Endogenous Growth, Human Capital, and Education

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Exogenous vs. Endogenous Growth Models

• Exogenous model
  – \( Y = AK^\alpha L^{1-\alpha} \)
  – Productivity levels (A) are given/residual
  – Diminishing returns inhibit sustained growth (limited to a steady-state)

• Endogenous models
  – Productivity accounted for within the model; an explanation for A
    • R&D, Human Capital
  – Constant marginal productivity
  – Absence of steady-state behavior
Romer’s Model of Human Capital

• Human capital as an input in productivity growth
  – New technologies invented within economy
  – Time divided between production and innovation
  – Focus is on product variety

• Ideas directly increase A
  – Nonrivalrous, partially excludable, increasing returns
    Imperfect competition, patents and copyrights

• If human capital stock too small, there is no allocation to R&D; must be above threshold level
  \[ H_A = \begin{cases} 0, & \text{if } H \leq H_0 \\ (H-H_0), & \text{if } H > H_0 \end{cases} \]
Adapting Romer’s Model for Technology Transfer

• A is viewed as technological frontier; model based on adapting outside technologies
  – Labour can be used for skill accumulation or production
  – Technology transfer is effortless and technological frontier is exogenous
  – Growth rate of economy given by growth rate of skill

• The number of capital goods a worker is able to use is limited by skill level
  – Skill accumulation slows as skill level approaches frontier
Implications for Solow Model

• Mankiw, Romer, Weil
  – Variations in per capita income and growth rates 1960-1985 consistent with Solow model once augmented to include human capital

• Solow model still useful; easy to endogenize

• Human capital affects economic growth through accumulating new technology and facilitating technology diffusion
  – Need to model both effects
  – Some countries may focus on utilizing spillovers, while others focus on innovation
Cost Benefit Analysis

\[ F = \text{one time cost for human capital accumulation (or transfer of technology)} \]
\[ \Pi = \text{the expected present discounted value of the profit stream} \]

\[ \Pi > F \implies \text{Invest} \]
\[ \Pi < F \implies \text{Do not invest} \]

- Individuals and firms will invest in human capital if incentives are there (high profits and/or low costs are necessary)
- Rates of return to society: compare the additional earnings of better-educated individuals to the additional social cost of investing in more education
Quality of Human Capital

- Quality education is important for growth
- One standard deviation increase in international test scores (generalized) impacts growth rate by 1% per year
- 1% rise in literary scores compared to the international average associated with 2.5% rise in productivity and 1.5% rise in GDP per capita

Robert Barro; *The American Economic Review*; May 2001
Quantity of Education

- Initial stock of human capital measured by secondary and post-secondary completion
- An additional year in school raises the growth rate by 0.44% per year
- Secondary education contributed an annual 0.6% to productivity growth in OECD (1960-1995)
- Quality and quantity of education important for growth

Robert Barro; *The American Economic Review*; May 2001
More Evidence

• Engelbrecht
  – Level of education plays important role in technological catch-up
  – Productivity growth is more rapid where countries have higher levels of average schooling
  – Human capital has largest effects when specific to subcategories important for technological diffusion (science, math, engineering)

• Growth accountants find that increases in education account for perhaps one fifth of growth in output per worker
Peter Howitt

- Growth depends on both the rate and size of innovations
- 2 kinds of innovations: frontier and implementation
  - Human capital doesn’t affect 2 types of innovation in the same way
  - Education policies need to be appropriate to country’s position in relation to the frontier
    - Post-secondary education spending and growth in 48 US states
    - May explain discrepancies in correlations between education and growth
- Effects of liberal trade policy on domestic innovation