Adult Longevity and Economic Take-off from Malthus to Ben-Porath

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Longevity and Income

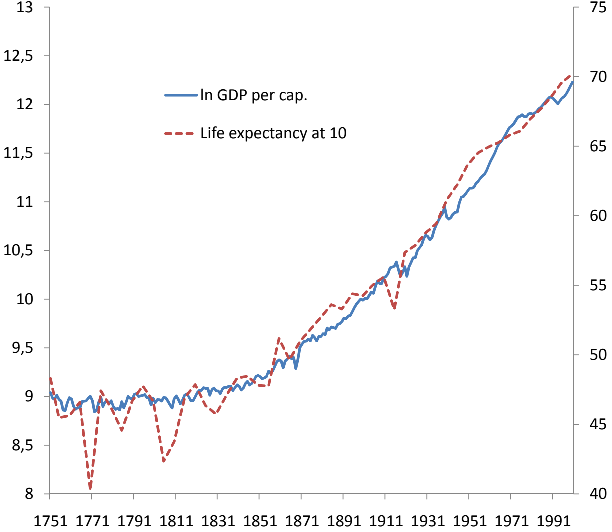
Take a fact as starting point:

Adult longevity is strongly correlated with income

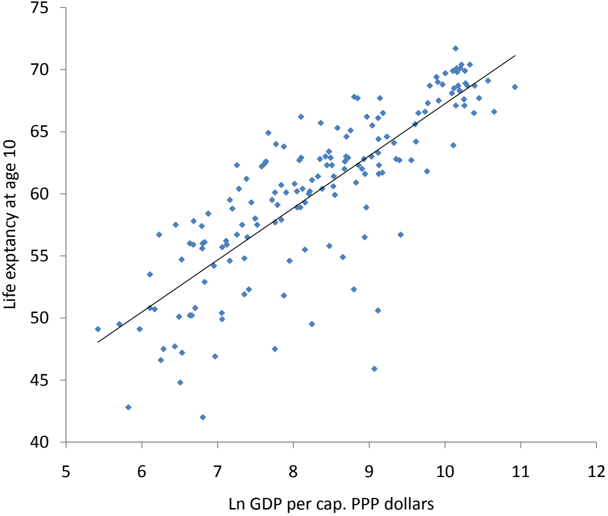
- over time
- across countries

Correlation over time

Life expectancy at age 10 and income per capita in Sweden



Correlation across countries



Question

Correlation does not mean causality

Knowing the direction of causality is important

- for understanding the past (industrial revolution)
- for today - development policy

Adult longevity and economic take-off (industrial revolution)

Two views

1. Improvements in longevity (following better living conditions) reinforce the growth process
2. Adult longevity rose before the industrial revolution and played a role in its release

The two views

Longevity as reinforcing growth

it appears that the industrial demand for human capital provided the inducement for investment in education and the associated reduction in fertility rates, whereas the prolongation of life may have re-enforced and complemented this process. [Galor 2006]

Longevity as a key factor

Changes in mortality can serve as *the basis* for a unified model that describes the complete transition from the Malthusian Regime to the Modern Growth Regime. Consider the effect of an initial reduction in mortality (due to an exogenous shock to health technology or to standards of living). The effect of lower mortality in raising the expected rate of return to human capital investments will nonetheless be present, leading to more schooling and eventually to a higher rate of technological progress. This will in turn raise income and further lower mortality...[Galor and Weil AER 1999]

Adult longevity and underdevelopment today

Using cross-country panel data with geographical environment as an instrument for life expectancy, Lorentzen, McMillan, and Wacziarg (2008) find a positive causal effect of life expectancy on growth.

Acemoglu and Johnson (2007) find no causal effect of life expectancy on long-run growth when using the introduction of new drugs like penicillin as an instrument for life expectancy.

How could longevity affect growth

- Ben Porath effect: Cervellati and Sunde (2003) and Boucekkine, de la Croix and Licandro (2002),
- increased population density and thus efficiency of the transmission of human capital (Lagerlof 2003a),
- increased population growth and the advancement of skill-biased technologies (Weisdorf 2004),
- improved healthiness and thus the capacity to absorb human capital (Hazan and Zoabi 2006)
- stronger incentives to save and invest (e.g. for a farmer, Nicolini, 2004)

What we do

claim: improvements in longevity are key to income growth take-off

1. A model to illustrate the effect of life expectancy on growth inspired from de la Croix and Licandro (Econ Letters, 1999)
2. Look at some facts that back our claim
   - Early mortality
   - Forerunners
   - Rise in Medicine effectiveness
   - Height of Swedish soldiers

Demographics

Time is continuous and the equilibrium is evaluated from 0 onward.

At each point in time there is a continuum of generations indexed by their birth date, t.

the measure $V_{t,z}$ of the set of individuals born in t still living in z:

$$\mu(V_{t,z}) = e^{-\beta(z-t)}\,\pi \qquad \pi > 0, \beta > 0.$$

π: the measure of a new cohort.
β: the rate at which members of a given generation die.

The measure of each generation declines deterministically through time but each agent is uncertain about the time of his death.

Life expectancy

For an individual born in t, $\mu(V_{t,z})/\pi$ is the expectancy at time t to live at least until time z.

The life expectancy does not depend on age (perpetual youth):

$$\int_t^{\infty}(z-t)\beta e^{-\beta(z-t)}\mathrm{d}z \;=\; \frac{1}{\beta}$$

The size of total population is π/β.

Preferences

Unique material good, the price of which is normalized to 1, used for consumption.

Technology using labour as the only input.

An individual born at time t has the following expected utility:

$$\int_t^{\infty} c(z,t)e^{-(\beta+\theta)(z-t)},$$

$\theta > 0$ is the pure rate of time preference

Intertemporal budget constraint

$$\int_t^{\infty} c(z,t)R(z,t)\mathrm{d}z = \int_{t+T(t)}^{\infty} \omega(z,t)R(z,t)\mathrm{d}z$$

$R(z,t) = e^{\int_t^z (r(s)+\beta)ds}$ is the discount factor

$r(s)$ risk free rate. Perfect life insurance markets

The agent is assumed to go to school until time $t + T(t)$.

After this education period, he/she earns a wage $\omega(z,t)$ per unit of time.

Technology

Wages depend on individual human capital, $h(t)$:

$$\omega(z,t) = h(t)w(z),$$

$w(z)$ is the wage per unit of human capital.

The individual's human capital is a function of the time spent at school $T(t)$ and of the *average* human capital $\overline{H}(t)$ at birth:

$$h(t) = A\,\overline{H}(t)T(t) \quad A > 0.$$

The parameter A is a productivity parameter.

The presence of $\overline{H}(t)$: the cultural ambiance of the society at the time of the birth influences positively the future quality of the agent (through for instance the quality of the school).

Optimality conditions

The optimality condition for consumption is

$$r(z) = \theta$$

Reductio ad absurdum:
if $r(z) > \theta$ at some date z, consumption should be zero for all generations; as current workers are not allowed to go back to school and as consumption cannot be transformed into another good (like capital), a zero consumption level for all generations would violate the equilibrium condition on the goods market.
If $r(z) < \theta$ consumption would be infinite which is not compatible with goods market equilibrium.

The discount factor is

$$R(z, t) = e^{-(\theta+\beta)(z-t)}.$$

Optimality conditions (2)

The first order condition for $T(t)$ is

$$\int_{t+T(t)}^{\infty} e^{-(\theta+\beta)(z-t)} w(z)\mathrm{d}z = T(t)e^{-T(t)(\theta+\beta)} w(t+T(t)).$$

The left hand side is the marginal gain of increasing the time spent at school by one unit.
The right hand side is the marginal cost, i.e. the loss in wage income if the entry on the job market is delayed.

Labour market

The production function

$$Y(t) = H(t), \tag{1}$$

The equilibrium in the labour market

$$w(t) = 1.$$

Optimal education and dynamics

The first order condition for $T(t)$ becomes

$$T(t) = T \equiv \frac{1}{\theta + \beta},$$

The optimal time spent on education positively affected by life expectancy $1/\beta$.

The aggregate human capital stock is computed from the capital stock of all generations currently at work:

$$H(t) = \int_{-\infty}^{t-J(t)} \pi e^{-\beta(t-z)} \underbrace{h(z)}_{A\,\overline{H}(z)T(z)} \, \mathrm{d}z,$$

$t - J(t)$ is the last generation that entered the job market at t.

Growth is exclusively linked to the appearance of new generations.

Steady state

Assuming $H(t) = e^{\gamma t}$, the steady state growth rate of human capital γ is the solution to

$$\gamma + \beta = AT\beta e^{-(\beta+\gamma)T}.$$

Solution is unique

The growth rate does not depend on the size of the new cohorts π, as the externality has been specified in terms of average human capital.

Effect of longevity on steady state growth

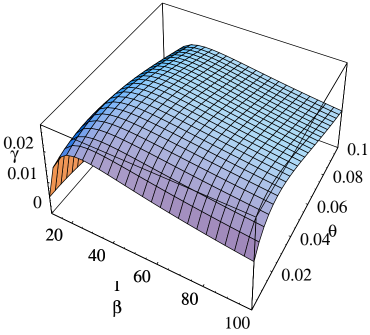
the effect of the instantaneous probability of death β on the growth rate γ is indeterminate.

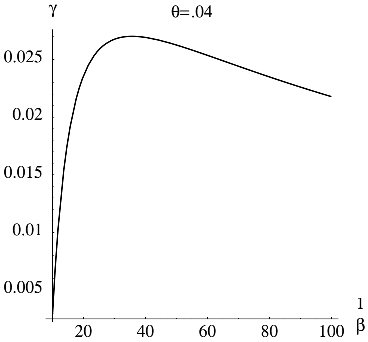
An increase in $1/\beta$ has three effects

- $(+)$ agents die later on average, thus the depreciation rate of aggregate human capital decreases;
- $(+)$ agents tend to study more because the expected flow of future wages has risen, and the human capital per capita increases;
- (-) agents enter the job market later in their life, thus the activity rate decreases.

Numerical assessment

Life expectancy and steady state growth rate ($A = .3$)





Conclusion

Numerical computations show that we observe that the effect of $1/\beta$ on γ is hump shaped.

We should thus observe that the effect of life expectancy on growth is positive for countries with a relatively low life expectancy, but could be negative in more advanced countries.

Argument 1: Look at mortality before the industrial revolution

From the end of the seventeenth century adult mortality started to decline

Exogenous improvements in adult mortality between 1600 and 1800 increased the individual incentive to build human capital.

As a consequence, investment in education rose, which exerted a positive effect on economic growth (Boucekkine, de la Croix and Licandro, SJE 2003).

Adult vs Children Mortality Declines

Key: to distinguish the fluctuations of infant mortality from the reduction in the mortality of adults.

Children are the first to suffer from bad crops and diseases : child mortality is volatile. Improvements in infant mortality have arisen very late in the nineteenth century.

The absence of large improvement in life expectancy at birth before 1850, due to a high and volatile infant mortality, may hide more subtle improvements on the front of adult mortality.

We eliminate the effects of this volatility and focus on the evolution of adult mortality.

Two data sets

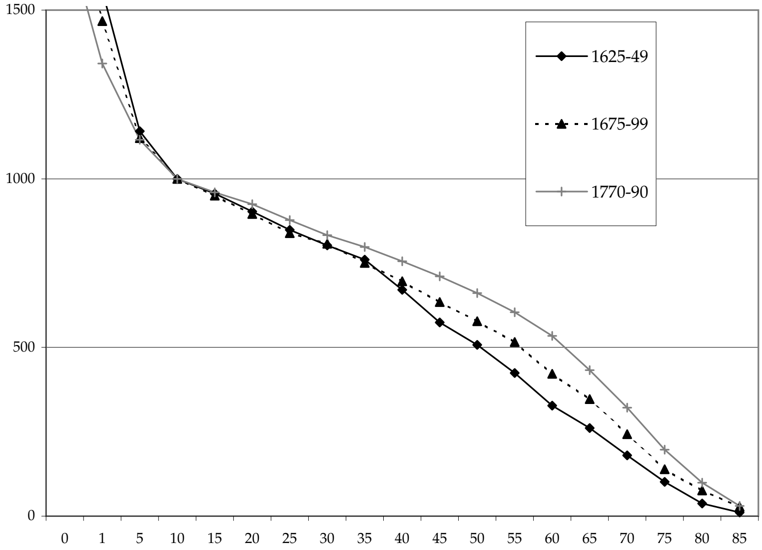
To study adult mortality, we need cohort life tables at different periods.

We have found two data sets:

from 1625 to 1825 in Geneva (Switzerland) (Perrenoud).

from 1600 to 1790 in Venice (Italy) (Beltrami).

Geneva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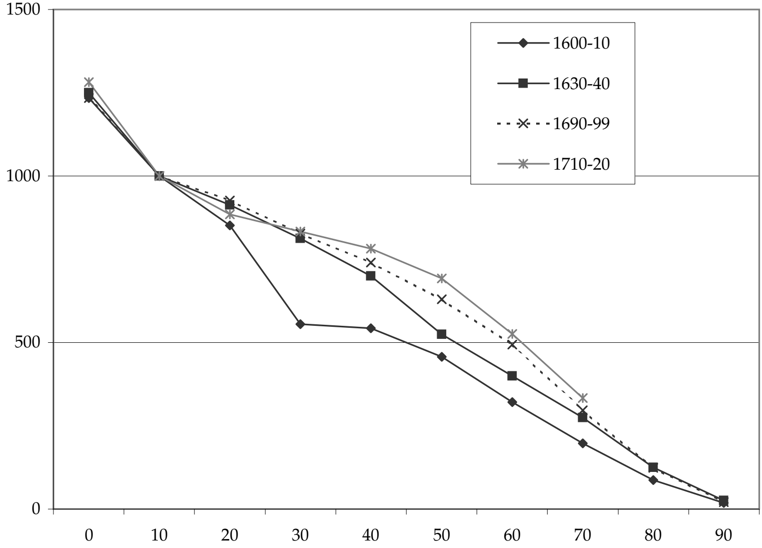
Venice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1710-20

Why was pre-industrial mortality reduced?

The debate is not settled yet.

Classical view: pre-industrial mortality was reduced when nutritional standards were improved.
This view is loosing ground.

Many claim that human factors (nutrition, medicine, sanitary conditions and economy) did not play a prominent role in the *first phase* of the process.

Instead, the decline in mortality should be found elsewhere; it can be connected to changes in immunology and/or improvement in the climate.

Selected facts: improvement in education

Illiteracy was a major problem at the beginning of the seventeenth century.

Anecdotes:

"In 1607 the Venetian government appointed a commission of four naval officers to decide upon the kind of ships to be used in a war against the pirates. They must have been officers of quality to be chosen for such a purpose; among the four officers, three of them signed their names with a cross." (Cipolla)

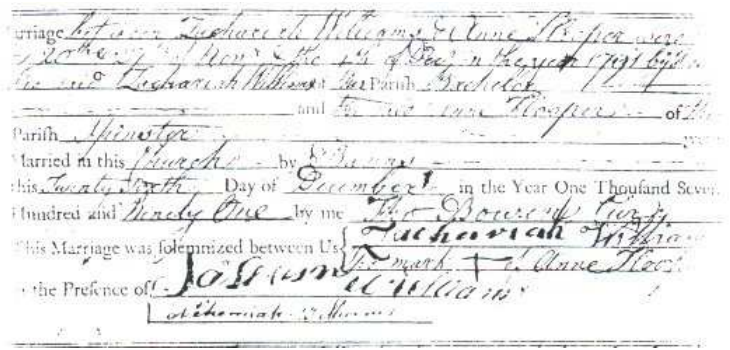
Improvements in literacy

French survey undertaken in 1877 by Maggiolo, who asked 15,928 teachers to count the signatures on marriage registers. They treated 219,047 documents over the period 1686-90 and 344,220 documents over 1786-90.

Percentage of newly married people who signed with marks

Department	1686-90	1786-90
Bouches du Rhône (Marseilles)	89	80
Gironde (Bordeaux)	86	81
Oise (close to Paris)	62	44
Pas-de-Calais (Flanders)	72	60
Rhône (Lyon, close to Geneva)	88	70
FRANCE	79	63

Example of a marriage register


rriage between Zachariah Williams & Anne Hooper were
Married in this Church by
this Twenty Sixth Day of December in the Year One Thousand Seven
Hundred and Ninety One by me
This Marriage was solemnized between Us
the Presence of

Improvements in literacy (2)

Similar, but less extensive, data are reported for England and Scotland (Stone).

Both data sets suggest that the gains in literacy over the eighteenth century were large.

As far as attendance is concerned, some fragmented pieces of evidence.

We know the number of students in medicine at the Montpelier university over three centuries (1500-1800). The series displays no trend from 1500 to 1730, then rises until the French revolution. The number of students doubled between 1720 and 1780.

Argument 2: Forerunners

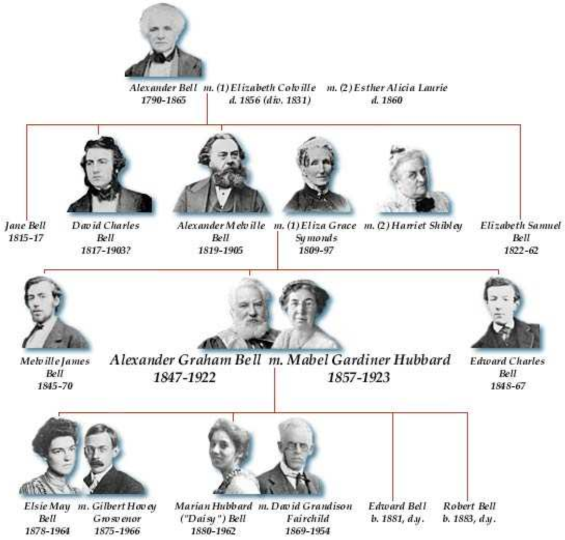
Look for forerunners in mortality decline

Even if the average life expectancy does not increase that much before the Industrial Revolution, it might be that it started to increase for *specific groups*

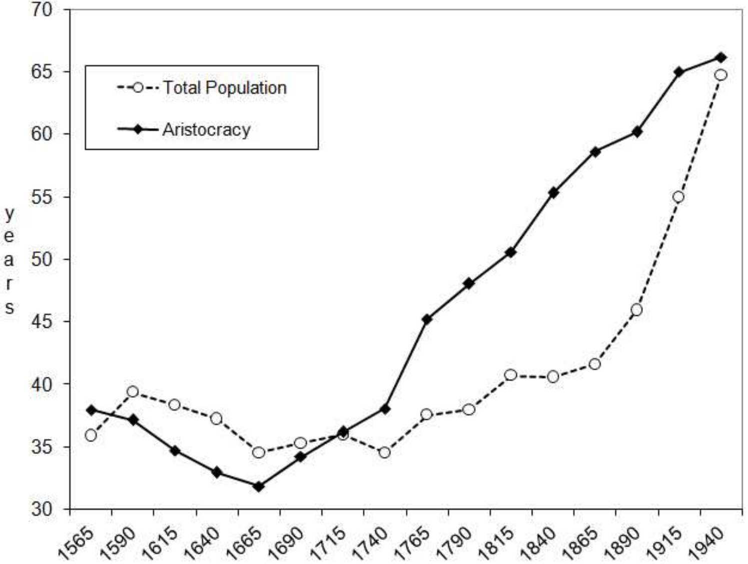
Hard to find data

For England, data on aristocrats based on genealogical trees.

Example of a genealogical tree



Life expectancy at birth



Differential mortality (2)

Before 1700, little difference between aristocrats and commons (urban penalty for aristo?)

After 1700, strong rise for aristocrats

Forerunners in mortality decline - before the acceleration in income growth

de la Croix and Sommacal (Math Pop Studies, 2009)

Possible explanation

Before 1700, medical effectiveness was very low

Buying the services of a doctor did not make a difference

After 1700, effectiveness increases

The rich are the first to benefit

Increase their incentive to invest

Survival rates in Geneva and Rouen

No difference between rich and poor confirmed in these two cities (except for child mortality)

	social class	Survival probabilities 0→15	15→30	30→45
Geneva XVII	workers	0.34	0.80	0.70
	merchants	0.45	0.84	0.74
	nobility	0.61	0.89	0.81
Rouen XVIII	workers	0.33	0.85	0.87
	merchants	0.49	0.87	0.86
	nobility	0.47	0.86	0.84

Argument 3: Rise in medical knowledge

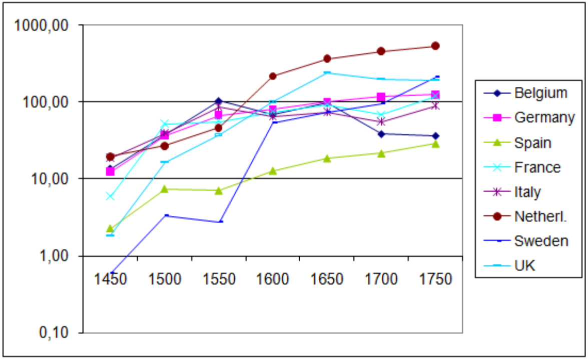
Common view: The period 1500-1870 does not contain major technology changes in health that could have increased life expectancy

But

- 1500-1800: medicine showed an increasingly experimental attitude: no improvement on theory but advances on practice and empirical observations. (new drugs coming from the New World)
- As early as 1829, Dr.F.B. Hawkins wrote a book entitled *Elements of Medical Statistics*, in which he described a set of diseases which were leading causes of death but can now (in 1829) be treated effectively: leprosy, plague, sweating sickness, ague, typhus, smallpox, syphilis and scurvy.
- Number of books containing lifestyle advice increasing significantly over the period 1750-1800.

Book production in early modern Europe, 1450/99-1750/99

number of new editions per million inhabitants



Baten en van Zanden (2007)

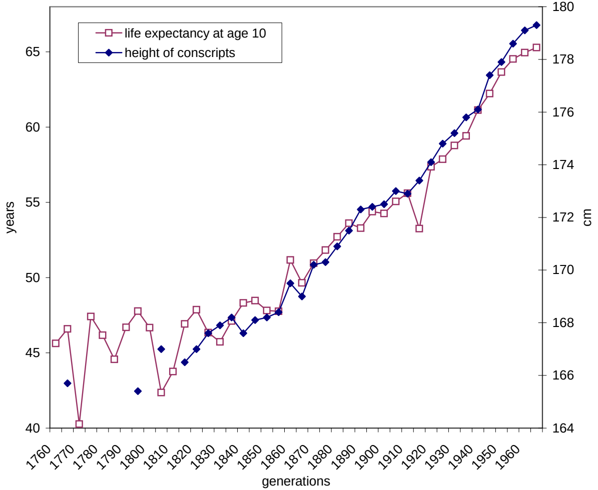
Number of books on health published in England, 1600-1800

Period	Number of books
1600-24	9
1625-49	16
1650-74	17
1675-99	25
1700-24	28
1725-49	34
1750-74	53
1775-1800	81

Argument 4: Height of Swedish Soldiers

- Height is a simple measure of childhood development
  - Better nutrition and lower exposure to infections leads to increased height
- Height is constant after, say, the age of 18
- It's a good predictor of life expectancy and mortality in old age
- Waaler (1984), the observed trend towards greater height means that younger cohorts will live longer

Height and Life Expectancy in Sweden



Height and Education in Sweden