

Economic Growth III: New Growth Theory

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new growth theory

- Although many economists worked on theoretical models of growth after Solow, it wasn't until Paul Romer published his model in 1986 that there was a resurgence of interest in growth.
- In contrast to the Solow model, where technological progress is exogenous, new growth theory attempts to explain the sources of technological progress. Three important candidates for the source of such progress are:
 - Ideas (Profit-Seeking Research)
 - International Openness
 - Human Capital Formation

ideas and growth

- Research (both formal and informal) leads to the development of new goods and better goods.
- ‘As for the Arts of Delight and Ornament, they are best promoted by the greatest number of emulators. And it is more likely that one ingenious curious man may rather be found among 4 million than among 400 persons....’
William Petty, 1682.
- Does this mean that the larger the world population, the faster the rate of growth (a growth effect of scale)?
- Or that the larger the world population, the greater the world income (a levels effect of scale)?

ideas-based growth

- One of the most influential new growth models is that of Paul Romer (1990) which stresses the importance of profit-seeking research in the growth process. This has been extended by Charles Jones (1995, 1999) into the following model.

- The aggregate production function takes the familiar form:

$$(3.1) \quad Y = K^{\alpha} (AL_Y)^{1-\alpha}$$

- There are constant returns to labour and capital but the presence of ideas (A) leads to increasing returns overall. Capital accumulates at the rate:

$$(3.2) \quad \dot{K} = s_K Y - dK$$

- And the workforce grows at a constant rate:

$$(3.3) \quad \dot{L} / L = n$$

the knowledge production function

- The main difference from the Solow model is that technological progress is no longer exogenous, but is a function of the number of researchers and their average productivity

$$(3.4) \quad \dot{A} = \bar{\delta} L_A$$

- Labour is used to either produce new ideas and to produce output

$$(3.5) \quad L_A + L_Y = L$$

- In addition, the productivity of researchers might be a function of the current stock of ideas:

$$(3.6) \quad \bar{\delta} = \delta A^\phi$$

- Substituting (3.6) into (3.4) and allowing for duplication in research yields:

$$(3.7) \quad \dot{A} = \delta L_A^\lambda A^\phi$$

- Where ϕ is the knowledge spillover parameter ($\phi < 1$) and λ represents duplication of research ($0 \leq \lambda \leq 1$).

the balanced growth path I

- What is the growth rate along the balanced growth path in the Jones model? Provided a constant fraction of workers are doing research, all per capita growth is due to technological progress.

$$(3.8) \quad g_y = g_k = g_A$$

- If we re-write the ideas production function (3.7):

$$(3.9) \quad \dot{A} / A = \delta L_A^\lambda / A^{1-\phi}$$

- But the LHS of (3.9) can only be constant if the growth of the denominator and numerator of (3.9) are at the same rate. Taking logs and derivatives:

$$(3.10) \quad 0 = \lambda \frac{\dot{L}_A}{L_A} - (1-\phi) \frac{\dot{A}}{A}$$

the balanced growth path II

- Along a balanced growth path, the growth rate of the number of researchers must be equal to the growth rate of the population.
- Substituting this into (3.10) gives:

$$(3.11) \quad g_A = \frac{\lambda n}{1 - \phi}$$

- The long-run growth rate of the economy is determined by the parameters of the production function for ideas and the rate of growth of researchers. Consider the special case where $\lambda=1$ and $\phi=0$ so that research productivity is the constant δ , so that the ideas production function is:

$$(3.12) \quad \dot{A} = \delta L_A \quad \text{or} \quad \dot{A} / A = \delta L_A / A$$

- In this case, for a given number of researchers, the growth rate of the stock of ideas eventually falls to zero. Therefore, for growth to be permanent we need population growth at rate n .

ideas based growth

Two views on the knowledge production function:

- Romer (1990) (3.13) $\frac{\dot{A}}{A} = \delta L_A$

δ is the productivity of each researcher

L_A is the number of researchers

- Jones (1995) (3.14) $\dot{A} = \delta L_A^\lambda A^\phi$

ϕ is the returns to the stock of ideas

$\phi > 0$ increasing returns to ideas 'standing on shoulders'

$\phi < 0$ decreasing returns to ideas 'over-fishing'

λ is the degree of congestion in current research

$\lambda < 1$ 'stepping on toes'

$\lambda > 1$ 'network externality'

scale and growth

- Levels effect of scale:

- When $\phi < 1$, then the growth rate of ideas is:

$$g_A = \frac{\lambda n}{1 - \phi}$$

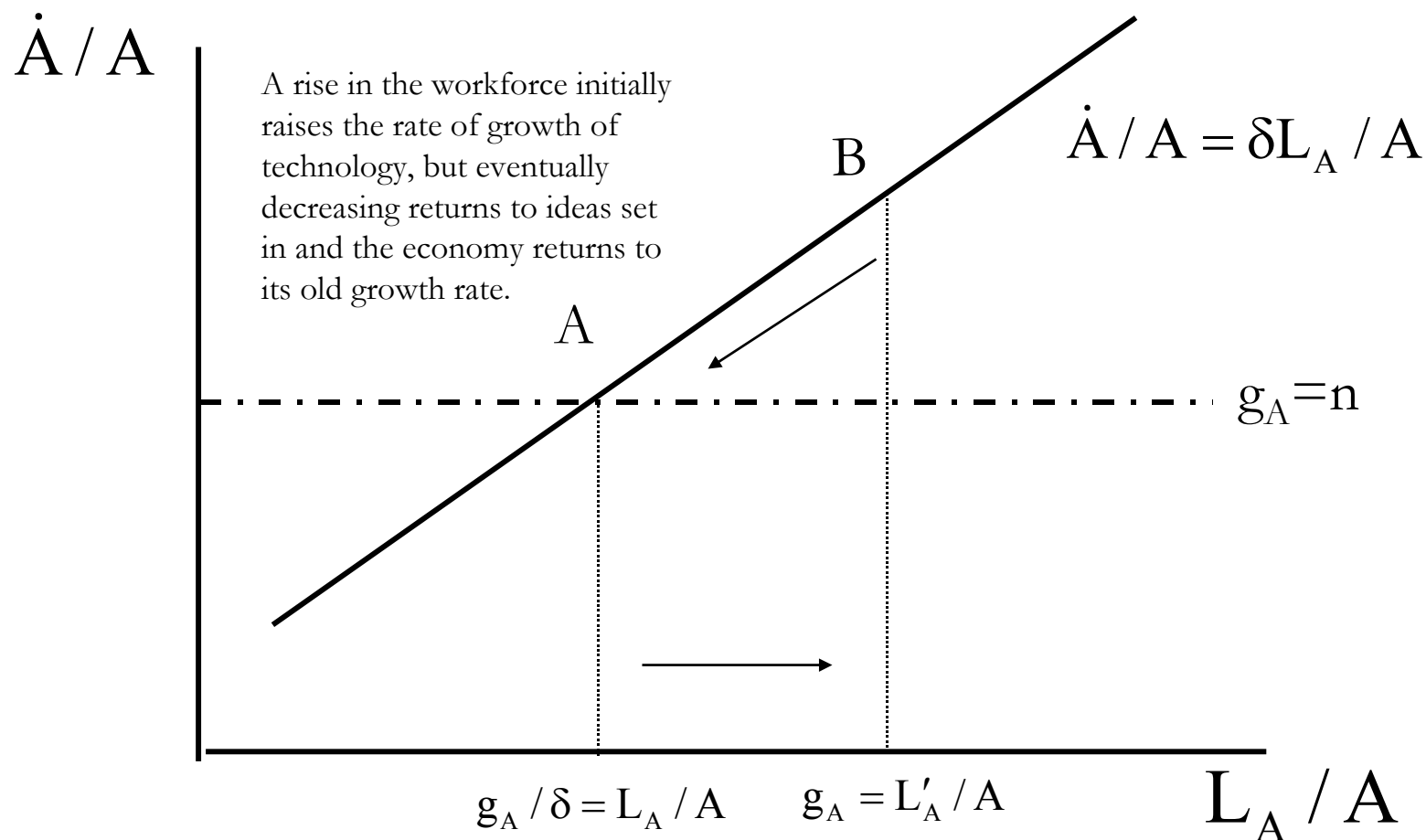
- Growth effect of scale:

- When $\phi = 1$, the growth rate of ideas is:

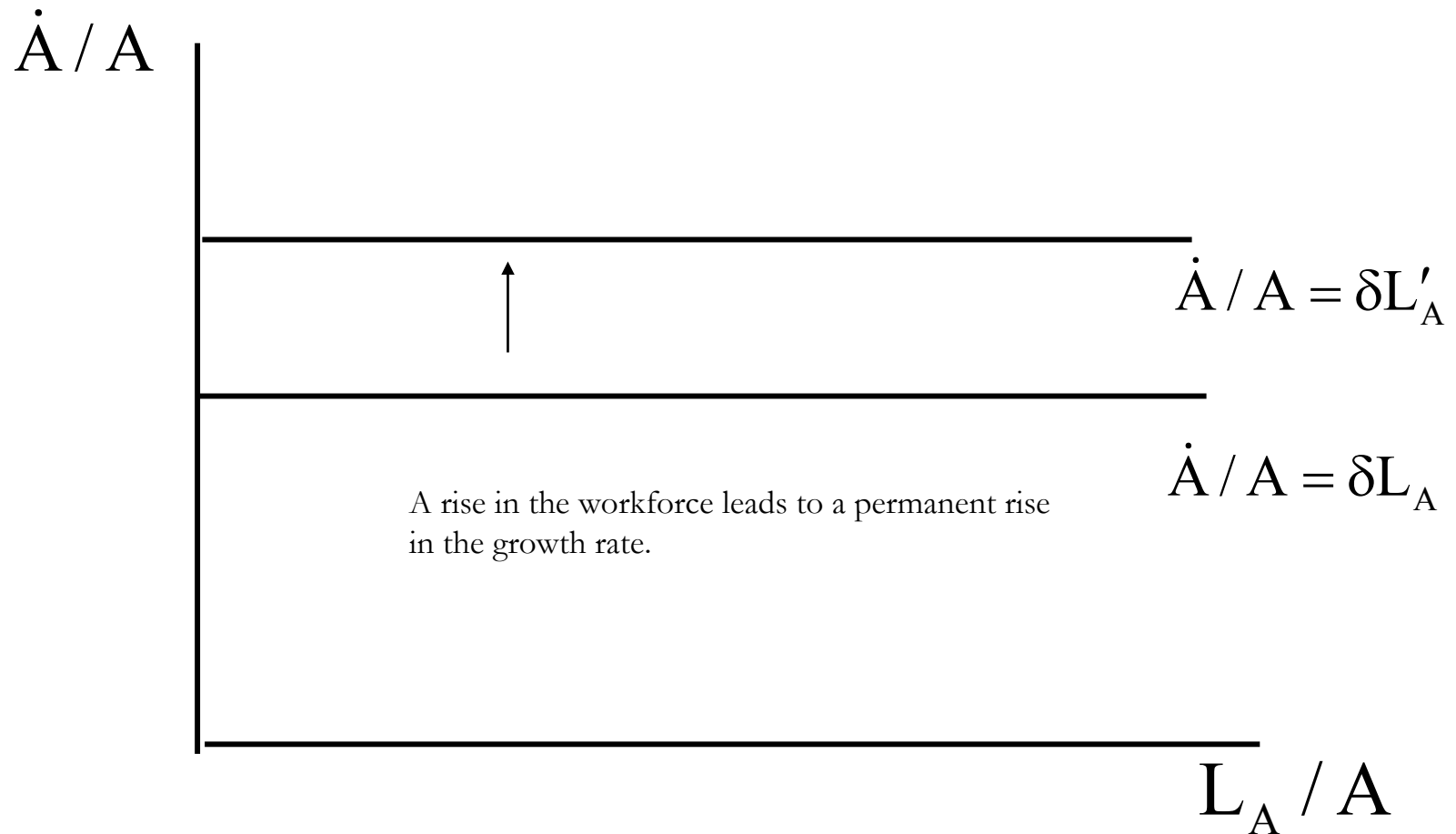
$$g_A = \delta L_A$$

- The latter is the original Romer (1990) formulation and implies that more researchers should lead to faster growth. This is contradicted by the evidence. The number of researchers in the US increased five-fold between 1950 and 1990 but the long-run growth rate continues to hover at about 2 per cent.
- The former, more reasonable model, is due to Jones (1995).

Jones diagram (level effect of scale)



Romer diagram (growth effect of scale)



openness and growth

- Static Effects:
 - Specialisation according to comparative advantage.
- Dynamic Effects:
 - Increased Market Size.
 - Increased Product Market Competition.
 - Access to Foreign Ideas and Capital (Knowledge Spillovers and Technology Transfer).
 - Elimination of duplication in innovation.

catch-up and innovation

- When we consider international economic growth we need to consider the following effects (Cameron, Proudman and Redding, 1998):
- The rate at which technology is adopted from abroad, θ .
- The proportion of foreign technologies that can be adopted, ω .
- The domestic rate of growth in the absence of technology transfer, γ .

a model of catch-up and innovation

- A technological follower grows at the following rate:

$$(3.15) \quad \Delta \log(A_t^F) = \gamma^F - \theta \log(A_{t-1}^F / \omega A_{t-1}^L)$$

- While a technological leader grows at:

$$(3.16) \quad \Delta \log(A_t^L) = \gamma^L$$

- Combining these into a first-order differential equation describing the relative levels of technology:

$$(3.17) \quad \log(A_t^F / A_t^L) = \gamma^F - \gamma^L + \theta \log \omega + (1 - \theta) \log(A_{t-1}^F / A_{t-1}^L)$$

- In steady-state this will be:

$$(3.18) \quad \log(A_t^F / A_t^L)^* = (\gamma^F - \gamma^L) / \theta + \log \omega$$

intuition and growth models

- The AK model and the Romer models generate endogenous growth because they contain a fundamental linearity in a differential equation.
- In the AK model this occurs in the production function and in the Romer model this occurs in the technology equation.
- The Lucas model of human capital also contains such a linearity.

Lucas (1988)

- The production function in the Lucas model is similar to that of the human-capital augmented Solow model:

$$(3.19) \quad Y = K^{\alpha} (hL)^{1-\alpha}$$

- Where h is human capital per person. This evolves according to:

$$(3.20) \quad \dot{h} = (1 - u)h$$

- Where $(1-u)$ is time spent learning and u is time spent working. Rewriting this shows that an increase in time spent learning raises the growth rate of human capital.

$$(3.21) \quad \dot{h} / h = (1 - u)$$

- This model works just like the Solow model where we call A human capital and let $g = (1-u)$. In the full Lucas-Uzawa model, the amount of time spent learning $(1-u)$ is endogenous. A policy that leads to a permanent increase in the time spent learning leads to a permanent rise in the growth of output per worker.

endogenous growth

- There are many endogenous growth models; most of them look at either technology creation or human capital formation as the source of long-run growth.
- They suggest that in the long-run, government policies should be able to either affect the level of income or the growth rate of income.
- In practice, the exact linearity required for a growth effect of scale is unlikely to be true of the real world.
- Therefore the best we can hope for is probably that government policies have permanent effects on income levels.
- Between 1960 and 1988, the United States, Honduras and Malawi all grew at roughly the same rate. But the citizens of the United States have a permanently higher level of income and this is not a negligible advantage!

new growth theory

- New growth theory attempts to look inside the 'black box' of technological progress. Is it exogenous, or is it influenced by the economic environment?
- Three key factors are R&D, openness to foreign ideas, human capital.
- Early models often predicted that growth in income per capita could continue in the long-run even in the absence of population growth. Later models have attempted to do without this somewhat undesirable growth effect of scale.
- Nonetheless, even if there are only levels effects of scale, policymakers should still pay attention. Levels of income matter!