outcomes

$I_j = constant + \gamma_I z_j + \epsilon_{I,j}$

$ln(v_j) = constant + \gamma_v z_j + \epsilon_{v,j}$

Comparing two indivudals with different latent health:

$I_1 - I_2 = \gamma_I(z_1 - z_2)$

$ln(w_1) - ln(w_2) = \gamma_v(z_1 - z_2)$

thus $ln(w_1) - ln(w_2) = \frac{\gamma_v}{\gamma_I}(I_1 - I_2)$

return to characterisic I is $\rho_I = \frac{\gamma_v}{\gamma_I}$

if we know ρ_I and the average values of I in countries i and j :

$ln(v_1) - ln(v_2) = \rho_I(I_1 - I_2)$

Estimating the Return to a Health Characteristic

- Suppose that we have experimental or quasi-experimental variation in a health input
- x is an element of X

$$\frac{d\ ln(w)}{dx} = \frac{dz}{dx}\gamma_v$$

$$\frac{dI}{dx} = \frac{dz}{dx}\gamma_I$$

thus....

$$\rho_I = \frac{\gamma_v}{\gamma_I} = \frac{\frac{d\ ln(s)}{dx}}{\frac{dI}{dx}}$$

$$\rho_I = \frac{\gamma_v}{\gamma_I} = \frac{\frac{d\, ln(s)}{dx}}{\frac{dI}{dx}}$$

- the return to a health outcome is just the ratio of the effect of varying the health input on log wages to the effect of varying the health input on the particular health outcome
- Because of the assumption that latent health is a scalar, the ratio of the change in any two health outcomes that results from changing a single element i n the health input vector will be the same as the ratio of the change in those two health outcomes that results from any change in the entire health input vector.

Bias from Assuming that Latent Health is Scalar

- bias will depend on how the ratio of change in human capital in the form of health (v) and the indicator (I) that is induced by variation in health inputs among countries compares to the ratio of changes in these same variables that is induced by the experiment used to estimate the return to the health characteristic.
- Example: nutritional intervention at a time in life which is crucial for determining adult height

The Big Remaining Problem

- The assumption that latent health is scalar allows us to use one source of variation in health inputs as a proxy for the full range of variations in health inputs that differ among countries.
- Estimating the return to health *still* requires exogenous variation in a health input!

Exogenous Variation in Health

- Behrman and Rosenzweig (2004): monozygotic twins
  - genetically identical, same family
  - different uterine nutrition
  - average gap in birth weight is 10.5 oz, compared to mean weight of 90.2 oz.
- B&R estimate that a one unit difference in fetal growth (oz/week of gestation) leads to gap of
  - 0.190 log wages
  - 3.76 centimeters adult height
  - 0.657 years of schooling

TSLS estimate of effect of height on log wages:

$$\rho_{height} = \frac{0.190}{3.76} = .051 = 5.1\% \text{ per centimeter}$$

- This is for health or nutrition induced height! Not for being genetically tall.

Effect of Education

- The 5.1% per centimeter effect includes causality running through education. But in our accounting framework, we are already measuring education

$$\frac{d\ schooling}{dx} = \frac{.657}{3.76} = .175$$

assume Mincerian return to schooling is 10%

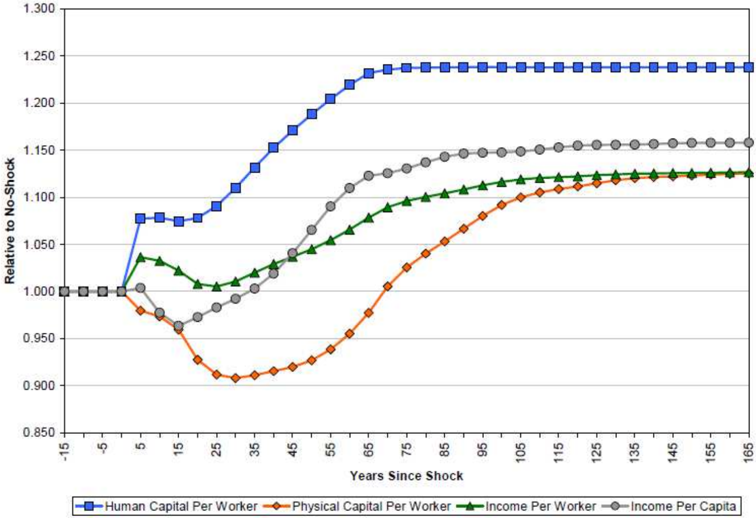
$$\rho_{height} = .051 - .1 \times .175 = .033$$

Applying this Coefficient

- Typical rise in height in developed countries in last 200 years has been 10 cm.
- Implies labor productivity due to health rose by factor of $(1.033)^{10} \approx 1.4$
- Since I don't have height data across countries, I have to convert this coefficient to a different measure (adult survival rate) using data on height and ASR from previous figure
- Increase ASR by 0.1 raises labor productivity by 6.7%
- Gap in labor productivity between Iceland (ASR=0.904) and Botswana (ASR=0.214) is factor of 1.59
- Eliminating health gaps would reduce variance of $ln(y)$ by 9.9%

Ashraf, Lester, and Weil (2009)

FIGURE 5: THE BASE CASE SCENARIO



Income Growth vs. Health Improvement: Welfare Comparison

Key papers are

Becker, Philipson, and Soares (2005)

Murphy and Topel (2006)

Jones and Klenow (2010)

Note: focus is on utility of being alive rather than utility from being in good health

The Value of a Statistical Life

Consider a person who is faced with the opportunity to avoid taking a small risk to his life in return for a small payment.

$\epsilon =$ be the probability of death and

$x =$the payment that makes the individual indifferent.

$$VSL = \frac{x}{\epsilon}.$$

- Commonly estimated by looking at wage premium associated with dangerous jobs
- \$4 million is typical value

Putting VSL in a Model

Define V as the expected future utility, we have

$$\epsilon V = (1-\epsilon)u'(c)x$$

$$U = \frac{c^{1-\sigma}}{1-\sigma} + \bar{u},$$

where utility from not being alive is normalized to zero.

"perpetual youth" model with constant mortality probability ρ and thus life expectancy of $1/\rho$.

$\theta =$ time discount rate (and interest rate)

$$VSL = \frac{x}{\epsilon} = c^{\sigma}\frac{\left(\frac{c^{1-\sigma}}{1-\sigma}\right) + \bar{u}}{\rho + \theta}.$$

$$\bar{u} = VSL \times c^{-\sigma}(\rho+\theta) - \left(\frac{c^{1-\sigma}}{1-\sigma}\right)$$

VSL in a Model, continued

assume

$c = \$35,500$ (US personal consumption expenditure per capita in 2012)

$\rho = .01333$ (give life expectancy of 75 years)

$\theta = 2\%$

σ	$\bar{u}$	"break even" consumption (\$)
0.8	-10.11	34
log	-6.72	830
1.5	.03055	4,286
2	0.000134	7,465

- Distressing how much the value of σ matters!

- We can solve for the gain in life expectancy that is equivalent to a (permanent) gain of 1% in consumption per capita:

$$\textit{gain in life expectancy} = \frac{c^{1-\sigma}\left(1+\frac{\theta}{\rho}\right)^2}{(\rho+\theta)\left(\frac{c^{1-\sigma}}{1-\sigma}+\bar{u}\right)} \times .01$$

Gain in Life Expectancy Equivalent to 1% Rise in Consumption

	consumption					
σ	35,000	17,750	8,875	4,437.5	2,218.75	1,109.38
0.8	.499	.525	.558	.602	.662	.747
1 (log)	.499	.612	.791	1.12	1.91	6.46
1.5	.499	.906	2.14	53.6	-	-
2	.499	1.36	9.92	-	-	-

- For the US, life expectancy gains quantitatively important
  - average rate of growth of life expectancy around 3 months per year
  - equivalent to 1/2 percent per year consumption growth
  - A bigger value of *VSL* would make that bigger
- For poorer countries, the gain in life expectancy equivalent to a 1% income gain is (much) larger than for the US

Cross-Country Applications of this Approach

1. Compare "full income" (inclusive of life expectancy) among countries
2. Compare growth of "full income" to growth of GDP

Comparing Full Income Among Countries

approach of Jones and Klenow (2010) (using log utility)

Facts:

	life expectancy	consumption
US	78.8	\$43,480
Zambia	49.4	\$1,358

Equivalent Variation: how much do we have to lower US consumption to match Zambian happiness?

Compensating Variation: how much do we have to raise Zambian consumption to match US happiness?

Ratio of income: 0.031

Equivalent Variation: 0.028

(inverse) Compensating Variation: 0.013

- People in Zambia not that happy to be alive, so the "compensation" that a US person would have to receive for the loss of life expectancy is small

Growth of "Full Income"

- Murphy and Topel (2006)
  - calculate value of health improvements by decade in the US
  - For first half of 20th century, these were roughly equal to value of conventional GDP growth
  - today, health improvements in US equal to 20% of growth of full income
- Becker, Philipson, and Soares (2005)
  - Over the period 1960-2000, average of 1.7 percentage points (40%) of annual growth of full income in poorer countries due to life expectancy, vs. 0.4 percentage points in richer countries.
  - Convergence of full income driven by health

VSL: Summing Up

- Assigning a utility value to being alive:
  - makes welfare gaps among countries larger (obviously)
  - may put a large dollar value on health improvements (parameter dependent)
  - may say that income gains are more important in poor countries than lifespan gains (parameter dependent)
- This literature is in an unsatisfactory state