Principles of Macroeconomics: Growth Accounting

Class 6

Alex Houtz

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University of Notre Dame

Overview

- Announcements:
  - LCs 7&9, GHs 7&9 due Friday at 11:59pm!
- Topics:
  - What is TFP?
  - Growth Accounting
  - Sources of Growth
- Readings:
  - Chapters 9.3-9.4, chapter 10.1

TFP Reminder

- What is TFP – Total Factor Productivity

$$Y = AK^{1/3}L^{2/3}$$

- A tells us how effective we are at transforming K ad L into Y
- But A is a left-over part of our production function – basically the part of output we don't know how to explain
- So let's try to explain A a little bit

Opening TFP

1. Human Capital
    - Workers possess knowledge and skills that makes them productive
    - We know there are big gaps between countries when it comes to average educational attainment
    - Accounting for human capital decreases the importance of TFP
2. Technology
    - High technology levels are not universal
    - R&D tends to occur in rich countries, so rich countries tend to have higher technology levels
    - It is not necessarily easy for technology to cross country borders

3. Institutions
    - Markets are good at allocating resources
    - But markets don't work well if ownership isn't well established
    - Some societies have strong property rights – gives incentive to invest, improve, innovate
    - Some societies have corrupt governments – this makes it harder to reliably produce
    - This idea is key and basically won the Nobel Prize last year
4. Misallocation
    - Some production in a country is good, some is inefficient
    - If capital and labor go to low productivity producers instead of high productivity producers, we consider those resources as misallocated
    - One potential example is labor "stuck" in agricultural production in some countries, rather than being allocated to more high-productivity roles in manufacturing

Growth Accounting

- Tuesday: Development Accounting
  - Why does income differ across countries?
- Today: Growth Accounting
  - Why does income grow over time?
- Before we start, two math rules: Suppose that x grows at rate g_x and y grows at rate g_y. Then:

$$\text{If } z = xy, \text{ then } g_z = g_x + g_y$$
$$\text{If } z = x^a, \text{ then } g_z = a g_x$$

These can be derived by taking logs and using: $\ln\left(\frac{x_{t+1}}{x_t}\right) \approx \frac{x_{t+1}-x_t}{x_t}$ for small Δx_{t+1}

Our Production Function

- Apply that to our production function:

$$Y_t = A_t K_t^{1/3} L_t^{2/3}$$

- The growth rate of Y_t is:

$$g_Y = g_a + \frac{1}{3} g_K + \frac{2}{3} g_L$$

Add Human Capital

- Now let's suppose workers possess human capital, so that workers with higher levels of human capital are more productive
- Define $H_t = h_t L_t$ as effective units of labor
  - L_t is the quantity of labor, i.e. hours worked
  - h_t is the quality of labor, i.e. how productive each hour is
- Put this into the production function:

$$
\begin{aligned}
Y_t &= A_t K_t^{1/3} H_t^{2/3} \\
\frac{Y_t}{L_t} &= A_t \left(\frac{K_t}{L_t} \right)^{1/3} h_t^{2/3} \\
y_t &= A_t k_t^{1/3} h_t^{2/3}
\end{aligned}
$$

- Now use our growth decomposition rules. For RGDP:

$$g_y = g_A + \frac{1}{3}g_K + \frac{2}{3}(g_h + g_L)$$

- For RGDP per hour worked:

$$g_Y - g_L = g_A + \frac{1}{3}(g_K - g_L) + \frac{2}{3}g_h$$

- We can calculate these growth rates, and then compute g_A as a residual

In the US

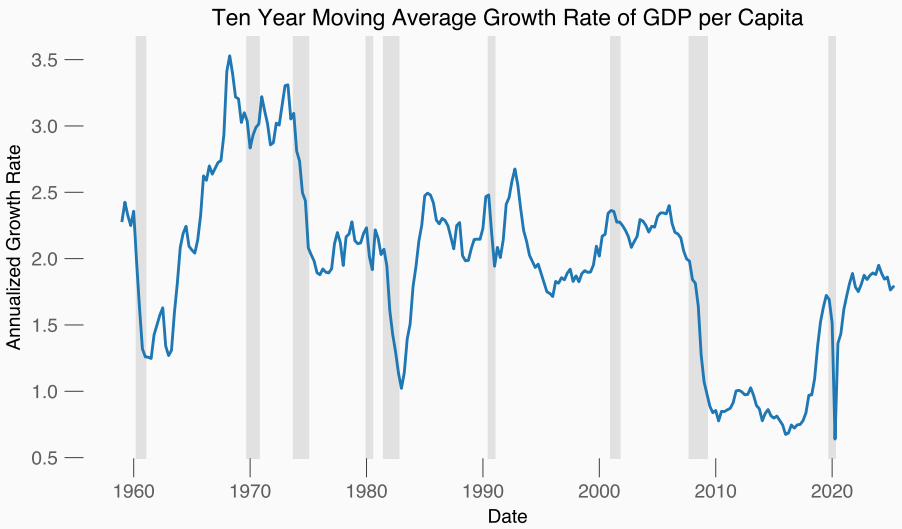
Measure	1948-2024	1948-1973	1973-1995	1995-2005	2005-2024
Output per hour (Y/L)	2.14	2.94	1.45	3.04	1.69
Contribution of K/L	0.86	0.85	0.77	1.25	0.74
Contribution of labor composition	0.25	0.16	0.27	0.24	0.3
TFP (A)	1.01	1.91	0.42	1.5	0.65

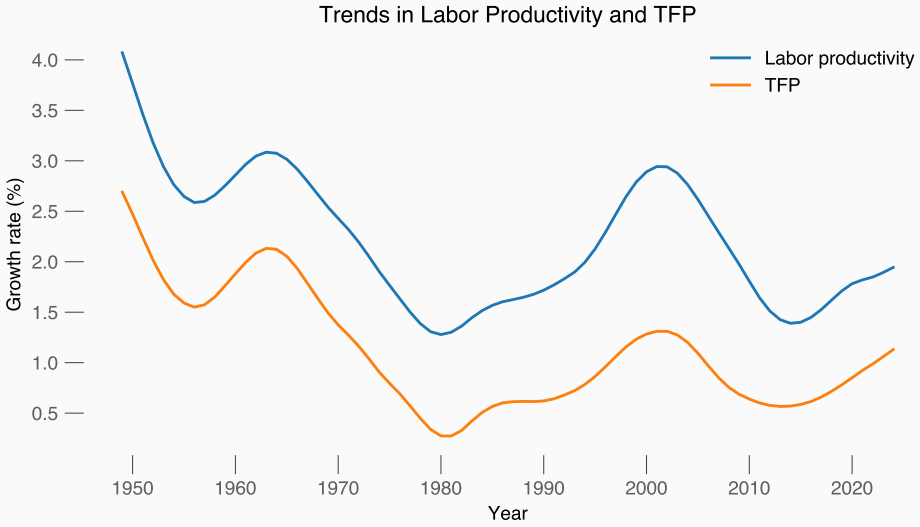
Past and Future US Growth

- TFP accounts for about half of past US economic growth (1.01/2.14)
- If we believe productivity growth drives human capital accumulation, then TFP drives even more
- If we believe productivity growth drives capital accumulation, then TFP drives even more

- BUT: US growth seems to be slowing since 2000
  - TFP growth is lower than any period besides 1973-1995 (what happened here???)
- What does this mean for us?

Slowing US Growth




Trends in Labor Productivity and TFP
Labor productivity
TFP
Growth rate (%)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
1950
1960
1970
1980
1990
2000
2010
2020
Year

Why Declining TFP Growth?

- High TFP growth requires innovation
- Innovation requires new and better ideas
- Innovations of the 19th and 20th centuries:
  - Electricity
  - Sanitation
  - Antibiotics
  - Internal combustion
- Innovations of the 21st century:
  - Computing power
  - Internet

- Some economists have been harsh on the internet:
  - Robert Solow: "You can see the computer age everywhere but in the productivity statistics."
  - Paul Krugman: "By 2005 or so, it will become clear that the Internet's impact on the economy has been no greater than the fax machine's."
- These seem too harsh to me. There was an increase in TFP growth during the computing boom.
- But, the last 10-15 years haven't seen high TFP growth – so innovations like social media are not increasing productivity (surprise!)
- And it is true that in general, the growth rate in TFP is falling

- Maybe we are just out of ideas that are "easy" to implement?
- So where do new ideas come from? Using resources for research
  - Scientists, engineers $\longrightarrow$ R&D labor
  - Labs, computers, etc $\longrightarrow$ R&D capital
- In a very simple, very naive world:

$$g_y = A_{research} \times L_{researchers}$$

- Fact: economic growth $\approx 2\%$ a year over the last century
- Fact: The number of researches as increased by 32x over the last century

- That means research productivity is falling a lot – ideas are harder to find?

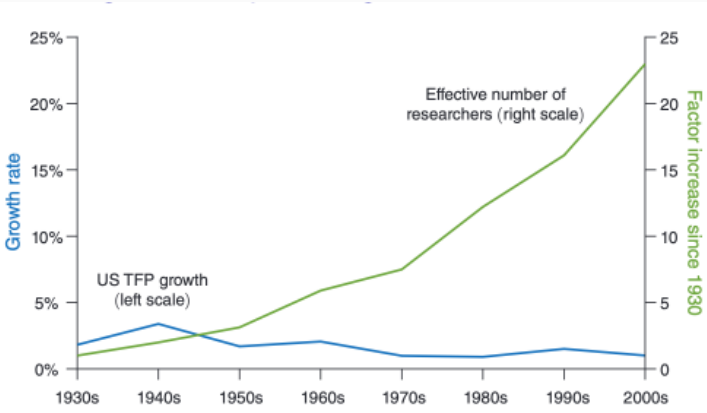


FIGURE 1. AGGREGATE DATA ON GROWTH AND RESEARCH EFFORT

Source: Bloom, Jones, Van Reenen, and Webb (2020)

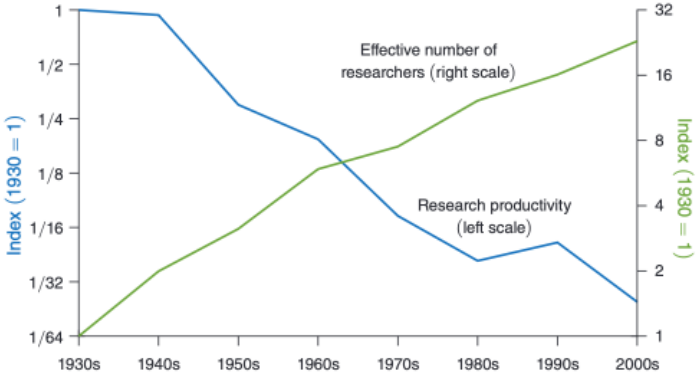


FIGURE 2. AGGREGATE EVIDENCE ON RESEARCH PRODUCTIVITY

Source: Bloom, Jones, Van Reenen, and Webb (2020)

Semiconductor Case Study

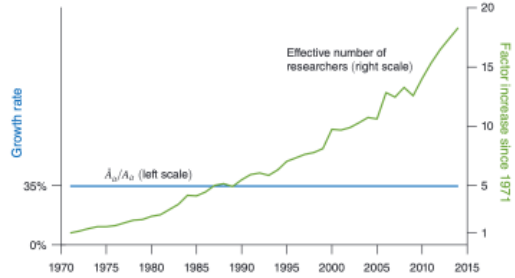


FIGURE 4. DATA ON MOORE'S LAW

Notes: The effective number of researchers is measured by deflating the nominal semiconductor R&D expenditures of key firms by the average wage of high-skilled workers and is normalized to 1 in 1970. The R&D data include research by Intel, Fairchild, National Semiconductor, Texas Instruments, Motorola, and more than two dozen other semiconductor firms and equipment manufacturers; see Table 1 for more details.

Source: Bloom, Jones, Van Reenen, and Webb (2020)

Implications

- Van Reenan said "just to sustain constant growth in GDP per person, the US must double the amount of research effort searching for new ideas every 13 years to offset the increased difficulty of finding new ideas."
- That doesn't seem sustainable, so what are ways we might be able to solve this?
  (1) Public policy?
    - More STEM?
    - Increased government spending on R&D?
  (2) AI?
    - Perhaps, but the ability of AI seems to be leveling off...
  (3) Globalization?
    - Untapped research talent in India, China, Africa – lots of new ideas maybe?

Summary

- Some parts of TFP include human capital and idea generation
- TFP growth is slowing
- There are a few ways people have proposed fixing this problem

- Remember: homework due tomorrow night
- Switching to investment and financial markets next week – read section 10.1