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3.1 Introduction

3.1 Introduction

Life Expectancy Versus GDP per Capita

- Life expectancy at birth, 2000 (years)
- GDP per capita, 2000

Countries labeled in the graph:
- Japan
- United States
- Costa Rica
- Denmark
- China
- India
- Gabon
- South Africa
- Kenya
- Ethiopia
- Botswana
3.1 Introduction

- health and income are endogenous variables

⇒ direction of causality?

- the figure above: $h \uparrow \rightarrow y(h) \uparrow \rightarrow h \uparrow$ with decreasing returns
3.1 Introduction

- $y^A > y^B$, with $A$ and $B$ representing to observations. Problem: the curves are not observable.
- Panel (a): $A$ has better health because of climatic reasons, such that the same level of income determines different levels of health; (Acemoglu, Johnson, and Robinson 2001)
- Panel (b): $A$ is more productive and generates at any level of income a higher level of health; bad health is the result of poverty.
3.2 The Model

- Consider an OLG-economy with agents living for two periods.
- Agents work (supply inelastically one unit of time) and save during their first period of life.
- They consume their savings plus accrued interests in their last period of life.
- The survival probability, i.e. the probability to reach the end of period two is $\phi_t$ and endogenous.
- Then, expected lifetime utility of an young adult - born in $t$ - reads

$$U_t = \ln c^t_t + \phi_t \ln c^t_{t+1}$$ (1)
3.2 The Model

- The survival probability depends on health capital $h_t$, i.e. $\phi_t = \phi(h_t)$, with $\phi(0) = 0$, $\lim_{h \to \infty} \phi(h) = \beta \leq 1$ and $\lim_{h \to \infty} \phi'(h) = \gamma < \infty$

- Public health expenditures in $t$ are financed through a proportional tax on labor, i.e. $\tau \in (0, 1)$.

- Assuming a one-to-one relationship between health expenditures per person ($\tau_t w_t$), health capital is given by

$$h_t = \tau_t w_t$$

(2)

- Thus the budget constraint reads

$$(1 - \tau_t)w_t = c_t^t + s_t^t$$

(3)
3.2 The Model

- Uncertain lifetime implies that agents die with positive net wealth (or debts)
- In this type of model the problem is circumvented by perfect annuity markets a la Blanchard and Yaari (1965, 1985), i.e. the current adult cohort sells its assets to an insurance company, such that the insurance company receives the assets in case that the agent dies at the beginning of period two, but commits itself to pay a return $\hat{R}_{t+1}$ in case that the agent survives
- Hence, profits per client of this insurance company read

$$\pi^S = R_{t+1}s_t - \phi_t \hat{R}_{t+1}s_t$$

(4)

Perfect competition induces $\pi^S = 0$, such that

$$\hat{R}_{t+1} = \frac{R_{t+1}}{\phi_t},$$

(5)

with $\hat{R}_{t+1} = R_{t+1}$, if $\phi_t = 1$. 
3.2 The Model

- Since, $c_{t+1}^t = \hat{R}_{t+1} s_t$, we obtain the usual solution of the canonical OLG model with respect to $s_t$,

$$s_t = \frac{\phi_t}{1 + \phi_t} (1 - \tau_t) w_t \quad (6)$$

- Final goods are produced using a neoclassical technology, such that output per worker is

$$y_t = Ak_t^\alpha, \quad (7)$$

with $A > 0$ and $\alpha \in (0, 1)$.

- Perfect competition implies then

$$w_t = (1 - \alpha) Ak_t^\alpha \quad (8)$$

$$R_t = 1 + \alpha Ak_t^{\alpha - 1} - \delta \quad (9)$$
3.2 The Model

- $k_{t+1}$ evolves in equilibrium according to

$$k_{t+1} = (1 - \tau)(1 - \alpha)\frac{\phi_t}{1 + \phi_t} A k_t^\alpha$$

with $\tau$ exogenously given and

$$\frac{\phi_t}{1 + \phi_t} = \frac{\phi(\tau(1 - \alpha) A k_t^\alpha)}{1 + \phi(\tau(1 - \alpha) A k_t^\alpha)}$$
3.3 Implications

- Savings are an increasing function in life expectancy, $\phi(h_t)$. More savings imply more capital and more output.

- Vice versa, high mortality rates lead individuals to heavily discount the future and to save less. The future capital stock and the level of output thus is low (implying low health expenditures given $\tau$).

$\Rightarrow$ High mortality rates and low incomes tend to reinforce each other.

- Whether or not differences in initial income and mortality persist depends upon the uniqueness and the stability properties of steady states.

- A unique and stable steady state implies that differences in income and health vanish in the long-run.
3.3 Implications

- The same levels of initial income and capital may induce long-run differences in income and health, if survival probabilities between two countries differ, e.g. due to climatic reasons.

\[ \phi(h_t) = \beta_i \frac{h}{1 + h}, \quad (12) \]

with \( i = S, N \) and \( \beta_S < \beta_N \).

- Differences in \( A \) (caused by what?) induce not only differences in incomes per capita but also in mortality rates.
3.3 Implications

\[ k_{t+1} \]

\[ k_0 \quad k_t \]

Low Mortality \((\phi = \beta)\)

High Mortality
3.3 Implications

- Given that $\alpha > 1/2$, the model generates multiple steady states.
- An economy with low levels of initial capital per capital is unable to escape the vicious cycle of poverty and mortality.
- Flows of medical technologies to developing countries (antibiotics, vaccines, sanitation, hygiene, etc) should make the emergence of traps less likely.
- Such advances could be interpreted as exogenous shifts in $\phi$.
- The health tax is exogenous. Endogenizing the tax by maximizing agent’s lifetime utility implies that poor economies even choose to under invest in health.
3.3 Implications

The diagram illustrates the relationship between $k_{t+1}$ and $k_t$ with labels for low and high mortality. The axes represent $k_{t+1}$ and $k_t$ with specific points $k_0$, $k_1$, $k_2$, and a 45° line indicating the boundary between low and high mortality.
3.4 Extension: mortality and education

- $x_t$ represents the average stock of skills.
- Agents can improve productivity $x_t$ by investing a fraction $s_t$ in schooling when young.

\[ x_{t+1} = x_t \mu(s_t), \]  \hspace{1cm} (13)

with $\mu(0) = 1$, $\mu' > 0$, $\mu'' < 0$.
- Thus lifetime income reads

\[ (1 - \tau)(1 - s_t)w_t x_t + \frac{w_{t+1} x_{t+1}}{\hat{R}_{t+1}} \]  \hspace{1cm} (14)

→ maximizing lifetime income with respect to $s_t$

\[ \frac{\partial \mu}{\partial s_t} = \frac{(1 - \tau)(1 - s_t)w_t x_t}{w_{t+1}/\hat{R}_{t+1}} \]  \hspace{1cm} (15)
3.4 Extension: mortality and education

- Given that $\mu$ is strictly concave
  
  $s_t^* = s \left( \frac{\phi_tw_{t+1}}{w_tR_{t+1}} \right)$, \hspace{1cm} (16)
  
  with $s$ increasing in its arguments.

- Through perfect annuities, individuals can fully insure against their mortality risks on physical capital investment.

- This does not work for their educational investment.

  $\Rightarrow$ a mortality decline raises the relative attractiveness of human capital.

- Moreover, this effect is reinforced through a general equilibrium effect: mortality decline promotes savings through the length-of-life effect. This implies higher capital accumulation promoting the returns of labor relative to capital which further raises the return on education.