Early mortality declines at the dawn of modern growth

Raouf Boucekkine	David de la Croix	Omar Licandro
IRES and CORE	IRES and CORE	EUI and FEDEA

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Understanding the take-off of traditional societies:

the size of population influences the growth rate of technology (Galor - Weil, Jones)

or

decreasing returns to scale in agriculture + constant returns in manufacturing. With technical progress, manufacturing becomes more profitable at some point and the transition starts (Hansen - Prescott, Jones)

or

a drop in child mortality making investment in kids education more profitable / a drop in adult mortality making personal investment more profitable.

Look before the Industrial Revolution:

- from the end of the seventeenth century adult mortality started to decline

- during the same period significant improvements in literacy were achieved

- growth starts to accelerate during the eighteenth century.

Standard view: improvements in longevity are a consequence of better economic conditions.
However, many argue that the very early decline in mortality should be considered as exogenous to the economic system.

Our hypothesis:

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.

What we do:

We present the relevant facts about mortality (whole survival curves), education and growth in the pre-industrial age.

We build a theoretical model linking education and growth to survival probabilities.

We quantitatively estimate the shift in the survival law + calibrate the model + compute the effect of rising longevity on education and growth.

Selected Facts: Early Adult 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:

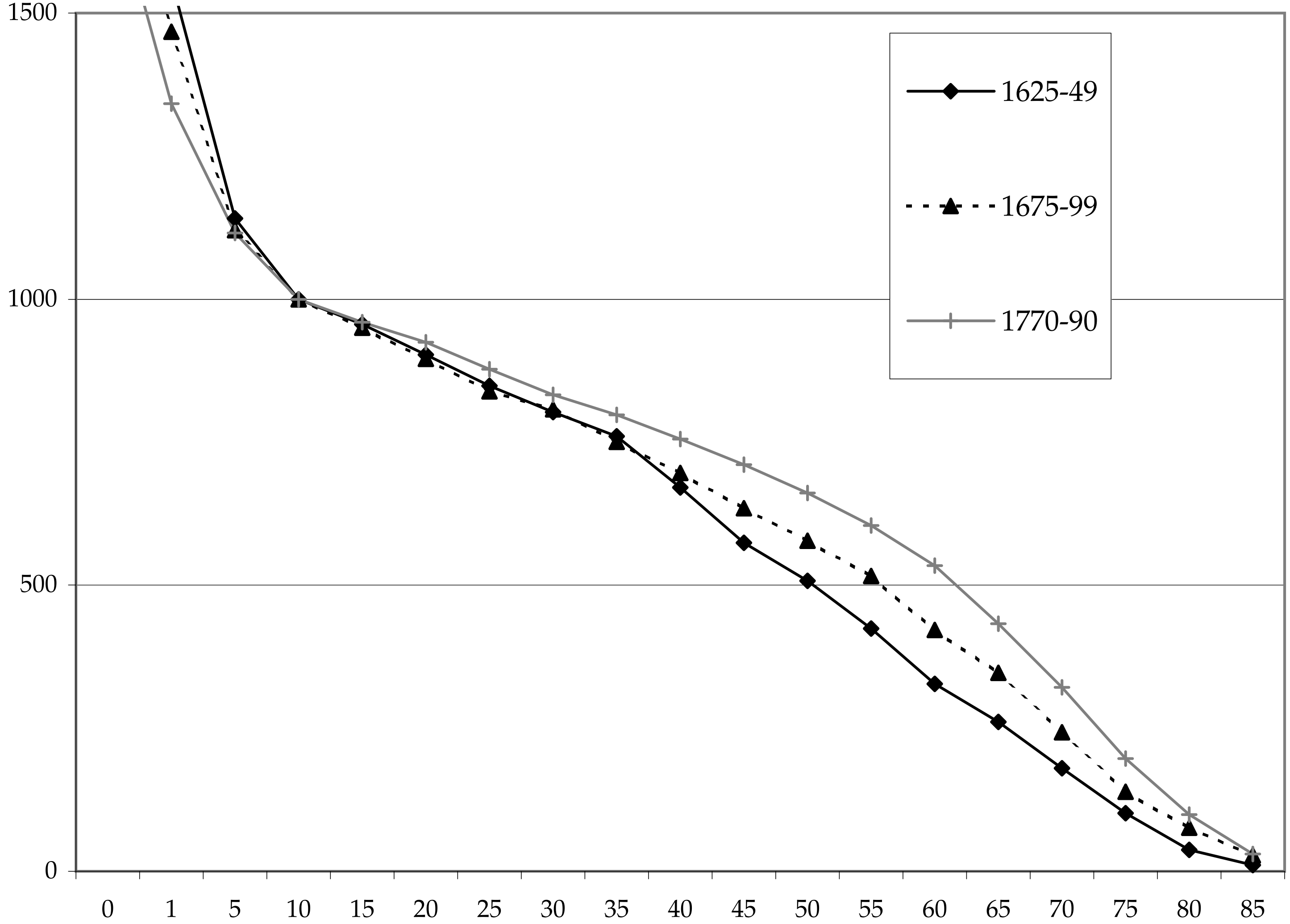
To study adult mortality, we need cohort life tables at different periods.

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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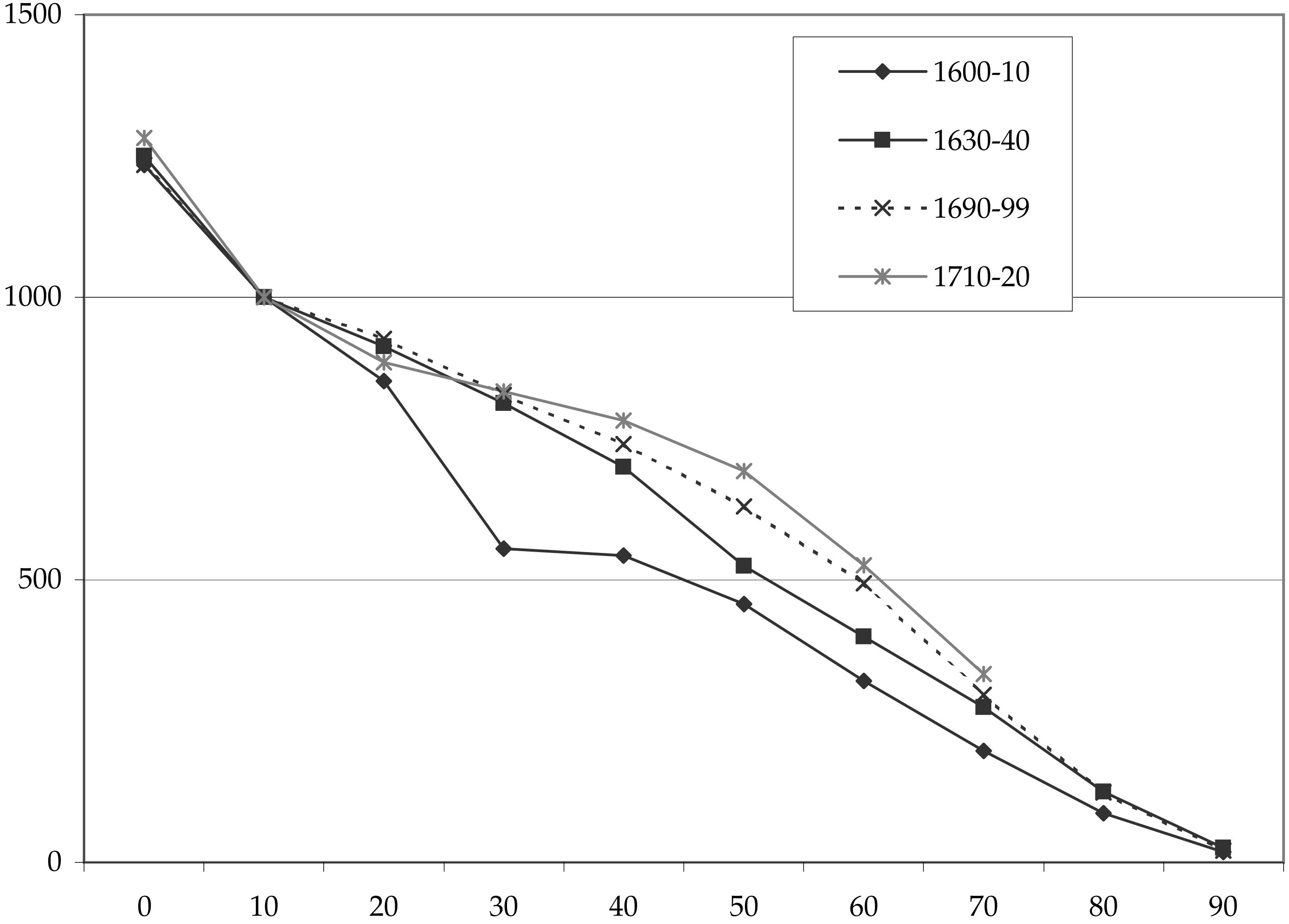
Venice: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Why was pre-industrial mortality reduced?

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

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.

Selected facts: The Acceleration of Growth

Growth in Western Europe (Maddison)

	500-1500	1500-1700	1700-1820	1820-1980
Population	0.0	0.2	0.4	0.9
GDP	0.0	0.3	0.6	2.5
GDP per capita	0.0	0.1	0.2	1.6

The model: demographics

Continuous time – generations indexed by their date of birth.

The unconditional probability for an individual belonging to the cohort t of reaching age $a \in [0, \mathsf{A}(t)]$, is:

$$m(a,t) = \frac{\alpha(t) - e^{\beta(t)a}}{\alpha(t) - 1}, \quad (1)$$

concave for $\beta(t) > 0$ and $\alpha(t) > 1$

it allows to model improvements in mortality which do not necessarily affect all ages proportionally

The model: demographics (2)

Maximum age

$$\mathsf{A}(t) = \frac{\log(\alpha(t))}{\beta(t)}. \tag{2}$$

The unconditional life expectancy

$$\Lambda(t) = \frac{\alpha(t)\log(\alpha(t))}{(\alpha(t)-1)\beta(t)} - \frac{1}{\beta(t)}. \tag{3}$$

The model: demographics (3)

Size of a newborn cohort: $\zeta e^{n(t)t}$

The size of this cohort at time $z > t$ is

$$\zeta \, e^{n(t)t} \, m(z-t,t), \text{ for } z \in [t, t+\mathsf{A}(t)]. \tag{4}$$

The size of population at time t is given by

$$P(t) = \int_{t-\overline{\mathsf{A}}(t)}^{t} \zeta \, e^{n(z)z} \, m(t-z,z)\mathrm{d}z, \tag{5}$$

where $\overline{\mathsf{A}}(t)$ is the age of the oldest cohort still alive at time t

Production Technology

$$Y(t) = H(t). \tag{6}$$

At equilibrium $w(t) = 1$

Households

Expected utility:

$$\int_t^{t+\mathsf{A}(t)} c(t,z)\; m(z-t,t)\; e^{-\theta(z-t)} \mathrm{d}z, \tag{7}$$

The pure time preference parameter is θ.

We assume the existence of complete markets.

The inter-temporal budget constraint:

$$\int_t^{t+\mathsf{A}(t)} c(t,z) R(t,z) \mathrm{d}z = h(t) \int_{t+\mathsf{T}(t)}^{t+\mathsf{A}(t)} R(t,z) \mathrm{d}z. \tag{8}$$

Human capital

$$h(t) = \frac{\mu}{\eta}\bar{H}(t)\mathsf{T}(t)^{\eta}, \tag{9}$$

$\bar{H}(t)$ introduces the typical externality

Aggregate human capital:

$$H(t) = \int_{t-\overline{\mathsf{A}}(t)}^{t-\overline{\mathsf{T}}(t)} \zeta\, e^{n(z)z}\, m(t-z,z)h(z)\mathrm{d}z, \tag{14}$$

The average human capital:

$$\bar{H}(t) = \frac{H(t)}{P(t)}. \tag{15}$$

Dynamics

$$H(t) = \int_{t-\overline{\mathsf{A}}(t)}^{t-\overline{\mathsf{T}}(t)} \zeta \, e^{n(z)z} m(t-z,z) \, \frac{\mu \mathsf{T}(z)^{\eta} H(z)}{\eta P(z)} \, \mathrm{d}z \qquad (16)$$

We need to know initial conditions for $H(t)$, for $t \in [-\overline{\mathsf{A}}(0), 0[$.

Stationary environment $n(t) = n$, $\alpha(t) = \alpha$ and $\beta(t) = \beta$:
$\exists$ balanced growth path $H(t) = He^{\gamma t}$, $H > 0$, if and only if :

$$\frac{\mu \mathsf{T}^{\eta}}{\eta \kappa} \int_{\mathsf{T}}^{\mathsf{A}} m(z) \, e^{-\gamma z} \, \mathrm{d}z = 1 \quad \text{with} \quad \kappa = \int_0^{\mathsf{A}} m(a) e^{-na} \mathrm{d}a. \qquad (18)$$

Empirical Assessment: The empirical model

We disregard the huge swings affecting infant mortality

we consider that the birth date in our model corresponds to age 10 in the data.

If the birth date is 10, the true schooling time is not $T(t)$, but $T(t) + T_0$, where T_0 is the time spent at school before 10.

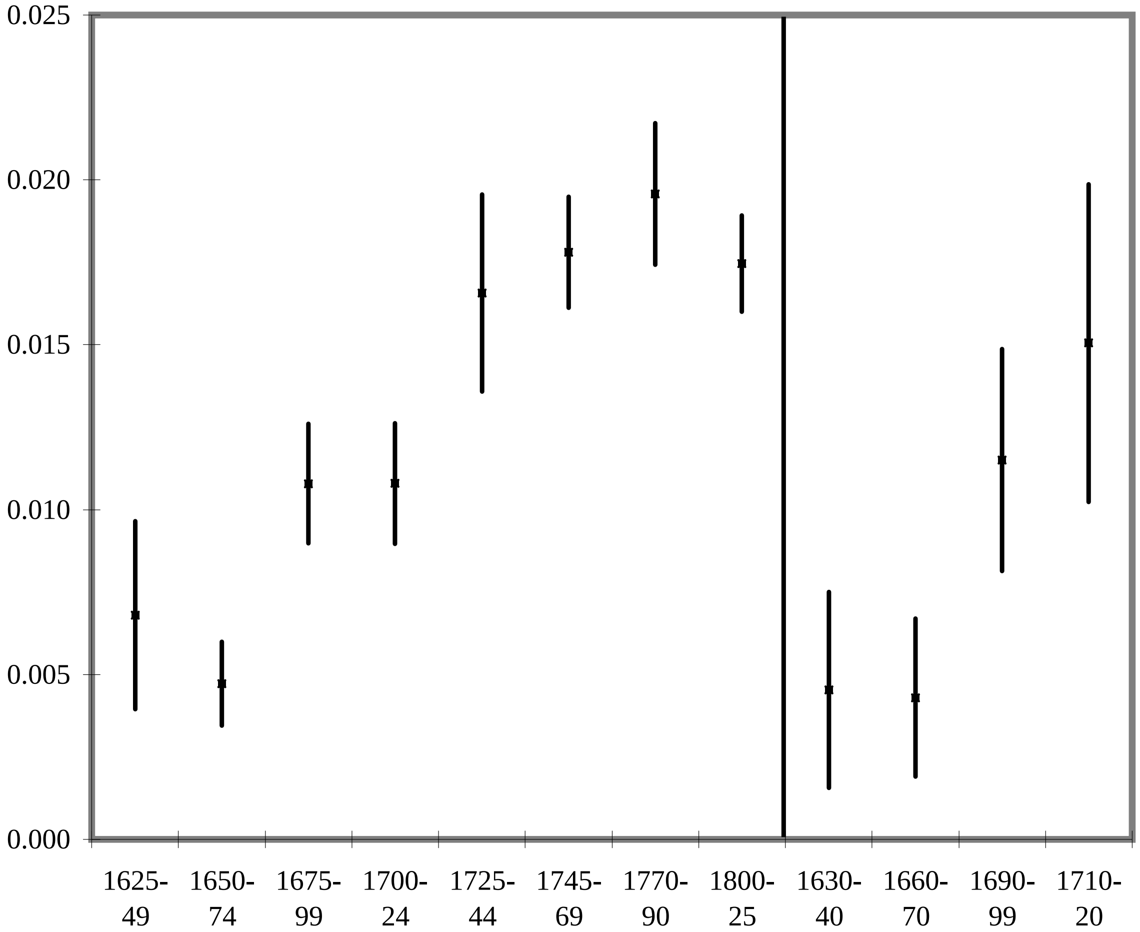
we assume $T_0 = 4$.

Empirical Assessment: Estimation of the survival law

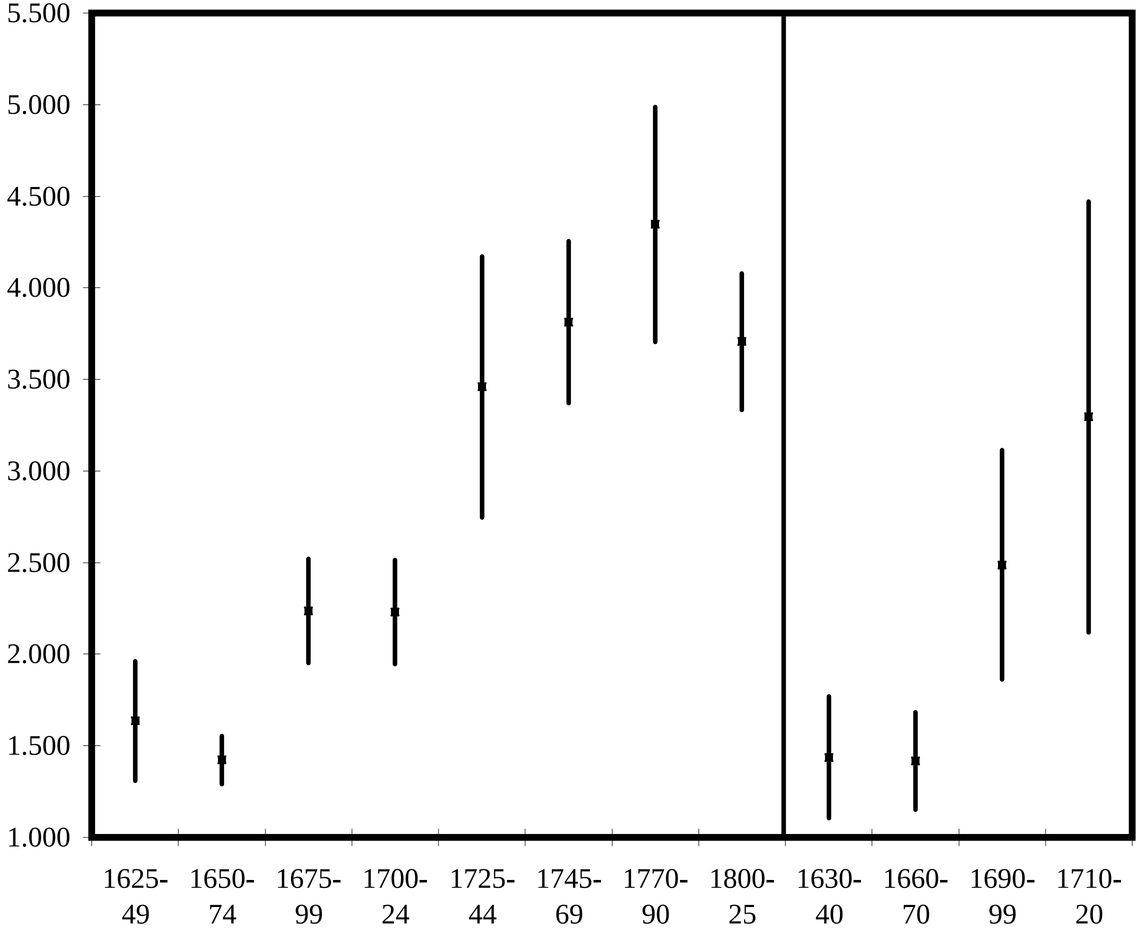
Geneva and Venice laws are very close to each other and the parameters change at the same time in both cities

There are only three significantly different laws corresponding to the periods 1625-1674, 1675-1724, and 1725-1825.

	1625-1674	1675-1724	1725-1825
α	1.455	2.178	3.859
β	0.0050	0.0103	0.0179
Life Exp. at 10	49.83	52.57	56.00
Max Age	84.97	85.45	85.50



β Geneva Venice



α Geneva Venice

Empirical Assessment: Calibration

The psychological discount parameter θ is set to 0.04.

Parameters μ and η are jointly set such that before 1663, the economy was in a balanced growth path, with GDP per capita growing at 0.1 percent and the age of entry in the labor market being 13 years, which correspond to $\mathsf{T}(t) = 3$.

Accordingly, $\mu = 0.2$ and $\eta = 0.4$.

Empirical Assessment: Simulation

Age of entry on the labor market

	1625-1674	1675-1724	1725-1825
$10 + T$	13	13.2	13.57

Simulated growth

	1500-1700	1700-1750	1750-1820
Population	0.20	0.33	0.28
GDP	0.30	0.47	0.47
GDP per capita	0.10	0.14	0.19

Empirical Assessment: Results

Averaging over 1700-1820, we get a population growth of 0.3% and a GDP per capita growth of 0.17%.
Maddison data: 0.4% and 0.2 % respectively.

The two shifts of the survival law can thus account for
– half the acceleration in population growth, the rest being due to changes in fertility and/or infant mortality that we have not modelled here.
– 70% of the acceleration in growth over the period 1700-1820.

Activity rate effect versus Education effect:
28% of the acceleration in growth are accounted for keeping constant schooling (activity rate effect).
The remaining 42% are thus related to a stronger accumulation of human capital (education effect).

Empirical Assessment: Sensitivity results

choice of η

η	0.3	0.4	0.5	0.6	0.7
μ	0.19	0.20	0.20	0.18	0.16
T(1600)	1.3	3	4.6	6.2	7.8
Growth 1700-1820	0.145%	0.17%	0.19%	0.21%	0.23%
% explained	45%	70%	91%	111%	128%

Conclusion

Our study promotes the view that the early decline in adult mortality is responsible for a large part of the acceleration of growth at the dawn of the modern ages.

What's next ?

Find more data sets

Question: to what extent was a higher literacy rate necessary to adopt new technologies, so paving the way for the industrial revolution.

Extension: to model the feedback from growth to mortality occurring in the nineteenth and twentieth centuries