Unified Growth Theory and Comparative Economic Development

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Economic Growth and Comparative Development

Unified Growth Theory

Why?

Inconsistency of non-UGT with the Growth Process

- Inconsistent with the qualitative aspects of the growth process during the Malthusian epoch and the Post-Malthusian Regime
- Limited to the modern growth regime – a miniscule fraction (0.1%) of the entire process of development
- Do not capture the forces that brought about the transition of developed countries from stagnation to growth and hence unable to shed light of the hurdles faced by LDCs in their attempt to take-off to a state of sustained economic growth
- Unable to capture the role of deep rooted factors in the contemporary disparity in income per-capita across the globe

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The Underlying Hypothesis

The understanding of contemporary variations in income per capita across the globe would remain obscured unless growth theory would capture:

- The process of development in its entirety
  - The forces that triggered the transition from stagnation to growth of the currently developed economies
    - $\Longrightarrow$ hurdles faced by LDCs
  - The role played by deep rooted factors in the differential timing of the transition from stagnation to growth
    - $\Longrightarrow$ comparative development

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Virtues of Unified Growth Theory

- Sheds light on historical and contemporary patterns of development
- Identifies the forces the permitted the currently developed economy to transit from an epoch of Malthusian stagnation to sustained economic growth
- Uncovers the hurdles faced by LDCs in their transitions from stagnation to growth
- Derives policies that may expedite the transition of LDCs to sustained economic growth

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- Identifies the persistent effect of initial biogeographical conditions on the growth process
- Encompasses existing hypothesis about the role of geographical, cultural, institutional factors, and the composition of human traits, in comparative development

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Development of a unified growth theory that accounts for:

- An epoch of Malthusian stagnation
- The take-off from the Malthusian Regime
- The emergence of human capital as a significant factor
- The demographic transition
- A shift to sustained economic growth
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A dynamical system that permits an escape from a *stable* Malthusian Steady-State:

- A major shock in an environment characterized by multiple locally stable equilibria
  (inconsistent with evidence of a gradual transition)
- A gradual escape from an absorbing (stable) equilibrium
  (contradiction to the essence of a stable equilibrium)

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Origins of the Phase Transition

- The evolution of a latent state variable that ultimately affects the qualitative properties of the dynamical system
- The latent evolution of the demand for human capital ultimately changes the dynamical system qualitatively:
  - The Malthusian equilibrium vanishes endogenously
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Characteristics of the Main Transitions

- Transition from Malthusian to Post-Malthusian Regime:
  - Faster rates of technological progress
  - Faster rate of population growth
- Transition from the Post-Malthusian to Modern Growth Regime:
  - Faster rate of technological progress
  - Faster rate of human capital accumulation
  - Decline in population growth

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- The forces behind these transitions may be hidden therefore in the understanding of how:
  - changes in the technological environment affects population size and quality
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The Basic Structure of the Model

- Overlapping-generations economy
- $t = 0, 1, 2, 3...$
- One homogeneous good
- 2 factors of production:
  - Labor (measured in efficiency units)
  - Land

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Factor Supply

- Land is fixed over time
  - e.g., surface of planet earth
- Efficiency units of labor evolves endogenously
  - determined by households' decisions about the number and level of human capital of their children

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- Sources of Technological Progress
- Origins of Human Capital Formation
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- A subsistence consumption constraint
- Positive effect of income on population
  - reflecting household's optimization
- Fixed factor of production - Land
- Output per capita fluctuates around a constant level
  - reflecting diminishing returns to labor in agriculture and a positive effect of income on population

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  - $y \uparrow \implies L \uparrow$
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  - $L \uparrow \implies AP_L \downarrow \implies y \downarrow$
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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
  - $X \equiv$ land

- Output per worker produced at time t

$$y_t = \left[\frac{H_t}{L_t}\right]^{\alpha} \left[\frac{A_t X}{L_t}\right]^{(1-\alpha)} \equiv h_t^{\alpha} x_t^{1-\alpha}$$

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  - $h_t \equiv H_t/L_t$ efficiency units per-worker
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- Very short-run (for a given population):
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Early stage of development

- Population size positively affects technological progress:

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- Channels:
  - Supply of innovations
  - Demand for innovations
  - Diffusion of knowledge
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- $g_{t+1} \equiv$ rate of tech progress
- $e_t \equiv$ education
- $L_t \equiv$ population size

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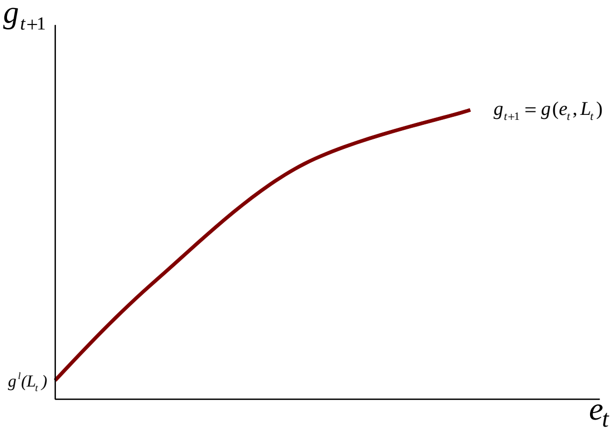
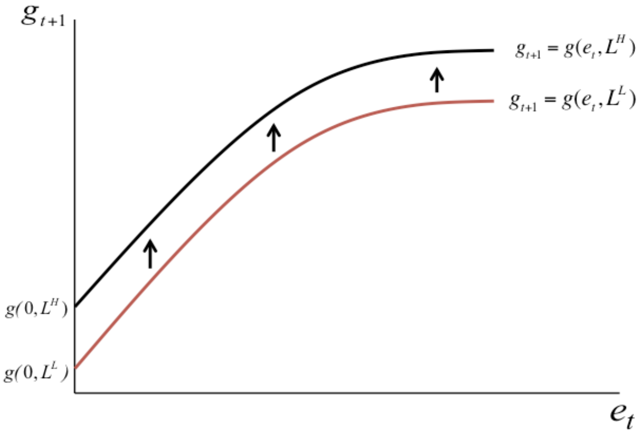


The Effect of Population Size on Technological Progress



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- The increase in the rate of technological progress increases the demand for human capital
  - 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 is skill-biased or skill-saving in the long run

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Human capital of an individual who join the labor force in period $t+1$

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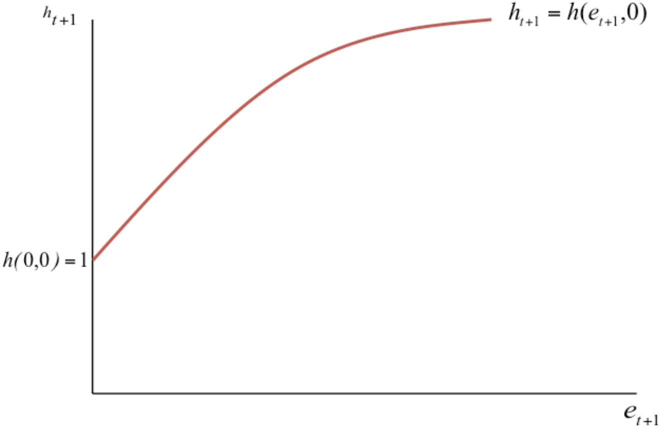

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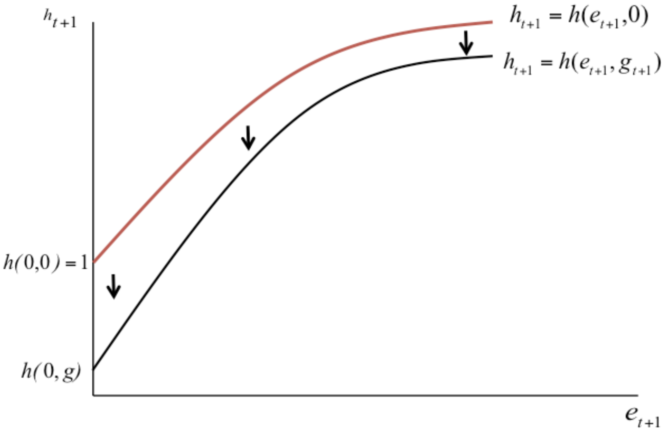

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- The rise in the *demand* for human capital induces parents to substitute quality for quantity of children
- The rise in income along with the rise in the potential return to human capital generates:
  - An income effect - more income to spend on children
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    - The opportunity cost of raising children increases
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Later part of the second phase of industrialization:

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- Live for 2 period
- Childhood: (1st Period):
  - Consume a fraction of their parental unit-time endowment
  - The required time increases with children's 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 time between childrearing and work
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$$z_t n_t(\tau + e_{t+1}) + c_t \leq z_t$$

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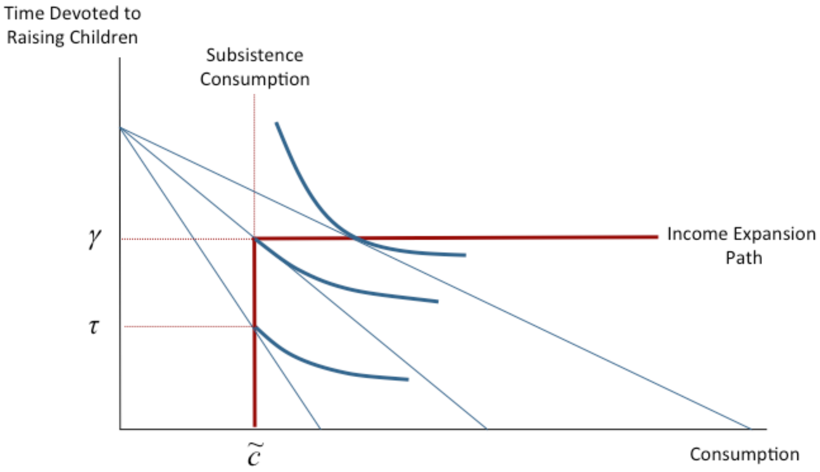


Optimization: Quantity and Quality of Children

- Budget constraint:

$$z_t n_t(\tau + e_{t+1}) + c_t \leq z_t \quad \Longleftrightarrow \quad c_t = z_t[1 - n_t(\tau + e_{t+1})]$$

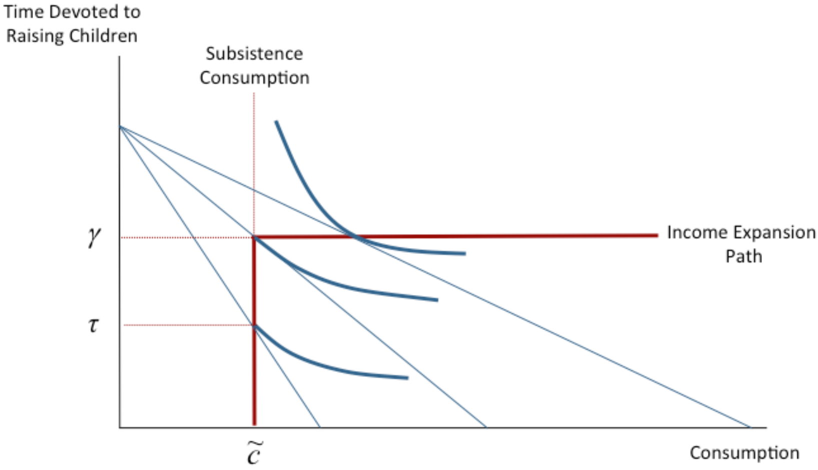
- For $c_t = \tilde{c}$,

$$[1 - n_t(\tau + e_{t+1})] = \frac{\tilde{c}}{z_t}$$

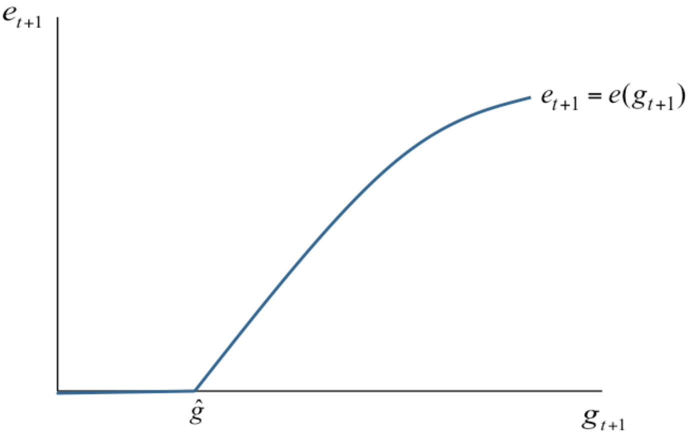
- Time devoted to children:

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

Constraints and Optimization



Optimal Investment in Child Quality

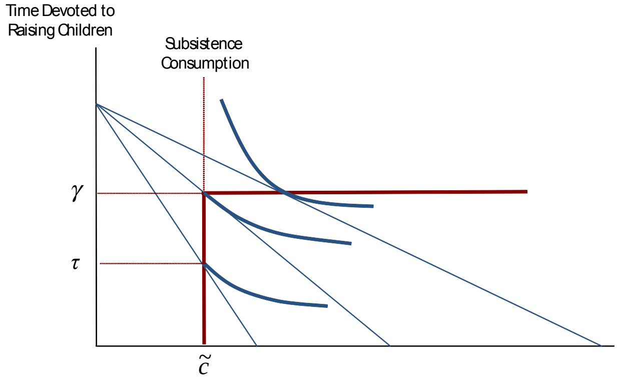


Optimization: Quantity and Quality of Children

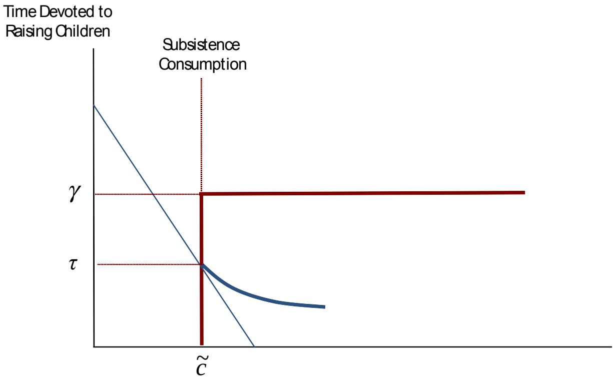
$$e_{t+1} = e(g_{t+1})$$

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

Optimization - Income Expansion Path



Optimization - Malthusian Epoch



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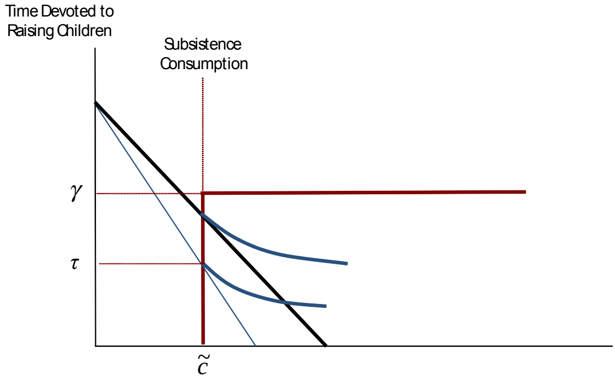

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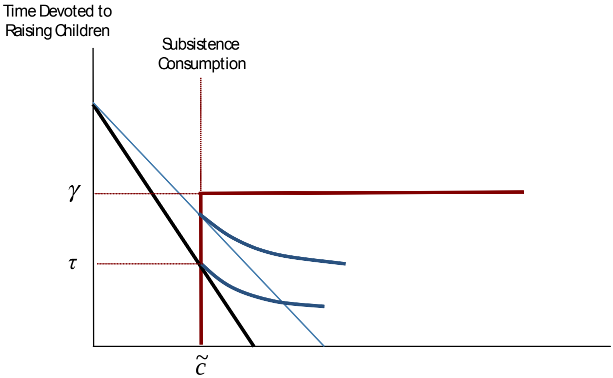

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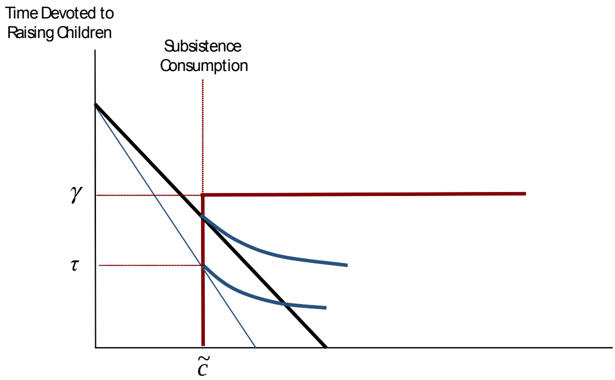

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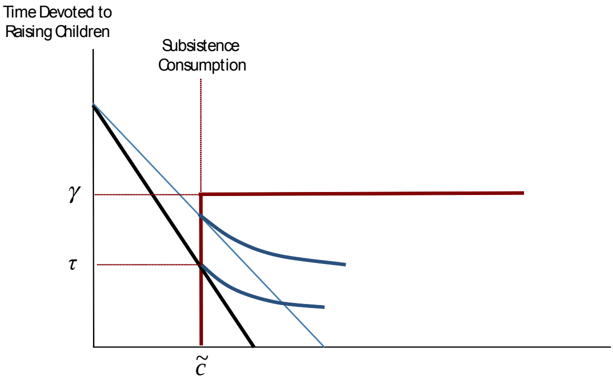

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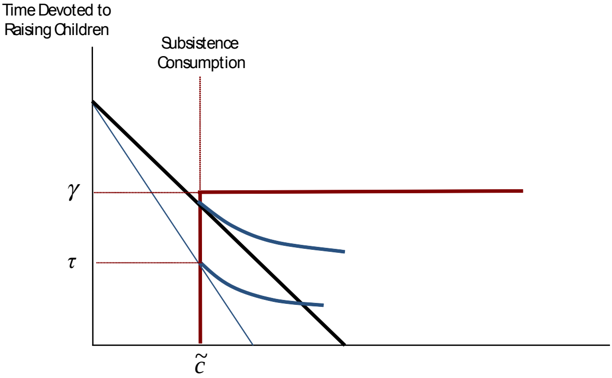

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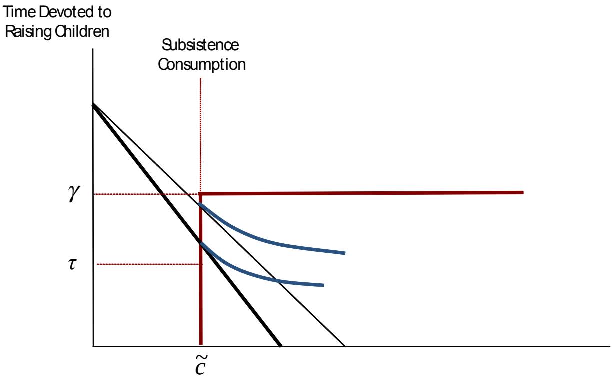
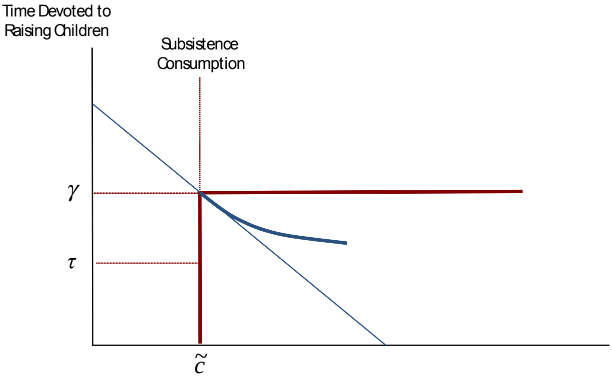


Income Expansion Path - Post-Demographic Transition



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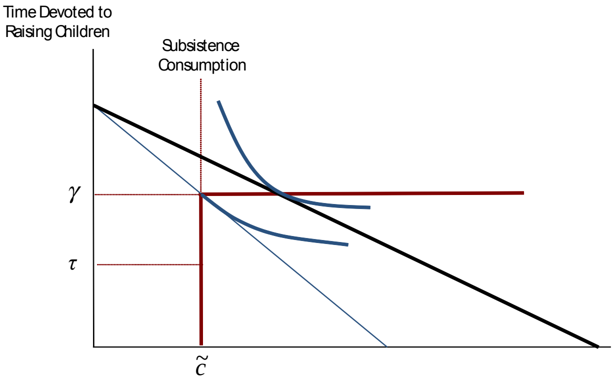

Technological Progress

Technological progress over time

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

- $g(0, L_t) > 0$
- $g_i(e_t, L_t) > 0$ and $g_{ii}(e_t, L_t) < 0, \quad i = e, L$

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Population Dynamics

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

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

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Dynamics of the Level of Resources per Worker

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

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

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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:

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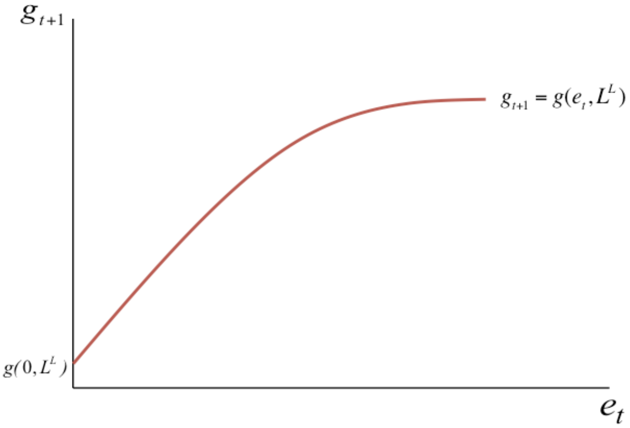
The Effect of Education on Technology



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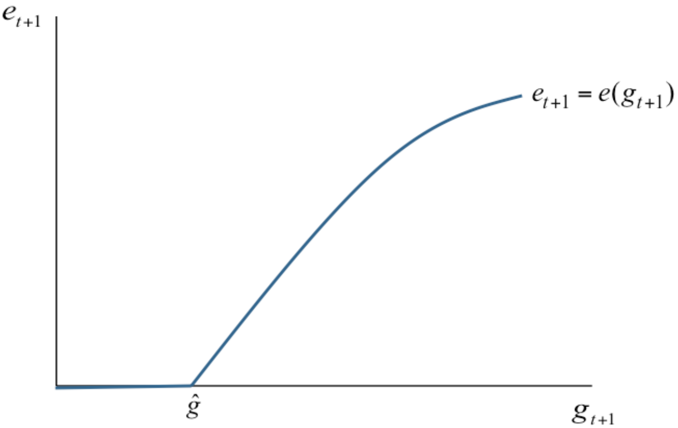
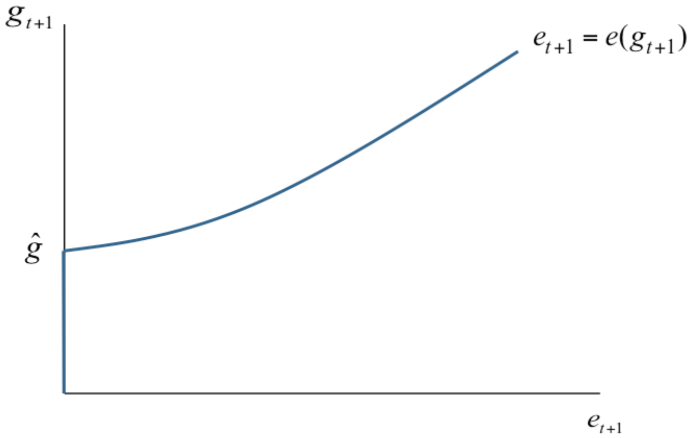
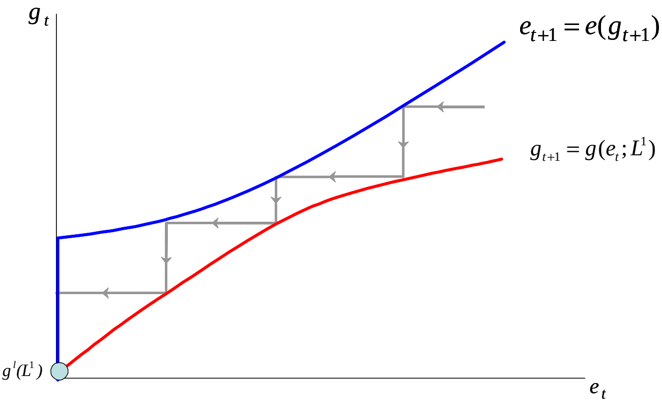


The Effect of Technology on Education: Flipped Axis



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



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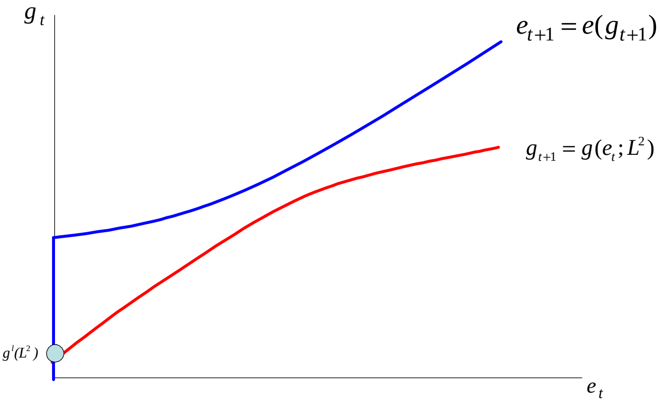

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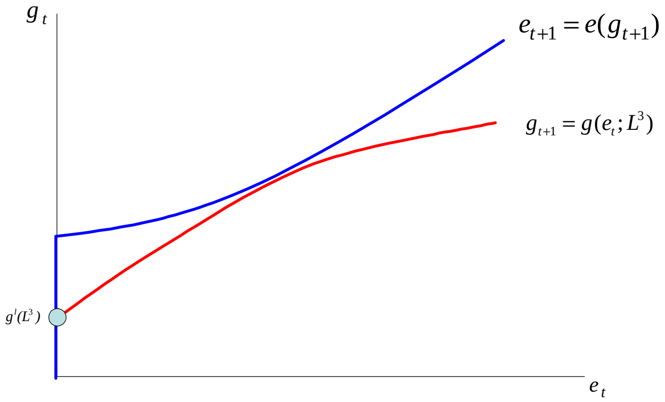

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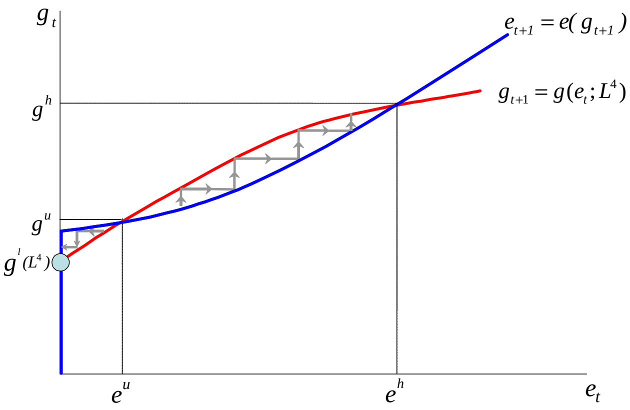

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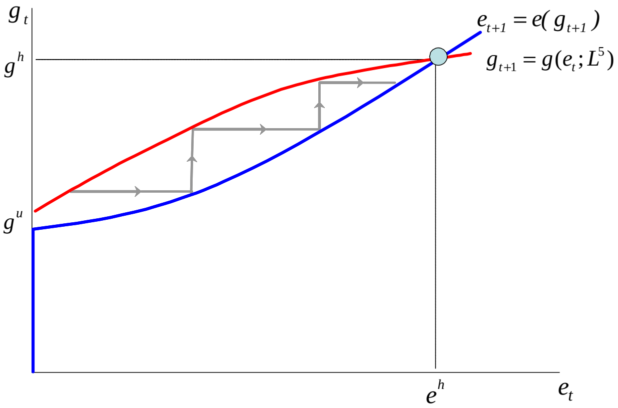
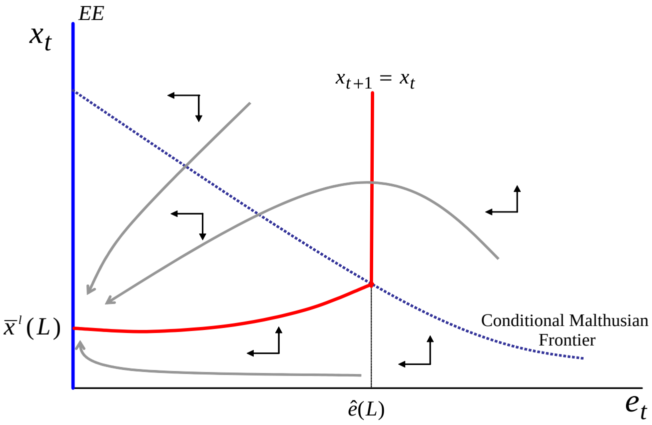
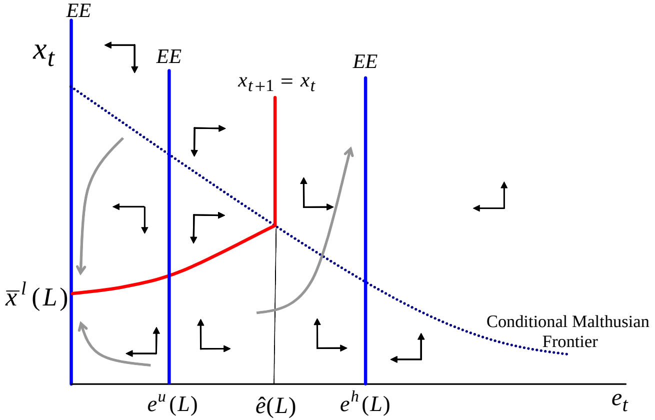


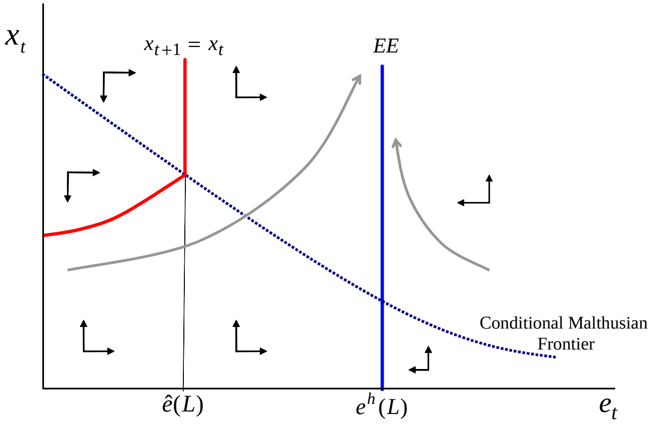
The Evolution of Education and Resources Per Worker: Small Population



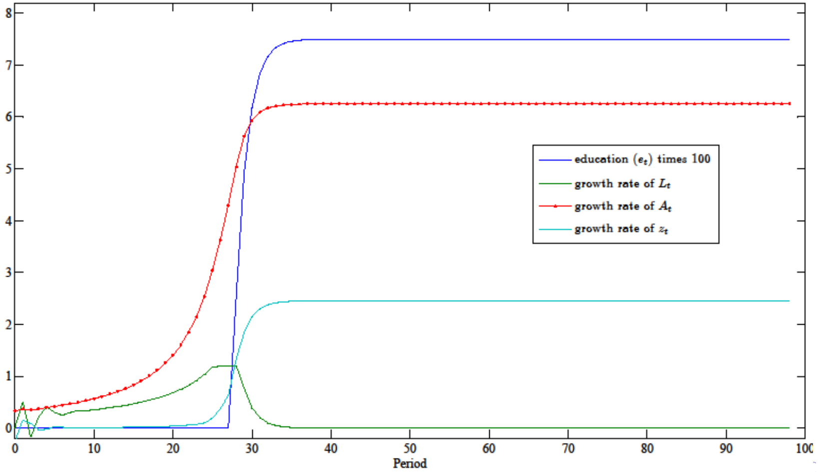
The Evolution of Education and Resources Per Worker: Intermediate Population



The Evolution of Education and Resources Per Worker: Large Population



Calibration



Implications

- The transition from stagnation to growth is an *inevitable* by-product of the process of development
- The inherent Malthusian interaction between technology and population, accelerated the pace of technological progress, and eventually brought an industrial demand for human capital
- Human capital formation, triggered a demographic transition, enabling economies to convert a larger share of the fruits of factor accumulation and technological progress into growth of income per capita
- Variations in the timing of the take-off contributed significantly to the divergence in income per capita in the past two centuries

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Implications for the Emergence of Convergence Clubs

- Differential timing of takeoffs from stagnation to growth segmented economies into three fundamental regimes:
  - Slow growing economies in the vicinity of a Malthusian regime
  - Fast growing countries in a sustained growth regime
  - Economies in the transition from one regime to another

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$$g_{t+1}^i = g(e_t^i, L_t^i, \Omega_t^i)$$

$\Omega_t^i \equiv$ characteristics affecting tech progress in country i:

- Protection of intellectual property rights (policy)
  - Positive effect on the incentive to innovate
  - Adverse effect on the proliferation of existing knowledge
- The stock of knowledge within a society
  - Rate of knowledge creation
  - Rate of knowledge diffusion
- The propensity of a country to trade (geography & policy)
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  - Attitude toward knowledge creation and diffusion (e.g., The Inquisition)
- The composition of interest groups in society
  - Incentives to block or promote technological innovation (e.g., Luddite, landowners)
- Cultural and genetic diversity
  - Diversity may allow for greater division of labor/economic specialization
  - Wider spectrum of traits are more likely to contain the ones complementary to the adoption or implementation of new technologies
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- Production of Human Capital

$$h_{t+1}^i = h(e_{t+1}^i, g_{t+1}^i, \phi_t^i)$$

  - $\phi_t^i \equiv$ country-specific characteristics affecting HC formation:

- Preferences for Quality

$$u_t^i = (1-\gamma)\ln(c_t^i) + \gamma \ln[(n_t^i)^{1-\mu_t^i}(h_{t+1}^i)^{\mu_t^i}]$$

  - $\mu_t^i \equiv$ degree of preference for child quality

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- Optimization:

For country-specific characteristics $\Psi_t^i \equiv [\phi_t^i, \mu_t^i]$

$$e_{t+1}^i = e(g_{t+1}^i; \Psi_t^i) \begin{cases} = 0 & \text{if} \quad g_{t+1}^i \leq \hat{g}(\Psi_t^i), \\ > 0 & \text{if} \quad g_{t+1}^i > \hat{g}(\Psi_t^i) \end{cases}$$

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- Ability of individuals to finance the cost of education and the forgone earnings
  - Extent of under-investment in education
- The availability, accessibility, and quality of public education (policy & interest groups)
  - Extent of human capital formation
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- The effect of geographical attributes on health
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Consider two economies, A and B :

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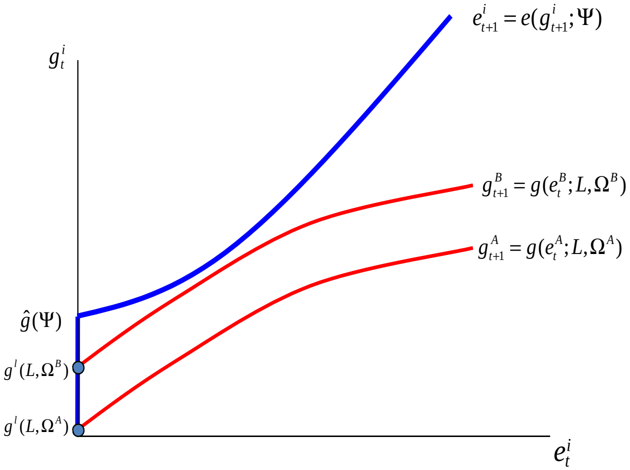

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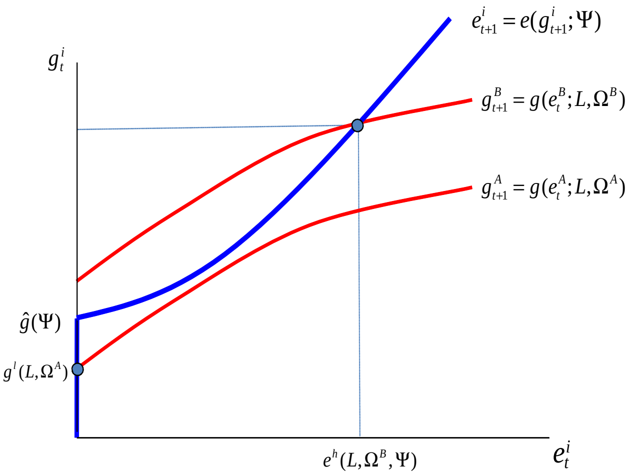

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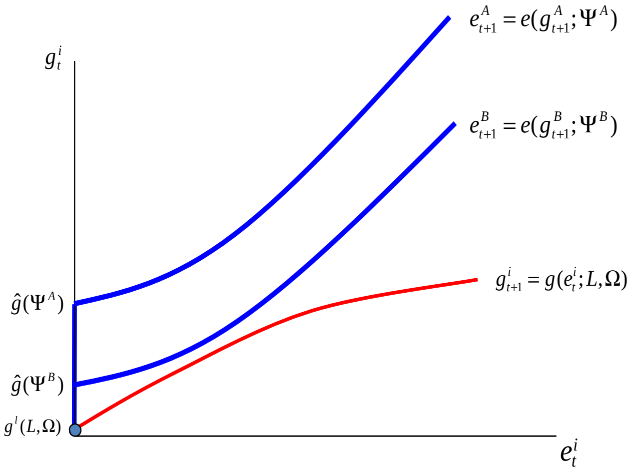

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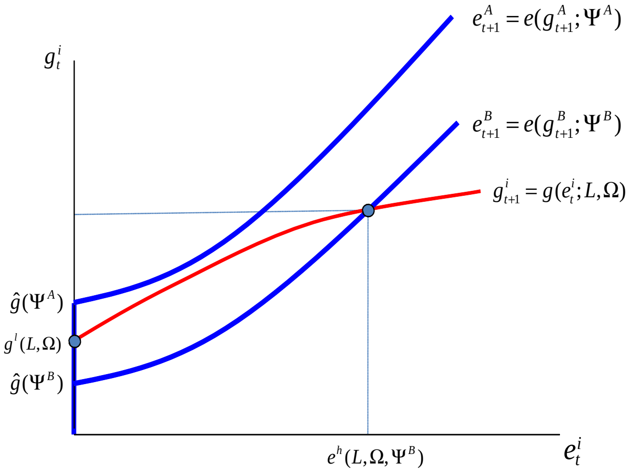

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