Mortality decline, human capital investment, and economic growth
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Presented by Arrow Team: Kuan Liu, Ibrahim Keita, Daijing Lü, Alecia Waite

1. Introduction

- This paper explores the relationship between increased life expectancy and investment in human capital during the process of economic growth. Its main conclusion is that the effect of mortality decline on schooling works through increasing the horizon in which the returns to schooling are paid off.
- The growth process is characterized by:
  - Mortality ↓: due to higher incomes (which lead to better nutrition) and advances in health technology
  - Fertility ↓: due to the decline in mortality
  - Human capital investment ↑: due to increase in returns to schooling.
    - This is linked to the decrease in fertility via a quantity-quality tradeoff → Becker-Lewis
    - Linked to higher output (Mankiw) and higher growth rate of technology (Lucas)
- Previous papers examined the relationship between human capital investment in discrete time; Kalemli-Ozcan et al do so in continuous time, overlapping generations model similar to that of Blanchard
- Quick Review of Blanchard Model
  - Agents are of different ages, and thus have different levels and compositions of wealth.
  - Agents have different propensities to consume due to their horizons.
  - Assumes that the planning horizon is age-independent and is distributed exponentially (“perpetual youth” assumption). Implications:
    - The death rate equals μ (a constant, independent of age).
    - The expected planning horizon equals 1/μ in that case. (Note: As μ = 0 we have the Ramsey model again.)
  - Main finding: Aggregate consumption is less than in the Ramsey case because newborns are poorer than the average household and thus bring down aggregate consumption in every period. In essence, the aggregate consumption Euler equation differs from the individual consumption Euler equation because of the overlapping generations.
- Kalemli-Ozcan et al seek a general equilibrium solution where we can sort out the direct effects of mortality decline on capital accumulation, interest rates, and labor supply from the effects of increased schooling that is induced by mortality decline.

2. A model of schooling and growth with finite horizons

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1 Special thanks to last year’s group: Huichun Sun, Zaara Ahmed, and Zhixia Ma
2.1 The structure of the Model

- Assumptions:
  - Individuals face a probability of dying per unit time $\rho$ which is constant throughout their life
    - Reductions in mortality take the form of lowering death probabilities at all ages. Is this realistic? Don’t we lower infant mortality more when we increase health technology?
  - A cohort is born at every instant and the population can be viewed as large enough that the size of a cohort declines deterministically throughout time. The size at any time $t$ is $\int_{-\infty}^{t} \rho e^{-(\rho(t-b))} \, db = 1$
    - Note that we can graph this as follows:

- Individuals’ life expectancy is $1/\rho$
- Individuals are endowed with one unit of time per period and now wealth. They invest in education at the beginning of time and then work for the rest of their life.
- Their wages depend on human capital, which is a function of schooling. The only cost of schooling is foregone income
  - Shouldn’t the cost of schooling differ for different people?
- Earnings of an individual no longer in school: $E=wh(s)$ where $w$ is the wage per unit of human capital and $h()$ gives the quantity of human capital as a function of schooling.
  - Since $\ln(E) = \text{constant} + f(s)$ is the general “structural earnings function”, we get that: $h = e^{f(s)}$, where $f''(s) > 0, f''(s) < 0$
  - Uncertainty about the date of an individual’s death creates the need for an annuity contract. Under the assumption that the annuity business is

\[ E(b) = \int_{-\infty}^{t} be^{-\rho(t-b)} \, db = \int_{-\infty}^{t} \frac{1}{\rho} e^{-\rho(t-b)} \, db = \frac{1}{\rho} e^{-\rho(t-b)} \bigg|_{-\infty}^{t} = \frac{e^{-\rho(t-b)}}{\rho} \bigg|_{-\infty}^{t} = \frac{1}{\rho} (1-0) = \frac{1}{\rho} \]

\[ E(b) = \int_{-\infty}^{t} be^{-\rho(t-b)} \, db = \int_{-\infty}^{t} \frac{1}{\rho} e^{-\rho(t-b)} \, db = \frac{1}{\rho} e^{-\rho(t-b)} \bigg|_{-\infty}^{t} = \frac{e^{-\rho(t-b)}}{\rho} \bigg|_{-\infty}^{t} = \frac{1}{\rho} (1-0) = \frac{1}{\rho} \]
perfectly competitive, and that the market interest rate is \( r \), the interest rate paid on these annuities will be \( r + \rho \). Also, there will be a market for annuitized loans, in which borrowers will pay an interest rate of \( r + \rho \), but in which the loan will be forgiven if the borrower dies.

2.2 Individual Maximization

- Individuals maximize

\[
\max_z \int_{\tilde{b}}^{\infty} \left[ \ln(c(z)) e^{-(\theta + \rho)(z-b)} \right] dz, \tag{4}
\]

Subject to:

\[
\begin{align*}
\dot{k}(z) &= (r + \rho)k(z) - c(z) \quad z \in [\tilde{b}, \tilde{b} + \tilde{s}], \tag{5} \\
\dot{k}(z) &= (r + \rho)k(z) + hw - c(z) \quad z \in [\tilde{b} + \tilde{s}, \infty], \tag{6} \\
k(b) &= 0. \tag{7}
\end{align*}
\]

This yields that the optimal consumption path is:

\[
c(z) = [(r + \rho) - (\theta + \rho)]c(z) = [r - \theta]c(z), \tag{8}
\]

And the optimal initial value of consumption is:

\[
c(b) = \frac{(\theta + \rho)}{(r + \rho)} \left[ \frac{we^{(s)}e^{-(r + \rho)s}}{e^{(r - \theta)(s)}} \right]. \tag{12}
\]

And the optimal level of schooling is:

\[
f_s = r + \rho, \tag{13}
\]

- Which means that an individual chooses schooling up to the point at which his rate of return to schooling is equal to the effective interest rate.
- And so the individual’s maximization problem is solved by:

\[
c(b, t) = \frac{(\theta + \rho)}{(r + \rho)} \left[ \frac{we^{(s)}e^{-(r + \rho)s}}{e^{(r - \theta)(t-b)}} \right]; \quad t \in [b, \infty], \tag{14}
\]

\[
k^\text{sch}(b, t) = \frac{we^{(s)}e^{-(r + \rho)s}}{(r + \rho)} \left[ e^{(r - \theta)(t-b)} - e^{(r + \rho)(t-b)} \right]; \quad t \in [b, b + \tilde{s}], \tag{15}
\]

\[
k^\text{wk}(b, t) = \frac{we^{(s)}}{(r + \rho)} \left[ e^{-(r + \rho)s}e^{(r - \theta)(t-b)} - 1 \right]; \quad t \in [b + \tilde{s}, \infty], \tag{16}
\]

Where \( k^\text{sch} \) is the wealth of someone still in school and \( k^\text{wk} \) is wealth of someone who is working.
• Under assumption $r > \theta$ (shown later to hold), consumption rises over an individual’s life.
• Wealth is 0 at birth, drops during years of education, and increases later in life.
  o No retirement (all individuals work until they die) assumption => there is no decrease in wealth later in life and people do not save consumption for retirement.
  o Individuals die with positive wealth because they don’t know which period they will die in (This separates the model from standard Ramsey case)

2.3 General equilibrium and aggregation

• The production function for the total output is:

$$\bar{Y}(t) = AK(t)^{\alpha}H(t)^{1-\alpha},$$

(17)

• Maximize problem of the perfectly competitive firms

$$w(t) = A(1-\alpha)\left(\frac{K(t)}{H(t)}\right)^\alpha.$$  \hspace{1cm} (18)

$$r(t) = A\alpha\left(\frac{K(t)}{H(t)}\right)^{\alpha-1}.$$ \hspace{1cm} (19)

w is the MP of human capital, r is the MP of physical capital

• Aggregate consumption at time t:

$$C(t) = \frac{(\theta + \rho)\rho}{(r + \rho)(\rho - r + \theta)}\left[w_{es}F(s)e^{-(r+\rho)s}\right].$$

(21)

• In equilibrium $\theta < r < \rho + \theta$, intuition:
  o If $r \leq \theta$, The optimal policy would always be in debt because individuals would want to decrease their consumption over their life time and thus no capital would be accumulated.
  o If $\rho < r - \theta = \frac{c(z)}{c(z)}$, The growth rate of consumption among the individuals in a $c(z)$ cohort who do not die will be higher than the rate at which members of the cohort are dying in, in which case the total consumption of the cohort will be rising over time and aggregate consumption will be infinite.

• Aggregate human capital at time t:
Aggregate capital stock at time $t$:

$$H(t) = \int_{-\infty}^{t-\bar{z}} h(b, t) \rho e^{-\rho(t-b)} \, db.$$  \hspace{1cm} (22)

- In steady state, we have six equations below and
- six steady state endogenous variables:
  - the aggregate quantities of consumption, $C$,
  - capital, $K$, and
  - human capital, $H$,
  - the wage, $w$,
  - interest rate $r$,
  - the age at which individuals leave school, $s$.

$$f_s = r + \rho,$$  \hspace{1cm} (13)

$$w(t) = A(1 - \alpha) \left( \frac{K(t)}{H(t)} \right)^\alpha.$$  \hspace{1cm} (18)

$$r(t) = A \alpha \left( \frac{K(t)}{H(t)} \right)^{\alpha-1}.$$  \hspace{1cm} (19)

$$C(t) = \frac{(\theta + \rho)\rho}{(r + \rho)(\rho - r + \theta)} \left[ we^{f(s)}e^{-(r+\rho)s} \right].$$  \hspace{1cm} (21)

$$H(t) = e^{f(s) - \rho s}.$$  \hspace{1cm} (23)

$$K(t) = \frac{we^{f(s)}}{(r + \rho)} \left[ \left( \frac{\rho}{\rho - r + \theta} + \frac{\rho}{r} \right) e^{-(r+\rho)s} - \left( 1 + \frac{\rho}{r} \right) e^{-\rho s} \right].$$  \hspace{1cm} (25)

- Specify a functional form for $f(s)$ (in the next part, we will have a more realistic for $m$ of the $f(s)$ function), thus in steady state

$$s = \frac{1}{r + \rho},$$  \hspace{1cm} (26)

$$\frac{K^*}{H^*} = \frac{w^*}{(r^* + \rho)} \left[ \left( \frac{\rho}{\rho - r^* + \theta} + \frac{\rho}{r^*} \right) e^{-r^*s^*} - 1 - \frac{\rho}{r^*} \right].$$  \hspace{1cm} (27)
There is a unique value of \( r^* \), and thus \( K^* \), \( H^* \), \( C^* \), \( w^* \), \( s^* \) are all unique.

Equation (28) implies that
- Interest rate is not dependent on productivity \( A \)
- Level of schooling also not dependent on \( A \)

Intuition interpretation:
- First, changes in productivity have offsetting direct effects on the optimal quantity of education. Higher productivity raises the costs(wage) and benefits(interest rate) of education by the same factor.
- Further, increases in productivity do not affect the quantity of schooling via the interest rate: a standard property of neoclassical growth models is that the interest rate is constant along balanced growth paths with changing technology.
- A further implication of the result that schooling does not depend on the level of productivity is that the model which we have examined in this paper can easily be combined with a model of growth due to changing technology.

3. Comparative static result

- Three main exercises:
  - To examine the effect of changing mortality on the equilibrium values of the endogenous variables.
  - To compare general equilibrium case to the case where schooling is held constant. *(This will allow us to assess the importance of the effect of mortality on schooling on which we have focused.)*
  - To compare the effect of mortality on schooling in general equilibrium with the partial equilibrium where interest and wage rates are held constant. *(This will highlight the importance of examining the determination of schooling in a general equilibrium framework, and will also allow for a comparison of the effects of mortality on schooling and consumption in a closed versus an open economy.)*
### 3.1 Analytical results

<table>
<thead>
<tr>
<th>Term</th>
<th>Expression</th>
<th>sign</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\frac{dr}{d\rho}$</td>
<td>$dr$</td>
<td>$+$</td>
</tr>
<tr>
<td>$\frac{ds}{d\rho}$</td>
<td>$\frac{dr}{d\rho} + 1$</td>
<td>$-$</td>
</tr>
<tr>
<td>$\frac{dK}{d\rho}$</td>
<td>$-\frac{e^{-\rho}}{(r+\rho)^2} \left[ \frac{1}{A\alpha(1-\alpha)} \frac{1}{AA} \frac{2-\alpha}{AA} \frac{dr}{d\rho} + \frac{r}{A\alpha} \frac{1}{r+\rho} \left( \frac{dr}{d\rho} + 1 \right) + \frac{1}{r+\rho} \right]$</td>
<td>$-$</td>
</tr>
<tr>
<td>$\frac{dw}{d\rho}$</td>
<td>$-\frac{r}{(A\alpha)} \frac{1}{(r+\rho)} \frac{dr}{d\rho}$</td>
<td>$-$</td>
</tr>
<tr>
<td>$\frac{dC}{d\rho}$</td>
<td>$A\alpha(\frac{K}{H})^{a-1} \frac{dK}{d\rho} + A(1-\alpha)(\frac{K}{H})^{a} \frac{dH}{d\rho}$</td>
<td>$-$</td>
</tr>
</tbody>
</table>

- $\rho$ is the mortality rate, $\rho$ increase means living a shorter lives, we can easily find the effect on six endogenous variables from the table above.

#### 3.1.1. General Equilibrium

Allow schooling to vary endogenously.

- $\frac{dr}{d\rho} > 0$ indicates that shorter lives lead to lower wealth accumulation, and thus to a higher marginal product of capital, which is the interest rate $r$.
- $\frac{ds}{d\rho} < 0$ means that as mortality increases individual would reduce the schooling years since they will not live long enough to benefit from the returns on investment in education.
- Also, we can think that since $f_s = r + \rho$, as mortality increases, the effective interest rate increases, and thus the marginal return of education increases. From the diminishing marginal return of education ($f_{ss} < 0$), we will end up with a shorter schooling years.
- $\frac{dH}{d\rho} < 0$ means that there are two aspects to effect total human capital $H(t)$: individual schooling years and the proportion of population who have finished their education. Moreover, when mortality increases, we know that the number of schooling years ($s$) for individuals decreases from the earlier equation (3-2). That is, the increase in mortality would reduce the human capital through its negative effect on schooling years. In addition, when mortality is high, a smaller fraction of the population will be composed of people who have completed their schooling. In other words, with high probability of dying, fewer people can live till the age they could finish their education. Thus, total human capital decreases with a higher mortality.
• \( \frac{dK}{d\rho} < 0 \) indicates that having a high probability of death reduces the incentive of individuals to invest in capital as they will not be able to benefit the returns at a future period. Thus an increase in \( \rho \) results in reduced \( K \).

• \( \frac{dc}{d\rho} < 0 \) indicates that the general equilibrium response of aggregate consumption to a change in \( \rho \), follows from the fact that aggregate consumption, \( C \), is equal to aggregate output, \( Y \), at the steady state (since there is no depreciation, population growth, or technical change). In other words, an increase in \( \rho \) will reduce investment which in turn will induce individuals to increase consumption. However, due to lower levels of human capital caused as a result of higher mortality, individuals will have a restriction on consumption due to lower earnings and thus will not be able to consume as high as they would like to.

**Hold Schooling Constant**

• The effect of a change in mortality on human capital, physical capital, and consumption is smaller in absolute value in the case where schooling is held constant than in the case where schooling varies endogenously.

• There are two aspects to effect total human capital \( H(t) \) : individual schooling years and the proportion of population who have finished their education. Because we have schooling fixed, the individual schooling year does not change when mortality increases. The increasing of mortality only reduces the part of population who could complete their education. Thus, the absolute value of the change of human capital is smaller.

• When mortality increases, people have less incentive to accumulate their wealth because they are afraid of not being able to enjoy the benefit from the investment. However, when people face fixed schooling, they hold fixed individual human capital as a result. Their earnings do not shrink as much as in the general equilibrium case. Thus, the change of physical capital is also smaller.

### 3.1.2 General Equilibrium VS. Partial Equilibrium

• Our analysis is based on the below inequalities.

\[
\left. \frac{ds}{d\rho} \right|_\rho = -\frac{1}{(r + \rho)^2} < 0 \quad \left. \frac{dH}{d\rho} \right|_\rho = -\frac{e^{-\frac{\rho}{r+\rho}}}{(r + \rho)^2} \left( \frac{r}{r + \rho} + 1 \right) < 0 \quad \left. \frac{dC}{d\rho} \right|_{\rho, \pi} < 0.
\]

• The last goal is to compare the general equilibrium response of schooling and consumption to a change in mortality to the response of these variables in case where wages and interest rates are held fixed – conditions which would hold, for example, in a small, open economy subject to factor price equalization.
The change in schooling in response to an increase in mortality is significantly larger in the general equilibrium than in the partial equilibrium case. This is because of changes in interest rates: when mortality increases the interest also increases in the general equilibrium case. A higher interest reduces the optimal quantity of schooling (as shown from \( f(s) = r + \rho \)). But since interest rates are constant in partial equilibrium one channel of causation will be eliminated, reducing the degree by which schooling varies.

Similarly, \( H \) will be less responsive to changes in \( \rho \) in partial equilibrium since the change of individual schooling years is relative smaller.

### 3.2 Calibration

<table>
<thead>
<tr>
<th>Variables</th>
<th>Steady state value</th>
<th>Elasticity with respect to ( \rho )</th>
<th>General equilibrium</th>
<th>General equilibrium with fixed schooling</th>
<th>Partial equilibrium</th>
</tr>
</thead>
<tbody>
<tr>
<td>( s )</td>
<td>10.69</td>
<td>-1.04</td>
<td>-0.64</td>
<td>-0.87</td>
<td></td>
</tr>
<tr>
<td>( H )</td>
<td>5.70</td>
<td>-0.89</td>
<td>-0.32</td>
<td>-0.87</td>
<td></td>
</tr>
<tr>
<td>( r )</td>
<td>0.05</td>
<td>-0.36</td>
<td>0.49</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( w )</td>
<td>1.50</td>
<td>-0.16</td>
<td>-0.21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( K )</td>
<td>71.70</td>
<td>-1.41</td>
<td>-1.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( c(b) )</td>
<td>3.66</td>
<td>-0.78</td>
<td>-0.98</td>
<td>-0.19</td>
<td></td>
</tr>
<tr>
<td>( C )</td>
<td>12.18</td>
<td>-1.04</td>
<td>-0.53</td>
<td>-2.54</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variables</th>
<th>Steady state value</th>
<th>Elasticity with respect to ( \rho )</th>
<th>General equilibrium</th>
<th>General equilibrium with fixed schooling</th>
<th>Partial equilibrium</th>
</tr>
</thead>
<tbody>
<tr>
<td>( s )</td>
<td>23.51</td>
<td>-0.69</td>
<td>-0.40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( H )</td>
<td>13.30</td>
<td>-0.92</td>
<td>-0.28</td>
<td>-0.66</td>
<td></td>
</tr>
<tr>
<td>( r )</td>
<td>0.04</td>
<td>0.21</td>
<td>0.26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( w )</td>
<td>1.67</td>
<td>-0.09</td>
<td>-0.11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( K )</td>
<td>242.92</td>
<td>-1.23</td>
<td>-0.66</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( c(b) )</td>
<td>7.24</td>
<td>-0.69</td>
<td>-0.79</td>
<td>-0.23</td>
<td></td>
</tr>
<tr>
<td>( C )</td>
<td>31.80</td>
<td>-1.01</td>
<td>-0.40</td>
<td>-3.76</td>
<td></td>
</tr>
</tbody>
</table>

We will now use empirical data to verify the model. Earlier we had assumed \( f(s) = \ln(s) \) but it is not realistic. So we examine the results using a more realistic functions earnings given by:

\[
f(s) = \frac{\Theta}{1 - \psi} s^{1-\psi}.
\]

The second column of each table shows the steady state values of the endogenous variables \( s, H, r, w, K, C \) (average consumption) and \( c(b) \) (the level of consumption in
the first instant of life).

- The third column shows the elasticity of each of these variables with respect to \( \rho \), the mortality probability.
- The fourth column holds \( s \) fixed in its steady state value and the fifth column holds \( r \) and \( w \) fixed at their steady state values.

### 3.2.1 Observations

- By examining the signs of the elasticity in both the tables we find that variables \( s, w, H, K, \) and \( C \) are negatively correlated with \( \rho \) and so they follow the model. As for \( r \), under the condition when the schooling is fixed, it shows a positive correlation with \( \rho \) in both tables, but fails to follow the model in general equilibrium with low life expectancy, where it shows a negative correlation with \( \rho \).
- By comparing the absolute values of the elasticity of \( H, K \) and \( C \) in general equilibrium to that of fixed-schooling equilibrium and partial equilibrium respectively, the pattern outlined by the model is followed; in fixed-schooling equilibrium and partial equilibrium, the absolute value of the elasticity of \( H \) and \( K \) are smaller than when in general equilibrium. Similarly the elasticity of \( C \) is greater in absolute value than the general equilibrium response as pointed out in the model.
- An important point to note is that at both high and low life expectancies there is a relatively large response of both total human capital and total physical capital to a decrease in mortality; at both high and low life expectancies the elasticity of average consumption with respect to mortality is approximately equal to one.

### 4. Conclusion:

- Higher life expectancy increases the optimal quantity of schooling (incentives to invest in education increases due to a declining mortality).
- In general equilibrium, this effect is enhances due to reduce interest rates.
- The magnitude of the effect of lower mortality on the length of schooling has an economical significant. This is shown by empirical estimates on the return to schooling.

### Limitations of the Models:

- **Change in mortality is taken exogenously**: we can make a link between higher income and lower mortality. This would produce an exogenous shock to income or mortality.
  - Exogenous shock to income would lower mortality and increase optimal quantity of schooling.
  - Increase schooling would raise income; hence we have a feedback effect.
- **Model does not allow for interaction between education and technology**:
  - Recent literature has drawn a link between increased education to higher rate of technological progress. One could extend the model by incorporating this aspect.
- **The model ignores fertility decisions**: "
o Both lower mortality and higher education are correlated to reduced fertility. Parents make decisions between quantity and quality of children.
o More educated parents have a higher opportunity cost of child rearing. We can refer to “On the interaction between quantity and quality of children” by Becker and Lewis (1973).

Variables List

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\rho$</td>
<td>the probability of dying per unit time; the size of a new cohort;</td>
</tr>
<tr>
<td>$\rho e^{-\rho(t-b)}$</td>
<td>size of a cohort born at time $b$, at time $t$;</td>
</tr>
<tr>
<td>$s$</td>
<td>the total years of schooling</td>
</tr>
<tr>
<td>$E$</td>
<td>the earnings of an individual who is no longer in school;</td>
</tr>
<tr>
<td>$w$</td>
<td>the wage per unit of individual human capital;</td>
</tr>
<tr>
<td>$h(s)$</td>
<td>the quantity of human capital as a function of schooling;</td>
</tr>
<tr>
<td>$f_s$</td>
<td>the marginal rate of return from schooling</td>
</tr>
<tr>
<td>$r$</td>
<td>the market interest rate;</td>
</tr>
<tr>
<td>$r + \rho$</td>
<td>interest rate paid on annuities; interest rate paid borrowers;</td>
</tr>
<tr>
<td>$\theta$</td>
<td>the pure rate of time discount of consumption;</td>
</tr>
<tr>
<td>$c(b,t)$</td>
<td>consumption of an individual who was born at time $b$ as of time $t$;</td>
</tr>
<tr>
<td>$k(b,t)$</td>
<td>assets of an individual who was born at time $b$ as of time $t$;</td>
</tr>
<tr>
<td>$k^{sc}(b,t)$</td>
<td>the wealth of a person who is still in school;</td>
</tr>
<tr>
<td>$k^{wk}(b,t)$</td>
<td>the wealth of a person who is working;</td>
</tr>
<tr>
<td>$h(b,t)$</td>
<td>human capital of an individual who was born at time $b$ as of time $t$;</td>
</tr>
<tr>
<td>$K(t)$</td>
<td>the total physical capital of workers in the economy at time $t$;</td>
</tr>
<tr>
<td>$H(t)$</td>
<td>the total human capital of workers in the economy at time $t$;</td>
</tr>
<tr>
<td>$C(t)$</td>
<td>aggregate consumption at time $t$;</td>
</tr>
</tbody>
</table>