

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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 - Existing hypotheses about the role of geographical, cultural, institutional and genetic 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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 - the rate of technological progress

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- Efficiency units of labor evolves endogenously
 - Determined by households' decisions about the number and level of human capital of their children

Main Elements

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

Production

- The output produced in period t

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

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- A_t \equiv technological level
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- $H_t \equiv$ efficiency units of labor
 - $A_t \equiv$ technological level
 - $X \equiv$ land
- 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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- Long-run (population reaches a new steady-state):
 - $L_t \uparrow \implies y \downarrow$ (back to \bar{y})

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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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Technological Progress

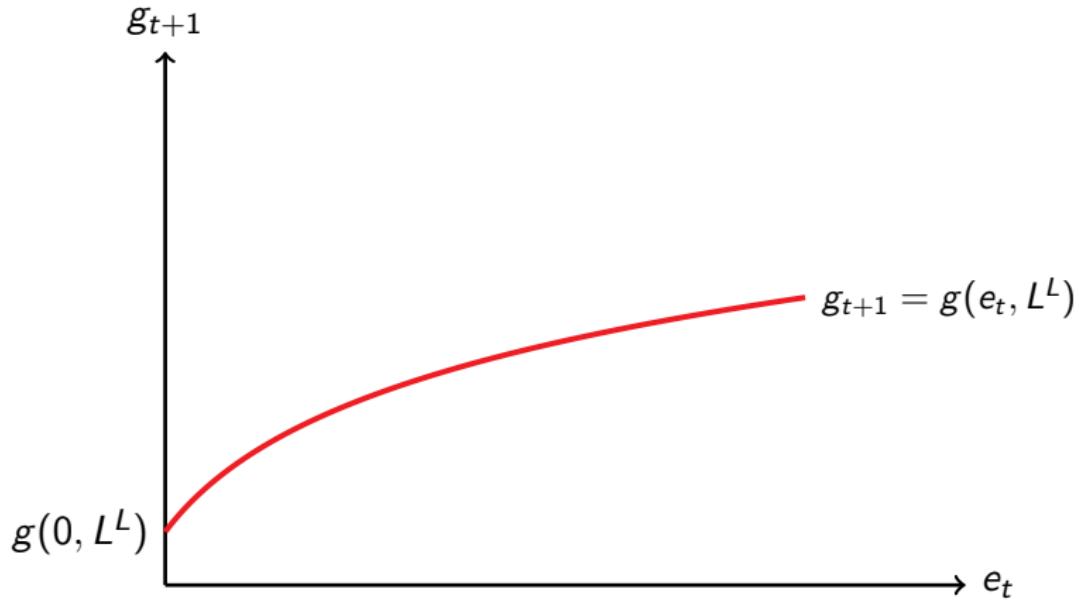
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 - The scale of the economy has a positive and diminishing effect on technological progress
- $g(0, L) > 0$ for $L > 0$
 - Technological progress is positive at the outset

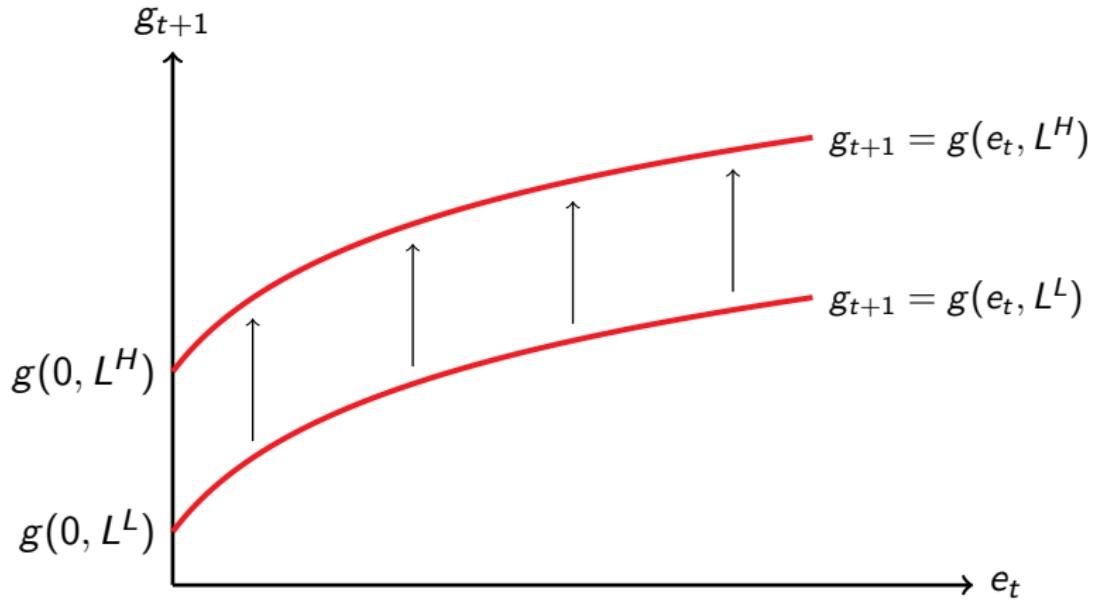
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The Effect of Population Size on Technological Progress



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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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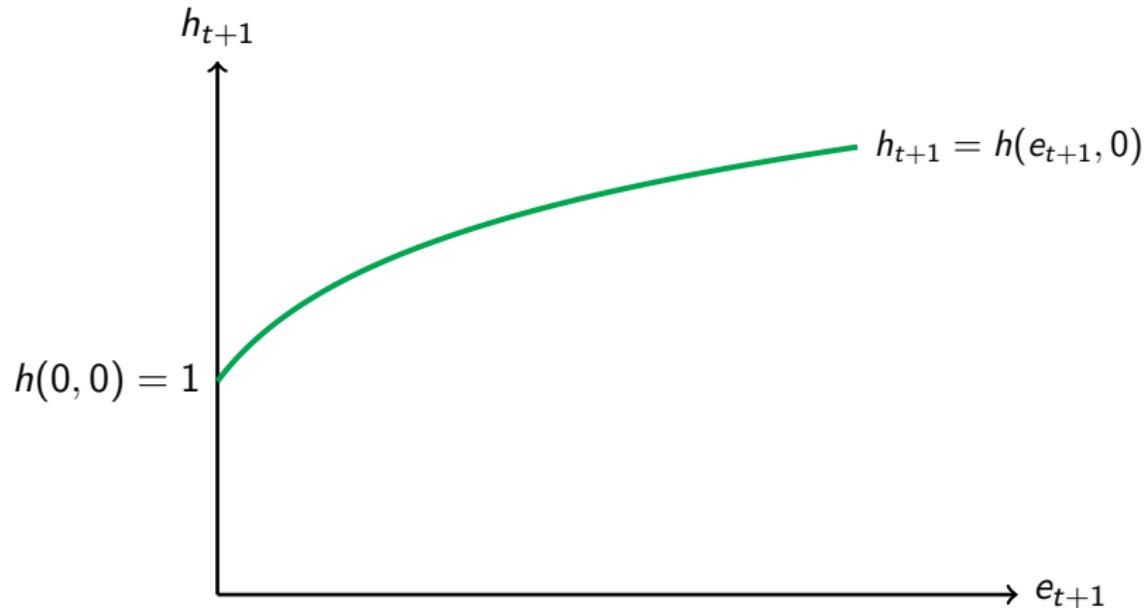
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- $h(0, g) > 0$
 - Basic level of human capital

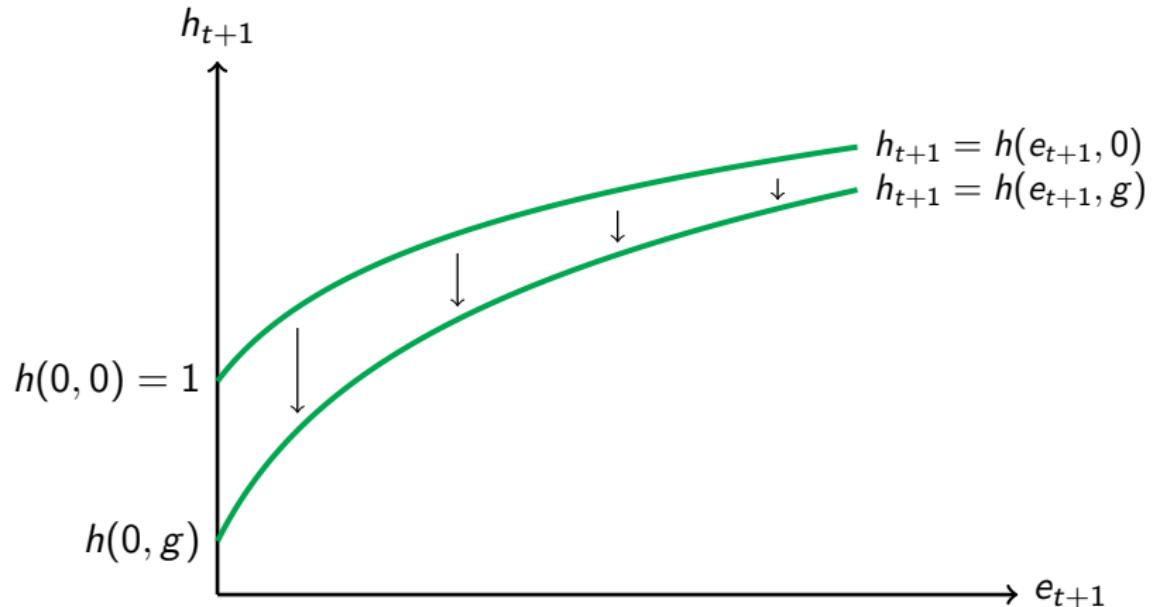
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Effect of Technological Progress on Human Capital Formation



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- Later part of the second phase of industrialization:
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 - Population growth declines & human capital formation increases further

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 - Consume a fraction of parental time endowment
 - The required time increases with child quality
 - $\tau \equiv$ 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):
 - 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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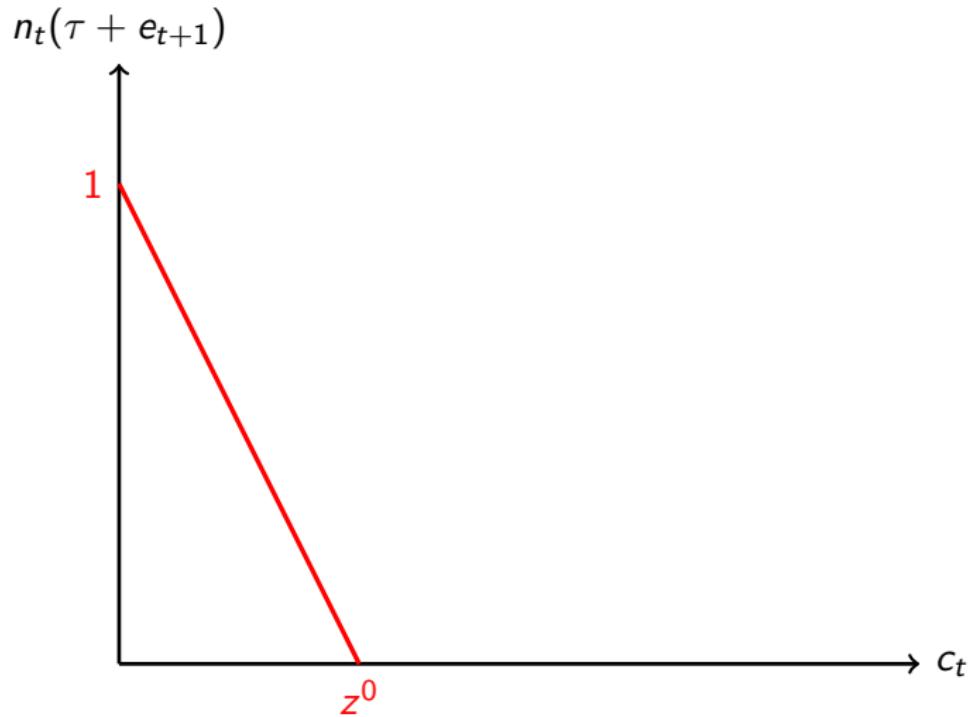
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$$z_t \equiv y_t = h_t^\alpha x_t^{1-\alpha} = z(e_t, g_t, x_t)$$

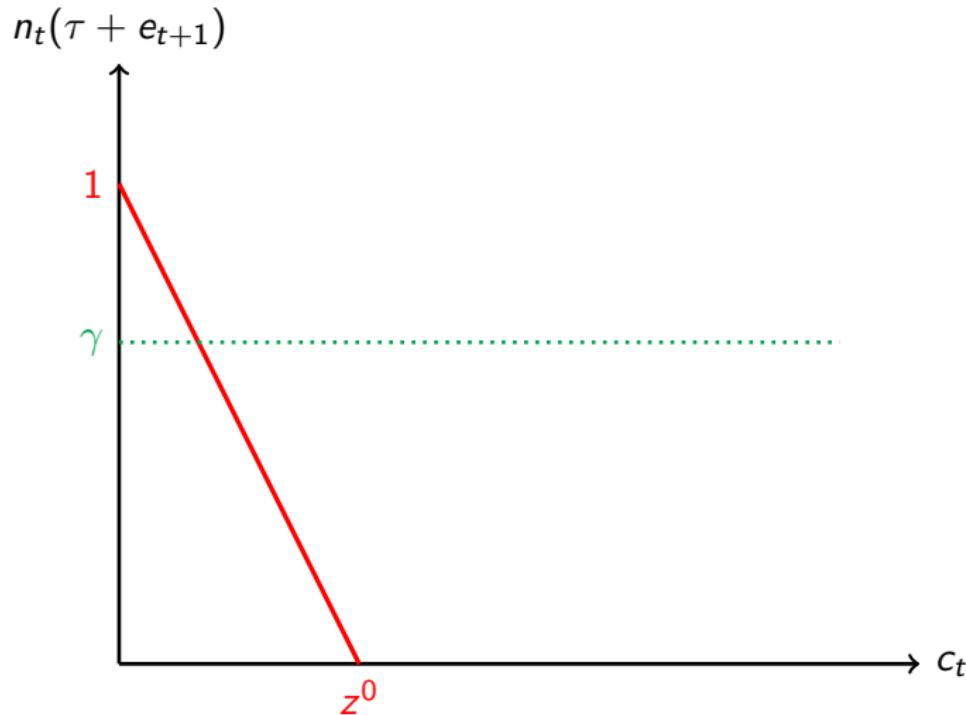
- Subsistence consumption constraint:

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

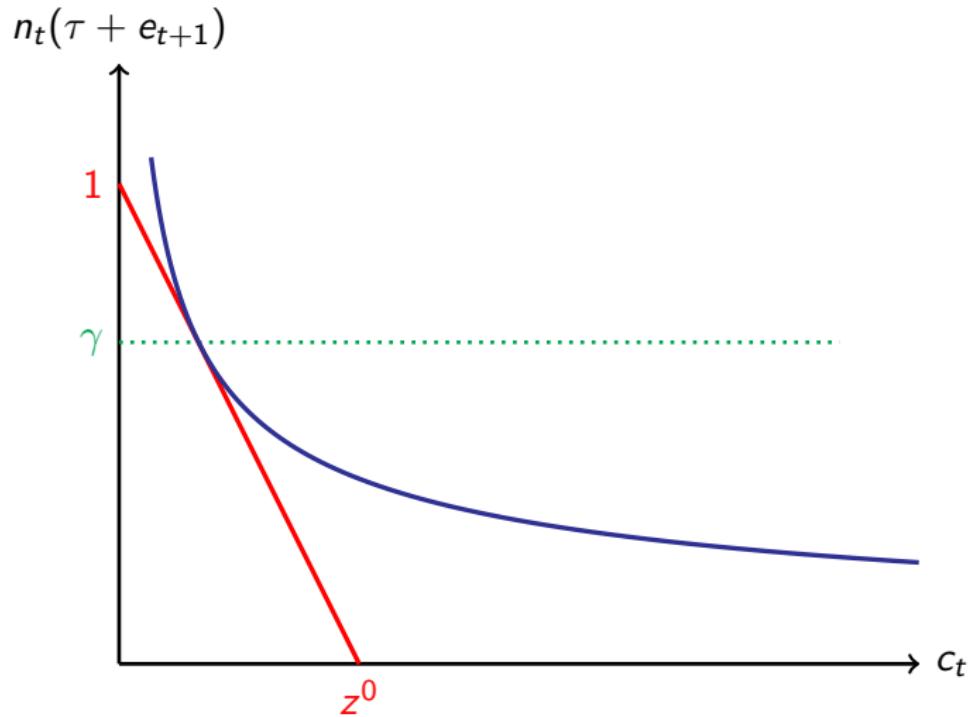
Constraint and Optimization



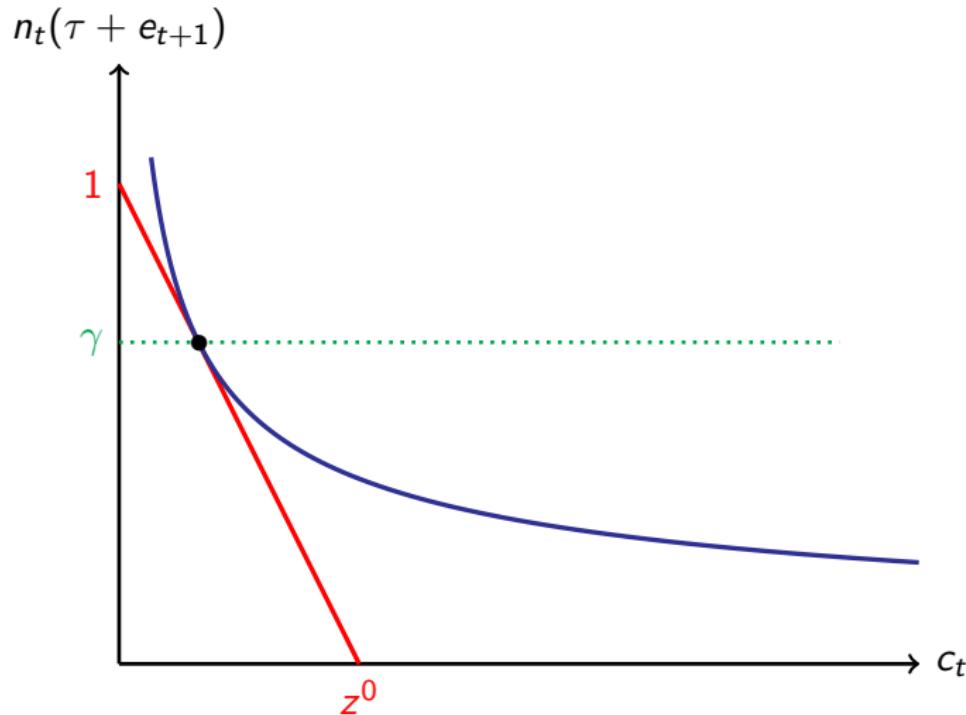
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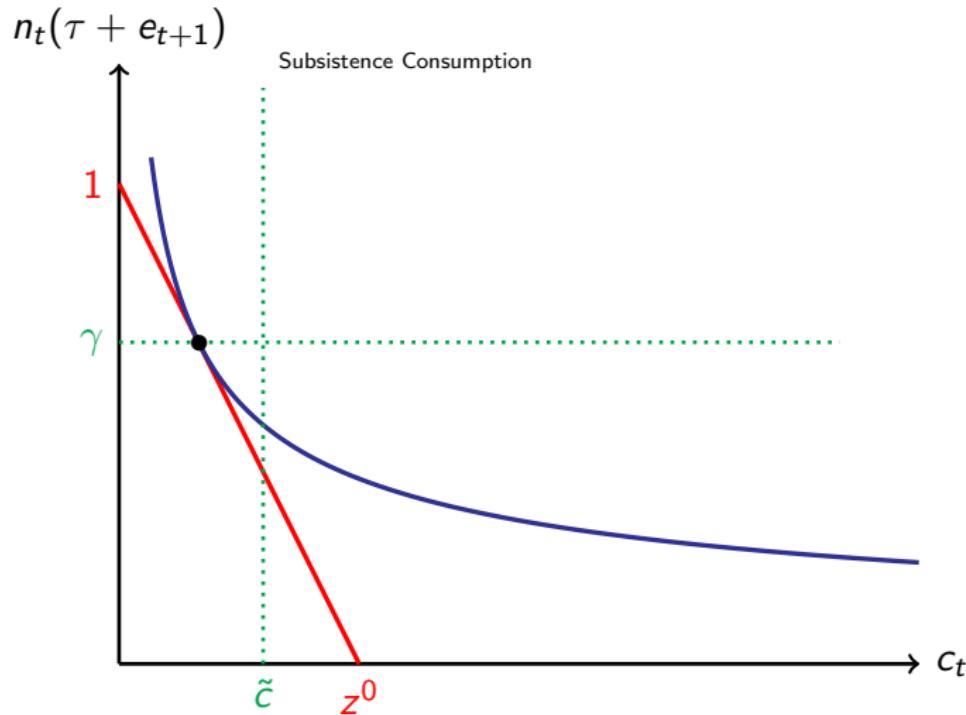
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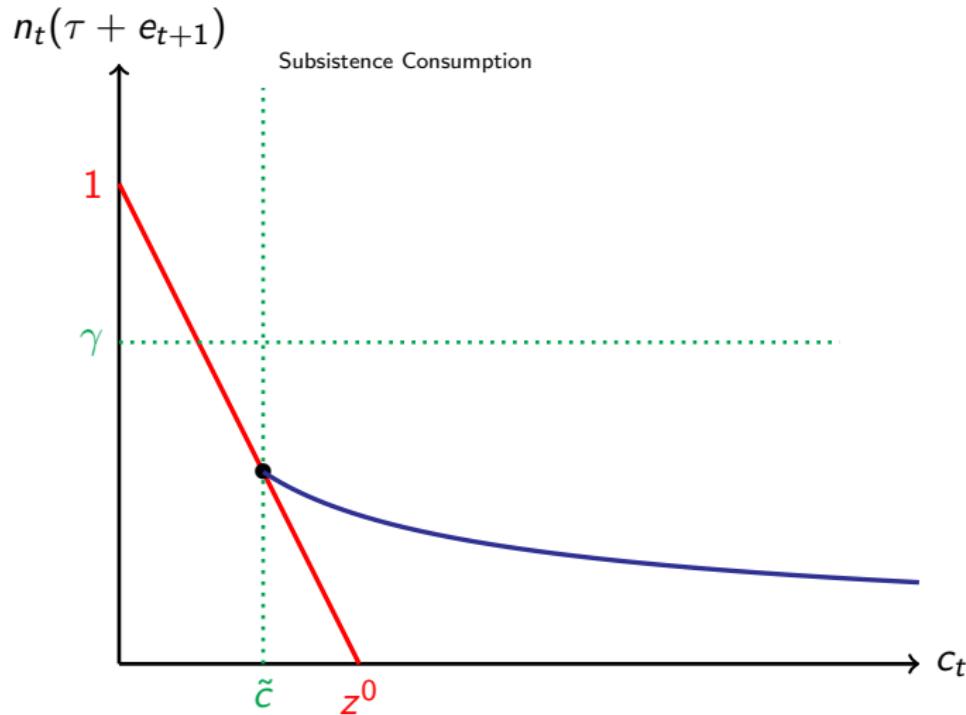
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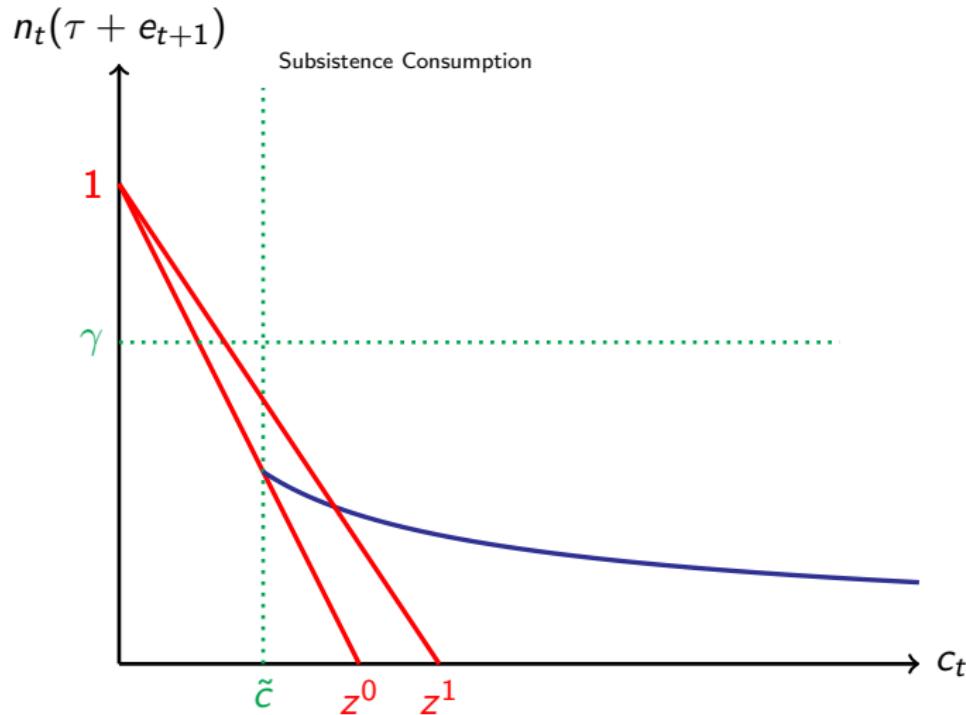
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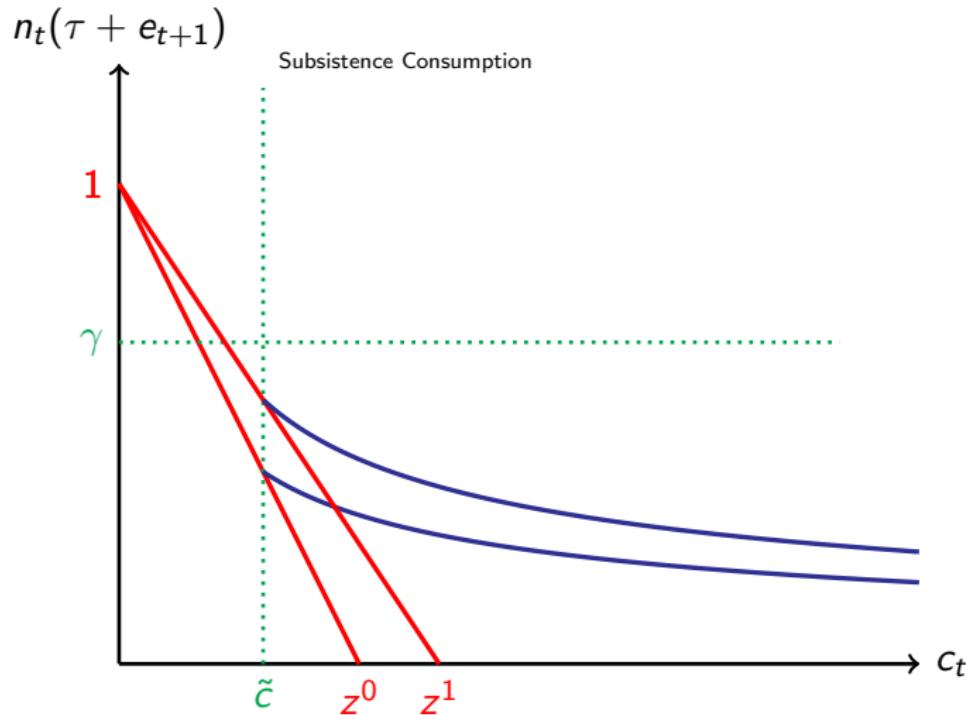
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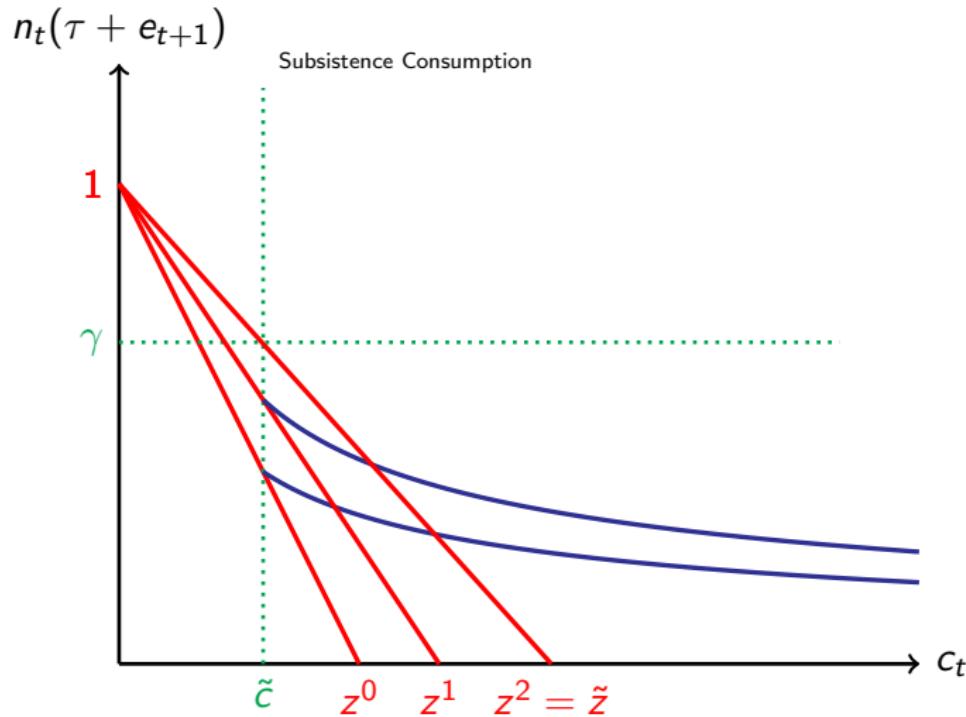
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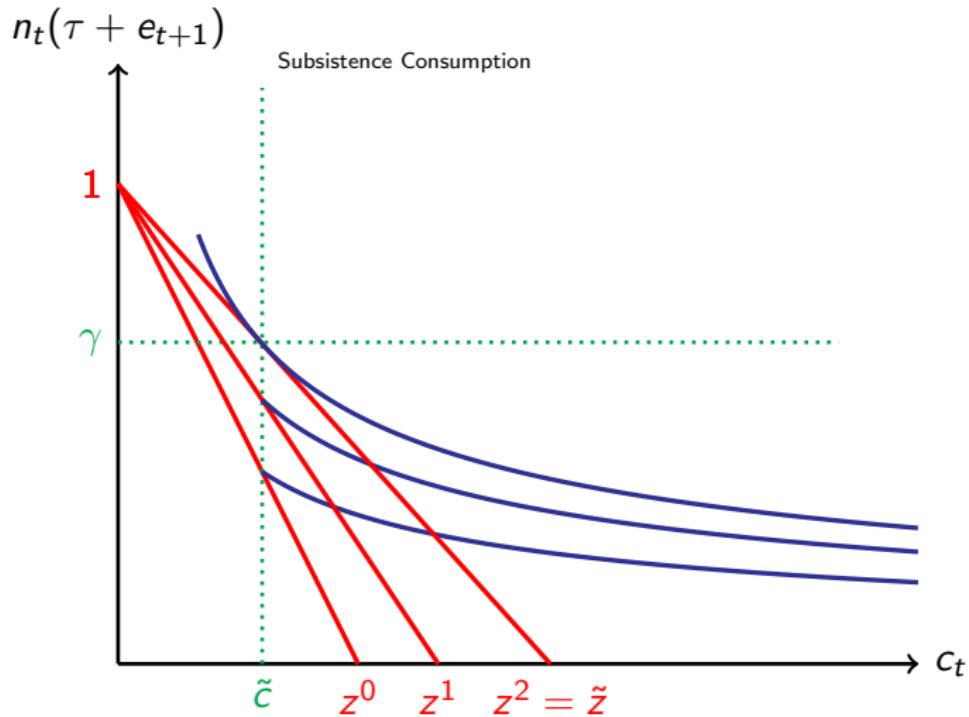
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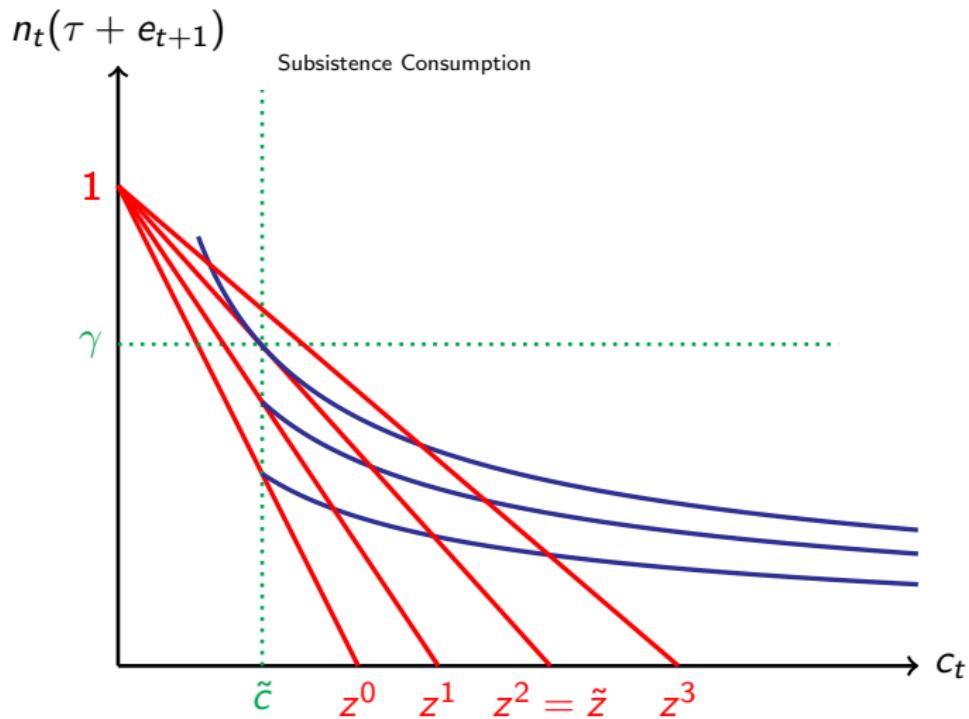
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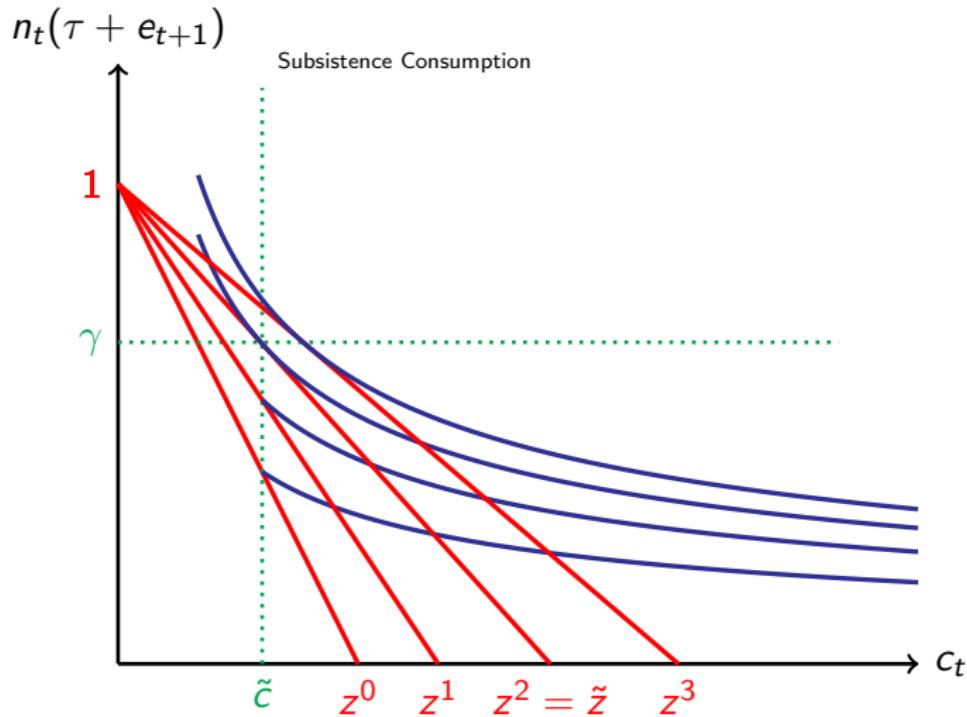
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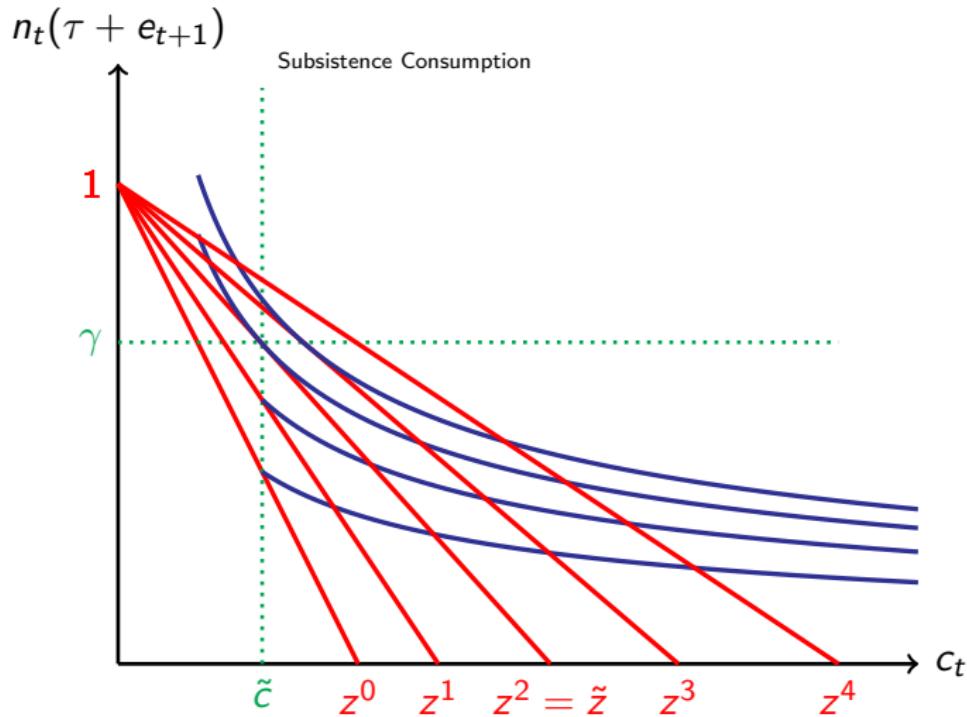
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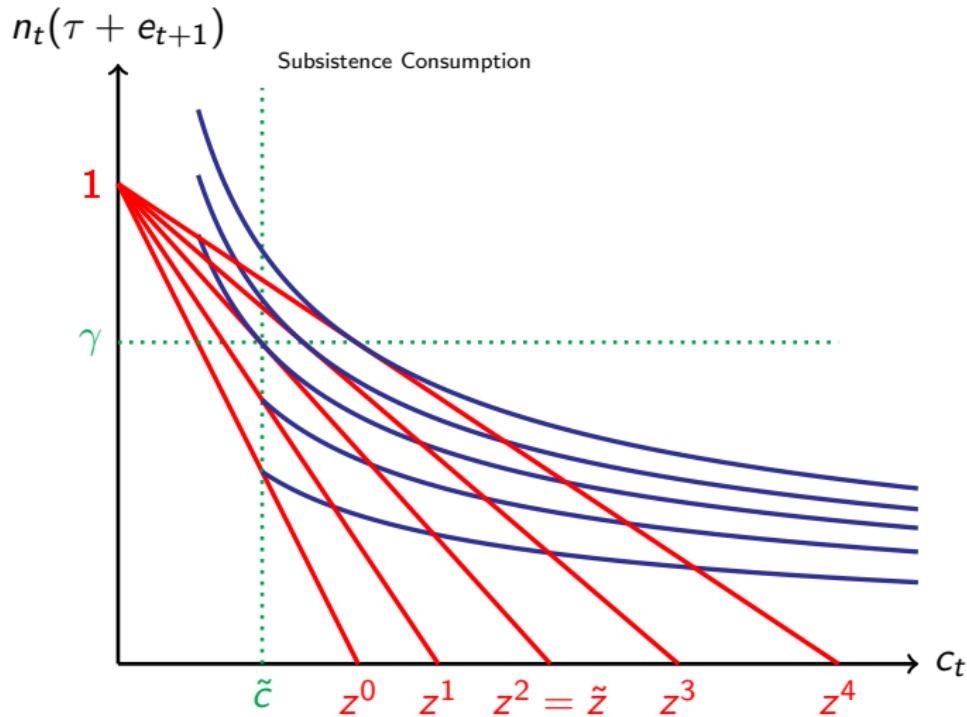
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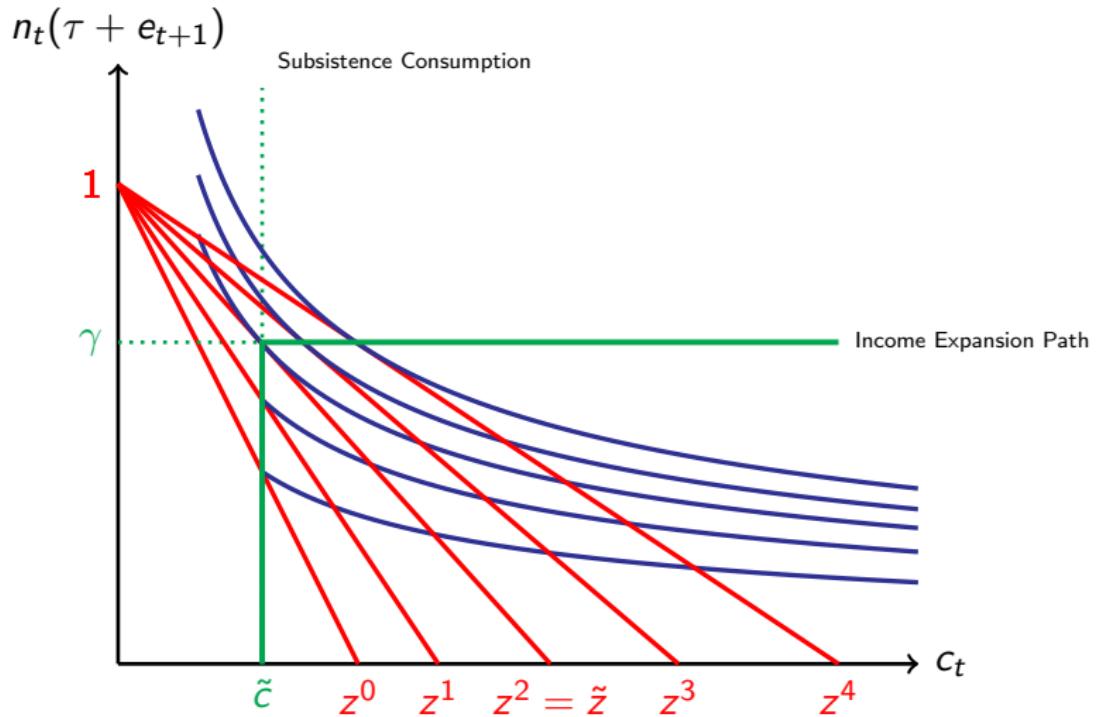
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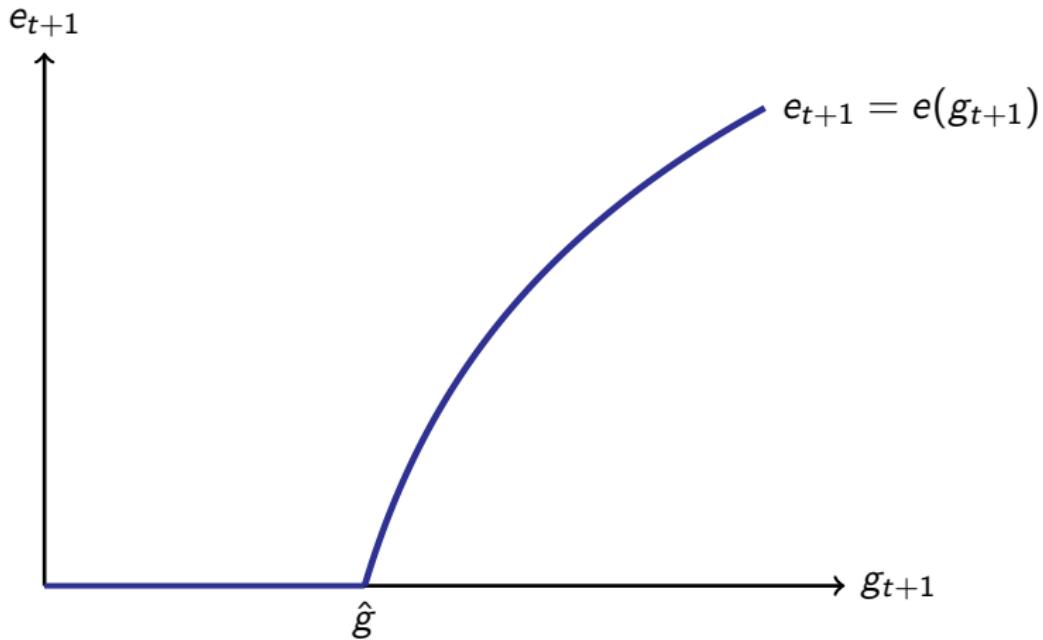
Constraint and Optimization



Optimal Investment in Child Quality



Optimal Investment in Child Quality



Optimization: Quantity and Quality of Children

- Time devoted to children:

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

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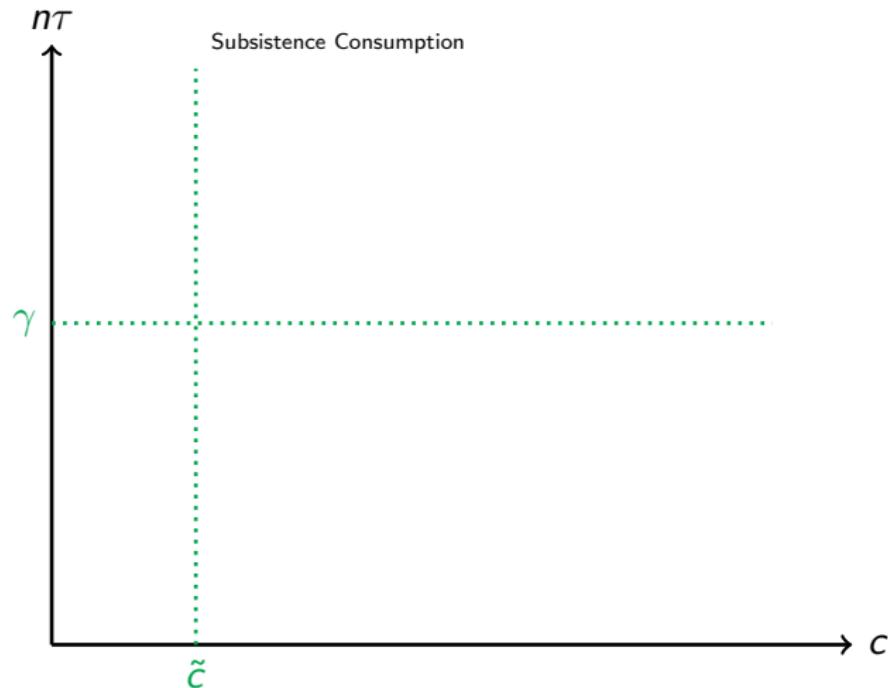
$$e_{t+1} = e(g_{t+1}) \implies$$

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

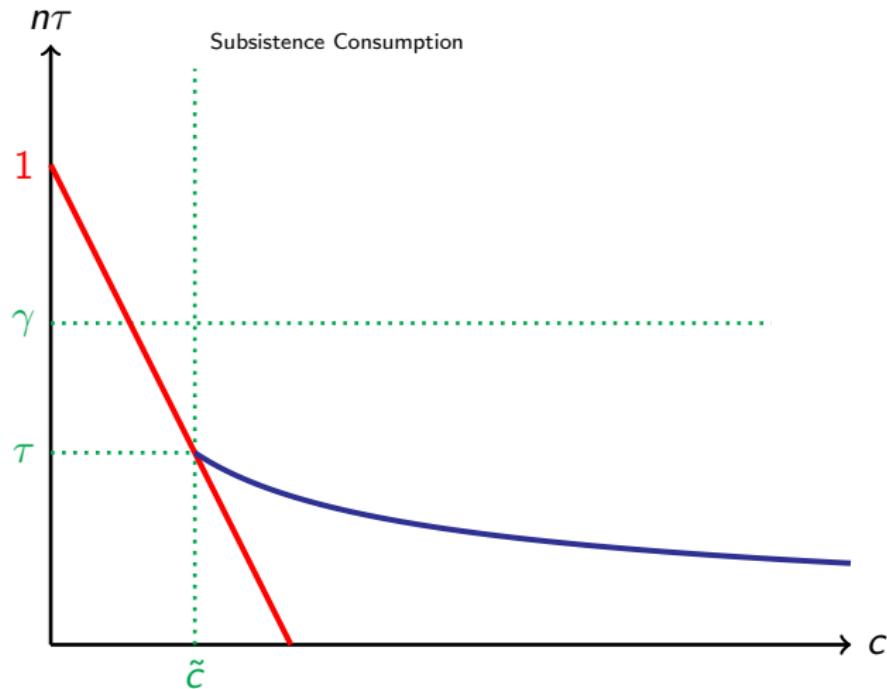
Malthusian Epoch



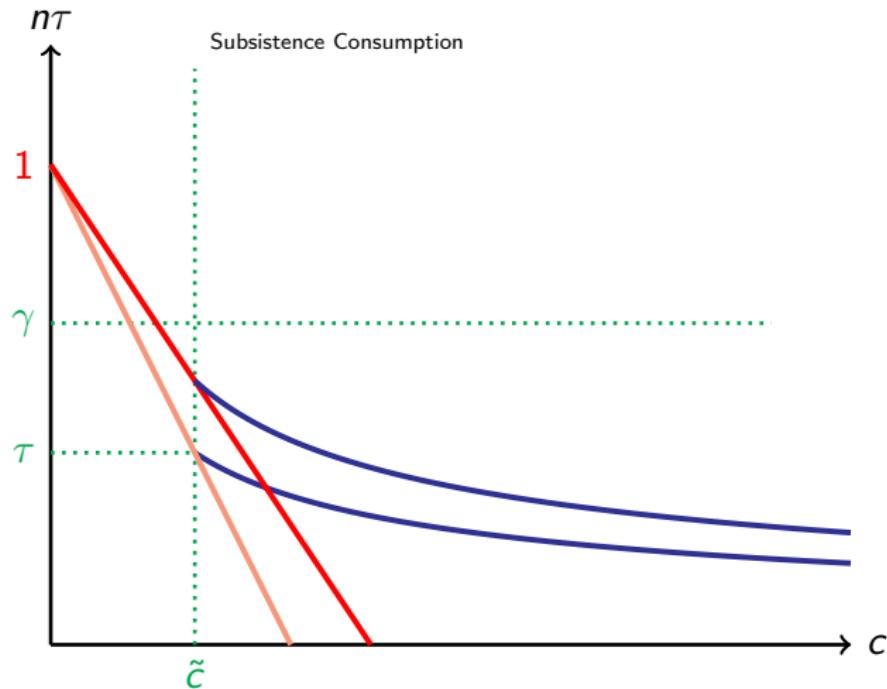
Malthusian Epoch



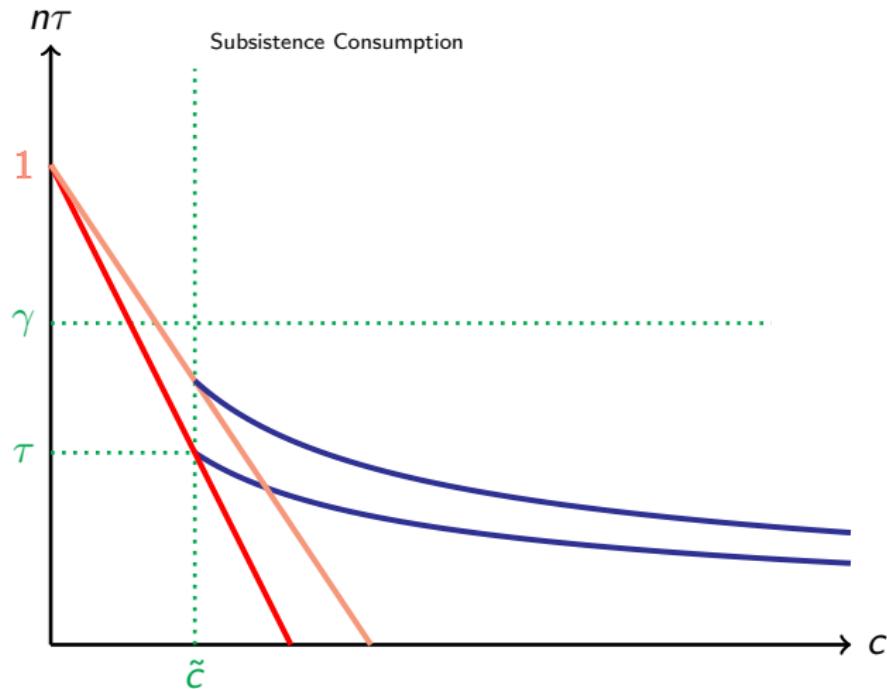
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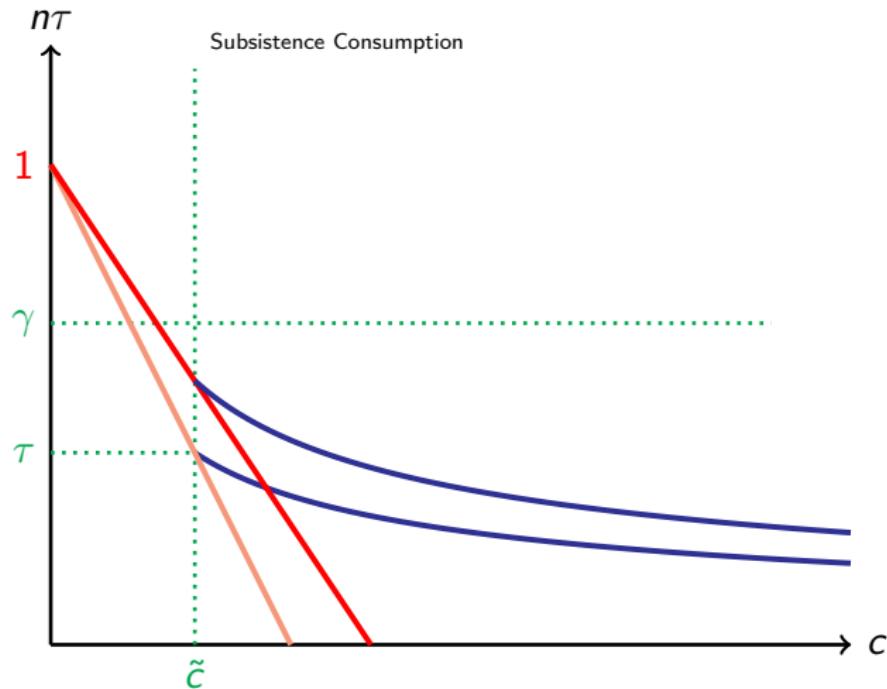
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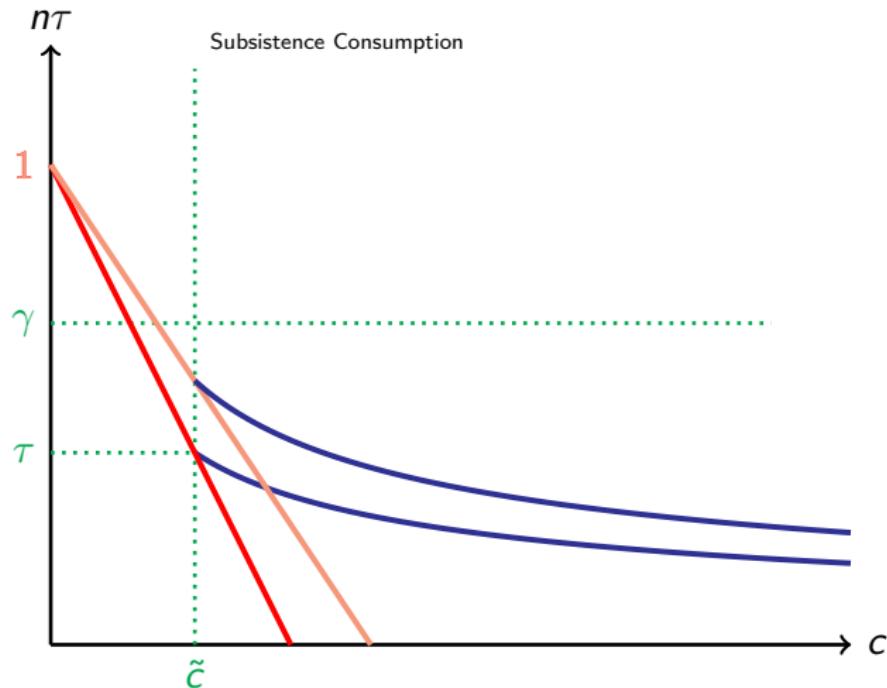
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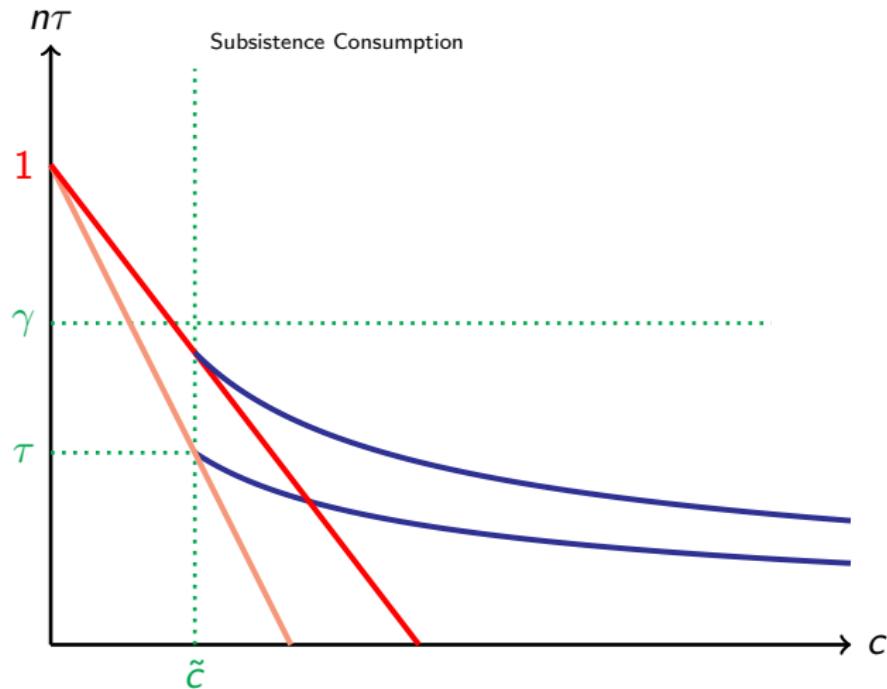
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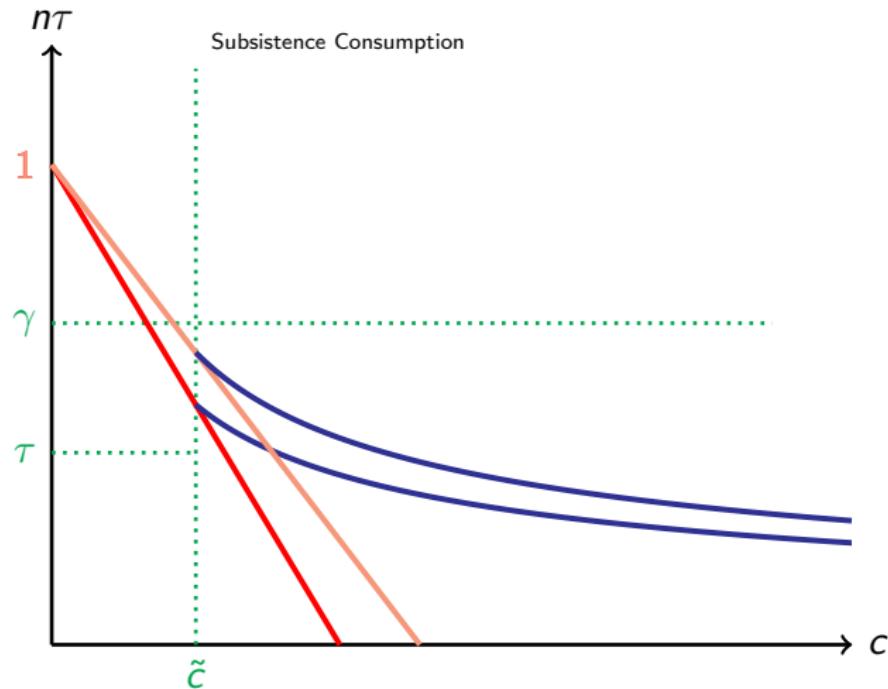
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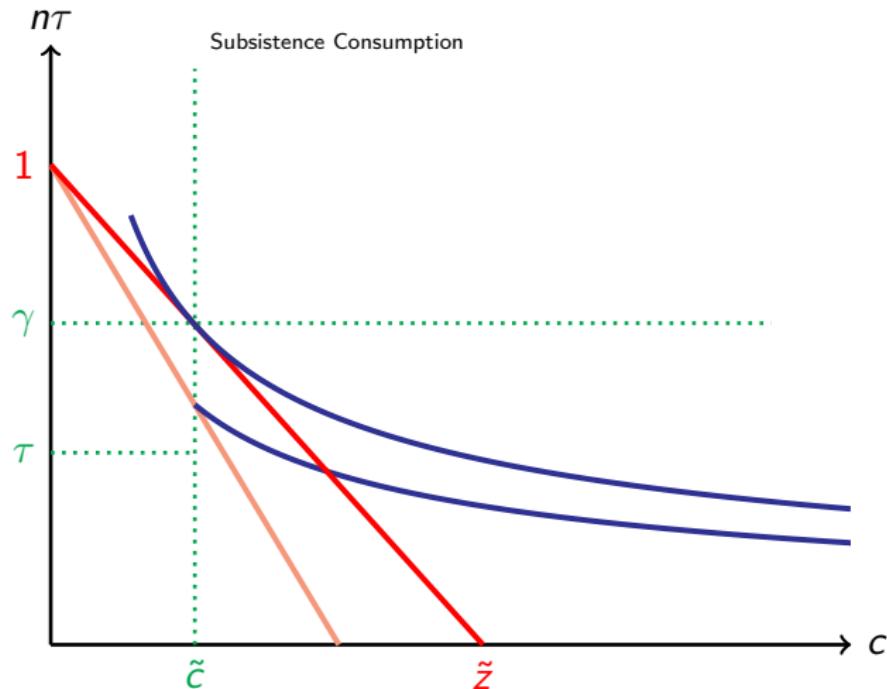
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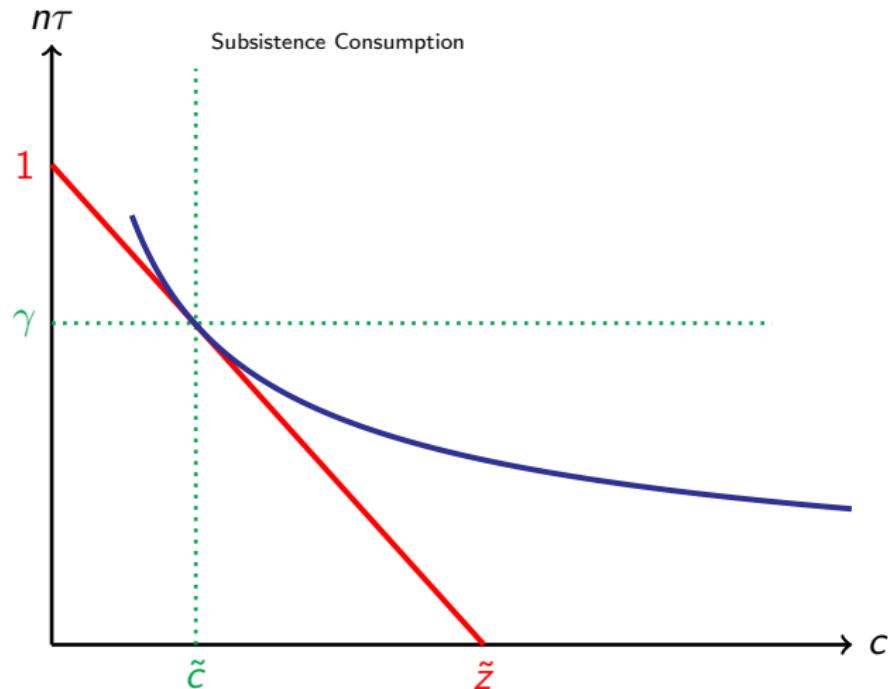
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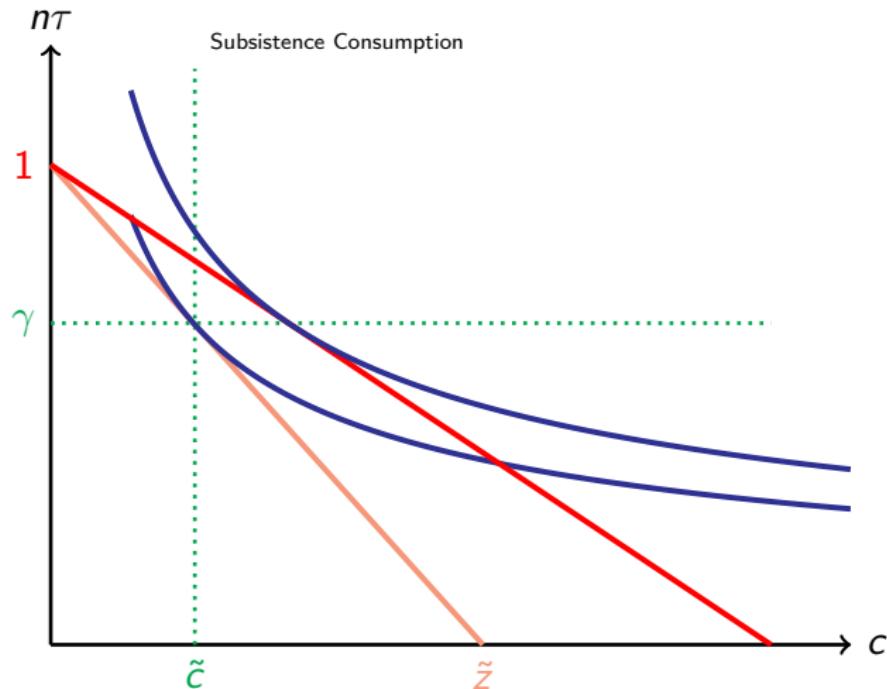
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Post-Demographic Transition



Post-Demographic Transition



Population Dynamics

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

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

Dynamics of the Level of Resources per Worker

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

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

The Dynamical System

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

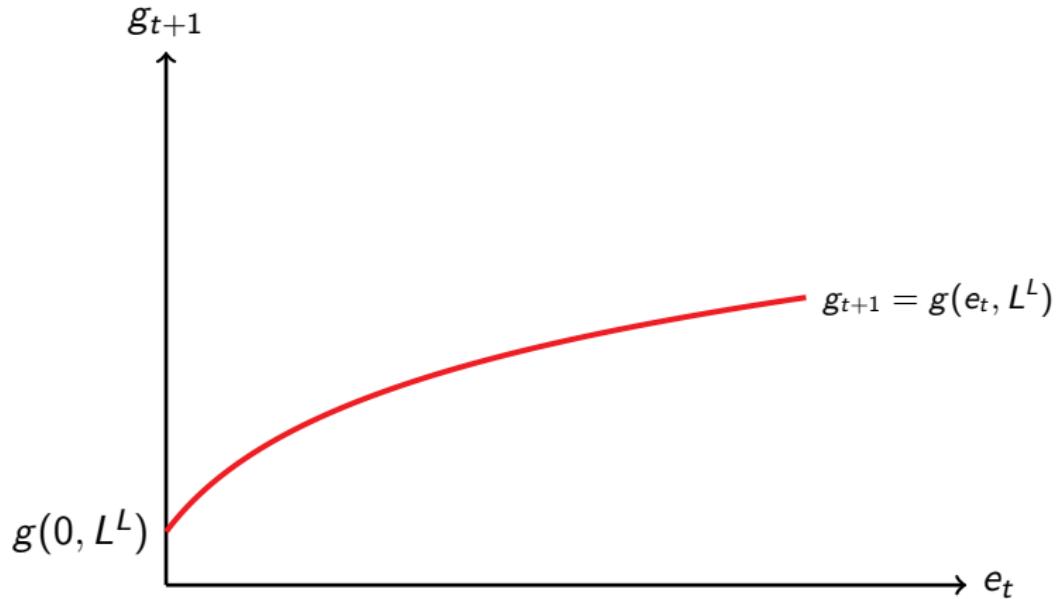
$$\begin{cases} x_{t+1} = \phi(e_t, g_t, x_t, L_t)x_t \\ e_{t+1} = e(g(e_t, L_t)) \\ g_{t+1} = g(e_t, L_t) \\ L_{t+1} = n(e_t, g_t, x_t, L_t)L_t \end{cases}$$

The Conditional Evolution of Technology and Education

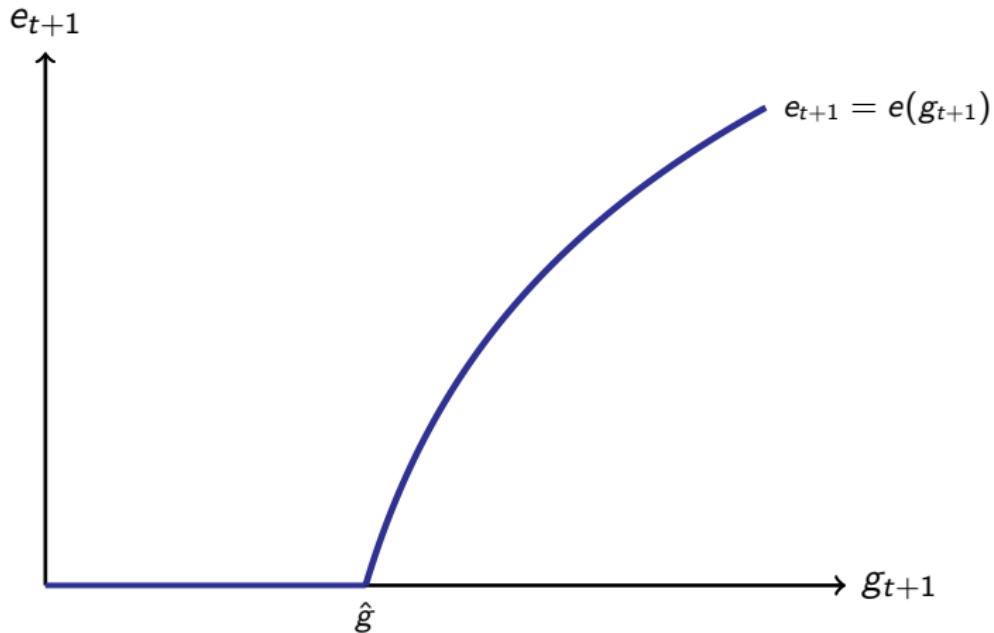
A sequence $\{g_t, e_t; L\}_{t=0}^{\infty}$ such that:

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

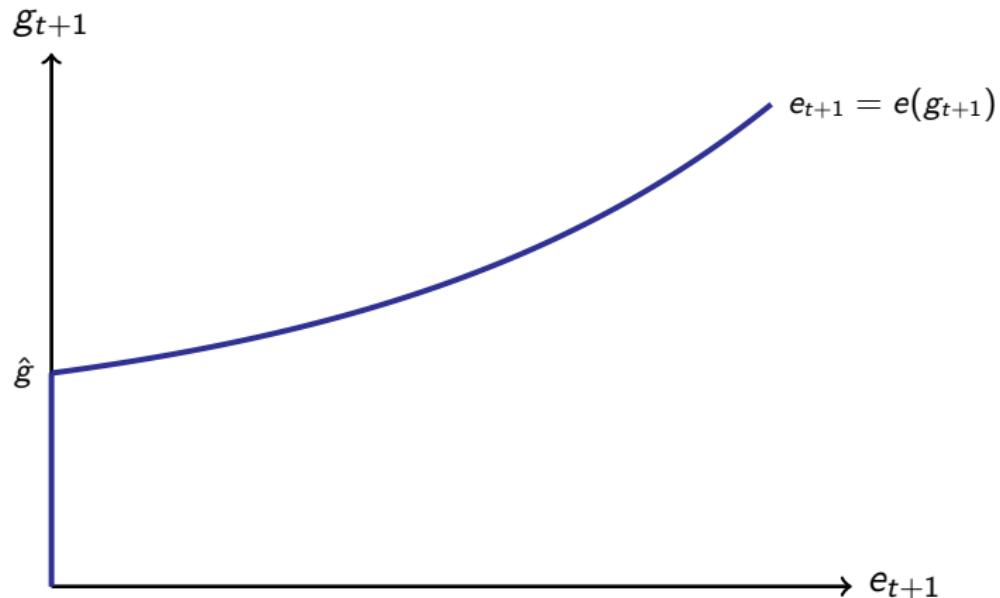
The Effect of Education on Technology



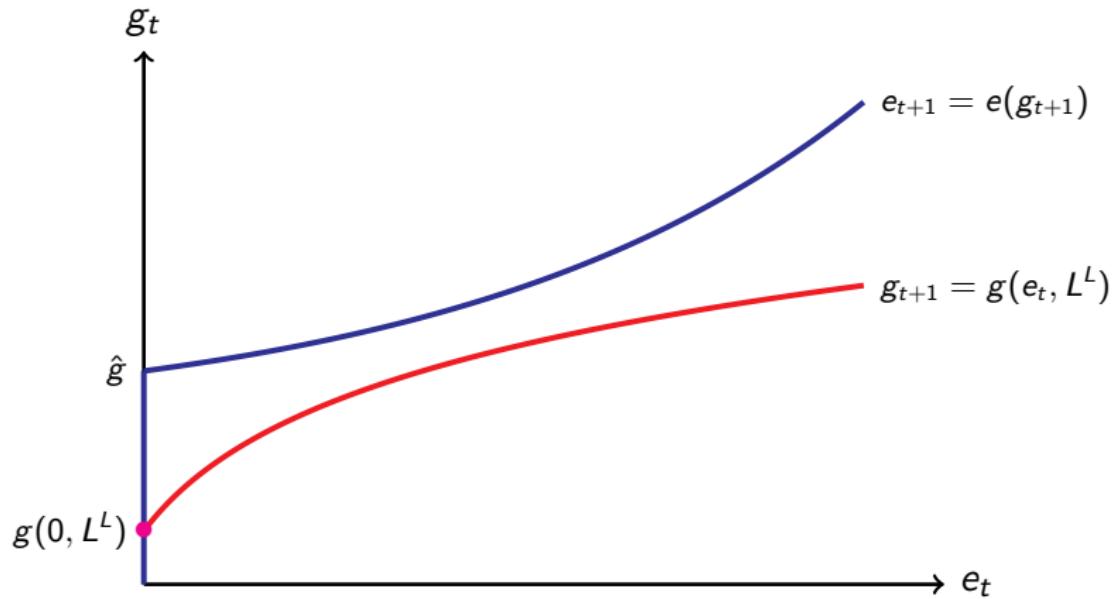
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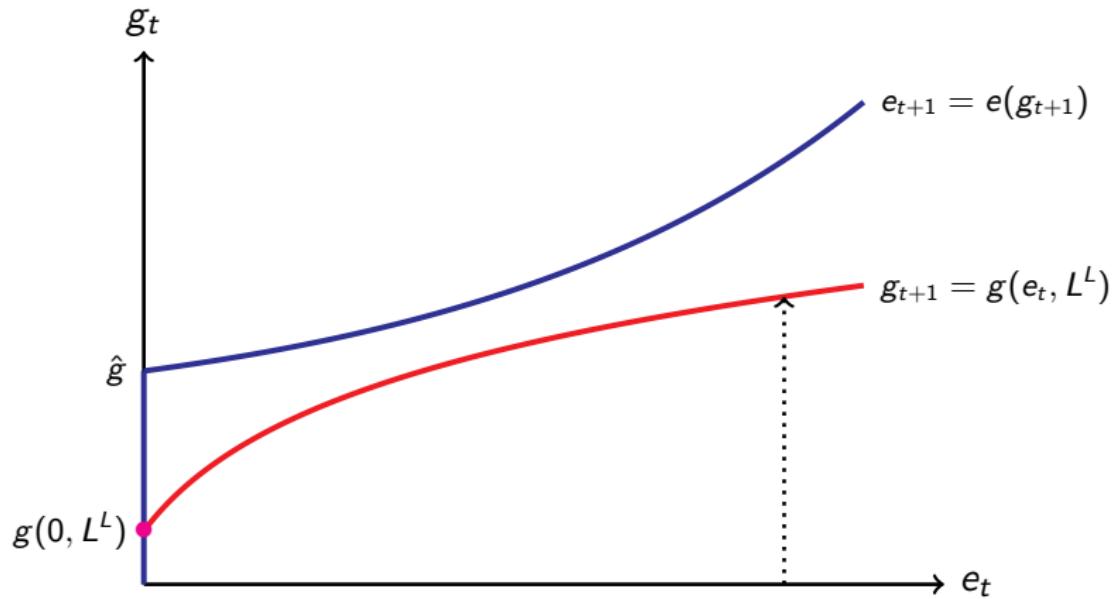
The Effect of Technology on Education: Flipped Axis



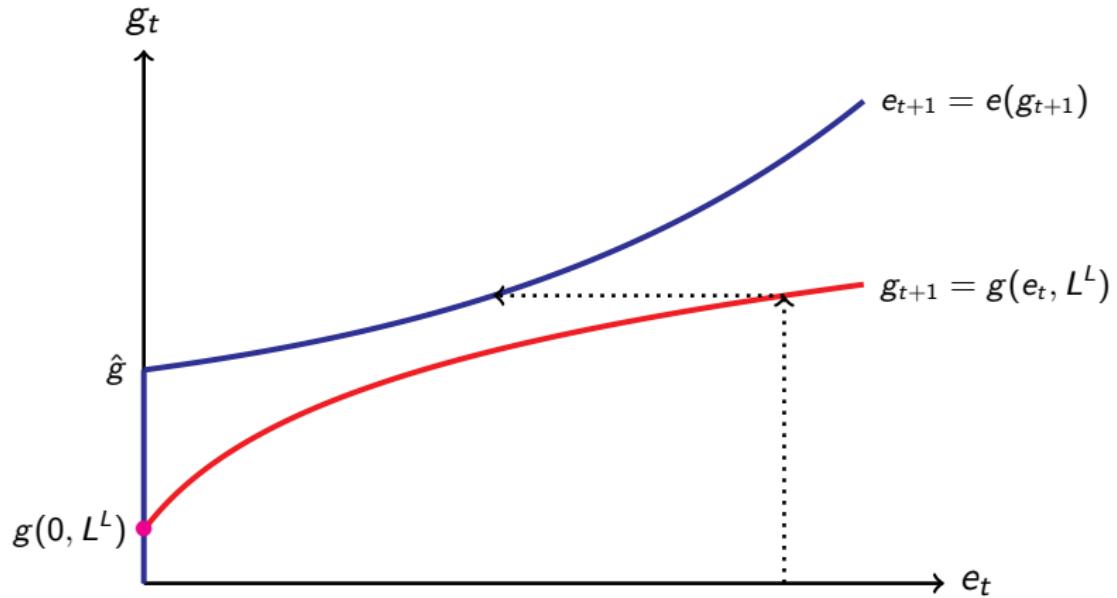
The Evolution of Education and Technology: For a Given Population Size



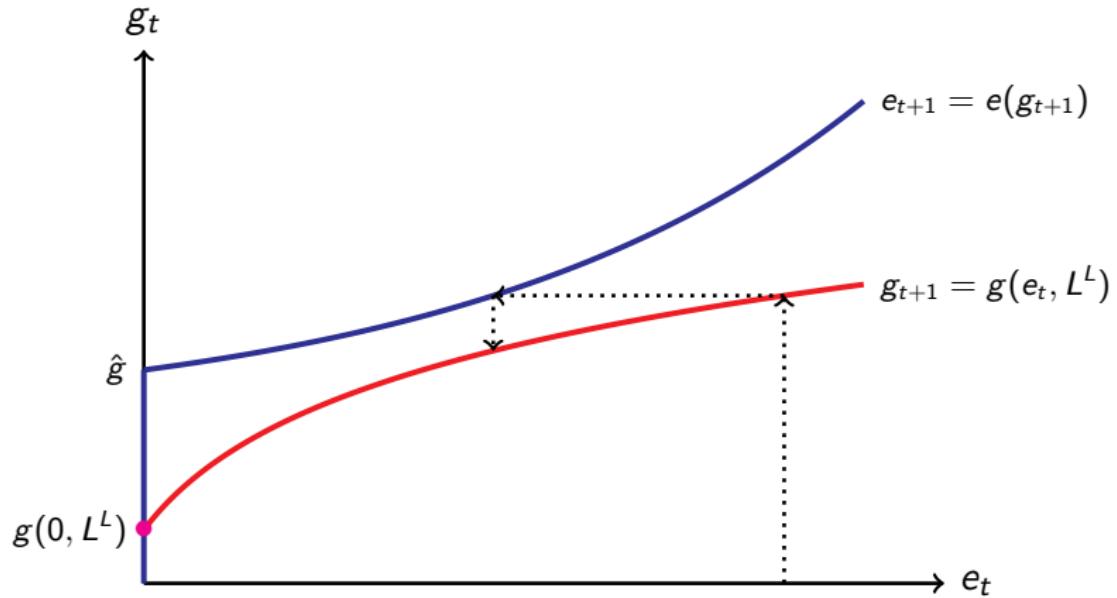
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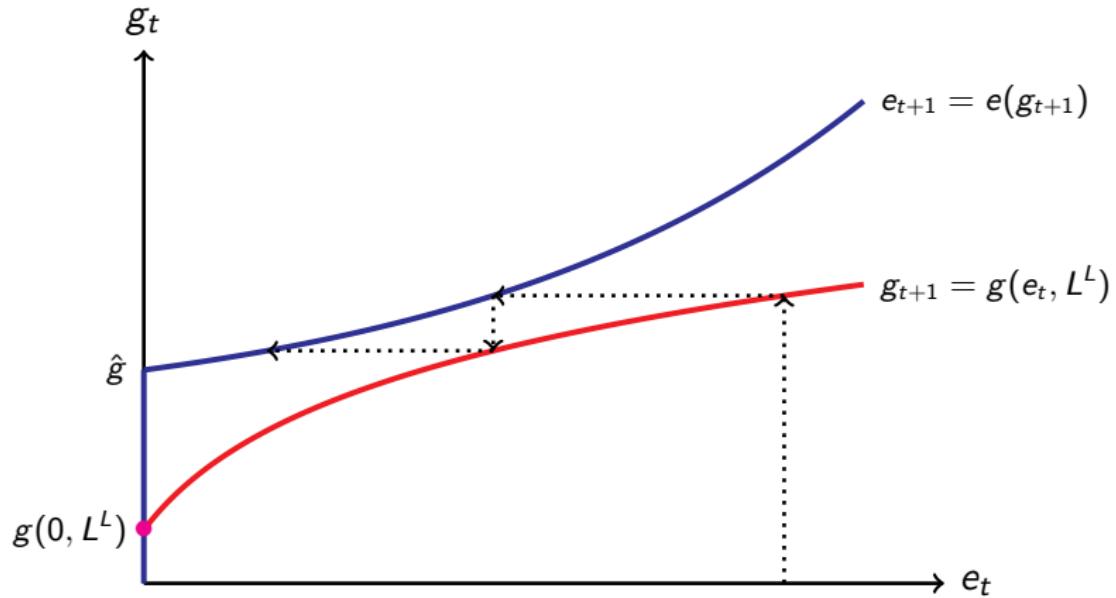
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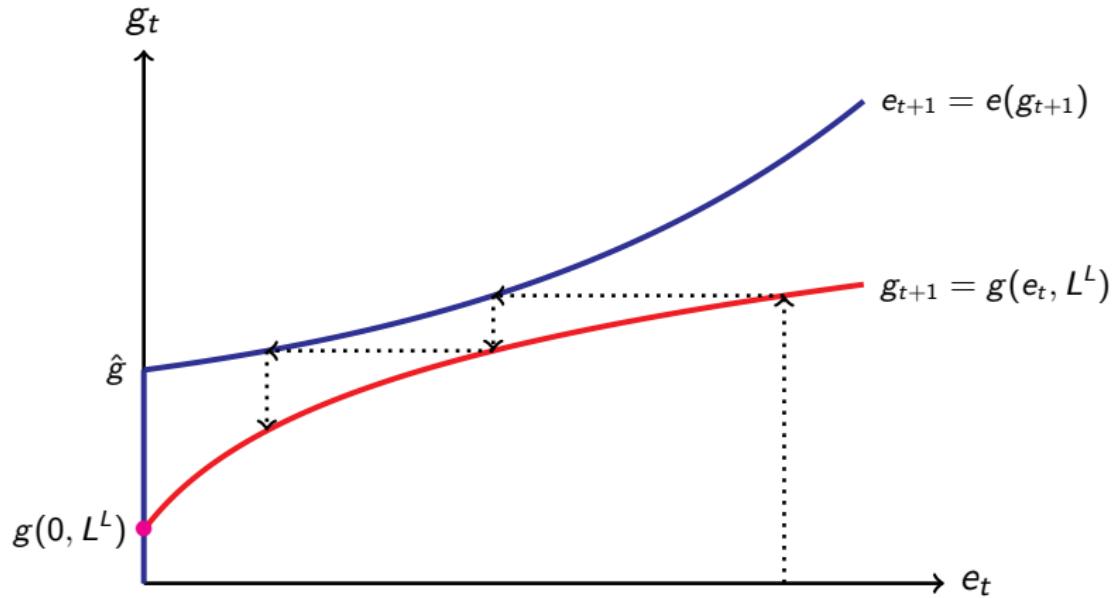
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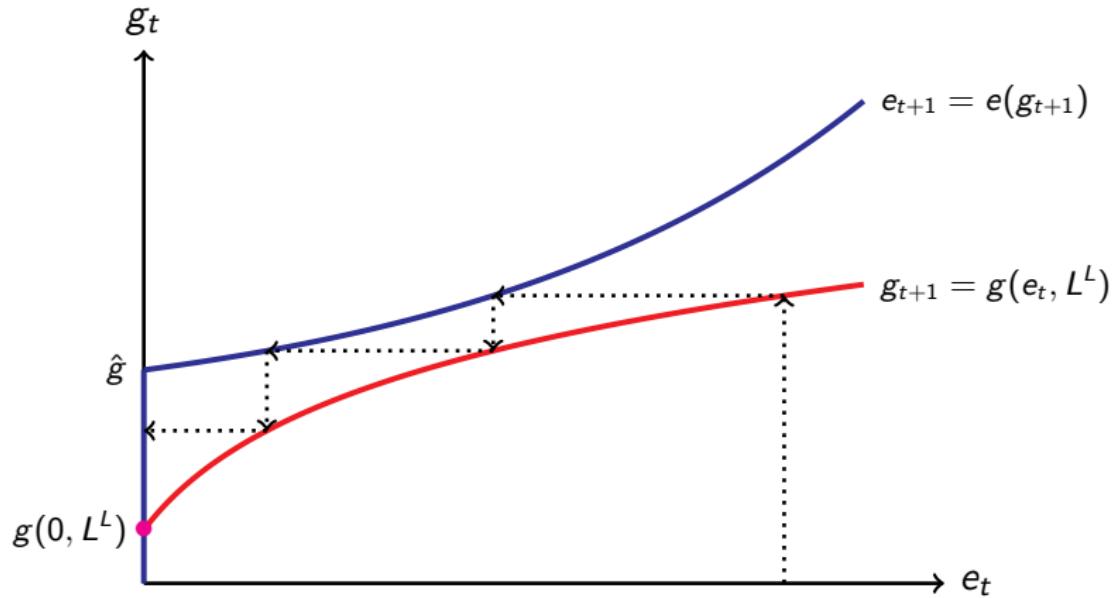
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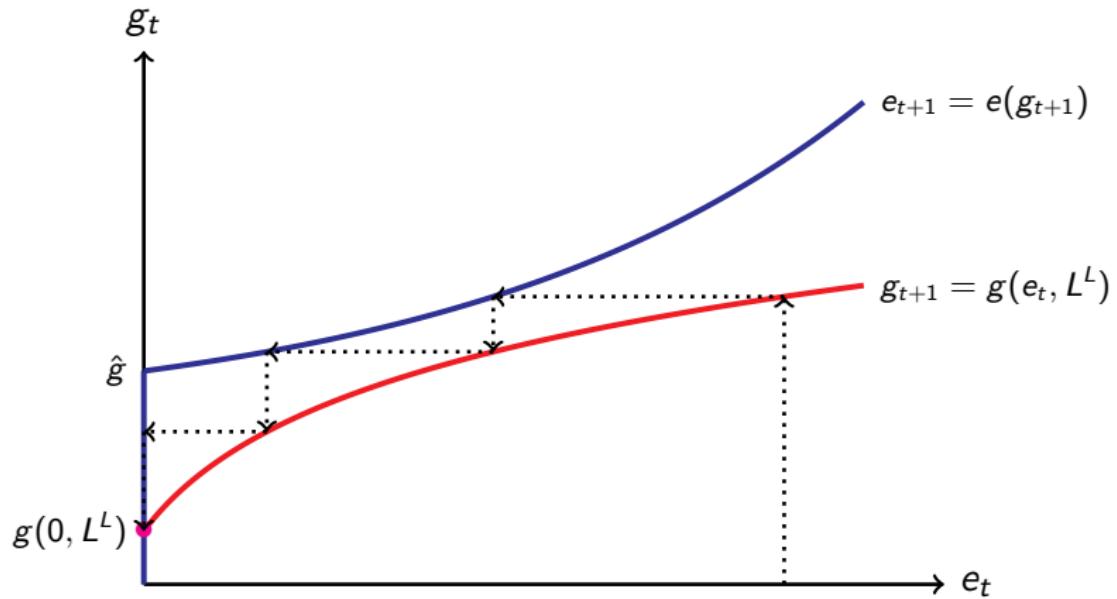
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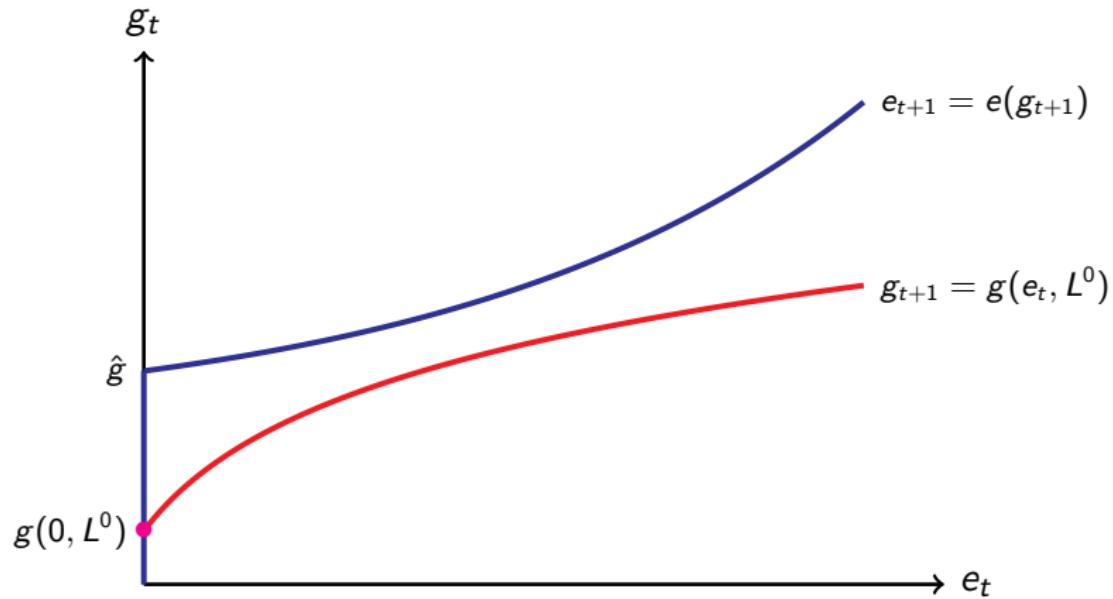
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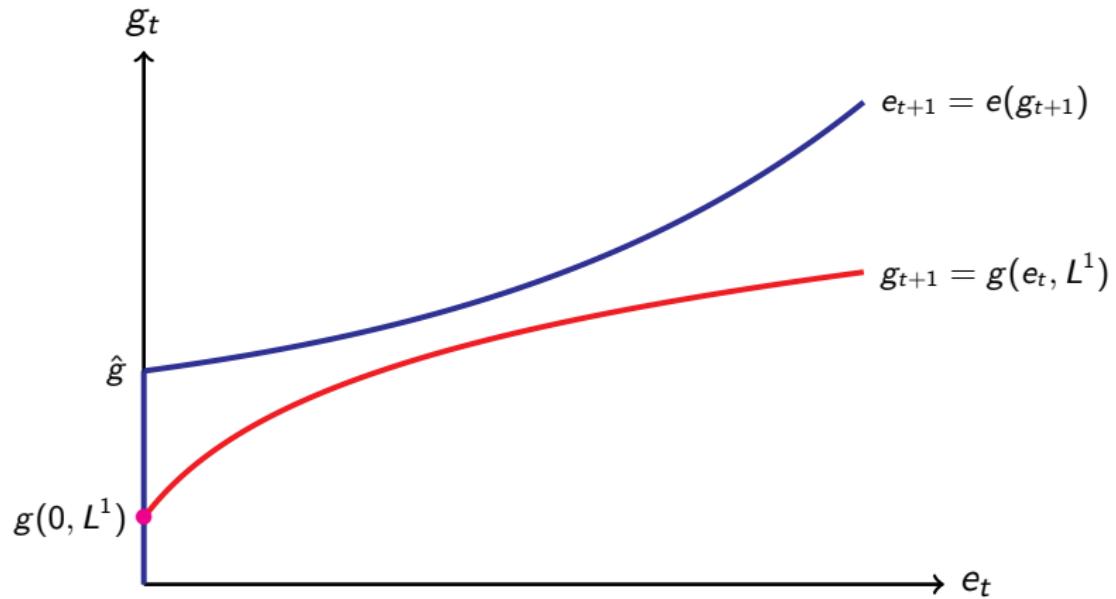
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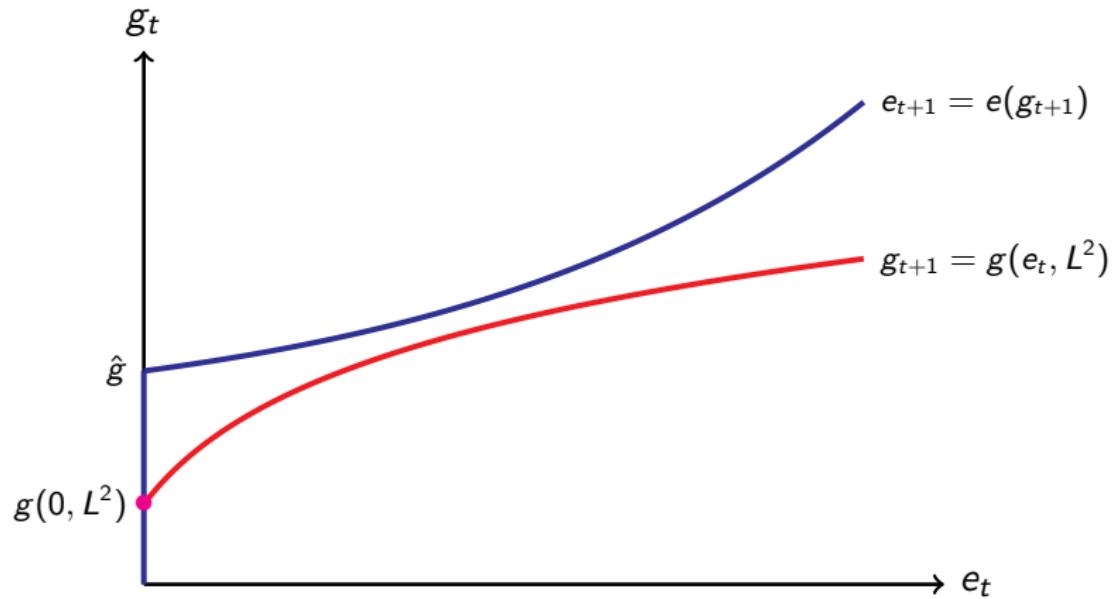
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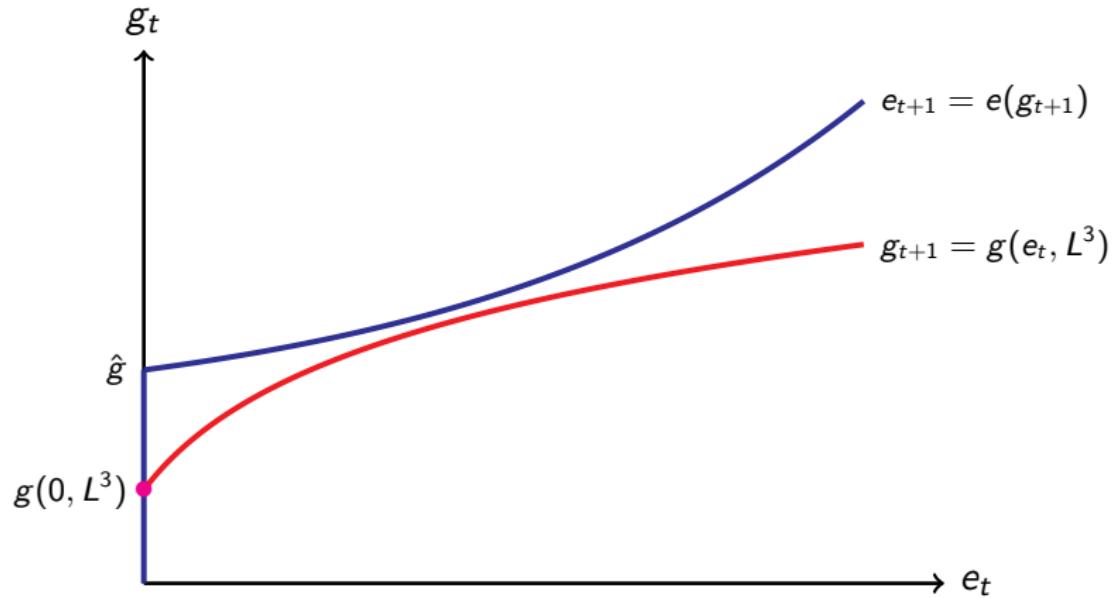
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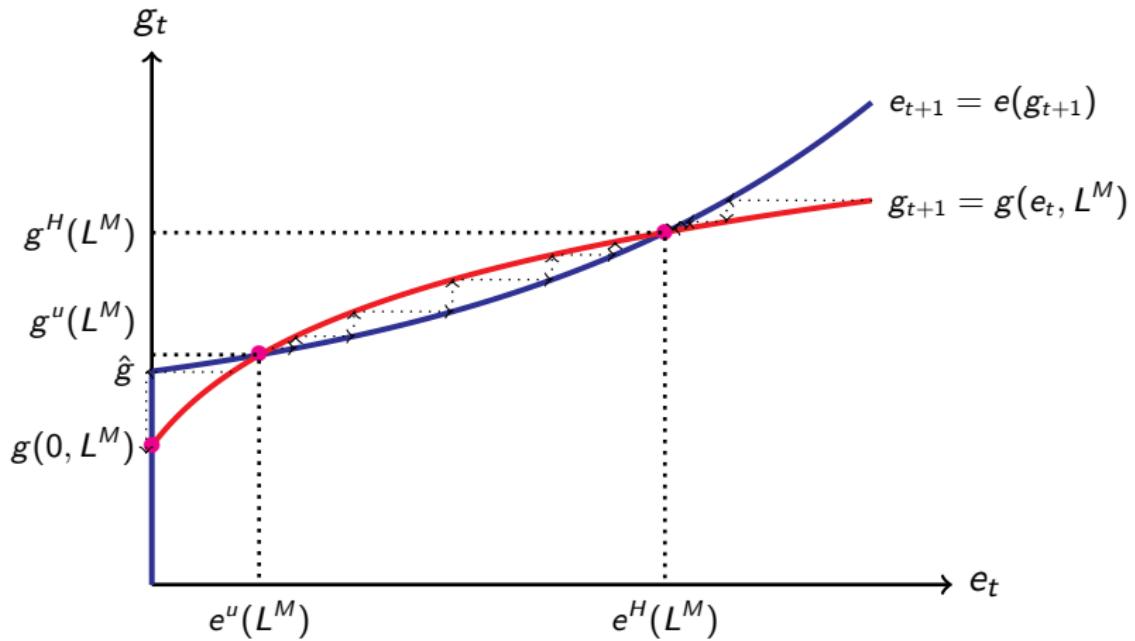
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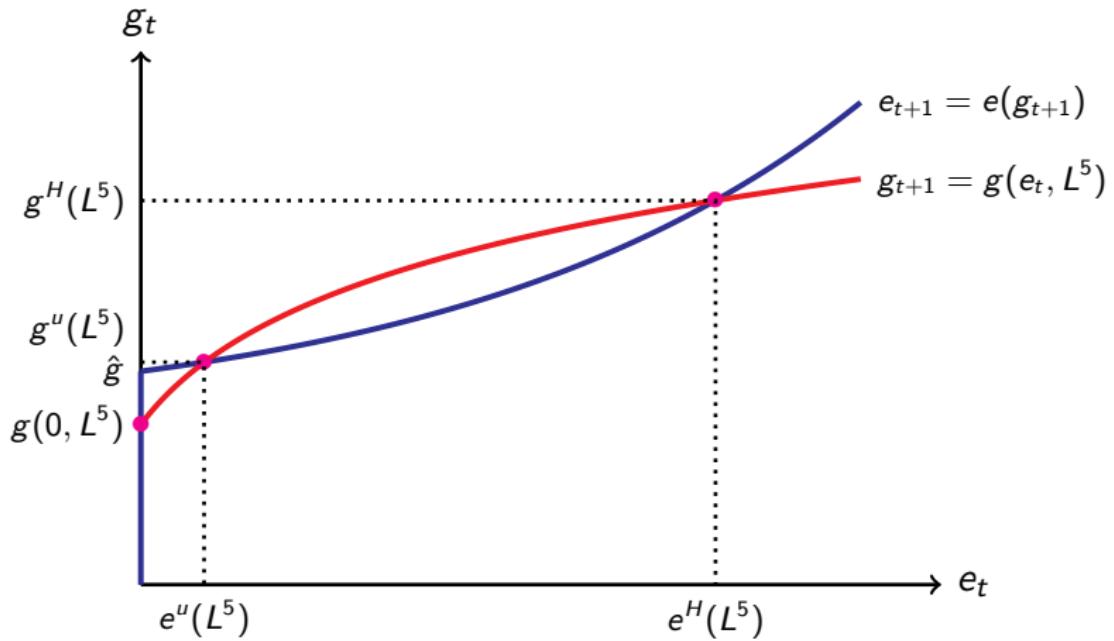
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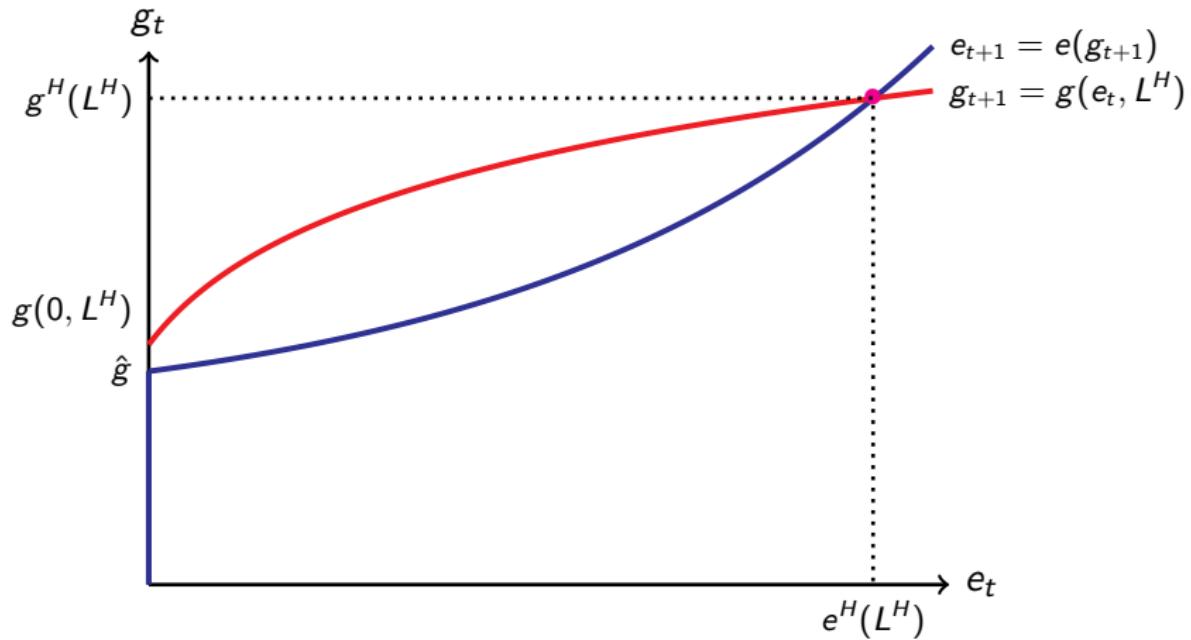
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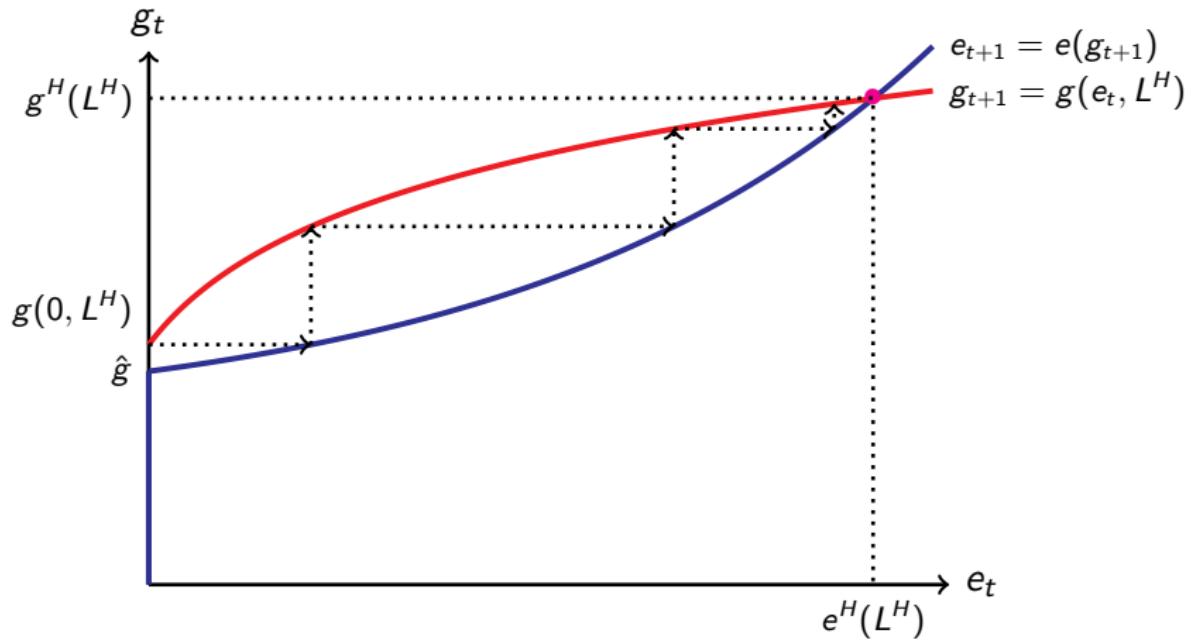
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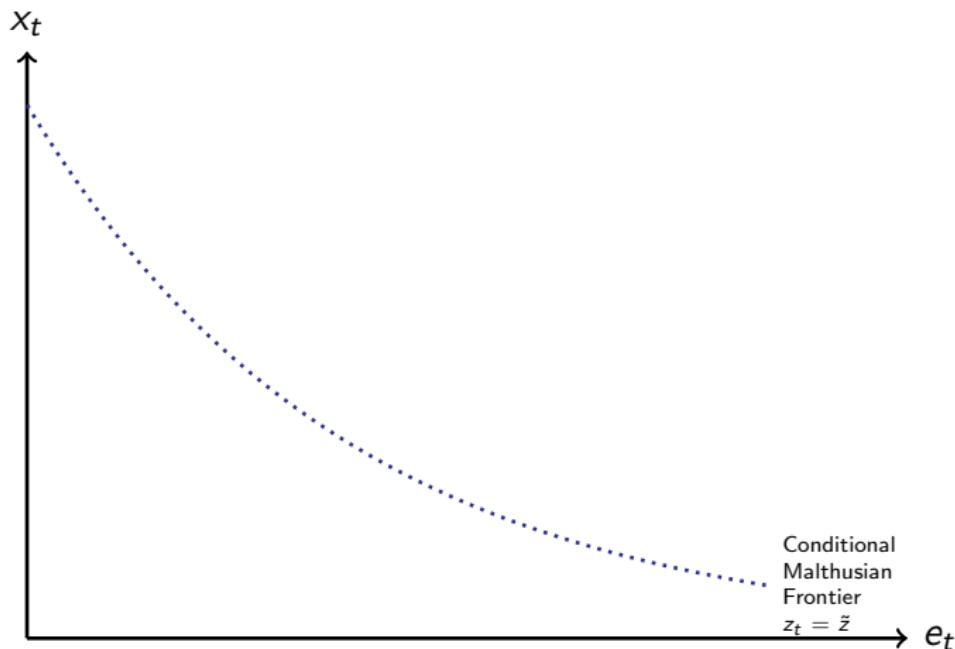
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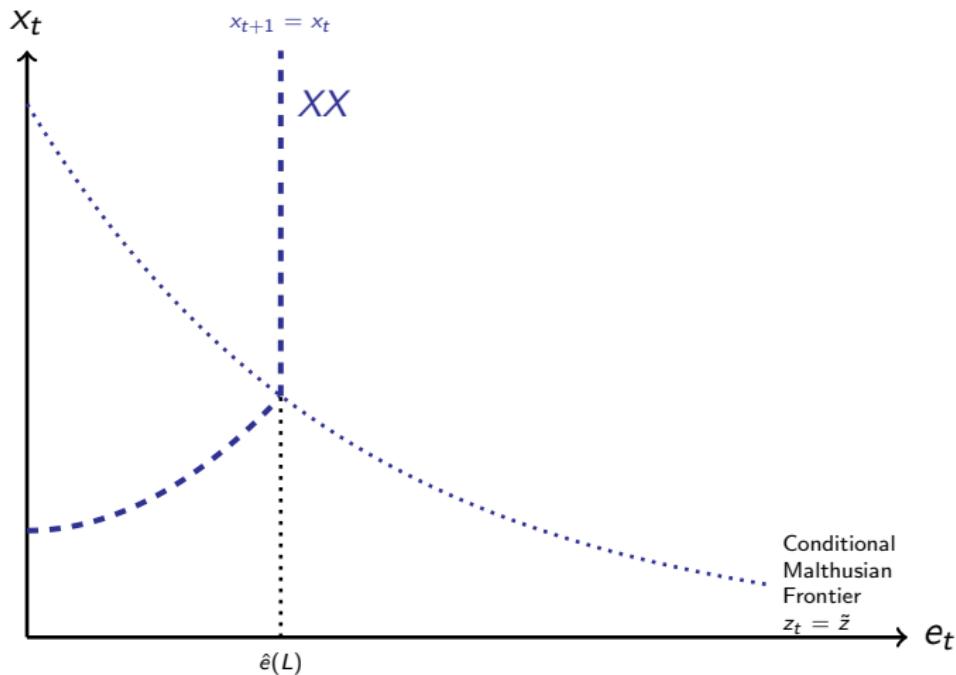
The Evolution of Education and Resources Per Worker: Small Population



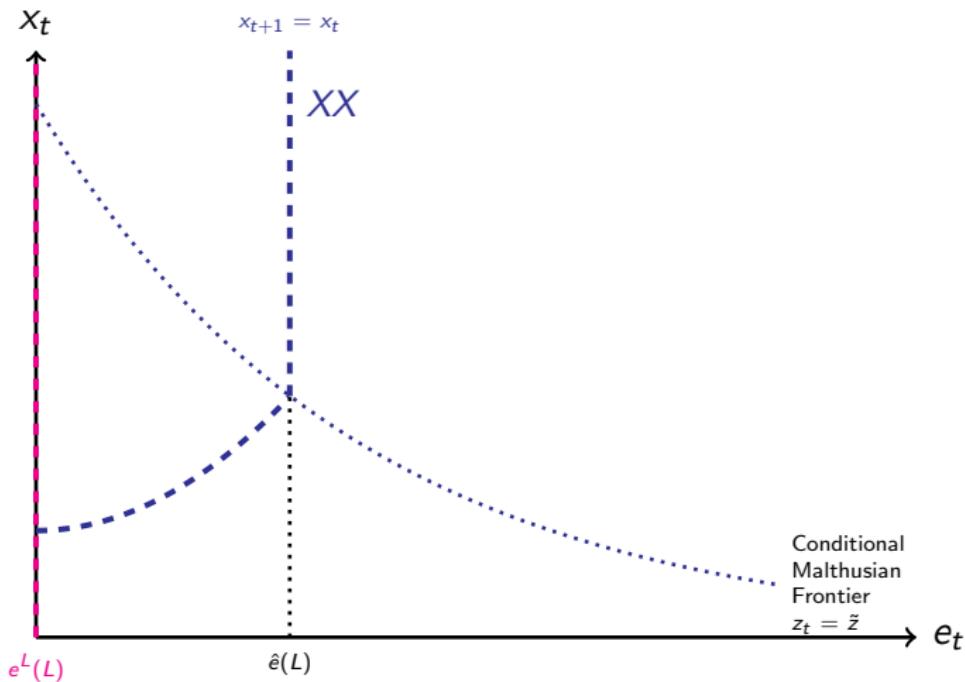
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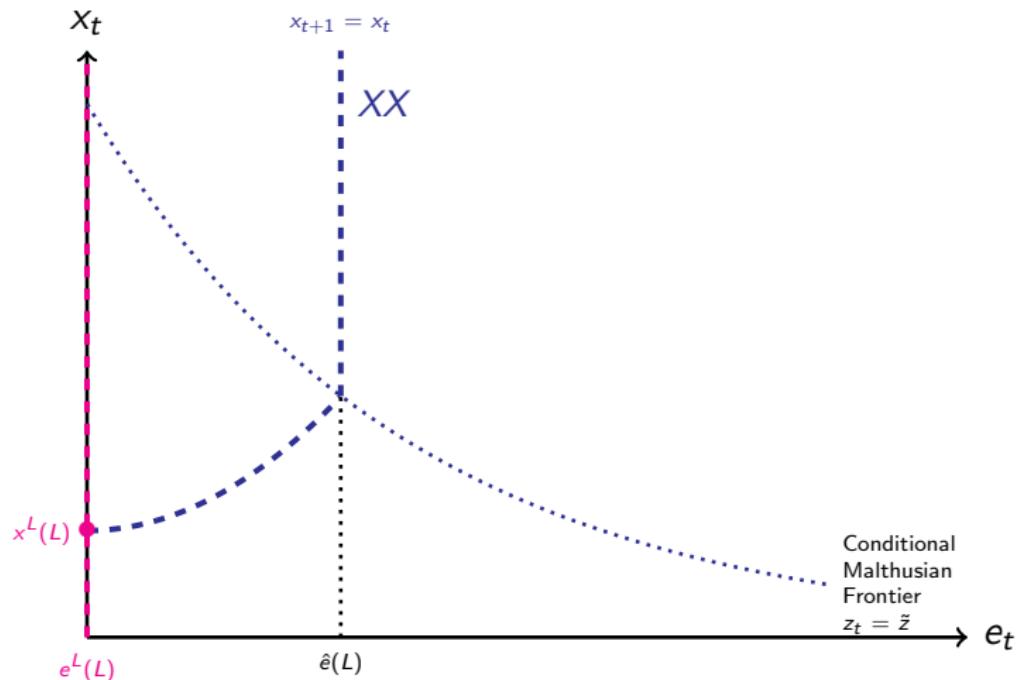
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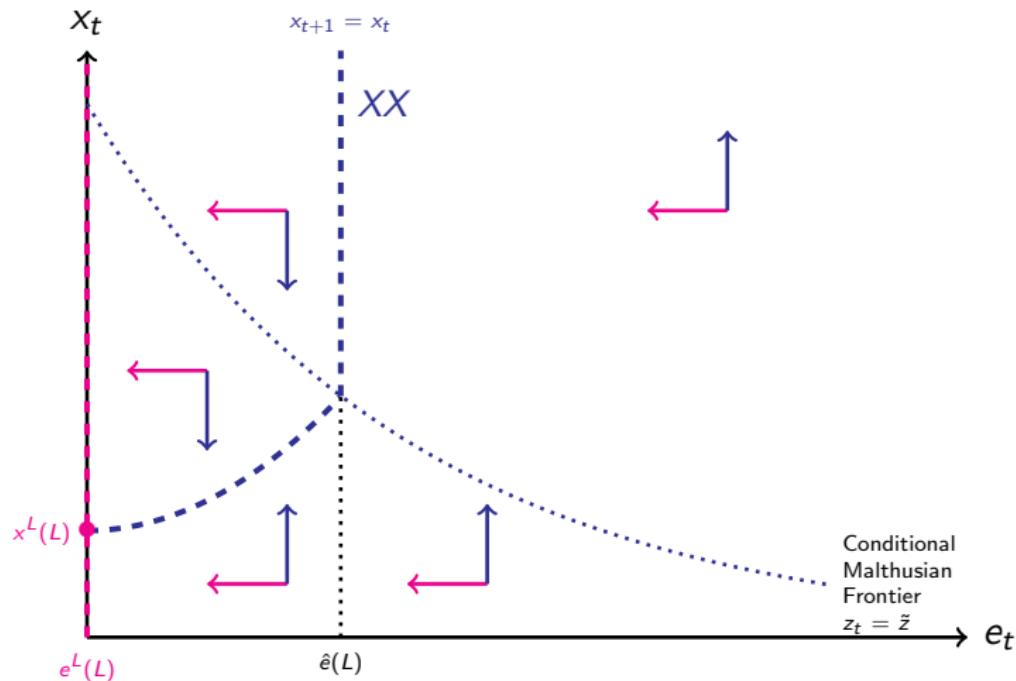
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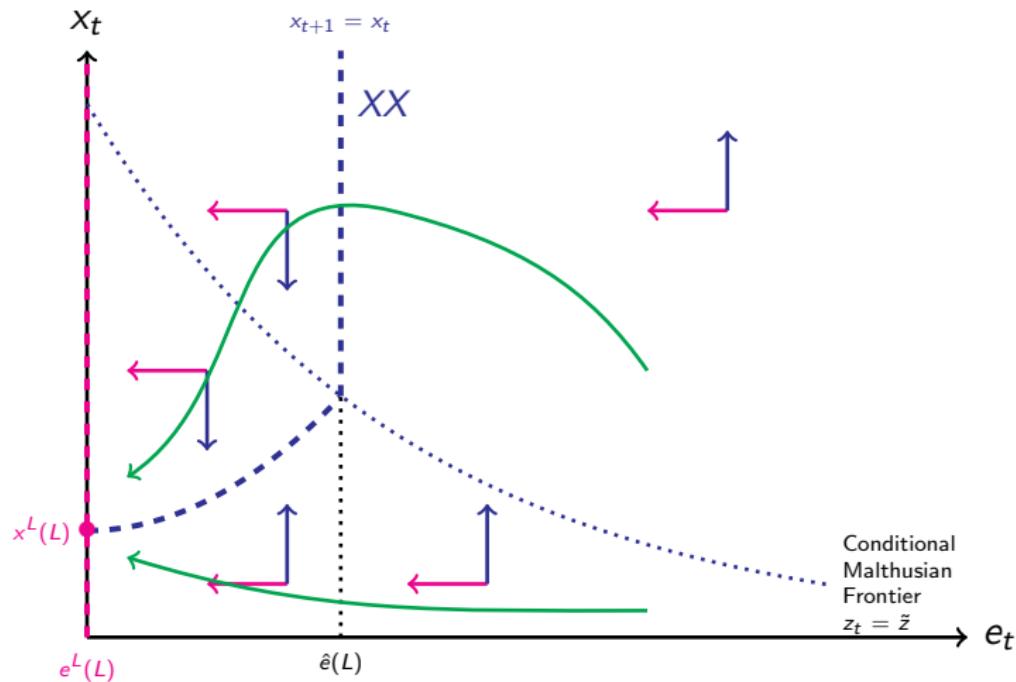
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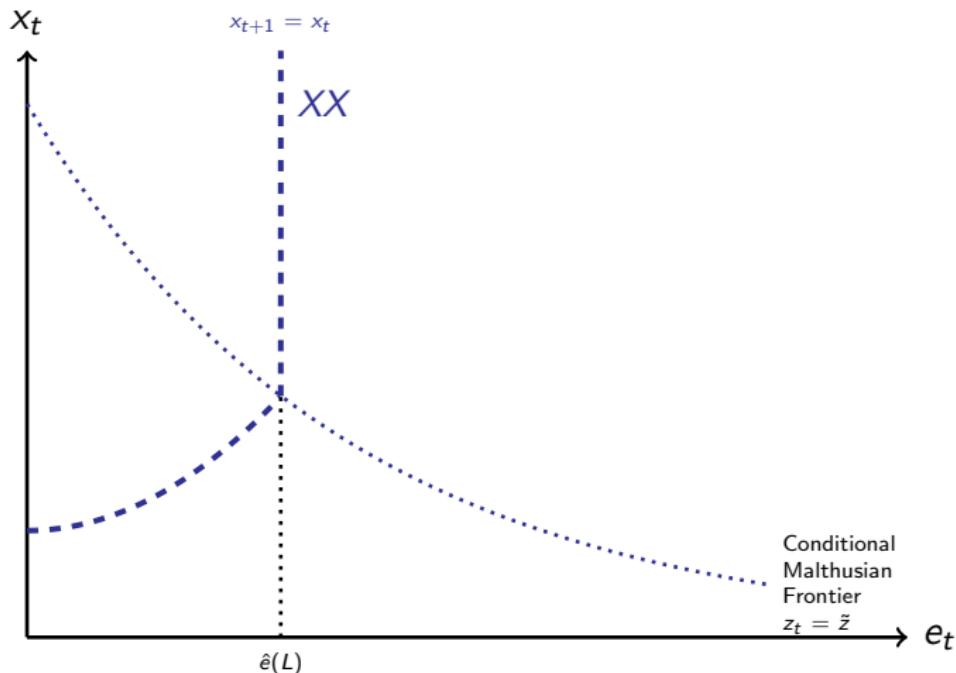
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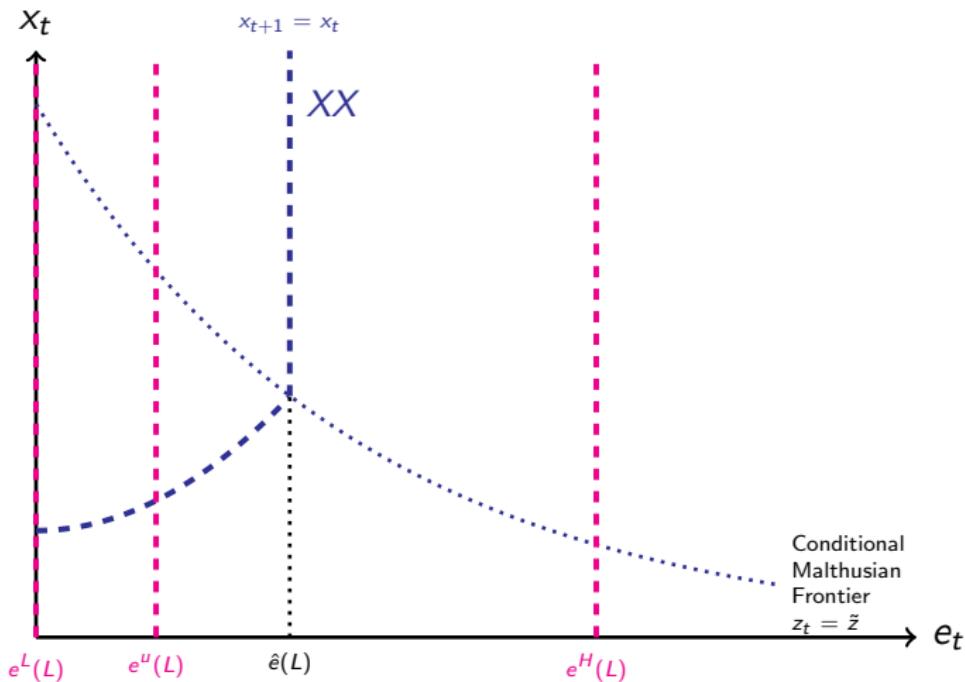
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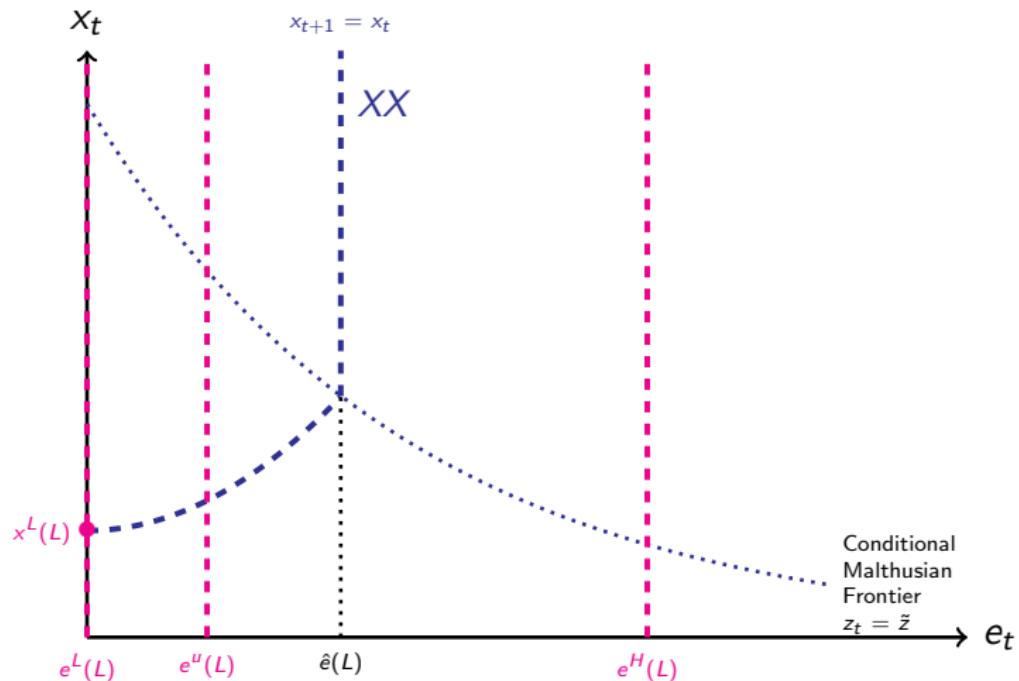
The Evolution of Education and Resources Per Worker: Intermediate Population



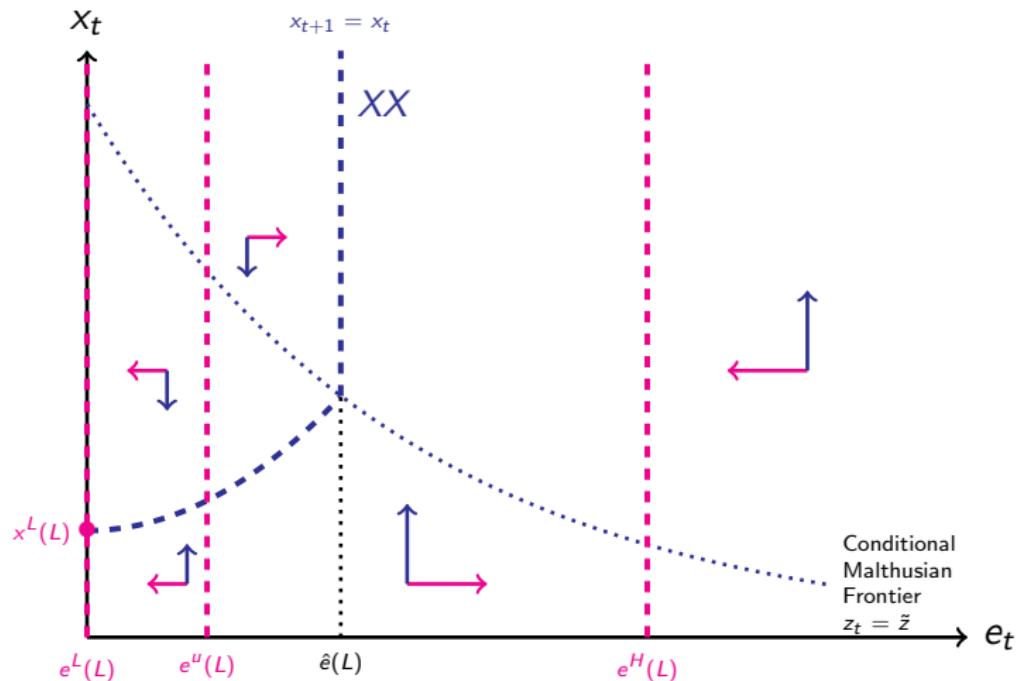
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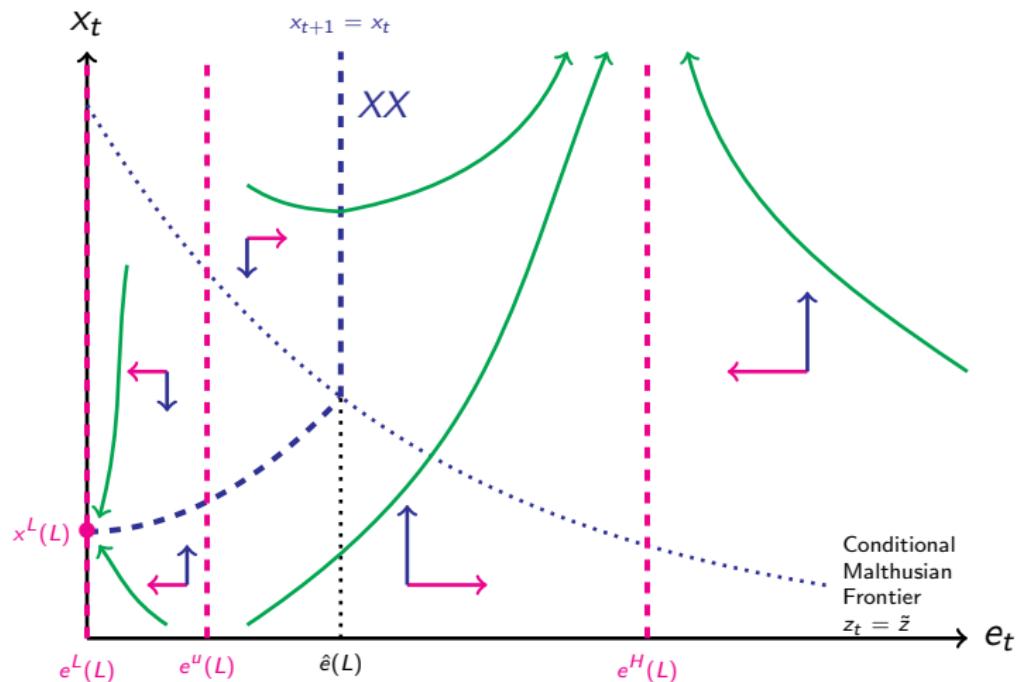
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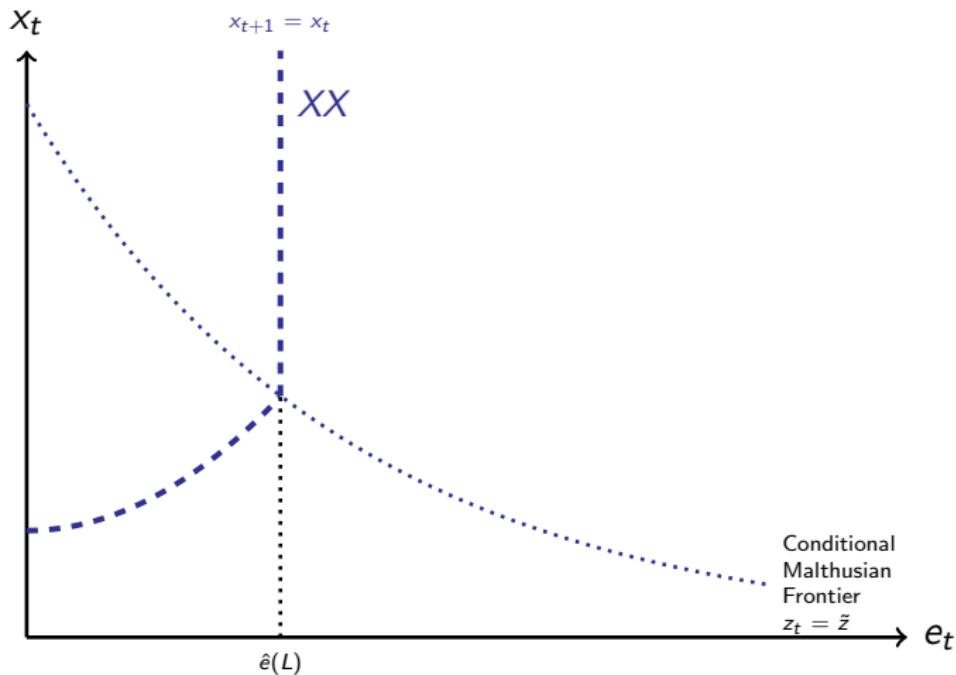
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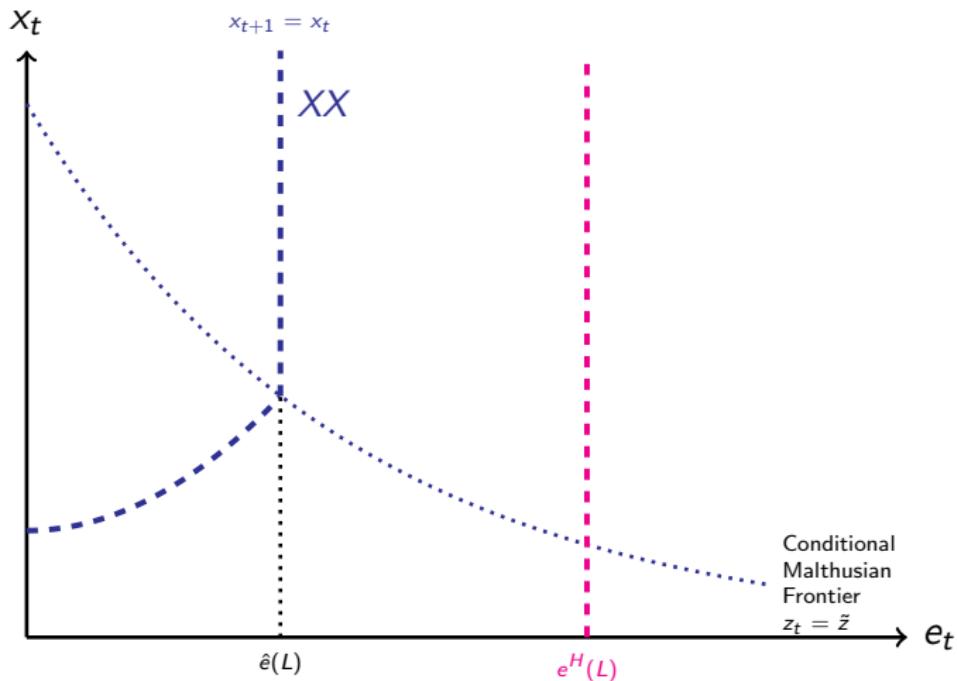
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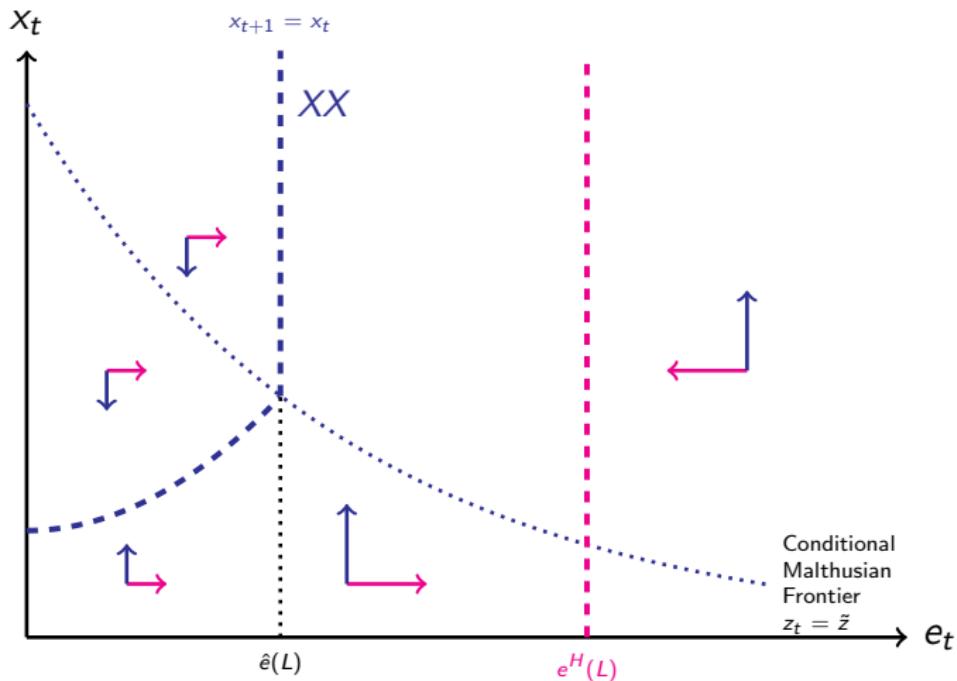
The Evolution of Education and Resources Per Worker: Large Population



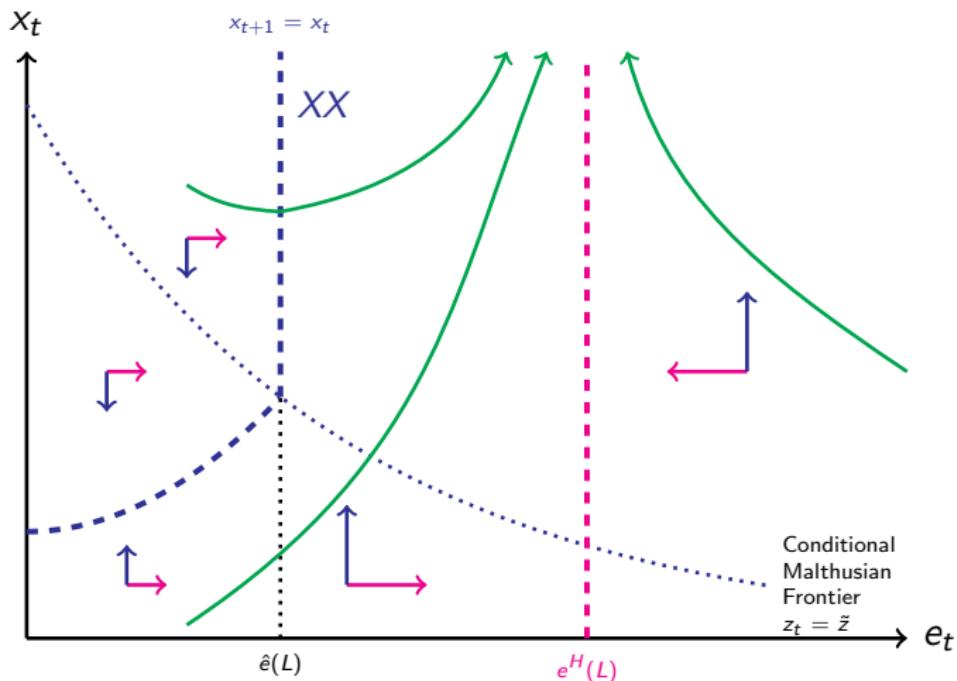
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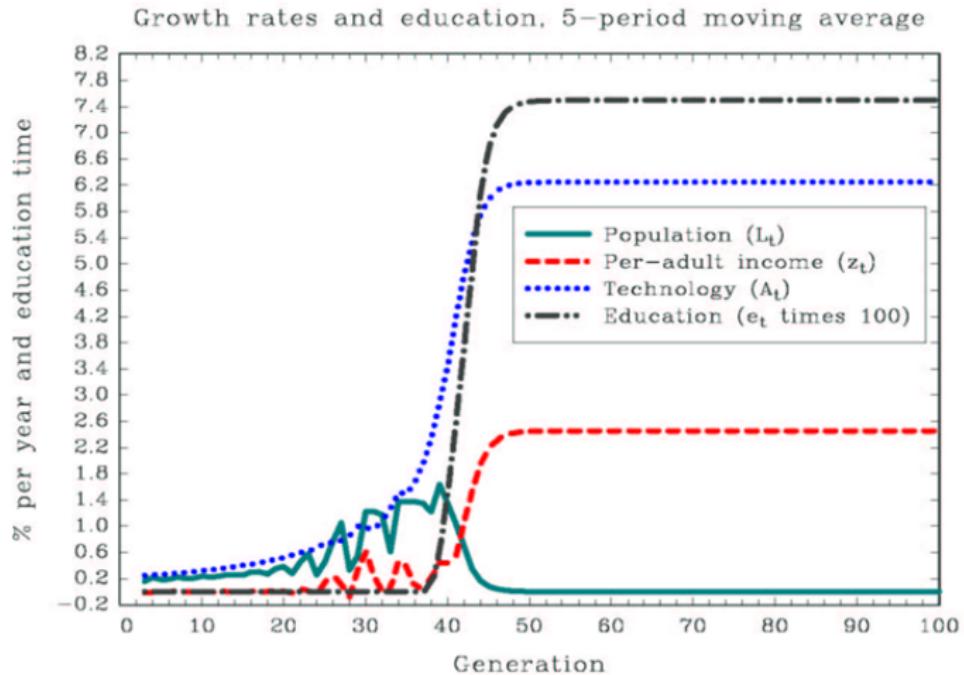
The Evolution of Education and Resources Per Worker: Large Population



The Evolution of Education and Resources Per Worker: Large Population



Simulation



Source: Lagerlöf (RED 2006)

Implications

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 - \Rightarrow Economic growth is freed from counterbalancing effects of population
 - Technological progress, human capital & decline in population growth
 - \Rightarrow Sustained economic growth

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Variations in Country-Specific Characteristics Conducive for Technological Progress

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 - Technological diffusion
 - Specialization and technological progress via learning by doing
 - Innovative Culture & Institutions

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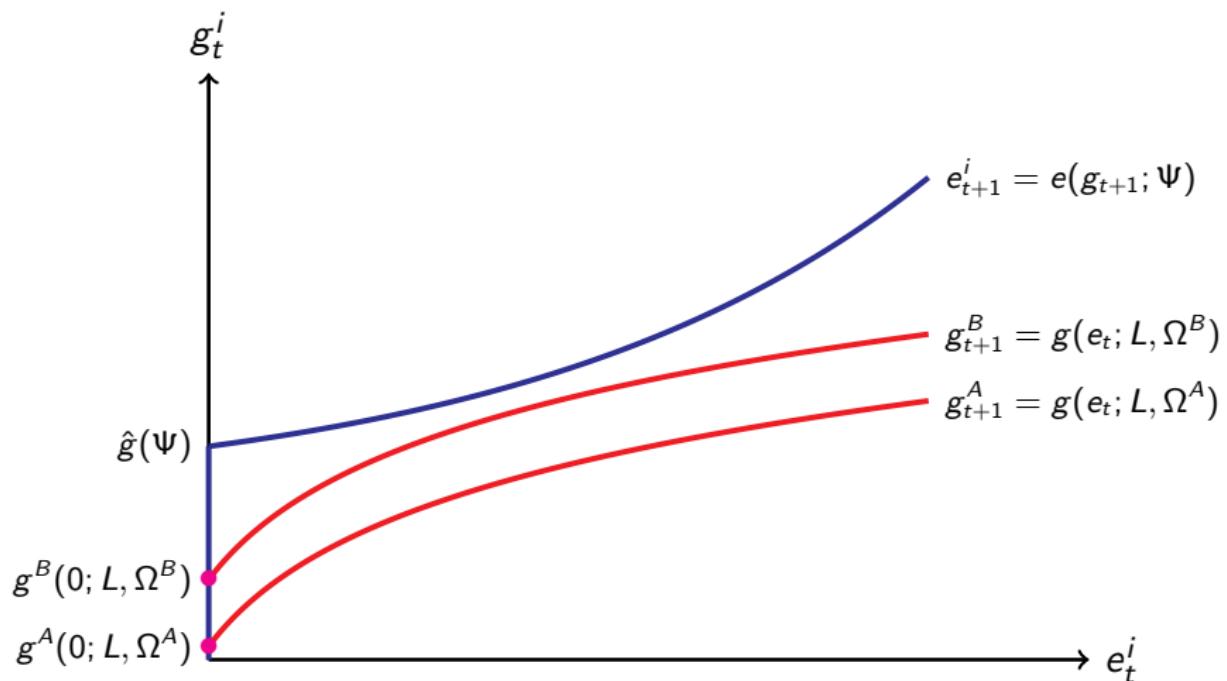
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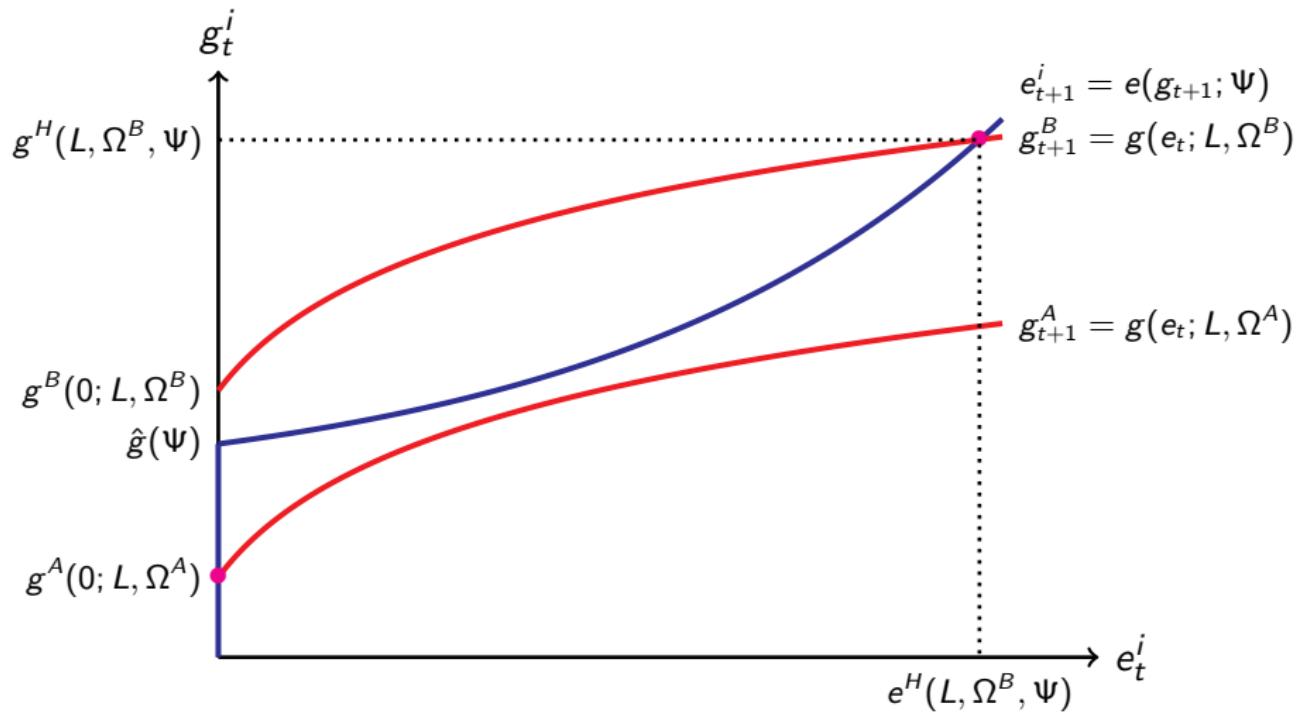
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Earlier Take-off in Country B



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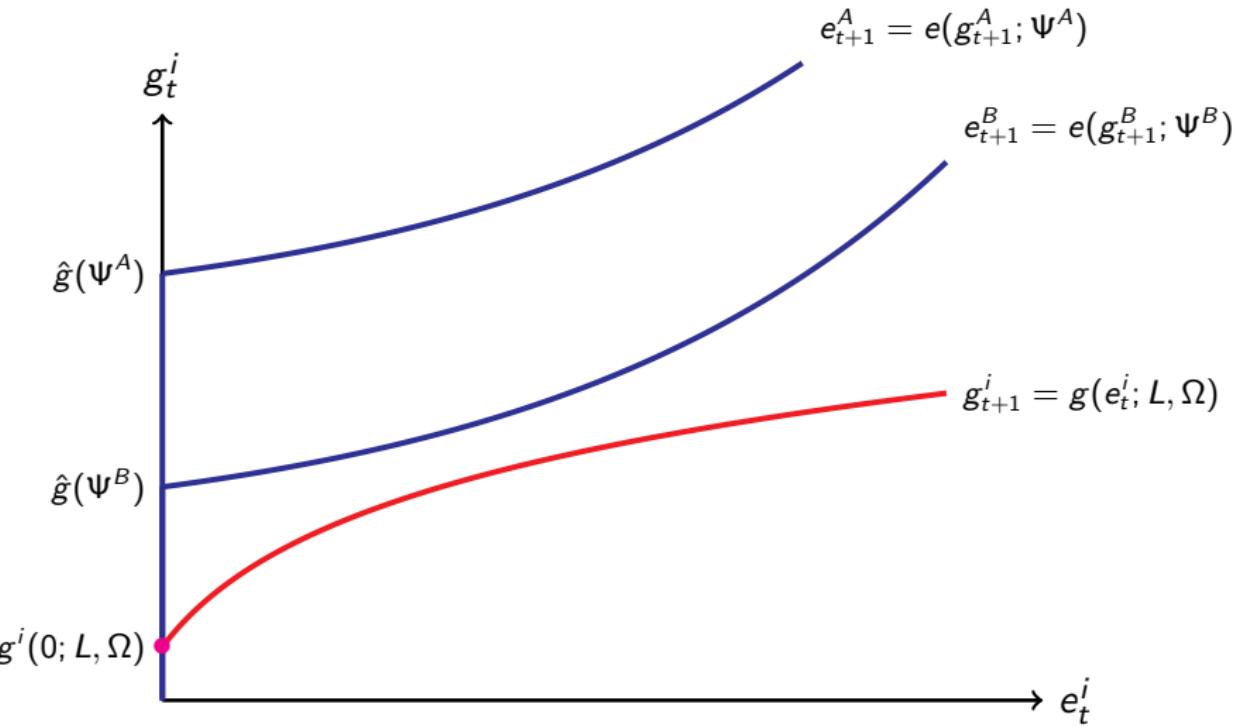
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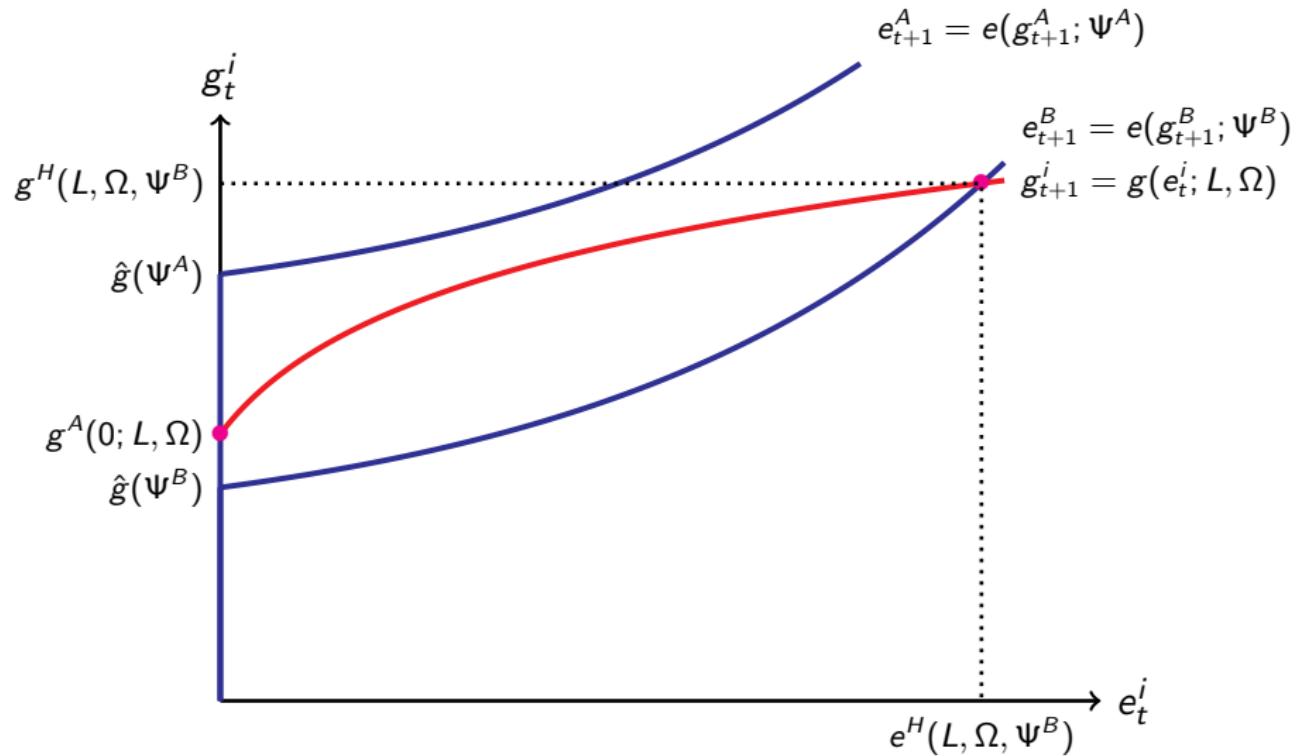
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