Unified Growth Theory and Comparative Development

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Economic Growth and Comparative Development

Fundamental Research Questions

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- What is the role of deep-rooted factors in explaining the observed patterns of comparative development?

Limitations of Non-Unified Growth Theory

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  - Importance of deep-rooted factors in comparative development

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  - Emergence of inequality in income per capita across countries

Origins of the Phase Transition

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    - The economy gravitates towards the emerging Modern Growth Regime

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Suggestive Evidence

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  - The effect of changes in the size and the quality of the population on:
    - the rate of technological progress

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  - Determined by households' decisions about the number and level of human capital of their children

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    - Reflecting diminishing returns to labor & positive effect of income on population

Production

- The output produced in period t

$$Y_t = H_t^{\alpha}(A_t X)^{1-\alpha}$$

  - $H_t \equiv$ efficiency units of labor
  - $A_t \equiv$ technological level
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- Output per worker produced at time t

$$y_t = h_t^{\alpha} x_t^{1-\alpha}$$

  - $h_t \equiv H_t / L_t \equiv$ efficiency units per-worker
  - $x_t \equiv (A_t X)/L_t \equiv$ effective resources per worker

The Malthusian Structure – Effects of Technological Progress

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  - $y_t \uparrow \implies L_t \uparrow$
- Long-run (population reaches a new steady-state):
  - $L_t \uparrow \implies y \downarrow$ (back to $\bar{y}$)

Sources of Technological Progress

- Earlier stages of development

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    - Division of labor
    - Extent of trade

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    - Educated individuals have an advantage in adopting and advancing new technologies

Technological Progress

$$g_{t+1} \equiv \frac{A_{t+1} - A_t}{A_t} = g(e_t, L_t)$$

- $g_{t+1} \equiv$ rate of tech progress
- $e_t \equiv$ education
- $L_t \equiv$ population size

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  - The scale of the economy has a positive and diminishing effect on technological progress
- $g(0, L) > 0$ for $L > 0$
  - Technological progress is positive at the outset

Technological Progress

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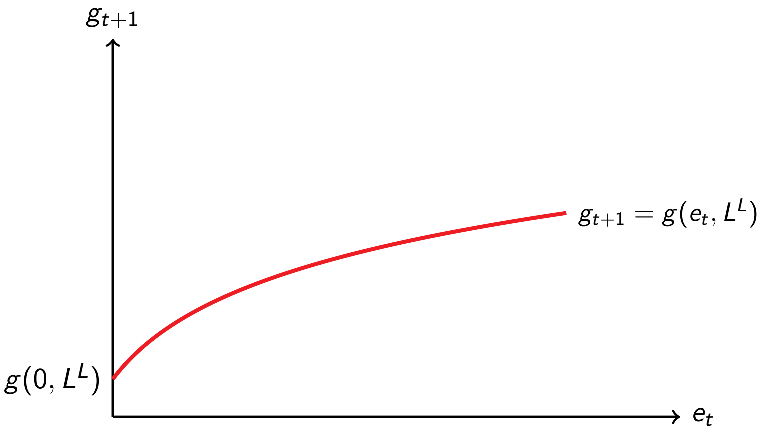
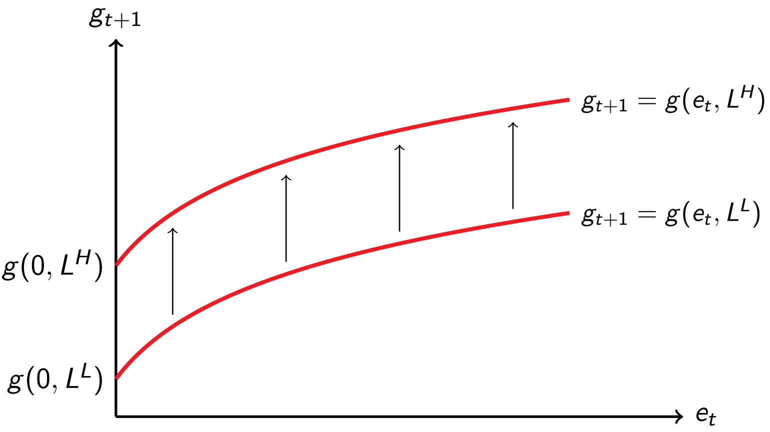


The Effect of Population Size on Technological Progress



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  - Human capital permits individuals to better cope with the changes in the technological environment
  - The introduction of new technologies is skill-biased in the short-run, although the nature of the technology can be skill-biased or skill-saving in the long run

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- $e_{t+1} \equiv$ the individual education level (determined by parental investment, subject to their subsistence constraint, in period t)
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Human Capital Formation

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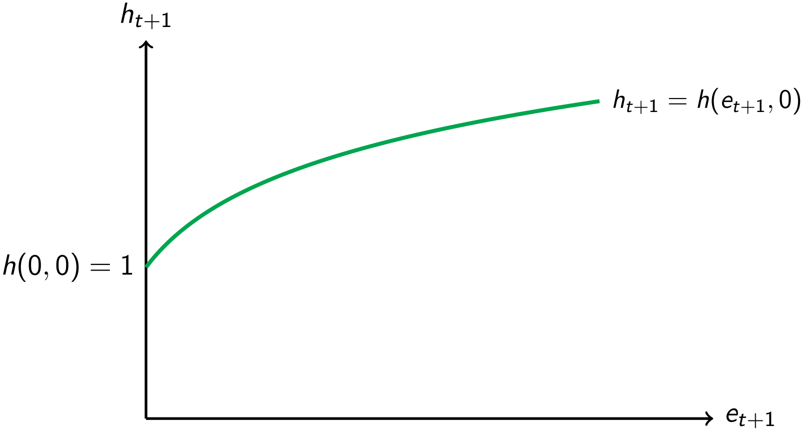
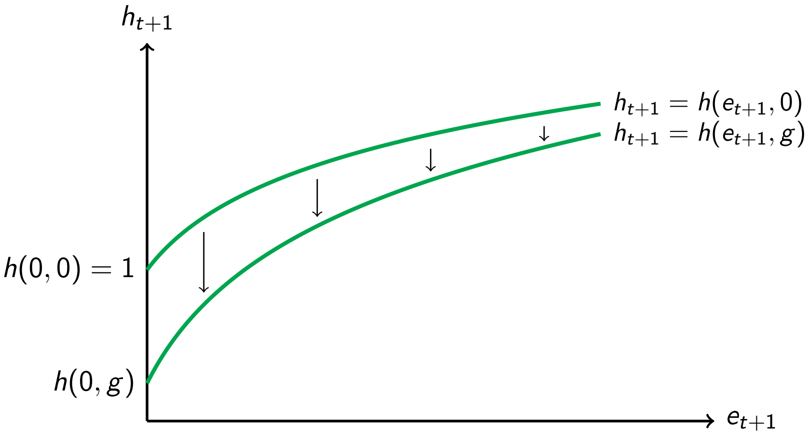


Effect of Technological Progress on Human Capital Formation



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    - The opportunity cost of raising children increases
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    - Population growth declines & human capital formation increases further

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    - $\tau + e_{t+1} \equiv$ time to raise a child with education e_{t+1}

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    - $\tau \equiv$ time required to raise a child, regardless of quality
    - $\tau + e_{t+1} \equiv$ time to raise a child with education e_{t+1}
- Parenthood (2nd Period):

Individuals

- Live for 2 periods
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    - Allocate the time endowment between childrearing and work

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- Parenthood (2nd Period):
  - Allocate the time endowment between childrearing and work
  - Choose the optimal mixture of child quantity and quality
  - Consume

Preferences

- The utility function of individual t (adult at time t)

$$u^t = (1-\gamma)\ln(c_t) + \gamma\ln(n_t h_{t+1})$$

  - $c_t \equiv$ consumption of individual t
  - $n_t \equiv$ number of children of individual t
  - $h_{t+1} \equiv$ level of human capital of each child

Budget and Subsistence Consumption Constraints

$$z_t n_t(\tau + e_{t+1}) + c_t \leq z_t$$

- $z_t \equiv$ potential income of individual t
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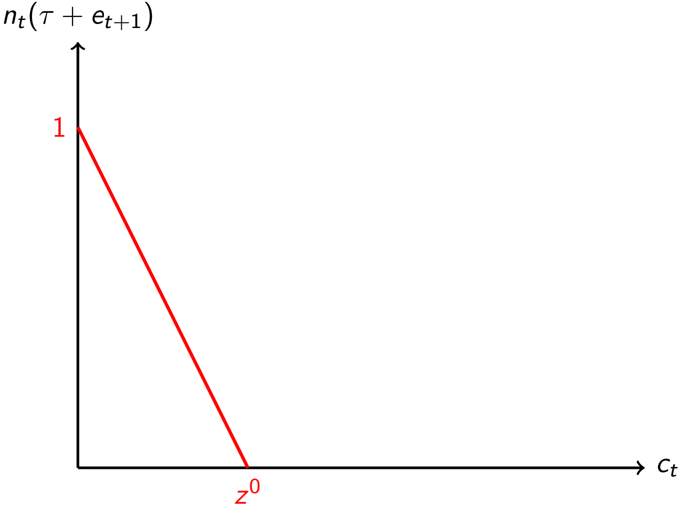
$$z_t \equiv y_t = h_t^{\alpha} x_t^{1-\alpha} = z(e_t, g_t, x_t)$$

- Subsistence consumption constraint:

$$c_t \geq \tilde{c}$$

Constraint and Optimization



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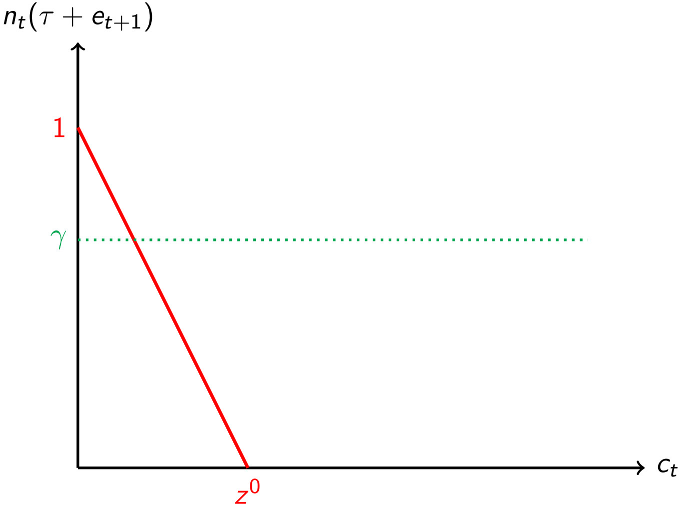

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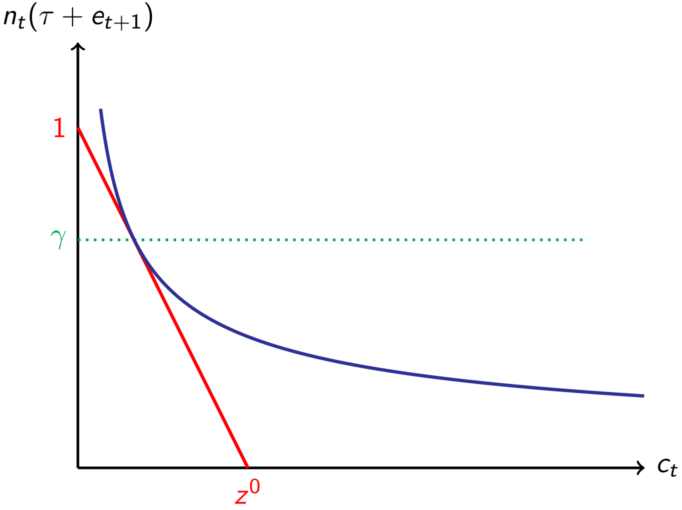

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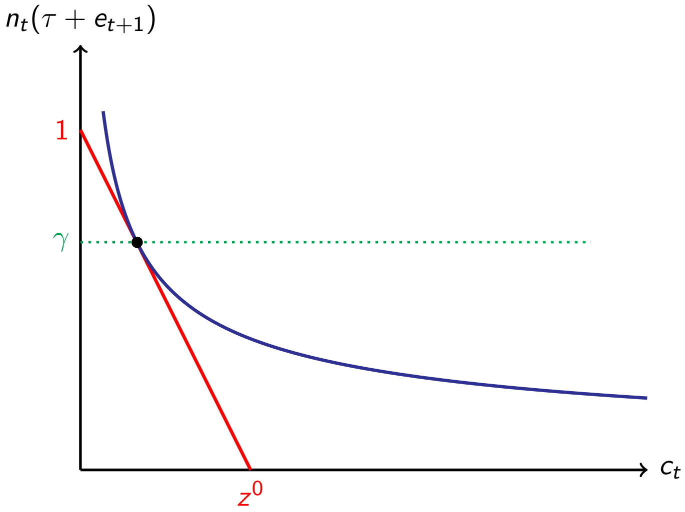

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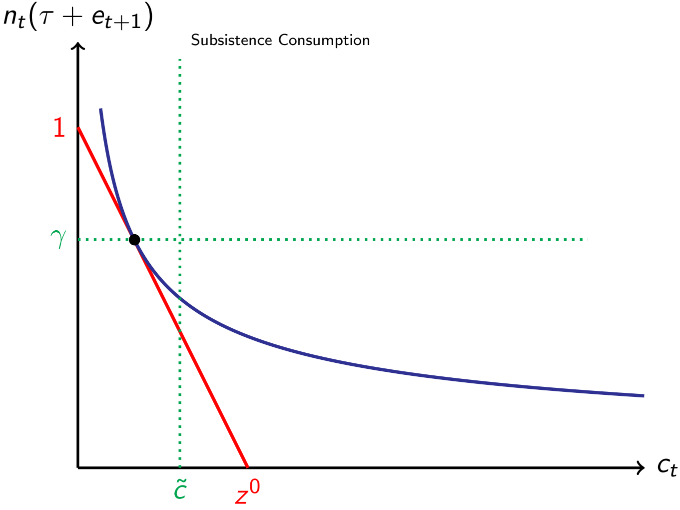

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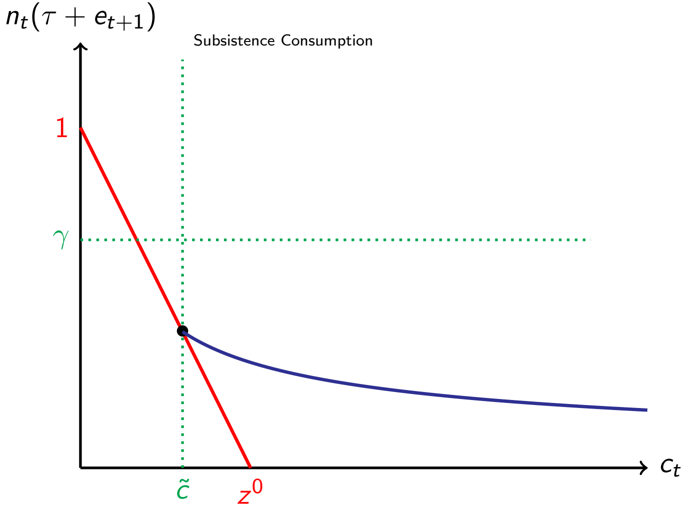

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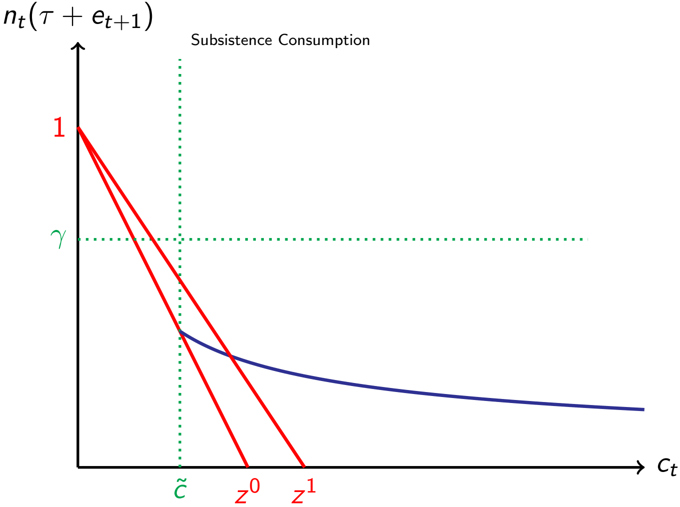

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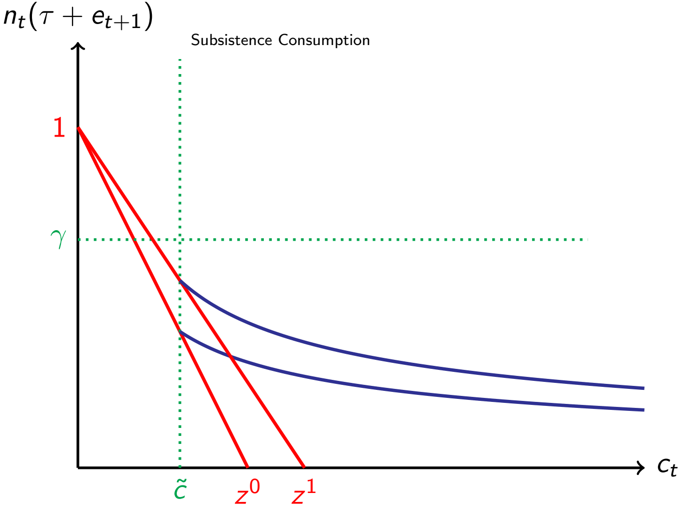

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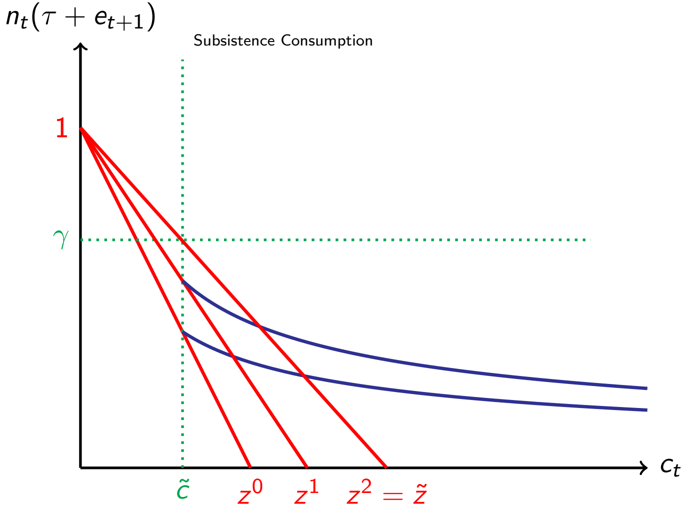

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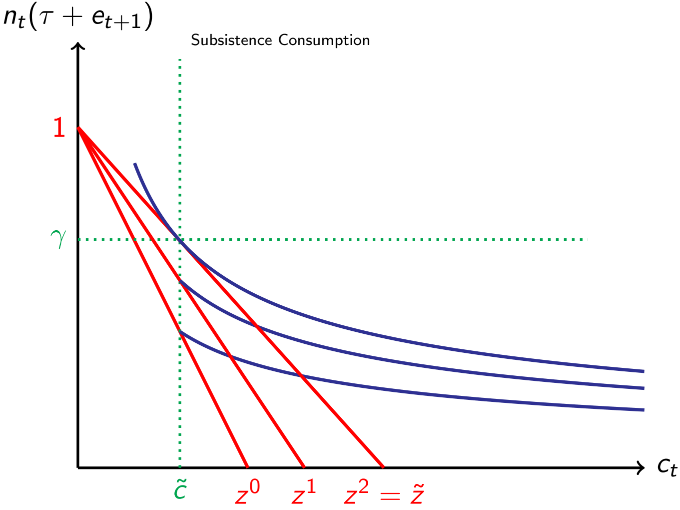

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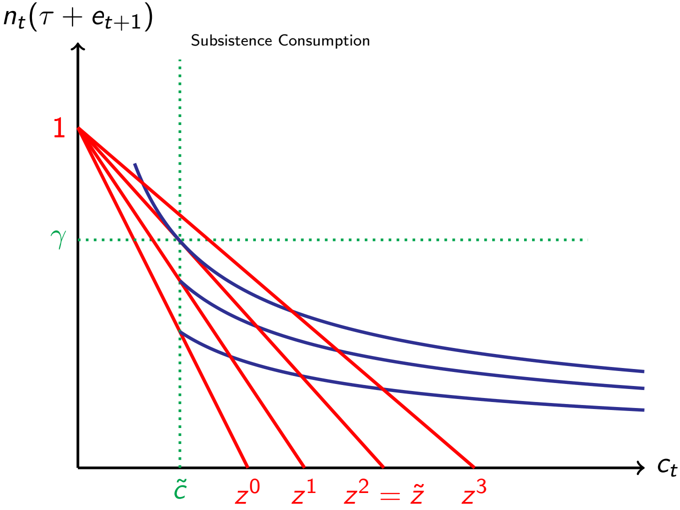

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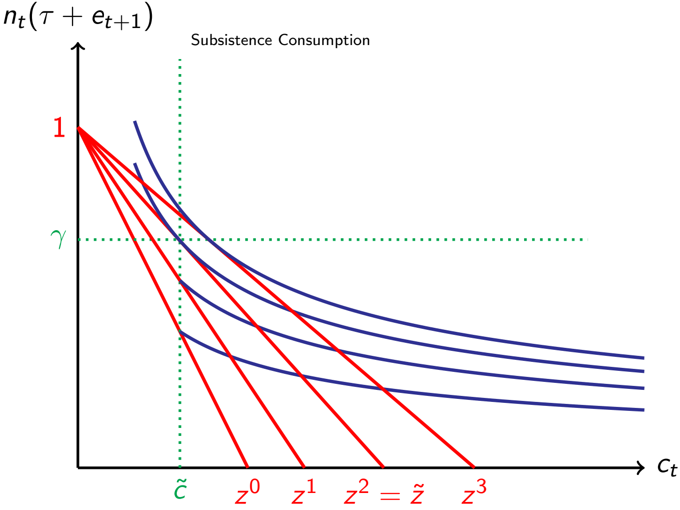

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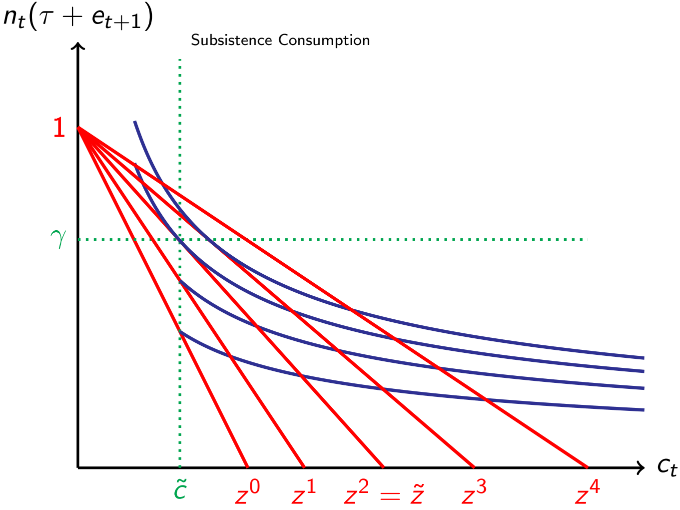

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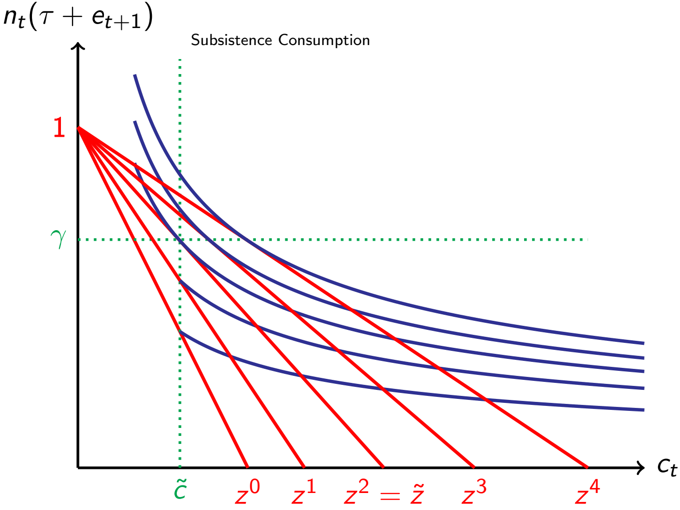

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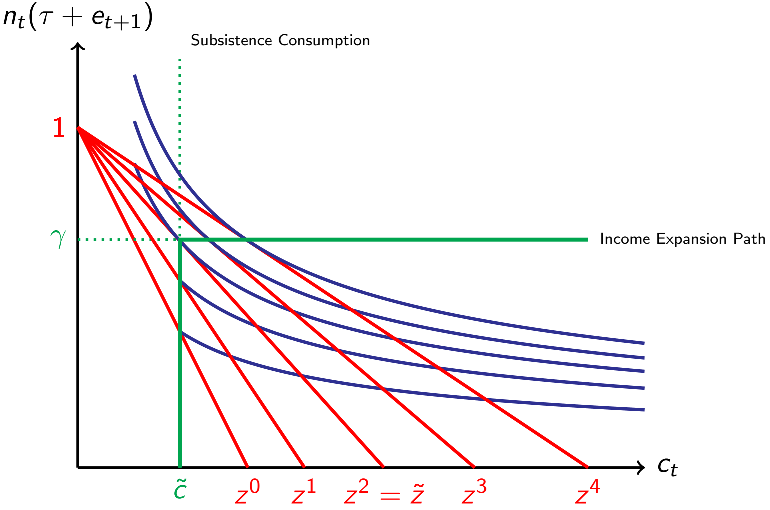

Optimal Investment in Child Quality

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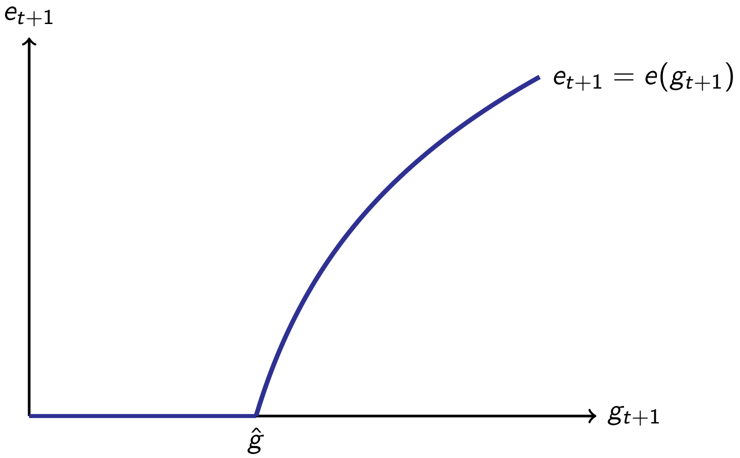

Optimization: Quantity and Quality of Children

- Time devoted to children:

$$n_t(\tau + e_{t+1}) = \begin{cases} \gamma & \text{if} \quad z_t \geq \tilde{z} \\ \\ 1 - \frac{\tilde{c}}{z_t} & \text{if} \quad z_t \leq \tilde{z} \end{cases}$$

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$$e_{t+1} = e(g_{t+1}) \quad \Longrightarrow$$

$$n_t = \begin{cases} \frac{\gamma}{\tau + e(g_{t+1})} \equiv n^b(g_{t+1}) & \text{if} \quad z_t \geq \tilde{z} \\ \frac{1-[\tilde{c}/z_t]}{\tau + e(g_{t+1})} \equiv n^a(g_{t+1}, z(e_t, g_t, x_t)) & \text{if} \quad z_t \leq \tilde{z} \end{cases}$$

Malthusian Epoch

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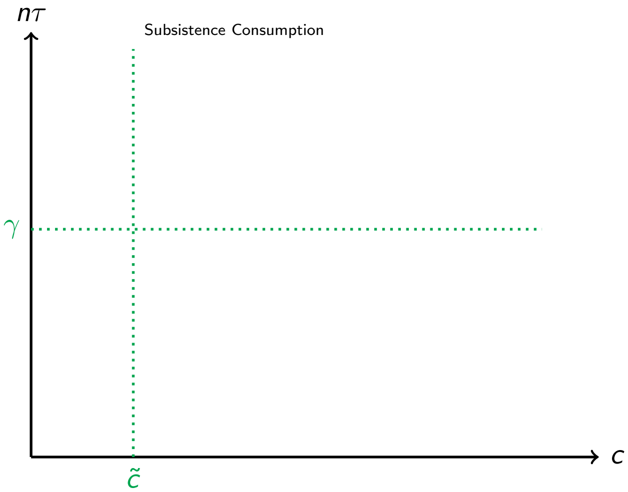

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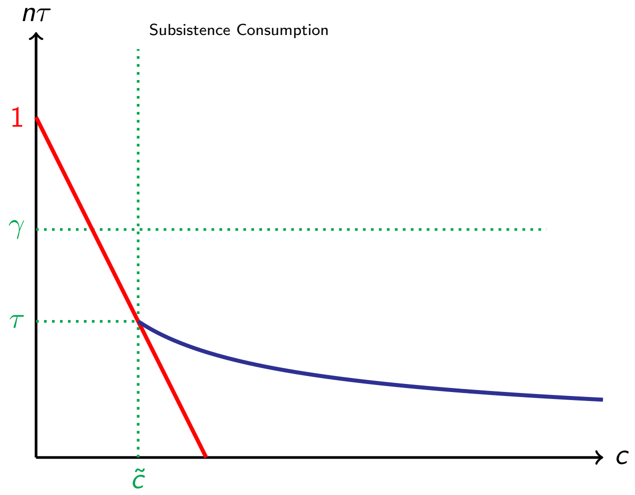

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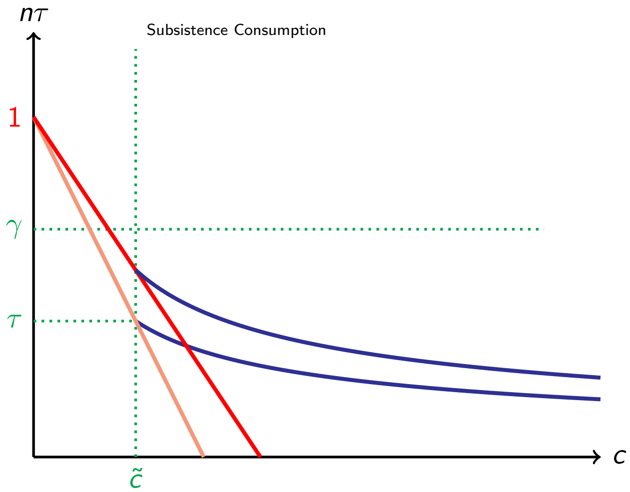

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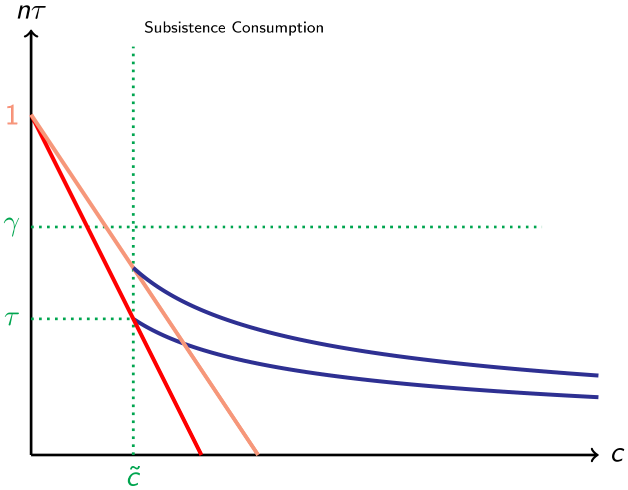

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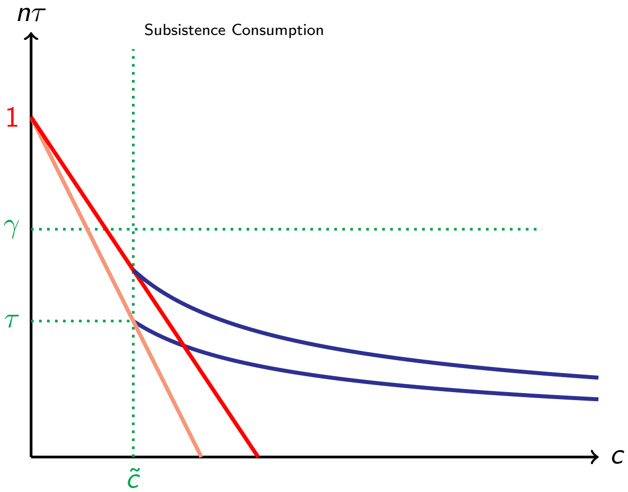

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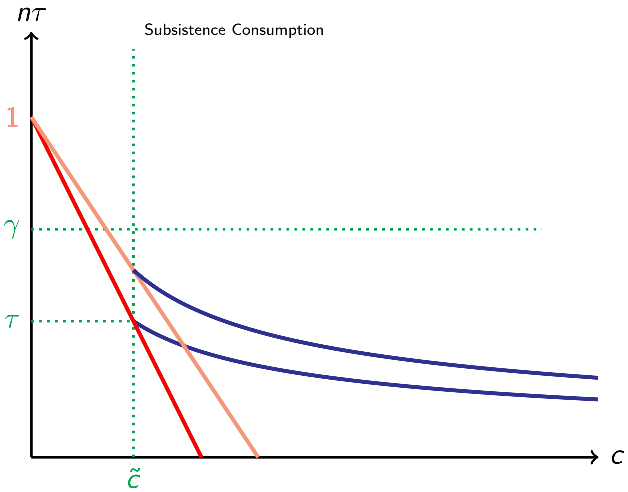

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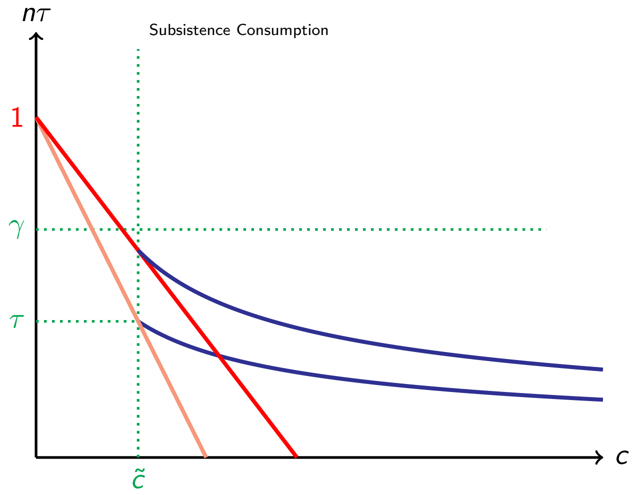

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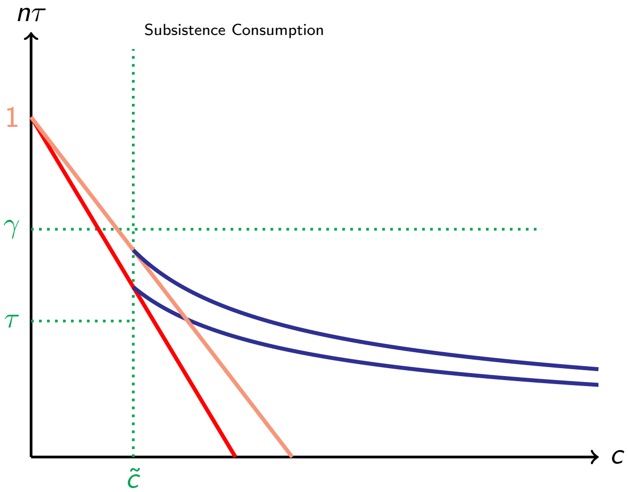

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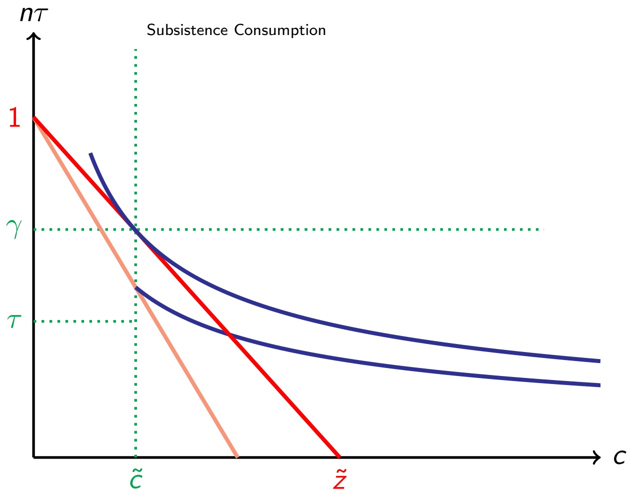
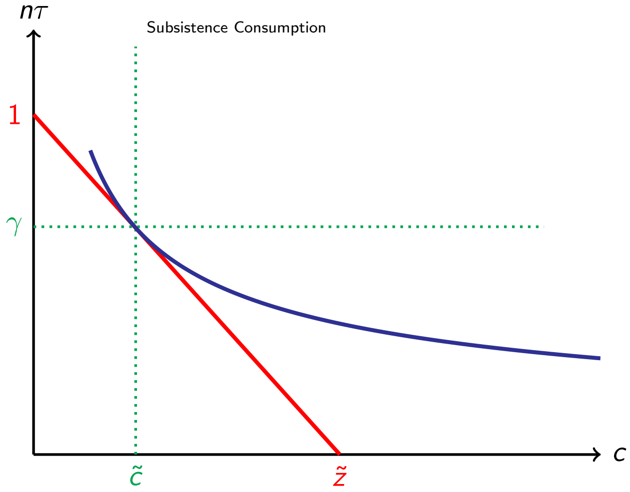


Post-Demographic Transition



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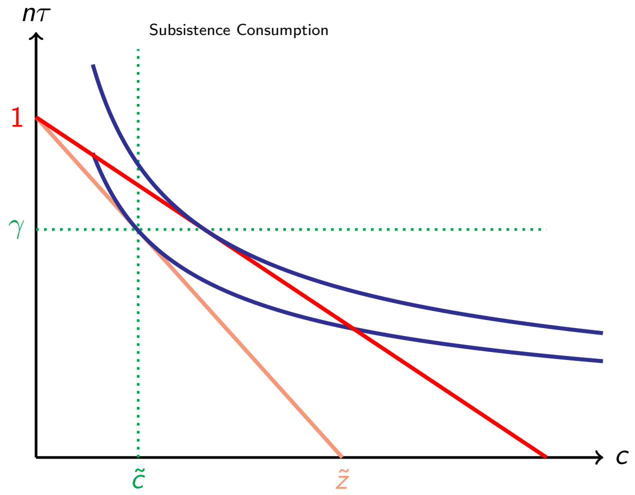


Population Dynamics

$$L_{t+1} = n_t L_t$$

$$L_{t+1} = \begin{cases} n^b(g_{t+1})L_t & \text{if} \quad z_t \geq \tilde{z} \\ n^a(g_{t+1}, z(e_t, g_t, x_t))L_t & \text{if} \quad z_t \leq \tilde{z} \end{cases}$$

Dynamics of the Level of Resources per Worker

$$x_{t+1} = \frac{A_{t+1}X}{L_{t+1}} = \frac{(1+g_{t+1})A_t X}{n_t L_t} = \frac{1+g_{t+1}}{n_t} x_t$$

$$x_{t+1} = \begin{cases} \frac{[1+g(e_t,L_t)][\tau^q+\tau^e e(g(e_t,L_t))]}{\gamma} x_t \equiv \phi^b(e_t; L_t) x_t & z_t \geq \tilde{z} \\ \frac{[1+g(e_t,L_t)][\tau+e(g(e_t,L_t))]}{1-[\tilde{c}/z(e_t,g_t,x_t)]} x_t \equiv \phi^a(e_t, g_t, x_t, L_t) x_t & z_t \leq \tilde{z}, \end{cases}$$

The Dynamical System

A sequence $\{x_t, e_t, g_t, L_t\}_{t=0}^{\infty}$ such that:

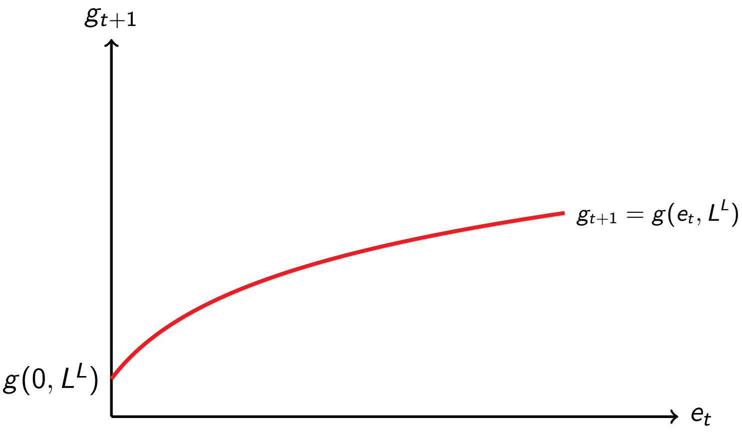
$$\begin{cases} x_{t+1} = \phi(e_t, g_t, x_t, L_t)x_t \\ e_{t+1} = e(g(e_t, L_t)) \\ g_{t+1} = g(e_t, L_t) \\ L_{t+1} = n(e_t, g_t, x_t, L_t)L_t \end{cases}$$

The Conditional Evolution of Technology and Education

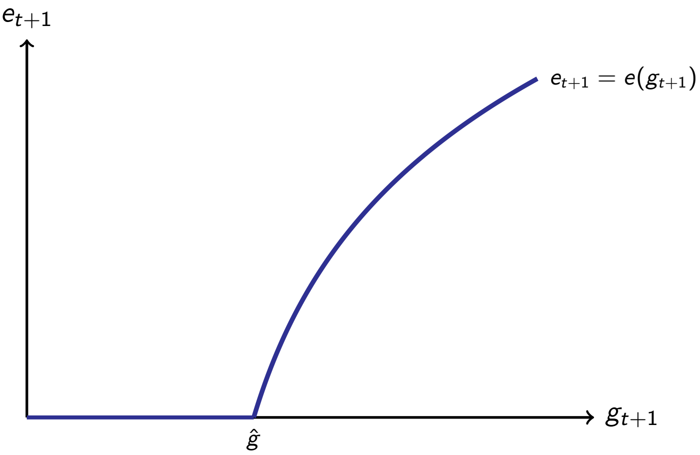
A sequence $\{g_t, e_t; L\}_{t=0}^{\infty}$ such that:

$$\begin{cases} g_{t+1} = g(e_t; L) \\ \\ e_{t+1} = e(g_{t+1}) \end{cases}$$

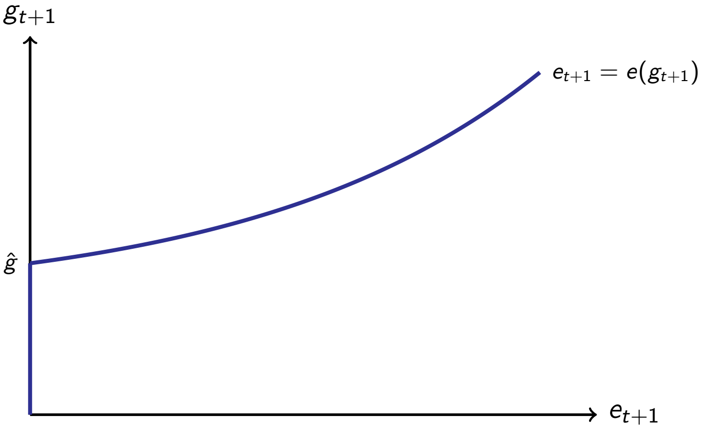
The Effect of Education on Technology



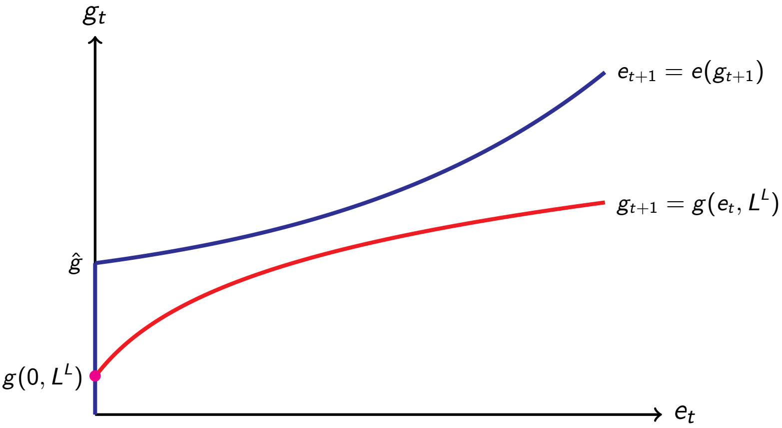
The Effect of Technology on Education



The Effect of Technology on Education: Flipped Axis



The Evolution of Education and Technology: For a Given Population Size



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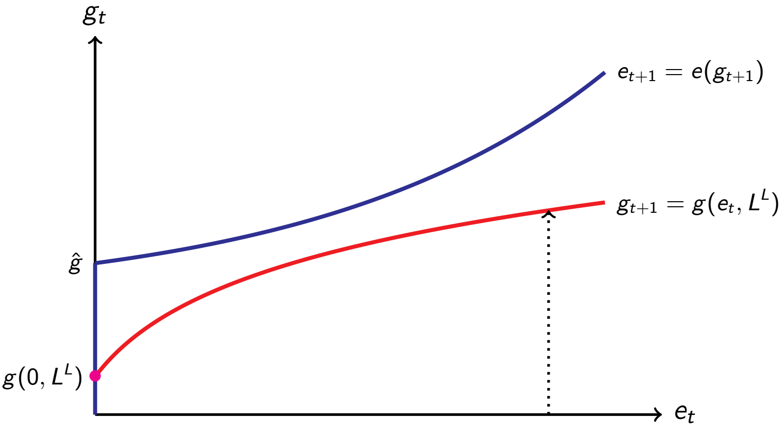

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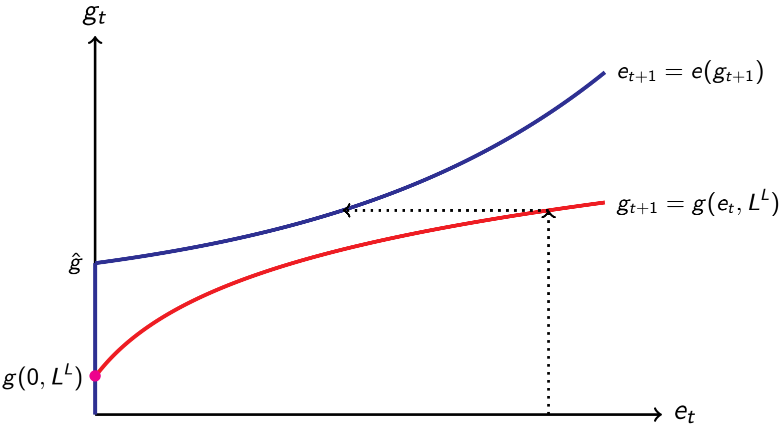

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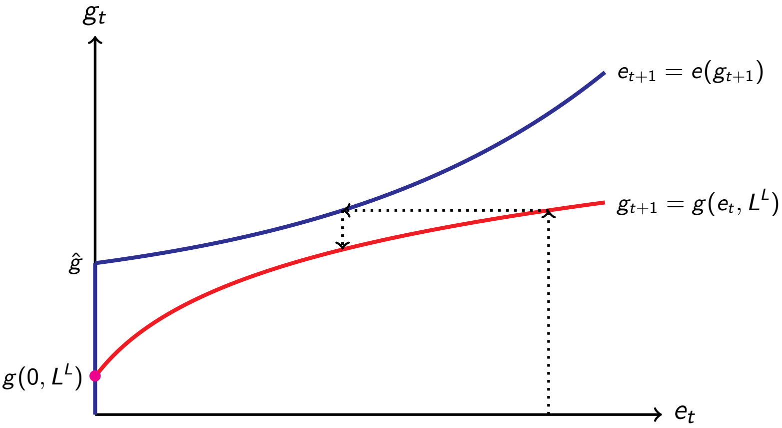

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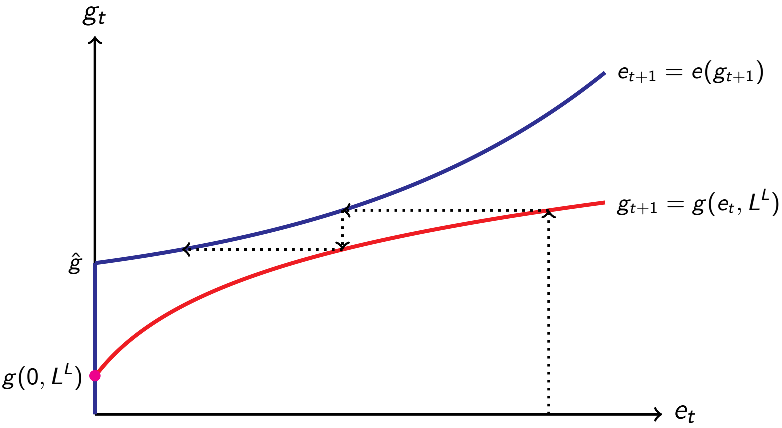

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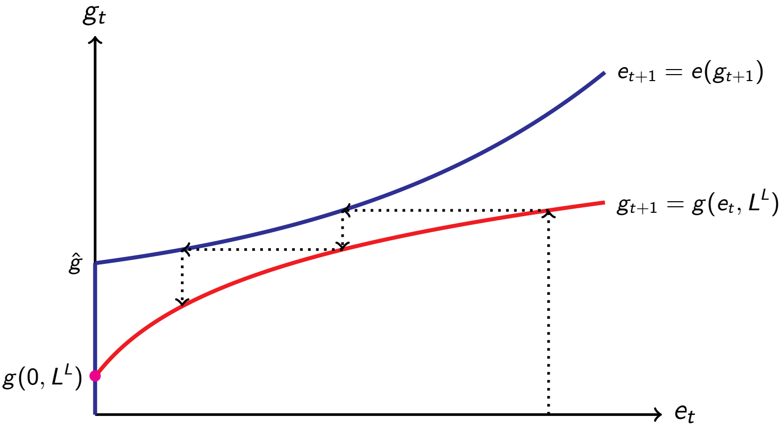

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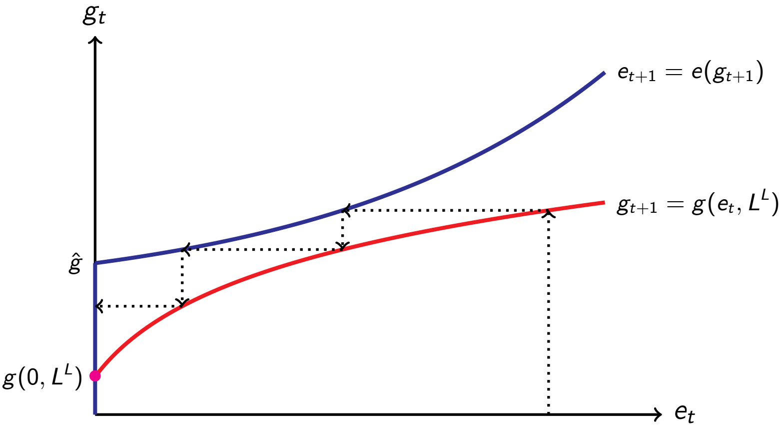

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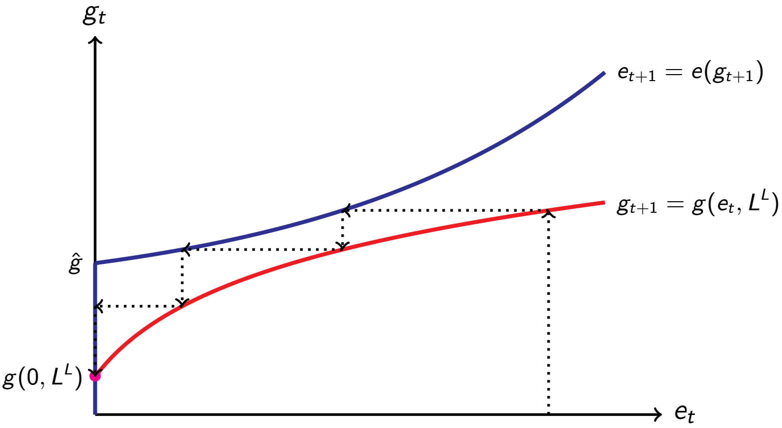

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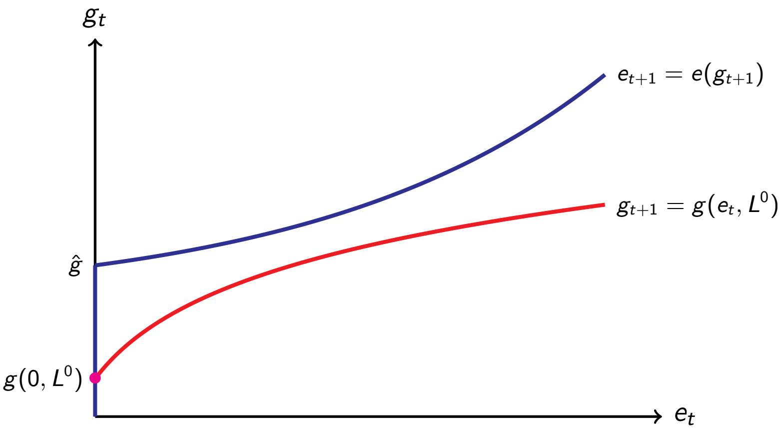

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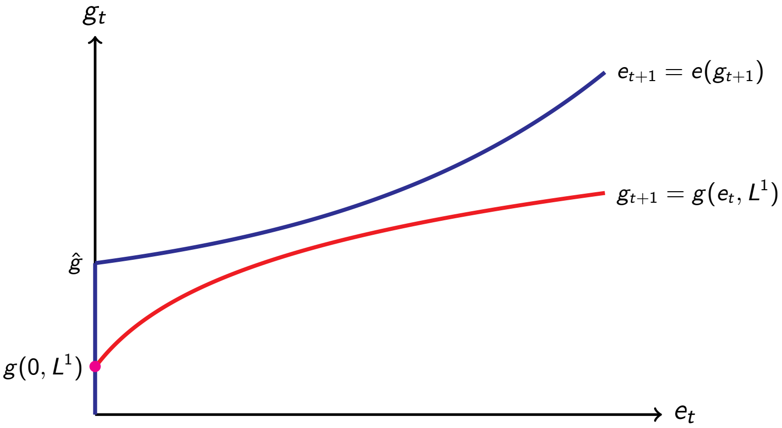

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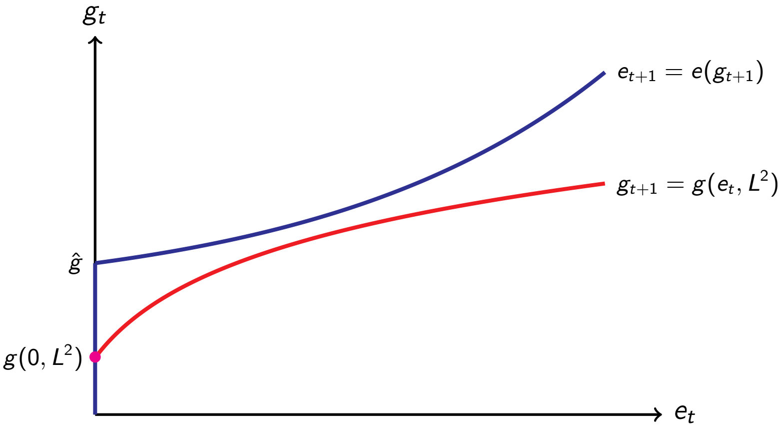

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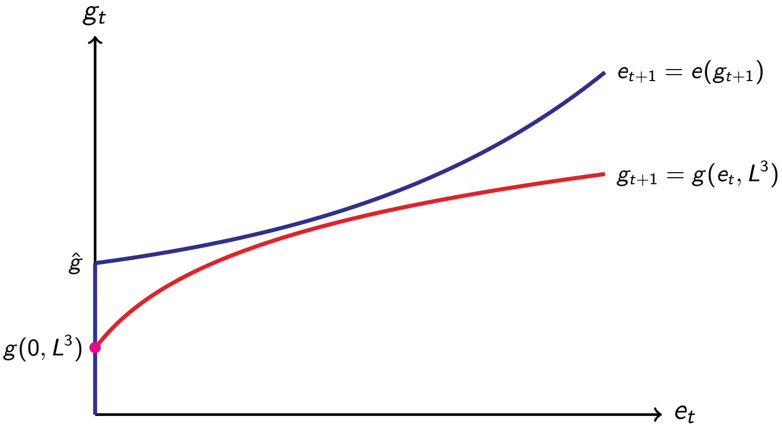

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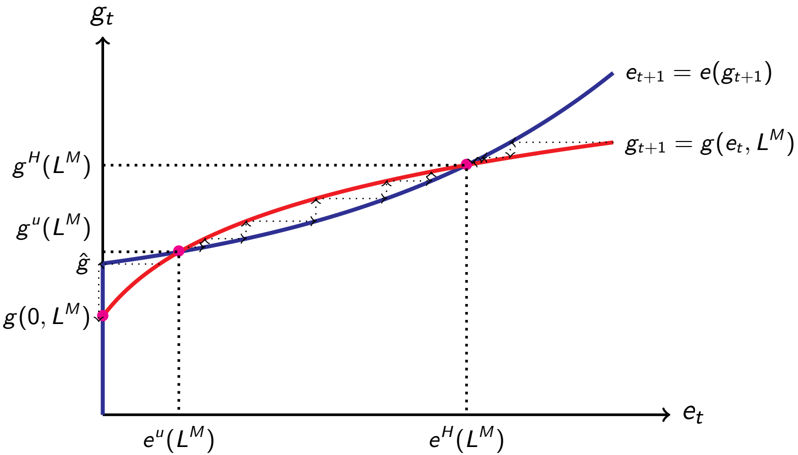

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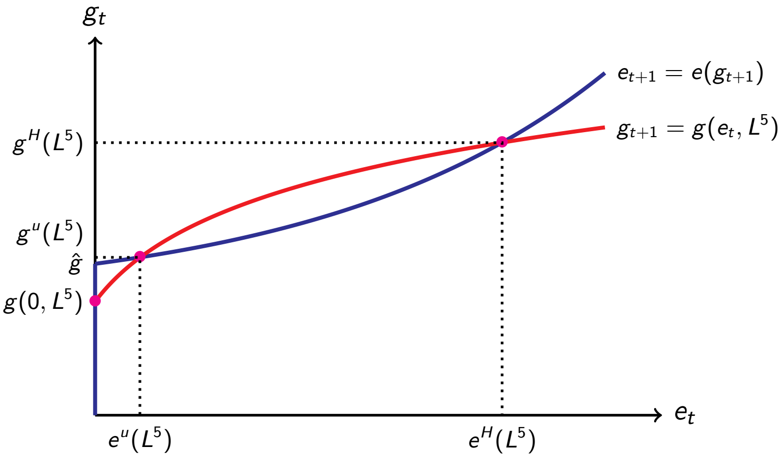

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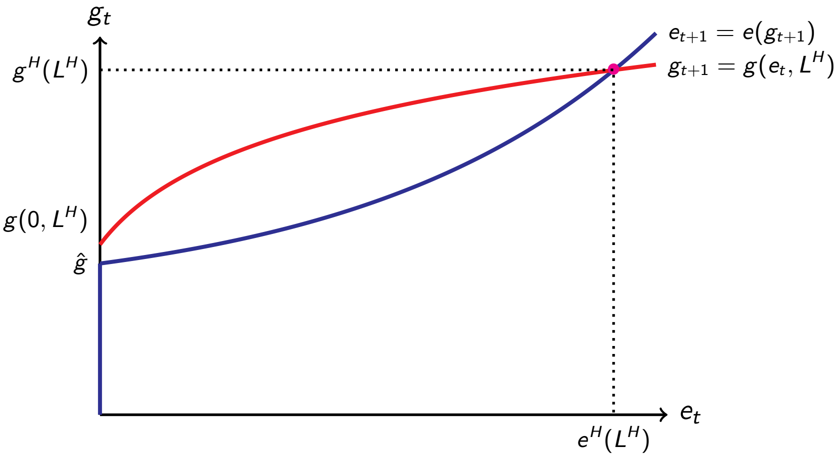

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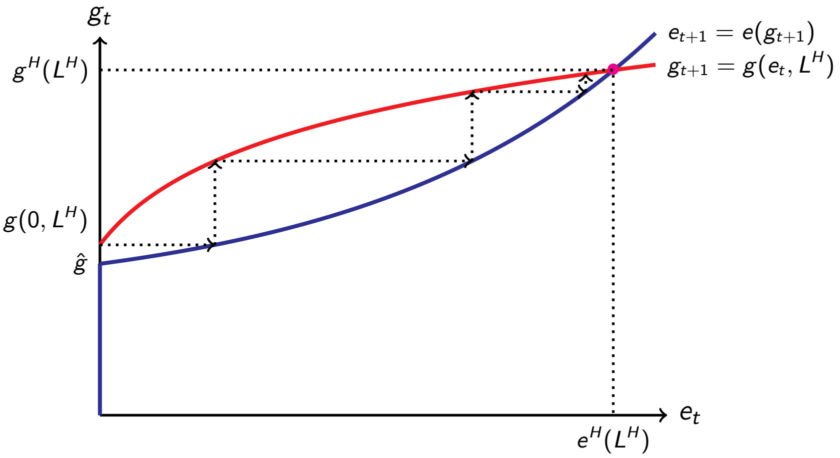

The Evolution of Education and Resources Per Worker: Small Population

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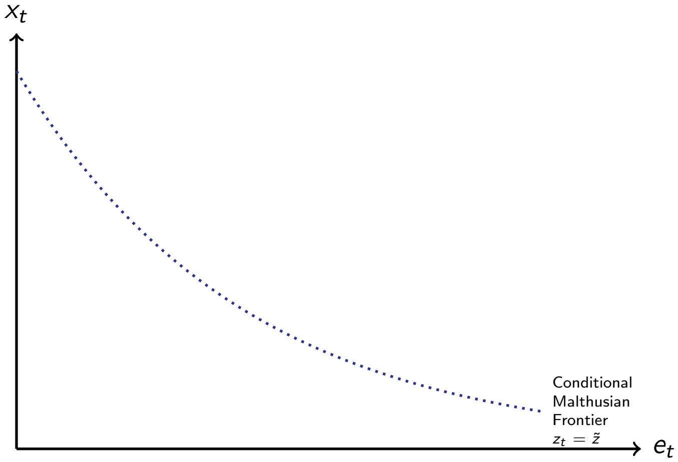

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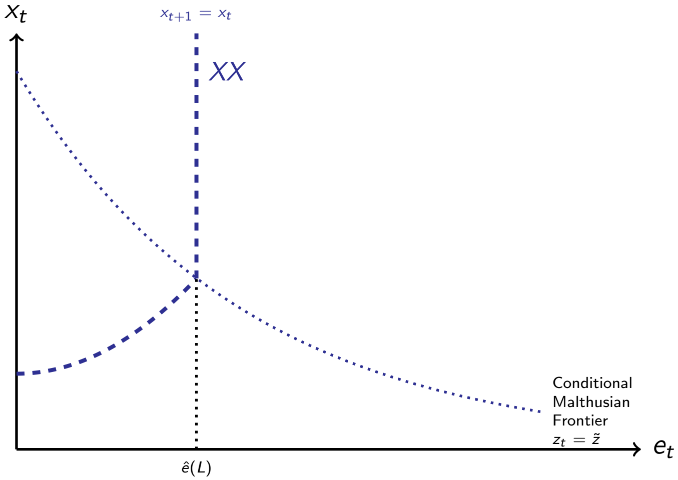

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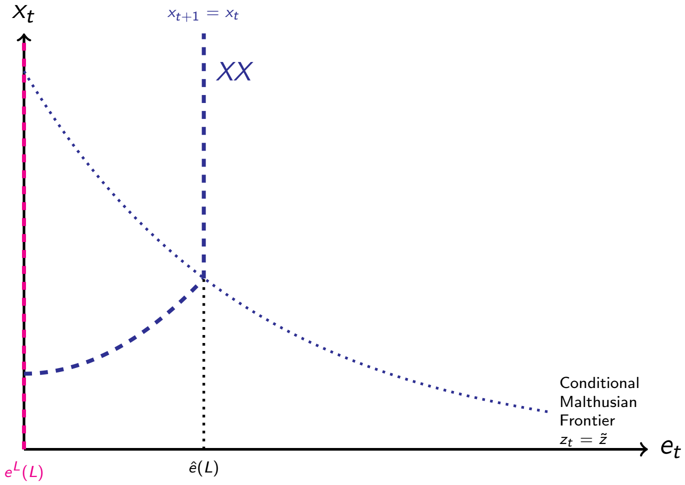

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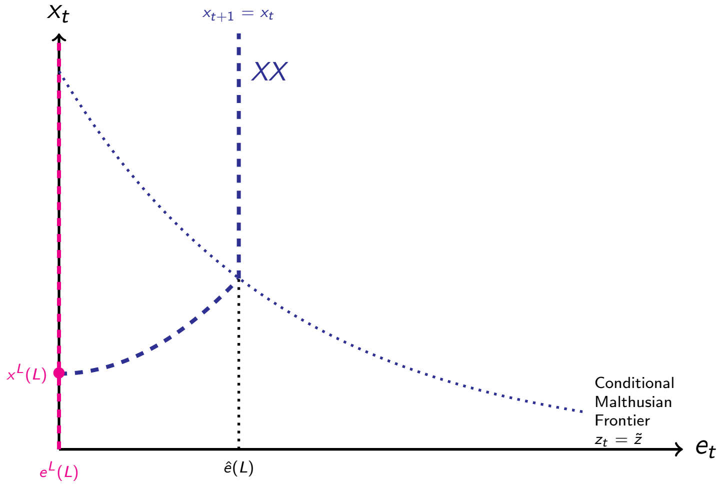

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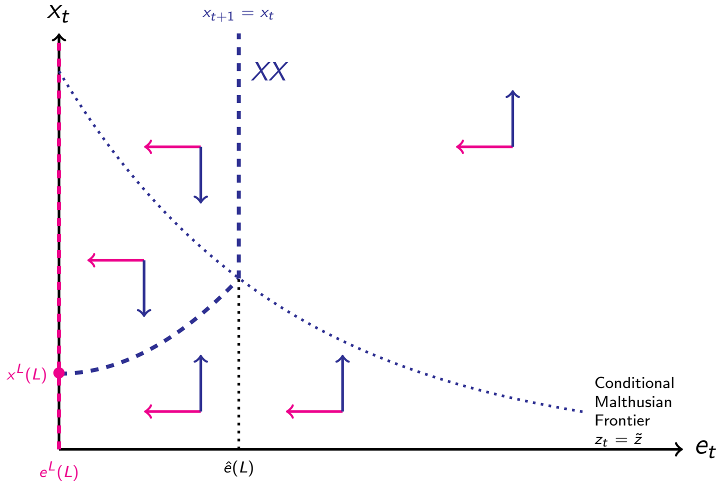

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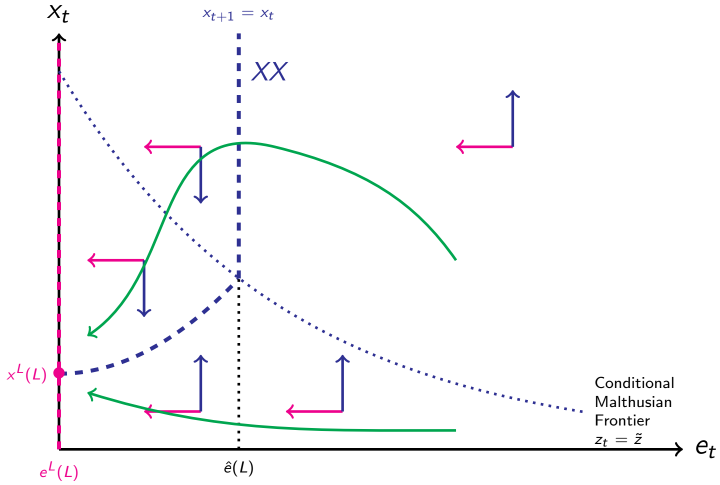
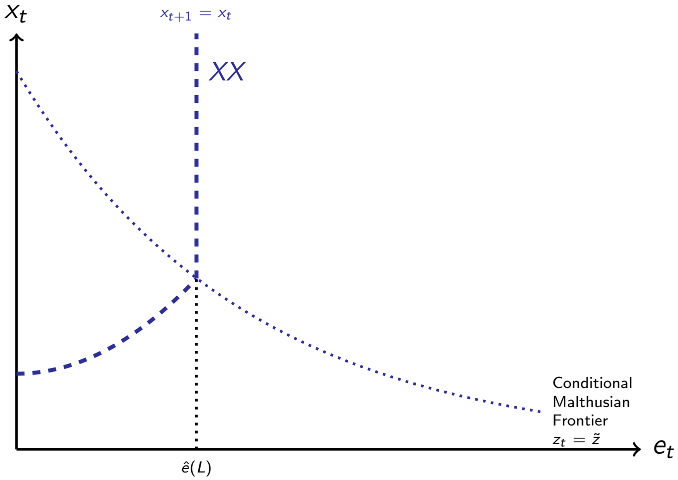


The Evolution of Education and Resources Per Worker: Intermediate Population



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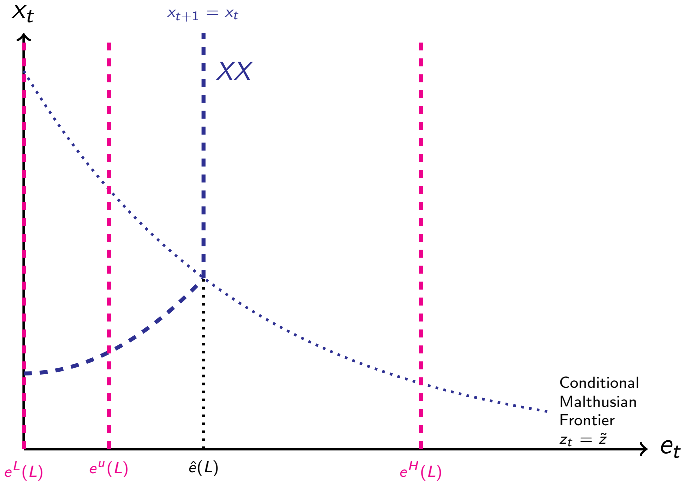
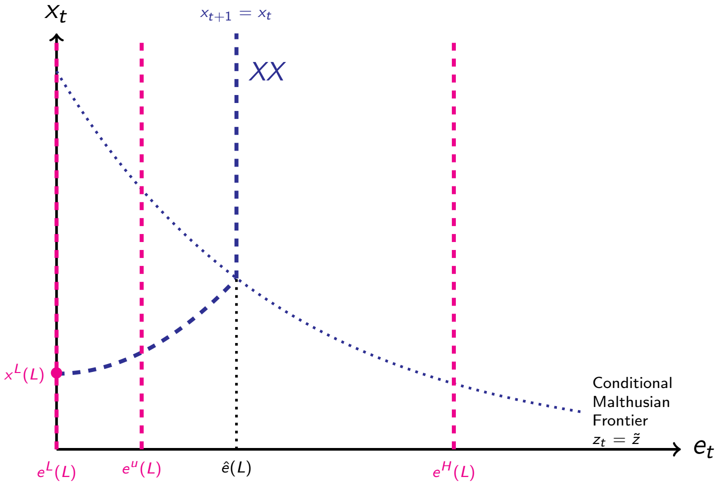


The Evolution of Education and Resources Per Worker: Intermediate Population



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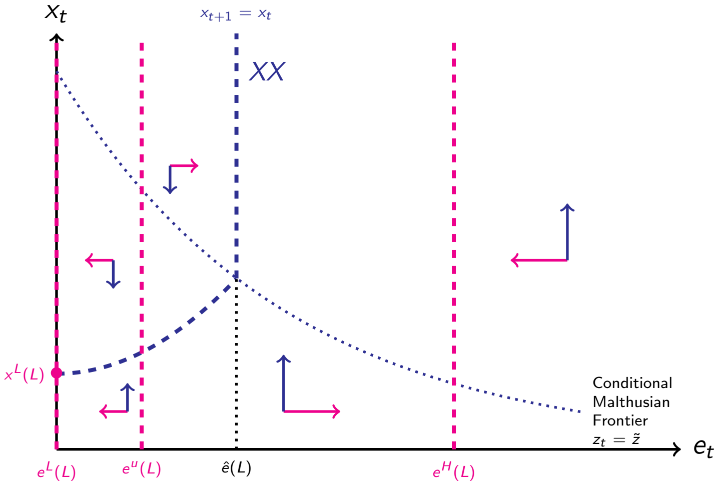

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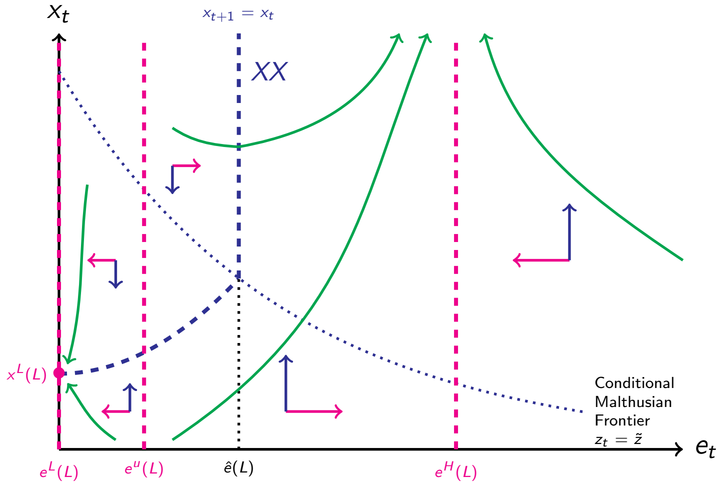

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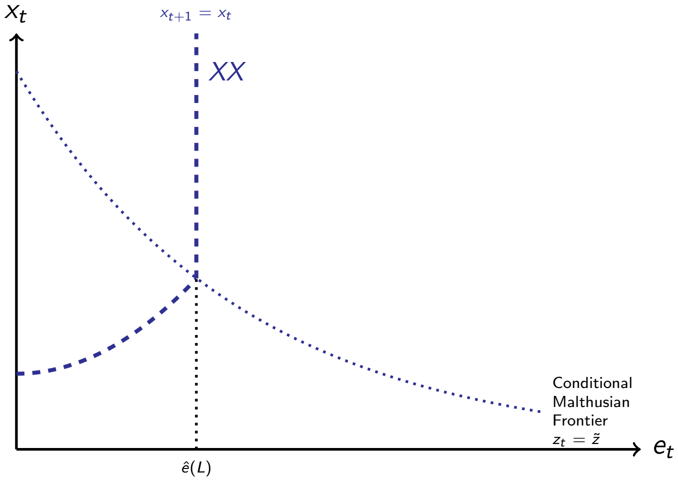

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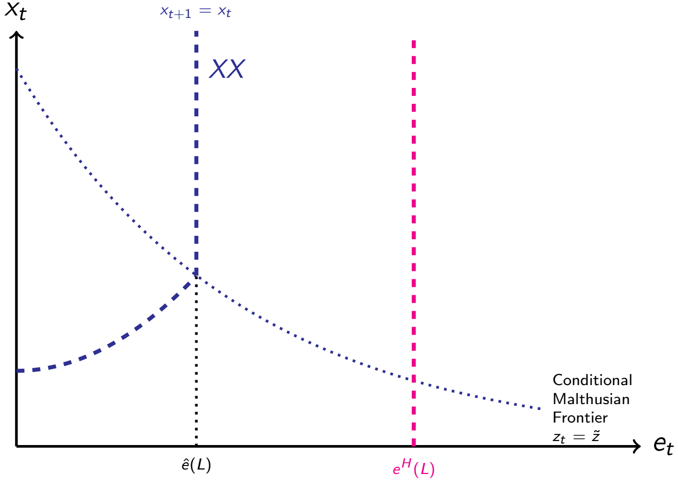

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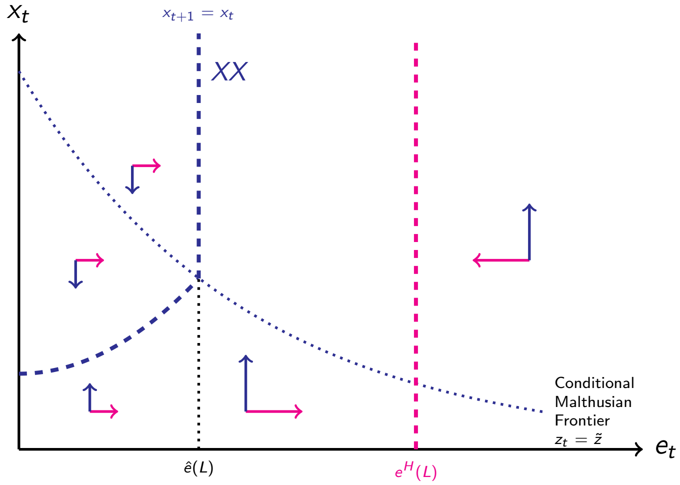

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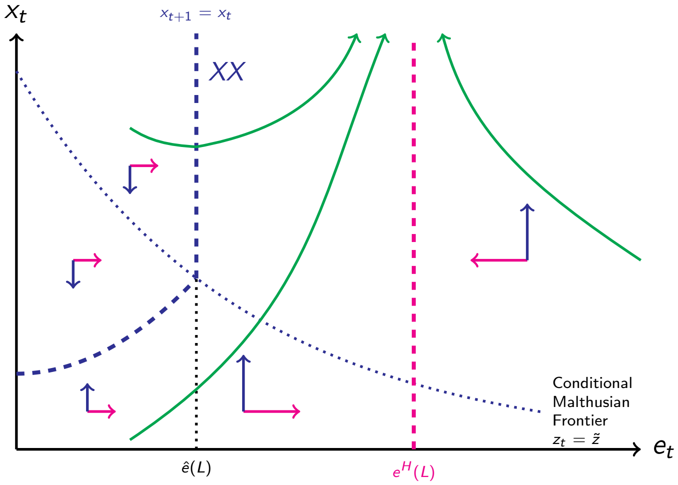
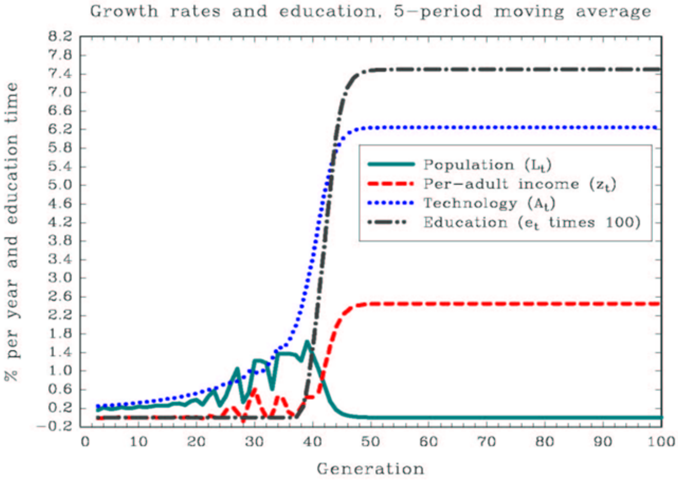


Simulation



Source: Lagerlöf (RED 2006)

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  - Technological progress, human capital & decline in population growth
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  - Technological diffusion
  - Specialization and technological progress via learning by doing
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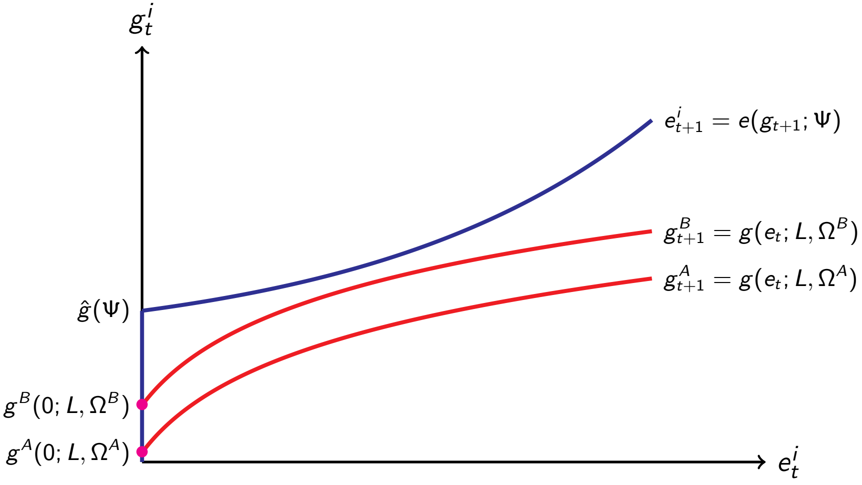
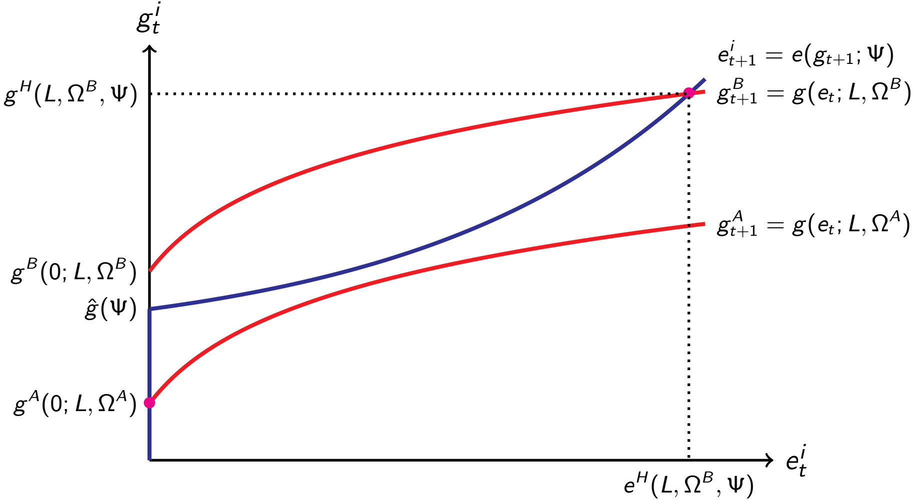


Earlier Take-off in Country B



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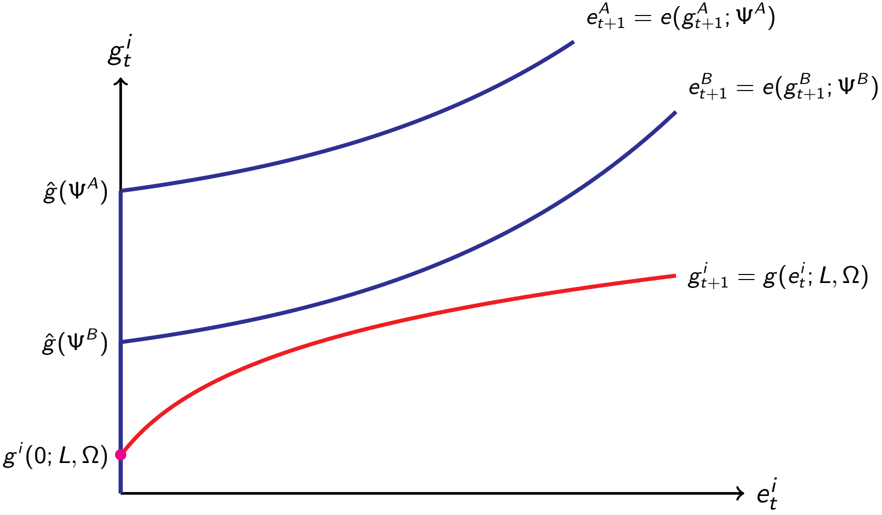

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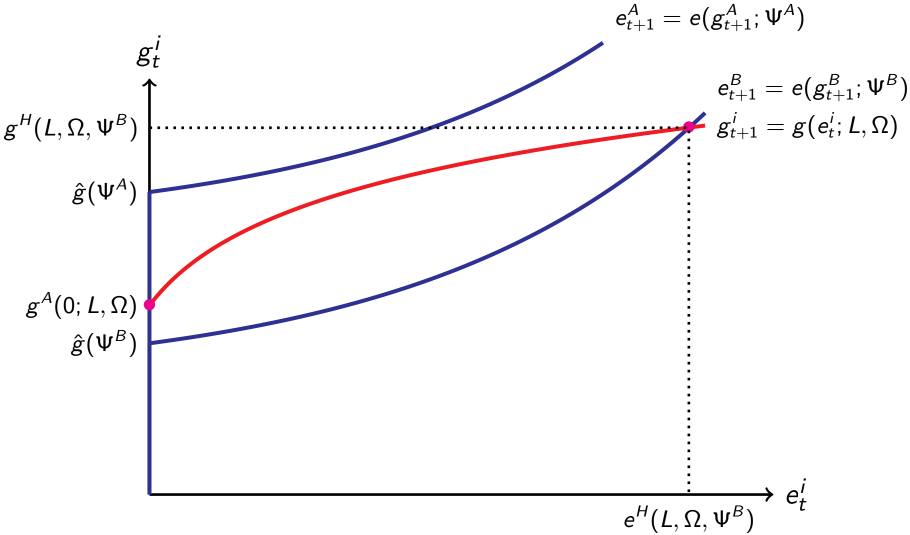

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