



Productivity Growth over the Next Decades

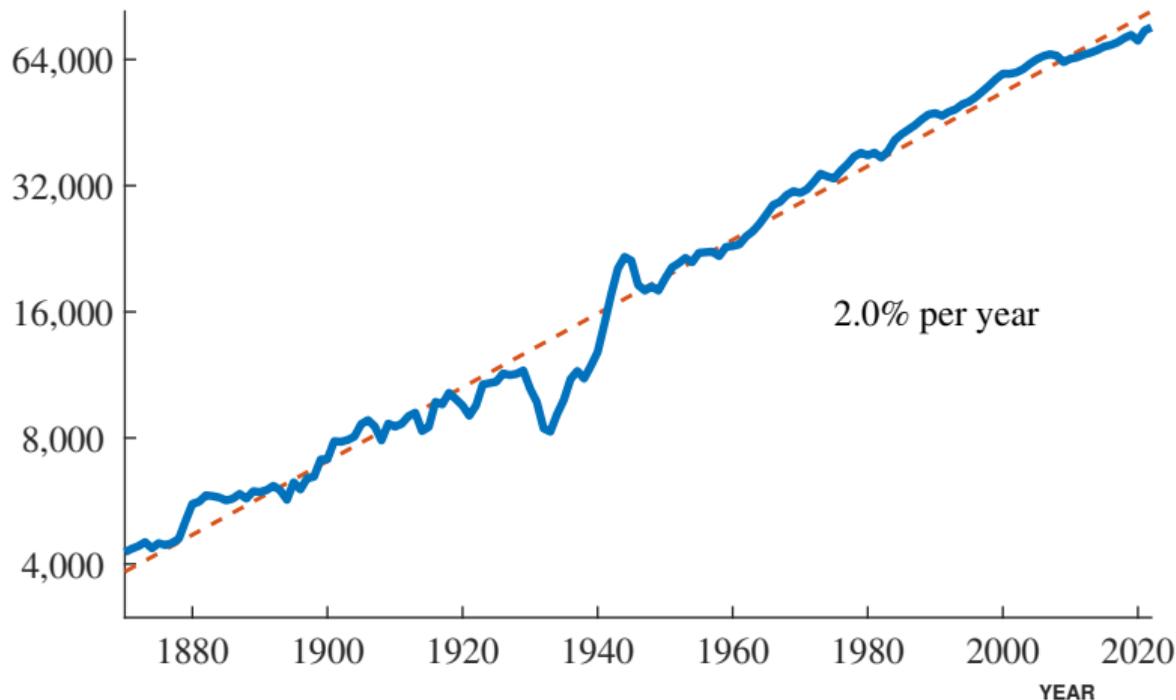
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U.S. Long-Run Economic Growth

2022 DOLLARS, RATIO SCALE



“The Past and Future of Economic Growth...” (*Annual Review*, 2022)

The Theory of Economic Growth

- Ideas are special: **infinitely usable** (Paul Romer, 2018 Nobel Laureate)
 - Standard goods: computer, barrel of oil, hour of a surgeon's time
 - Ideas: calculus, design of Covid vaccine, latest ML algorithm
- Implication for economic growth:
 - **One computer** \Rightarrow make **one worker more productive**
Need 1000 computers for 1000 workers
 - **One new idea** (e.g. invention of electricity)
 \Rightarrow make **any number of people more productive.**
- Income per person \leftarrow Ideas \leftarrow People

Growth in Y/L \leftarrow growth in people finding ideas

The Future of Economic Growth?

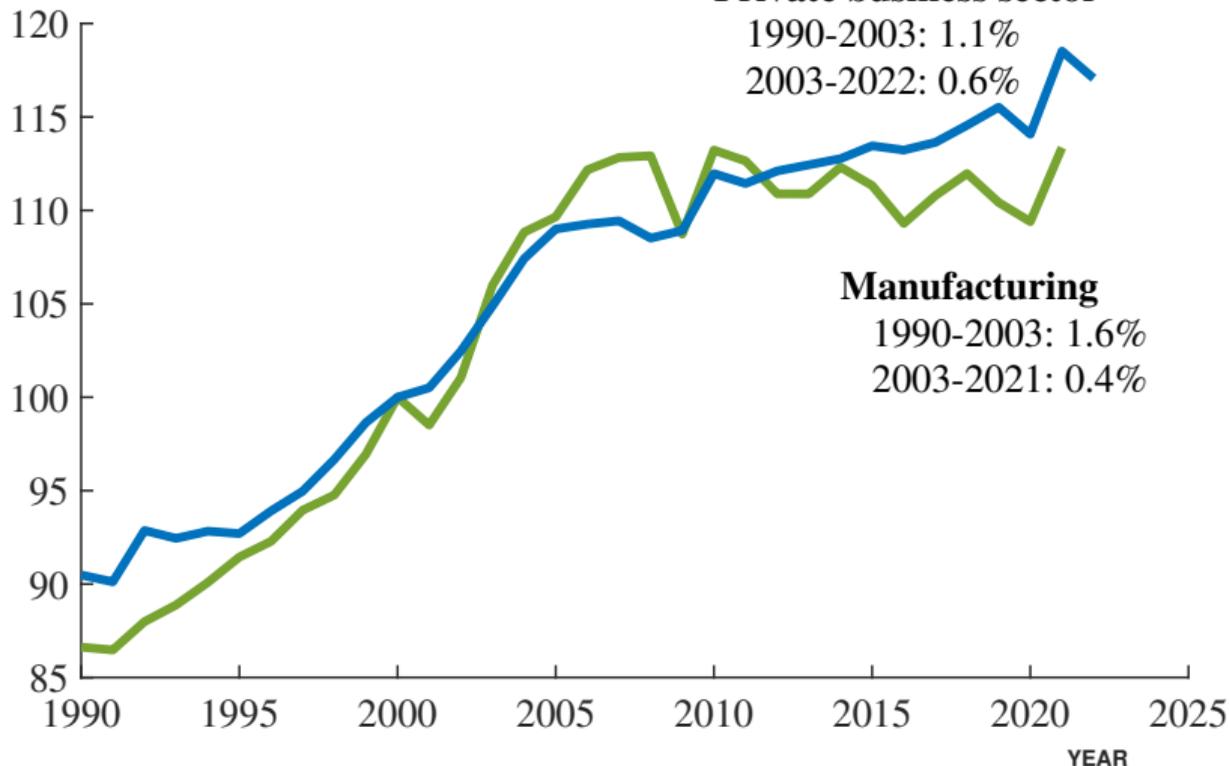
- **Headwinds**

- Ideas are getting harder to find
- Rising investment in IPP (infinitely usable goods)
- Educational attainment is leveling out
- Population growth slowing. Negative in the future?

- **Tailwinds**

U.S. Total Factor Productivity

TOTAL FACTOR PRODUCTIVITY (2000=100)



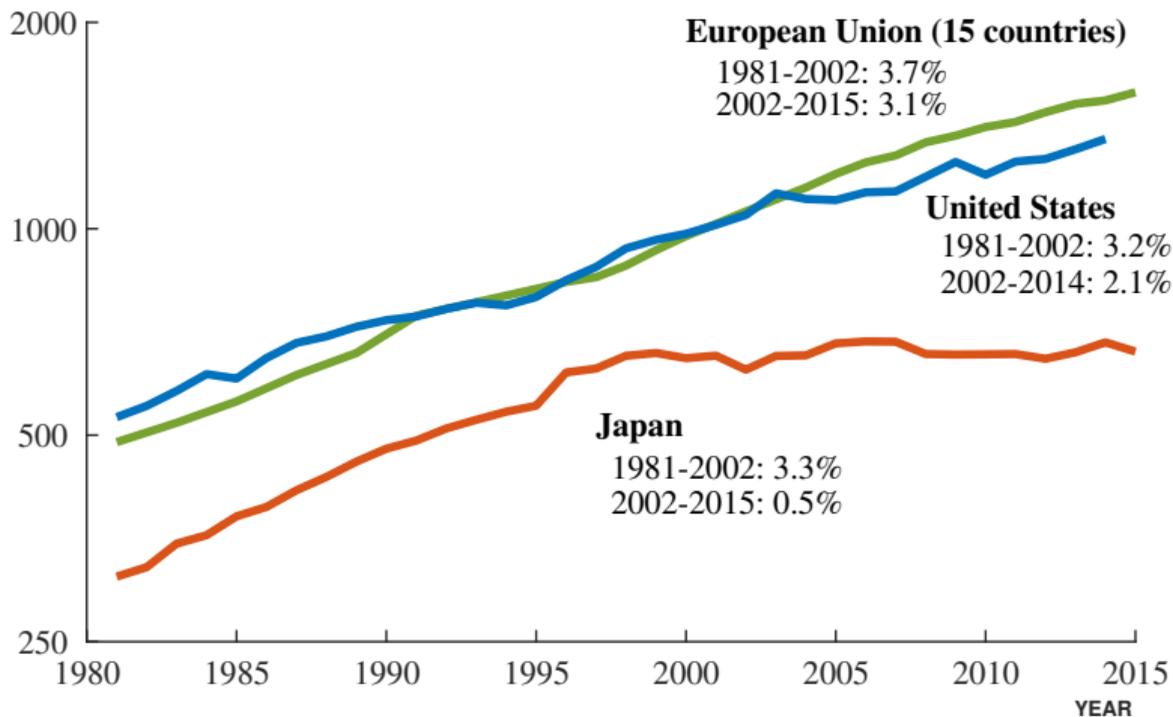
Ideas are getting harder to find

$$\begin{array}{ccccc} \text{Economic} & & \text{Research} & & \text{Research} \\ \text{growth} & = & \text{productivity} & \times & \text{effort} \\ \text{e.g. 2\%} & & \downarrow \text{ (falling)} & & \uparrow \text{ (rising)} \end{array}$$

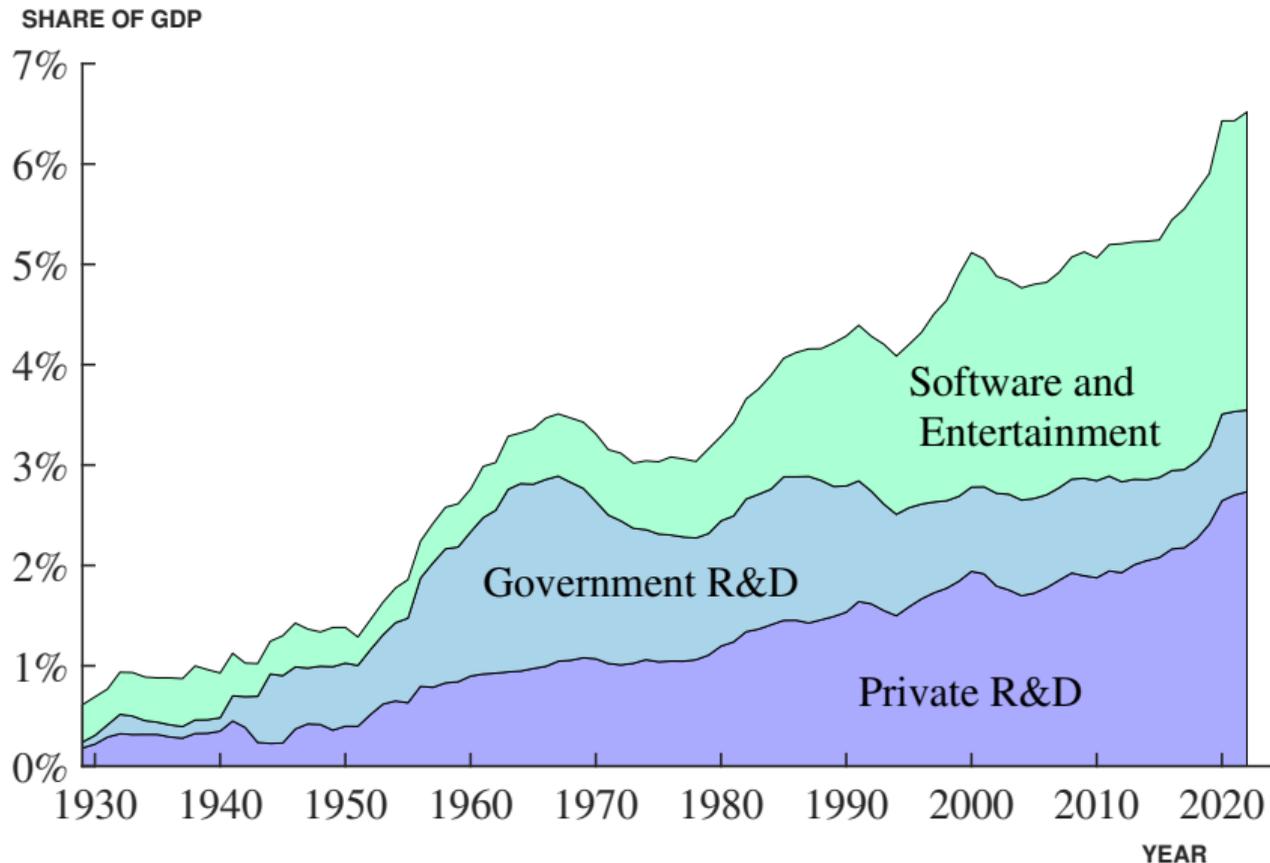
- We have to invest ever-rising resources in R&D just to maintain a constant rate of economic growth
 - Moore's Law: Research effort 18x higher in 2010s than 1970s
 - True in other areas: agriculture, health innovations, and firms
- **Red Queen Theory**: we have to run faster and faster to stay in the same place, i.e. to maintain 2% overall growth

Research Employment in Select Economies

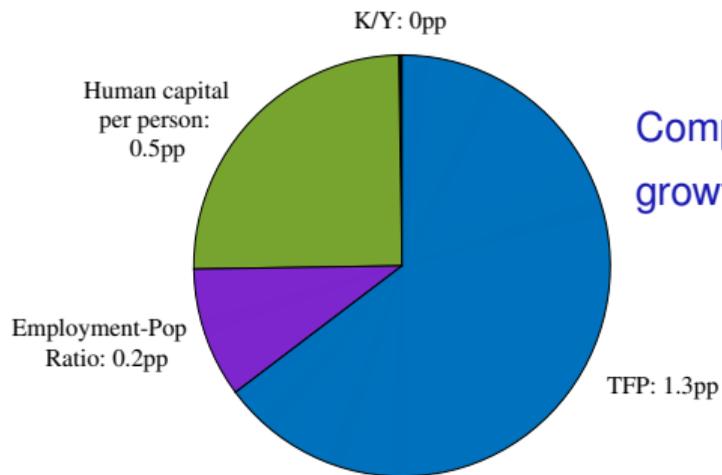
RESEARCH EMPLOYMENT (1000S, LOG SCALE)



Investment in Infinitely Usable Ideas

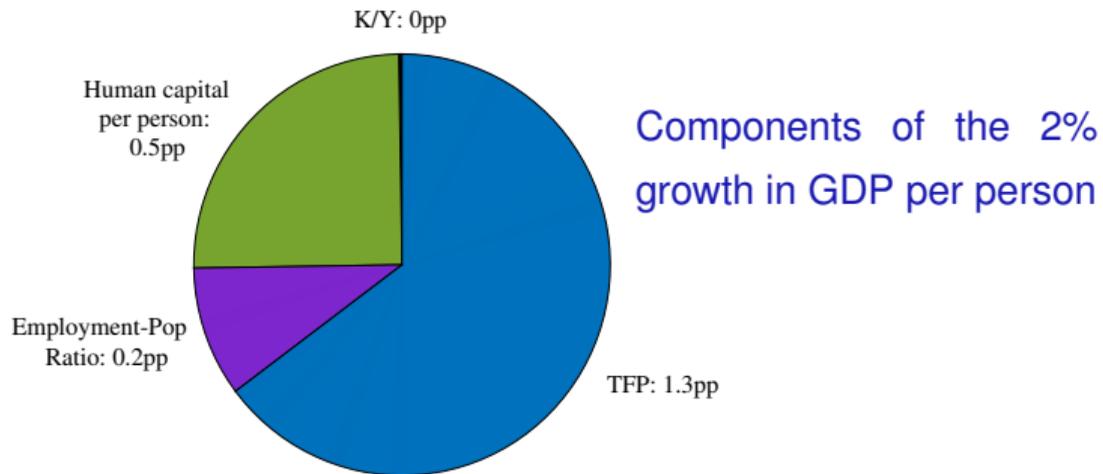


U.S. Historical Growth Accounting



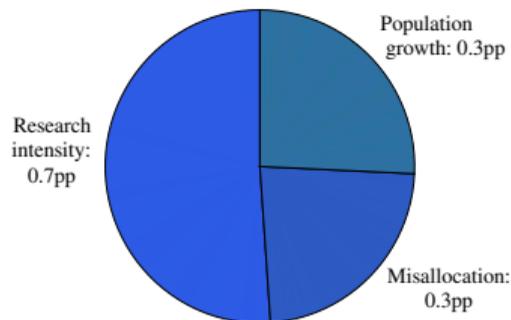
Components of the 2%
growth in GDP per person

U.S. Historical Growth Accounting



The long-run component of growth is only 15% of historical growth = 0.3pp!

Components of the 1.3% TFP growth



The Future of Economic Growth?

- **Tailwinds**

- China and India – each as populous as U.S. + Europe + Japan

In 2013-16, Tsinghua University: more of the 10 percent most highly cited papers in STEM than any other university

- How many future Steve Jobs and Jennifer Doudnas are waiting to realize their potential?
- Artificial intelligence?

Misallocation in the United States

- Sandra Day O'Connor, Supreme Court Justice (1981–2006)
 - Graduated 3rd in her class at Stanford Law School, 1952
 - Only job offer in the private sector: legal secretary
- Consider white men in U.S. business:
 - 1960: **94%** of doctors, lawyers, and managers
 - 2010: **60%** of doctors, lawyers, and managers
- Over the past 50 years, the U.S. allocation of talent has improved!
Accounts for
 - **40%** of growth in GDP per person, and
 - **20%** of growth in GDP per worker

Artificial Intelligence?

- Can machines augment or even replace people in finding ideas?
 - Theoretically possible
 - Virtuous circle that can potentially raise growth rates
- But **history** suggests caution
 - Automation has been ongoing for 200 years — stable growth
 - Steam engine, electricity, internal combustion, semiconductors
 - Maybe A.I. is the latest great idea that will allow 2% growth to be sustained a bit longer