

# Bob Solow and the Theory of Economic Growth

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## Outline

- The Solow model
- Growth accounting
- Critiques of new growth theory
- Lessons

## Simple Models

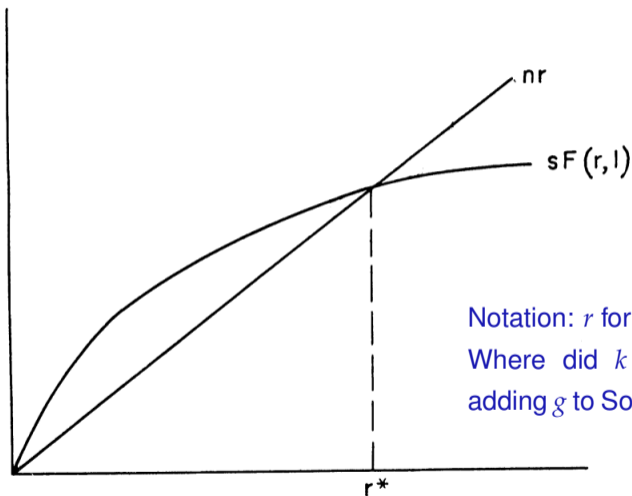
- Embodied the MIT tradition of elegant models
  - Zoom in on the essence
  - Highlight key forces
  - Analytic results whenever possible
  - Celebrate economic intuition
- Opening of Solow (1956)

*All theory depends on assumptions which are not quite true. That is what makes it theory. The art of successful theorizing is to make the inevitable simplifying assumptions in such a way that the final results are not very sensitive.*

## Features of Solow (1956)

- Original motivation was to show that smooth substitution between capital and labor eliminated Harrod-Domar's "knife edge" prediction (from Leontief) that if parameters were not just right, massive unemployment or prolonged inflation would result.
- A **general framework**, not narrow question — part of success
  - General  $F(K, L)$
  - $AK$  examples: where  $F_K$  remains large  $\Rightarrow$  sustained growth forever
  - Poverty traps (e.g. because  $s$  or  $n$  varies with income)
  - CES production — well before Arrow-Chenery-Minhas-Solow (1961)
  - Closed form solution for transition dynamics when  $F(\cdot)$  is Cobb-Douglas
  - **"Rule of thumb"** allocation: exogenous  $s$  versus Ramsey-Cass-Koopmans
  - Solow diagram

## Solow Diagram



Notation:  $r$  for  $K/L$ , No depreciation  
Where did  $k = K/L$ , depreciation,  
adding  $g$  to Solow diagram come from?

FIGURE I

## (Solow 1956 – continued)

- Role of exogenous technological progress in Solow (1956)
  - Just an “Extension” that is worked out in one page toward the end.
- For pedagogical reasons, we teach the Solow model differently
  - Narrative approach: **How do we understand sustained exponential growth?**
  - My tongue-in-cheek joke to students: “huge, disappointing failure!”

## Growth Accounting: Solow (1957)

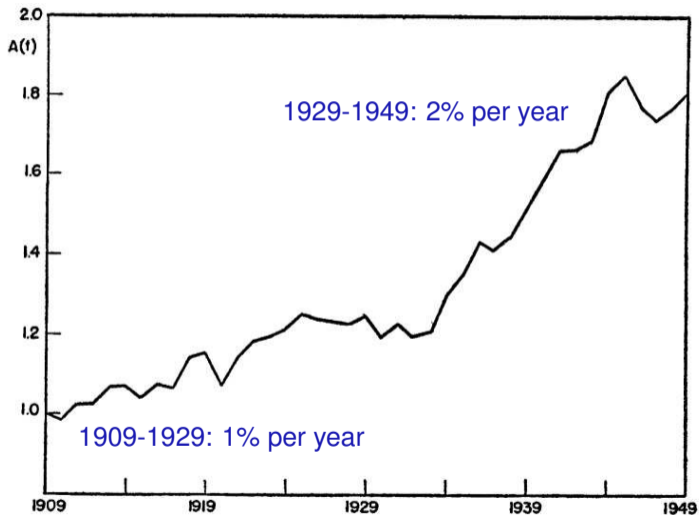
- The empirical anchor of growth economics
  - Accounting is an incredibly useful tool (identification hard!)
- Elegance: applies to general  $F(K, L; t)$

$$\frac{\dot{Y}_t}{Y_t} = \alpha_{Kt} \frac{\dot{K}_t}{K_t} + \alpha_{Lt} \frac{\dot{L}_t}{L_t} + \frac{\partial F / \partial t}{F}$$

where  $\alpha_{Kt} = F_{Kt}K_t/Y_t$ . (Solow even noted he could handle monopoly markups!)

- Stunning and revolutionary conclusion
  - The **Solow residual** of TFP growth accounts for a huge share of growth
  - The neoclassical inputs of Solow (1956) account for very little

## Solow (1957): The level of TFP over time



(Field 2012,  
Kelly et al 2021)



- Findings (+1956) demanded a **theory of technological change**
  - 1960/70s: Nordhaus, Phelps, Shell, Uzawa; anticipating 1980s/90s
- Other connections to 1980s/90s
  - Mankiw, Romer, Weil (1992): “This paper takes Robert Solow seriously.”
  - Hall and Jones (1999) “levels accounting”: Initially applied Solow’s chaining method across countries to avoid specifying a functional form. Such a powerful idea!
  - Klenow and Rodriguez-Clare (1997): Their version built on MRW/Cobb-Douglas to do accounting in terms of  $K/Y$  instead of  $k$ .

Better in that  $y_t = \left(\frac{K_t}{Y_t}\right)^{\frac{\alpha}{1-\alpha}} A_t$  credits the part of  $\uparrow K$  due to TFP to  $A$   
 — nicely combines the insights of the '56 and '57 papers

## Krugman “The Myth of Asia’s Miracle” (*Foreign Affairs*, 1994)

- One of my favorite essays for teaching
- Explains Solow (1956/57) in terms of the East Asian growth miracle
  - Alwyn Young’s famous growth accounting (1992, 1995)
- Lessons
  - No free lunch (rising employment, education, investment)
  - Diminishing returns: input-driven growth inevitably slows
  - Applications to the Soviet Union, Japan/HK/Singapore, and even China
- Especially great for undergraduates, MBAs, and masters students

## Aside: Uzawa (1961) Two Sector Model

- Two sectors: consumption goods and capital goods
  - Topic is the nature of substitution between capital and labor (a key motivation of Solow 1956)
  - Mathematical style: introduction, lots of equations, stop
- 1961 note, published on the pages directly after Uzawa (1961)

*I am afraid that many readers will be put off by the apparent mathematical difficulty of Uzawa's paper. I say "apparent" advisedly, because the paper is in part very easy; it requires only a little arithmetic and the bare elements of the calculus of functions of one variable. Any economist who cannot read it ought at least to insist that his students do so.*

- As always: Solow sought to understand / explain, with humor and beautiful writing

## Insightful commentary on New Growth Theory (1994 JEP)

- The fragile “knife-edge” character of endogenous growth models
  - Growth stops if the returns to accumulable inputs (e.g. capital) are below one
  - Explodes if even slightly above one (infinite income in finite time)
  - “you would have to believe in the tooth fairy to expect that kind of luck”
- Complimentary about Romer / Aghion-Howitt endogenizing technical change
  - “I think that the real value of endogenous growth theory will emerge from its attempt to model the endogenous component of technological progress as an integral part of the theory of economic growth.”
  - “It is easy to agree that the flow of innovations per unit time depends on the amount of resources devoted to creating them.”

## (on new growth theory – continued)

- However, another important critique:

*If an innovation generates a **proportionate increase** in  $A$ , then we have a theory of easy endogenous growth. Spend more resources on R&D, there will be more innovations per year, and the growth rate of  $A$  will be higher. But suppose that an innovation generates only an **absolute increase** in  $A$ : then greater allocation of resources to R&D buys a one-time jump in productivity, but not a faster rate of productivity growth.... [M]erely to adopt the more powerful assumption is no more than to assume the more powerful conclusion.*

- I agree with almost everything he wrote in that essay — deep and insightful
  - **Exception:** “[T]he presence of increasing returns to scale is not the essence of these newer approaches” (even our gods are not perfect!)

## Simple Models versus BBB

- Research in macroeconomics: **Simple Models** and “**Big Black Boxes**”
  - Growth theory (both 1950s/60s and 1980s/90s) was 95% simple, 5% BBB
  - Macro today is perhaps 10% simple and 90% BBB
- Both approaches are important and essential for learning about the economy
  - **Simple models**: key forces, economic intuition
  - **BBB**: Many forces interacting, rich heterogeneity, numerical solutions
    - the world is a complicated place.
- Has the balance shifted too far?
  - Solow *always* emphatically replied “Yes!”

## My Interactions with Bob

- Q4 of 1st-year macro, Spring 1990 — taught growth, including Romer (1986, 1987)
  - Witty, charming, and generous. The twinkle in his eye. The smiling laugh.
- Retired shortly thereafter, no longer attended seminars
- My regret and a lesson
  - I was too shy and never talked with Bob about my thesis or endogenous growth in the early 1990s
  - What a **missed opportunity** — don't be like that!
- As I get older I realize that Solow must have felt what I feel now:
  - Few greater pleasures than talking about our favorite subject
  - I could have learned so much...



by Jean-Felix Brouillette, 2023