New Growth: The Economics of Ideas
(Main reference: Jones ch.4-5.)

• Neoclassical growth modeling: Focus on capital accumulation

• New growth theory: Focus on technology, ideas, explaining economic growth “endogenously” rather than assuming a growth trend.
  - Targeted towards finding “engines of growth” = processes that do not suffer from the curse of declining marginal returns
  - Accepting increasing returns to scale a/o phenomena inconsistent with perfect competition—models include imperfect competition

• Starting point: Neoclassical growth model with standard production function:
  \[ Y = K^\alpha (AL)^{1-\alpha} \]

• New element: Theory of what “A” means, how and why it increases, and what determines if and how fast it increases over time: Specific interpretation: \( A_t \) = number of ideas/blueprints available at time t

• Key insight: Ideas/blueprints can be used repeatedly without additional cost: they have naturally increasing returns to scale/zero marginal cost.
Motivation: The Curse of Declining Marginal Returns

- Basic Solow model with constant A: Stagnant economy (pre-industrial?)
  
  Obstacle to growth: Declining MPK. Curved f(k) in the Solow diagram. Solutions:

- Approach #1 (Solow): Assume A grows. Then $Y/L = A^{1-\alpha} (K/L)^{\alpha}$ keeps shifting up.

- Approach #2 (AK model): Assume $Y = A \cdot K$ is linear, not curved. (As if $\alpha=1$. Modified “A”)
  
  Yields endogenous growth w/o growth in scale factor A. Solves the problem by assumption.

- Approach #3 (Lucas’ model): Assume skills grow in proportion to education: $\dot{h} = (1 - u) \cdot h$,
  
  where time is divided between work (share u) and education/training (1-u).

  - Production: labor input $u \cdot L$ has skill level $h$: $Y = K^{\alpha} (h \cdot uL)^{1-\alpha}$

    - For any value of u, $u \cdot h$ grows at a fixed rate $g = \dot{h} / h = 1 - u$

    - Yields endogenous exponential growth at rate g.

    - Trick: Linear function for $\dot{h}$ assumes away the problem of declining returns

- Approach #4 (Romer JPE1990 model, Jones JPE1995 version):

  - Increasing returns to scale for “ideas” offset decreasing returns to capital.

  - With every new product, society starts again with high marginal returns.

  - With enough new products, one obtains endogenous exponential growth.
The Economics of Ideas

• Attributes of goods: Rivalry & Excludability

• Increasing return to scale & Imperfect competition
  - Perfect competition: Price = marginal cost.
  - Increasing returns to scale: Average cost > Marginal cost.
  - Profits = Volume \cdot (\text{Price} - \text{Average cost})
  - Solutions: Inefficiency or price discrimination?

• Markets for non-rival or non-excludable goods:
  - Market Failure (Tragedy of the commons)
  - Government as supplier (traditional public-economics approach)
  - Intellectual property rights & competitive R&D (Romer model)
FIGURE 4.1 ECONOMIC ATTRIBUTES OF SELECTED GOODS

Rivalrous goods

- Lawyer services
- CD player
- Floppy disk

Nonrivalrous goods

- Encoded satellite TV transmission
- Computer code for a software application
- Operations manual for Wal-Mart stores
- National defense
- Basic R&D
- Calculus

Degree of excludability
Outline of the Romer/Jones model

• Combine neoclassical production with theory of Research & Development

• Basic principle: Technological progress isn’t free—it is the result of costly R&D efforts that must be rewarded in the market. (Key question: Who pays for research? Patents generate monopoly profits.)

• Economy with three sectors:

1. Production Sector: Final goods $Y$ are produced from intermediate products and labor $L_Y$ at a given level of technology $A$. Interpret “$A$” as number of existing blueprints/ideas.

2. Research Sector: New blueprints/ideas are created from labor inputs $L_A$, building on the existing technology $A$. Labor force $L = L_Y + L_A$.

   • Interpret innovation as change in number of blueprints over time: $\dot{A} = \delta \cdot L_A$

3. Intermediate Products Sector: included as device to model cost recovery for R&D, and to handle increasing returns to scale in $K$, $L$, and $A$.

• Final goods sector produces consumption and raw capital.

• Intermediate goods sector transforms raw capital into various specialized goods.

   - Transformation requires technical knowledge (patented) $\Rightarrow$ Demand for blueprints.

   - In equilibrium, production of intermediate good equals use of raw capital

$\Rightarrow$ Aggregate output depends on $(K, L, A)$ as in the Solow model
The Research Sector

- Research is labor-intensive. For simplicity, omit capital inputs to research.

- Basic version: research output at the individual level is proportional to the labor input:

  \[ \bar{\delta} = \text{rate at which an individual researcher discover new ideas.} \]

  \[ \dot{A} = \bar{\delta} \cdot L_A \] has constant returns to scale \( \Rightarrow g_A = \dot{A} / A = \bar{\delta} \cdot L_A / A \) \( \Rightarrow \) Balanced growth: \( g_A = g_{L_A} = n \)

- Extended version: Discovery of new ideas depends on the existing stock of ideas \( A \) and on the number of other researchers—modeled as externalities:
  - Positive spillovers from existing knowledge: High \( A \) might increase \( \bar{\delta} \).
  - Negative spillovers from existing research: High \( A \) might reduce \( \bar{\delta} \).
  - Congestion effects: If more people do research competitively, efforts might be duplicated or wasted:
    Higher \( L_A \) might reduce \( \bar{\delta} \) for all the researchers

- General formula: \( \bar{\delta} = \delta \cdot A^\phi \cdot L_A^{\lambda-1} \Rightarrow \dot{A} = \delta \cdot A^\phi \cdot L_A^\lambda \)

  with proportionality factor \( \delta, \phi \) as “spillover” parameter, and \( \lambda \) as “congestion” parameter.

  - Basic version has \( \phi=0 \) and \( \lambda=1 \). Then \( \bar{\delta} = \delta \) is constant; research output proportional to labor input.

  - Positive spillover means \( \phi>0 \), negative spillover means \( \phi<0 \), and congestion means \( 0<\lambda<1 \).
Endogenous Growth

- What growth rate of technology can be sustained in this economy?
  - Dynamics of the economy is complicated: Focus on balanced growth.

- Growth in A: New ideas relative to the existing stock of knowledge
  \[ g_A = \frac{\dot{A}}{A} = \delta \cdot \frac{L_A}{A} = \delta \cdot L_A^\lambda / A^{1-\phi} \]

- Labor: \( L = L_Y + L_A \) grows at rate \( n \). \( s_R = L_A/L \) = share of research labor.
  Whenever \( s_R \) is constant over time, \( L_Y \) and \( L_A \) also grow at rate \( n \)

- Under what conditions can \( g_A \) be constant?
  - Step 1: \( g_A \) depends on the ratio \( L_A^\lambda / A^{1-\phi} \Rightarrow g_A \) is constant if \( L_A^\lambda \) and \( A^{1-\phi} \) grow at the same rate.
  - Step 2: \( L_A^\lambda \) grows at rate \( \lambda n \); \( A^{1-\phi} \) grows at rate \((1-\phi)g_A\) \Rightarrow steady state must satisfy \( \lambda n = (1-\phi)g_A \).
  \[ \Rightarrow \text{The steady state growth rate is} \quad g_A = g_A^* = \frac{n \cdot \lambda}{1-\phi} \]

- Note: If \( g_A \) is constant, per capita output and capital grow at the same rate. In steady state, this economy works like the Solow model, except that growth is determined endogenously.
Steady State Growth:
\[ g_A^* = \frac{n \cdot \lambda}{1 - \phi} \]

- Linked to population growth \( n \): People are needed to discover new ideas.
  - Positive spillovers raise growth: if \( \phi > 0 \), then \( 1/(1-\phi) > 1 \) \( \Rightarrow \) \( g_A > n \lambda \).
  - Congestion effects reduce growth: \( \lambda < 1 \) \( \Rightarrow \) \( g_A < n/(1-\phi) \).
  - Growth rate vs. level effects: Changes in other variables will generate extra growth during a transition period, but not in the long run.

- Because of externalities and monopolistic pricing, the market allocation is generally NOT the most efficient allocation.

Transitional Growth

- New decision variable: \( s_R = \) Share of labor force in research. What happens if \( s_R \) is increased?
  - Actual growth is a function of \( A \) and \( L_A = s_R L \):
    \[ g_A = \frac{\dot{A}}{A} = \delta \cdot \frac{L_A}{A} = \delta \cdot A^{\phi-1} \cdot L_A^\lambda \]
  - An increase in \( s_R \) raises \( L_A \) relative to \( A \) and \( L \) \( \Rightarrow \) \( g_A \) jumps up. But \( g_A^* = \frac{n \cdot \lambda}{1 - \phi} \) remains unchanged.
  - During the transition, \( A \) grows faster than \( g_A^* \); \( A^{1-\phi} \) grows faster than \( L_A^\lambda \).

\( \Rightarrow \) Over time, \( g_A \) declines, converges to \( g_A^* \).
Learning Objectives for New Growth

Introduction only – mostly concepts:

• Conceptual: Know the basic ideas of New Growth
  - The problem of declining marginal returns.
  - The economics of ideas: Non-rivalry and excludability.
  - Outline of the Romer/Jones model and its main properties.

• Applied: Compute steady state TFP growth from the production function for research.