# Lecture 13. Technological Progress and Policies to Promote Innovations

There is no required reading for this lecture.

$$\Delta k_{t+1} = sf(k_t) - \delta k_t$$

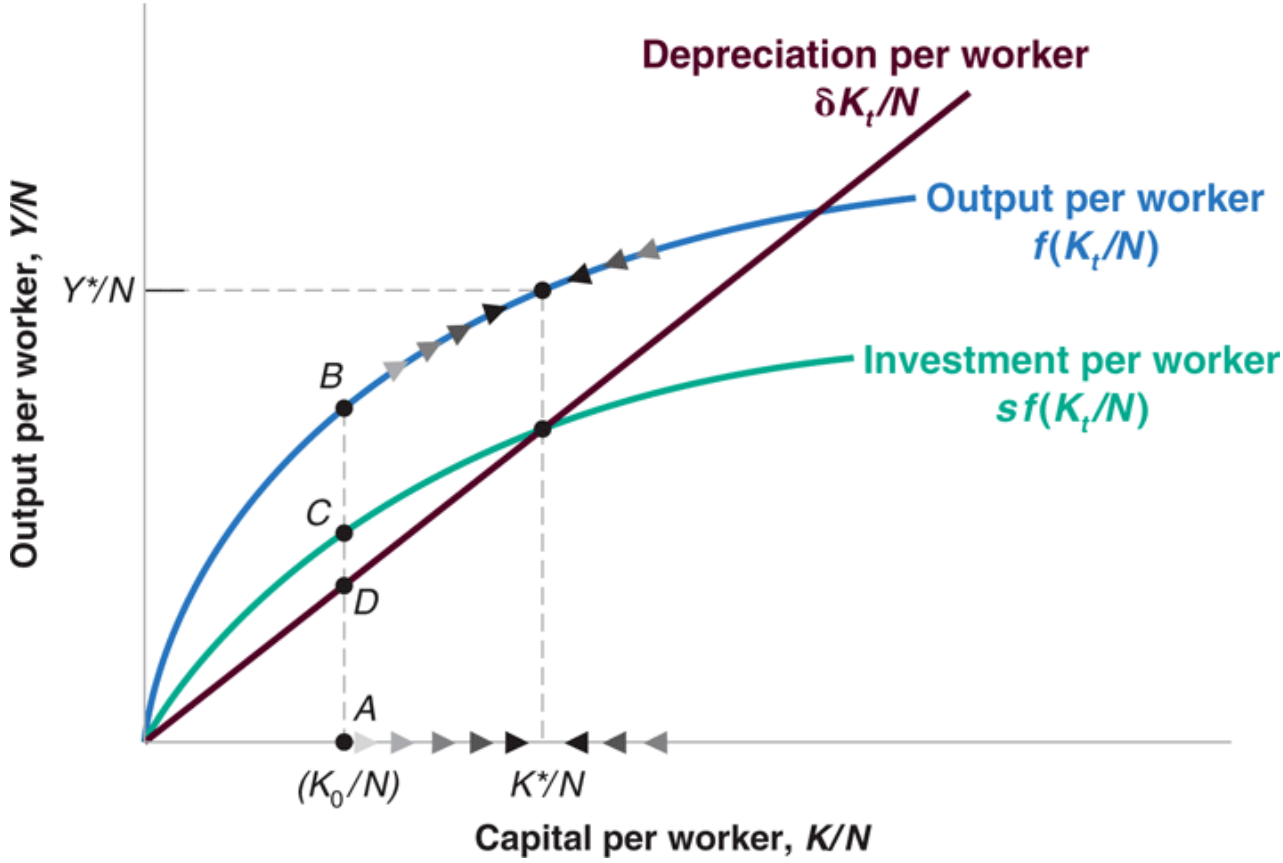
- $k_t < k^* \Rightarrow \Delta k_{t+1} > 0$, i.e., $k \uparrow$
- $k_t > k^* \Rightarrow \Delta k_{t+1} < 0$, i.e., $k \downarrow$

- The steady state of the economy:

$$k_t = k^* \Rightarrow k_{t+1} = k_{t+2} = \cdots = k^*$$
$$\Rightarrow y_t = y_{t+1} = \cdots = f(k^*)$$

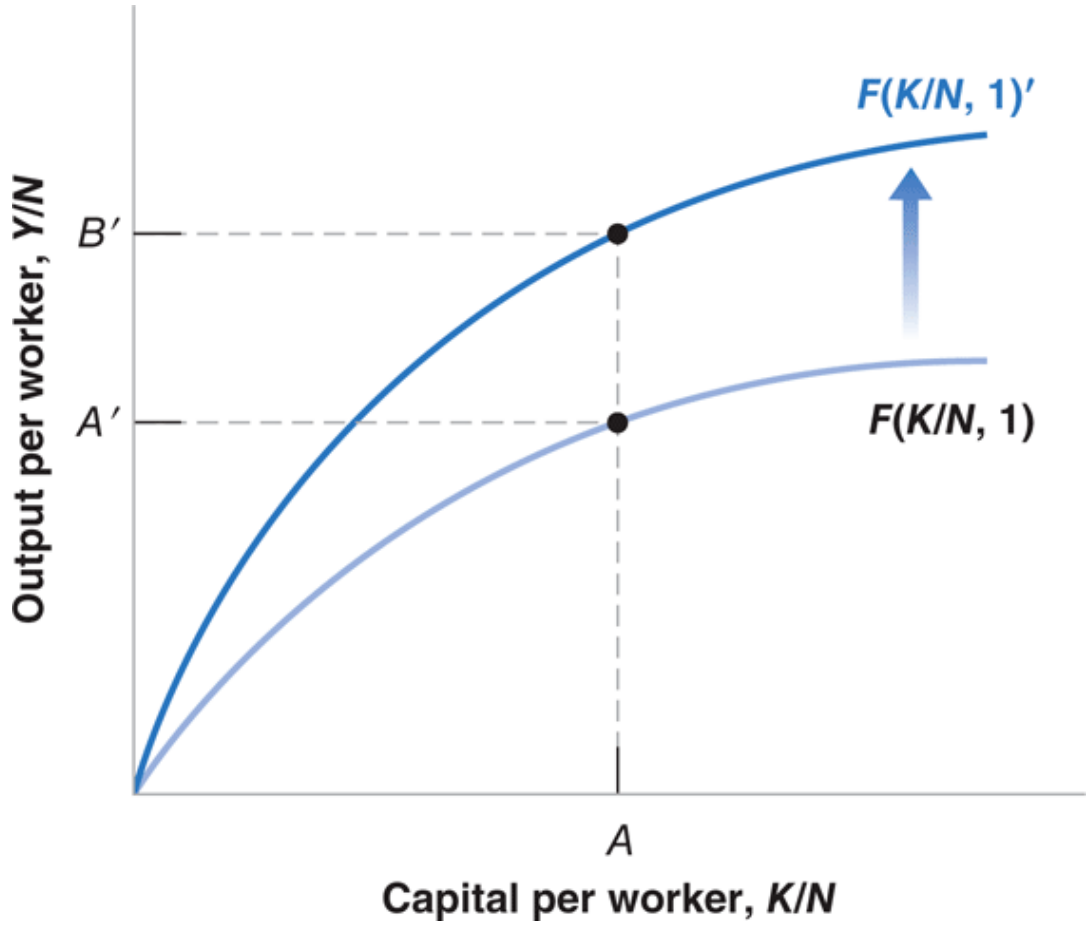
- $k^*$ satisfies

$$sf(k^*) = \delta k^*.$$



# Growth due to technological progress

- Given $k$ at A,
  as $\mathcal{A}$ increases, $y$ increases from A' to B'.



# Sources

- This lecture is based on four papers, which you do not need to read:
- Bloom, Nicholas, Charles I. Jones, John Van Reenen, and Michael Webb (2020), "Are Idea Getting Harder to Find?," *American Economic Review* 110(4): 1104-44.
- Bloom, Nicholas, John Van Reenen, and Heidi Williams (2019), "A Toolkit of Policies to Promote Innovation," *Journal of Economic Perspectives* 33(3), 163-184.
- Fernald, John (2016), "Reassessing Longer-Run U.S. Growth: How Low?" *Federal* Reserve Bank of San Francisco Working Paper Series 2016-18.
- Young, Alwyn (1995), "The Tyranny of Numbers: Confronting the Statistical Realities of the East Asian Growth Experience," *Quarterly Journal of Economics* 110(3): 641-680.

# Outline

- Steady state with $g_N \neq 0$ and $g_{\mathcal{A}} \neq 0$
- Four Asian tigers and the Asian miracle
- Recent productivity slowdown
- A toolkit of policies to promote innovation

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# Growth in steady state

- In the last lecture, we assume that $N$ and $\mathcal{A}$ are constant.
- In steady state, $k_t = k_{t+1} = \cdots = k^*$. So, $\frac{K}{N}$ does not grow.
- Because $N$ is constant, $K_t = K_{t+1} = \cdots = K^* = k^* N$ does not grow.
- Similarly, $y$ and $Y$ do not change.

# Growth in steady state

- When $N$ grows at the rate of $g_N \neq 0$ and $\mathcal{A}$ at $g_{\mathcal{A}} \neq 0$, we can still use the Solow model (if you're interested, read Chapter 12).

- In steady state, $\frac{K_t}{N_t}$ and $\frac{Y_t}{N_t}$ grow at the rate of $g_{\mathcal{A}}$.
- Similarly, $K_t$ and $Y_t$ grow at the rate of $g_{\mathcal{A}} + g_N$.

- Once an economy is close enough to its steady state, technology/productivity $\mathcal{A}$ becomes the key driver of a sustained economic growth!

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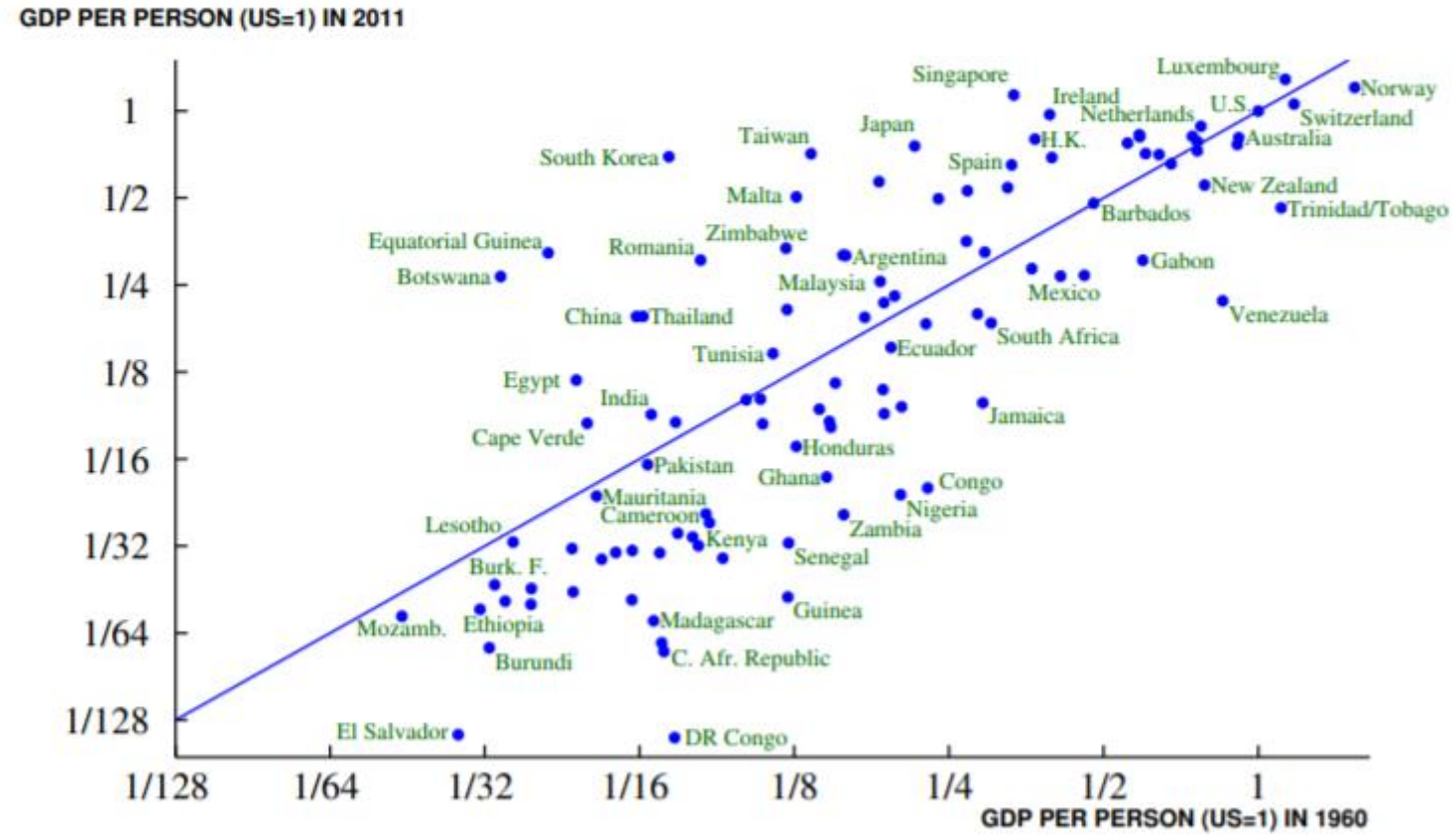
Figure 24: GDP per Person, 1960 and 2011




Source: The Penn World Tables 8.0.

- RGDP per person relative to that in the US in 1960 and 2011
- South Korea, Taiwan, Singapore, and Hong Kong successfully catch-up.

- How did the four Asian tigers (Hong Kong, Singapore, South Korea, and Taiwan) grow so fast and make the Asian miracle?

- Young, Alwyn (1995), “The Tyranny of Numbers: Confronting the Statistical Realities of the East Asian Growth Experience,” *Quarterly Journal of Economics* 110(3): 641-680.

- “Participation rates, educational levels, and (excepting Hong Kong) investment rates have risen rapidly in all four economies.”
- “[T]here has been a large intersectoral transfer of labor into manufacturing, which has helped fuel growth in that sector.”
- “Once one accounts for the dramatic rise in factor inputs, one arrives at estimated total factor productivity growth rates that are closely approximated by the historical performance of many of the OECD and Latin American economies.”

- In short, it was largely due to a fast rise in $K$ and $N$, not $\mathcal{A}$.

TABLE XIII

AVERAGE TOTAL FACTOR PRODUCTIVITY GROWTH

(PERCENT PER ANNUM)

| | Hong Kong (1966–1991) | Singapore (1966–1990) | South Korea (1966–1990) | Taiwan (1966–1990) |
|---|---|---|---|---|
| Economy* | 2.3 | 0.2 | 1.7 | 2.1 |
| Manufacturing# | NA | −1.0 | 3.0 | 1.7 |
| Other industry | NA | NA | 1.9 | 1.4 |
| Services | NA | NA | 1.7 | 2.6 |
| Private sector | NA | NA | NA | 2.3 |

NA-not available. *In the case of Korea and Taiwan, agriculture is excluded. #In the case of Singapore, the years are 1970–1990.

- For comparison: RGDP growth per annum (%)

  7.3 8.7 8.5 8.5

- It is consistent with the prediction of the Solow model for a country with a small initial $k$. While $k \uparrow$ to $k^*$, the economy grows fast. But such a fast growth cannot last forever.

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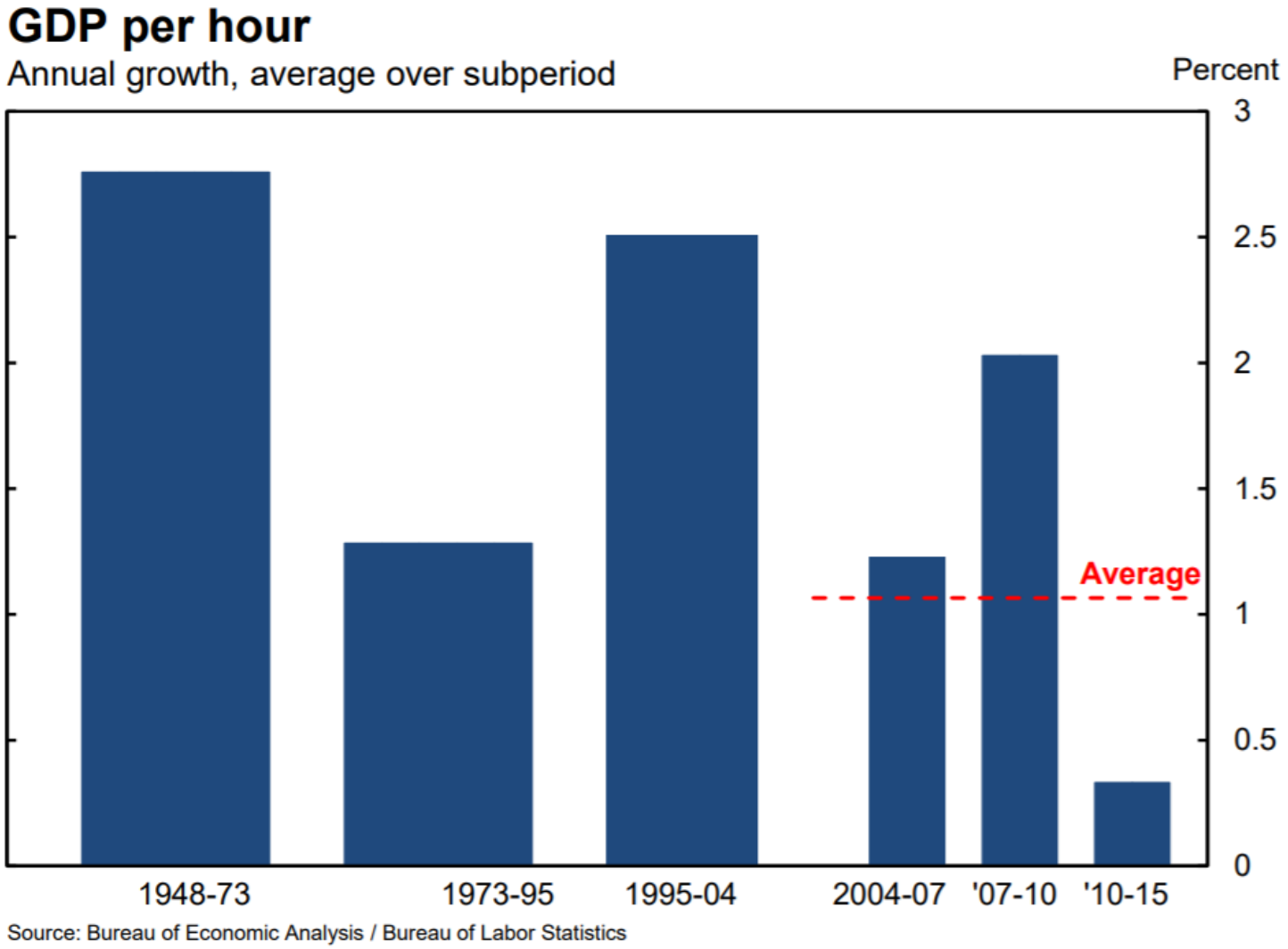
# The state of $\mathcal{A}$ in the US

**Fig. 4** Productivity slowed before Great Recession. *Source* Bureau of Labor Statistics

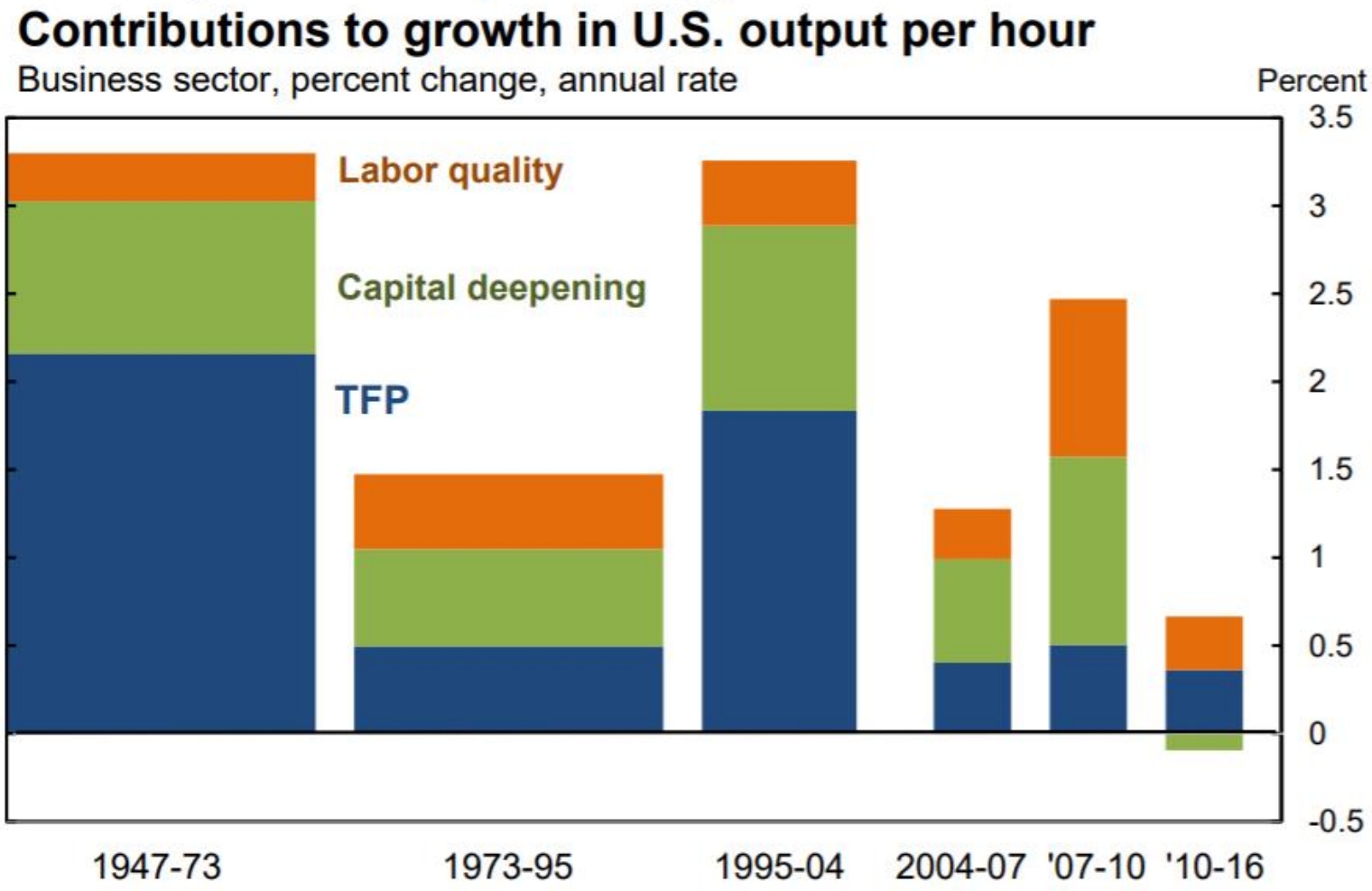

- Fernald, John (2017), "Is there an easy cure for low growth?" *Business Economics* 52:175–180.

Figure 2: Regimes in GDP per Hour




- Annual growth, RGRP per (working) hour

Figure 3: Recent productivity growth…weak and weaker




Source: Fernald (2014a). Quarterly; samples end in Q4 of years shown except 1973 (end Q1) and 2016 (end Q2). Capital deepening is contribution of capital relative to quality-adjusted hours. Total factor productivity measured as a residual.

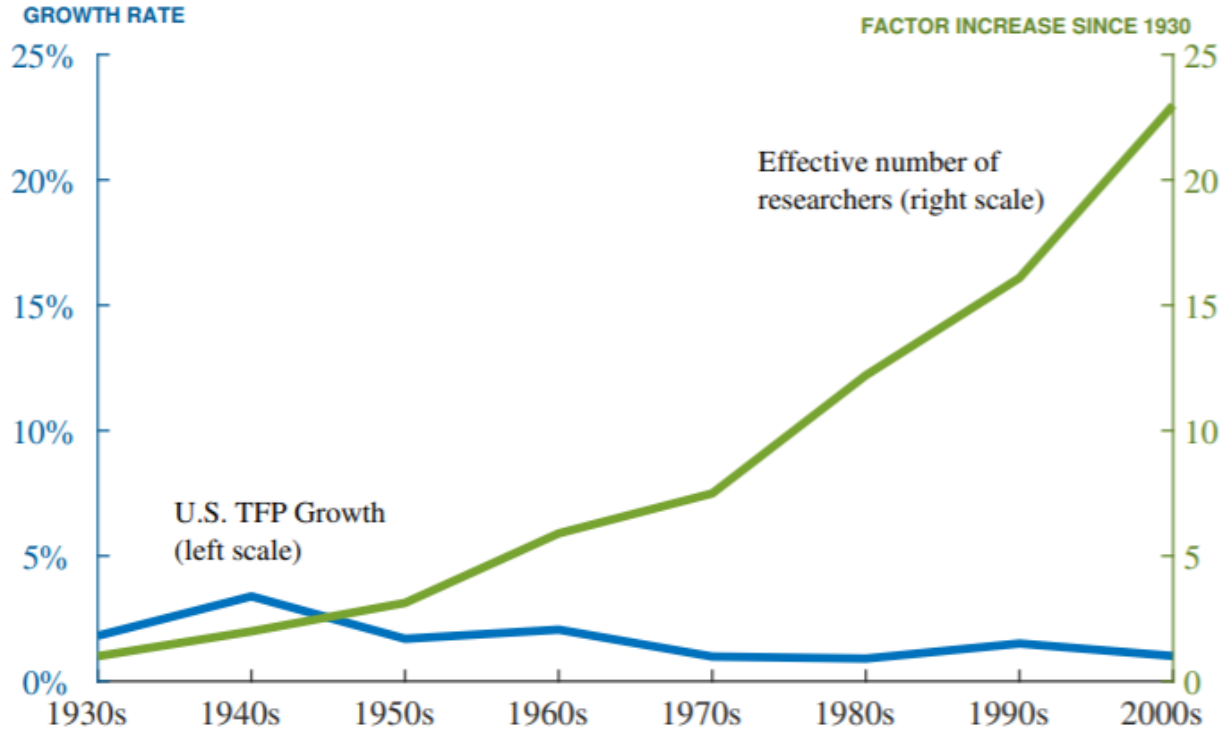
- TFP growth was exceptionally high during 1995-2004, when information technology (IT) improved quickly.
- Productivity slowdown and low growth: w/o another burst of IT-induced productivity growth, productivity growth is expected to be weak for a while.

# Are ideas getting harder to find?

- “We present a wide range of evidence […] that research effort is rising substantially while research productivity is declining sharply.”
- “A good example is Moore’s Law. The number of researchers required today to achieve the famous doubling every two years of the density of computer chips is more than 18 times larger than the number required in the early 1970s.”

- Bloom, Nicholas, Charles I. Jones, John Van Reenen, and Michael Webb (2020), “Are Ideas Getting Harder to Find?,” *American Economic Review* 110(4): 1104-44.

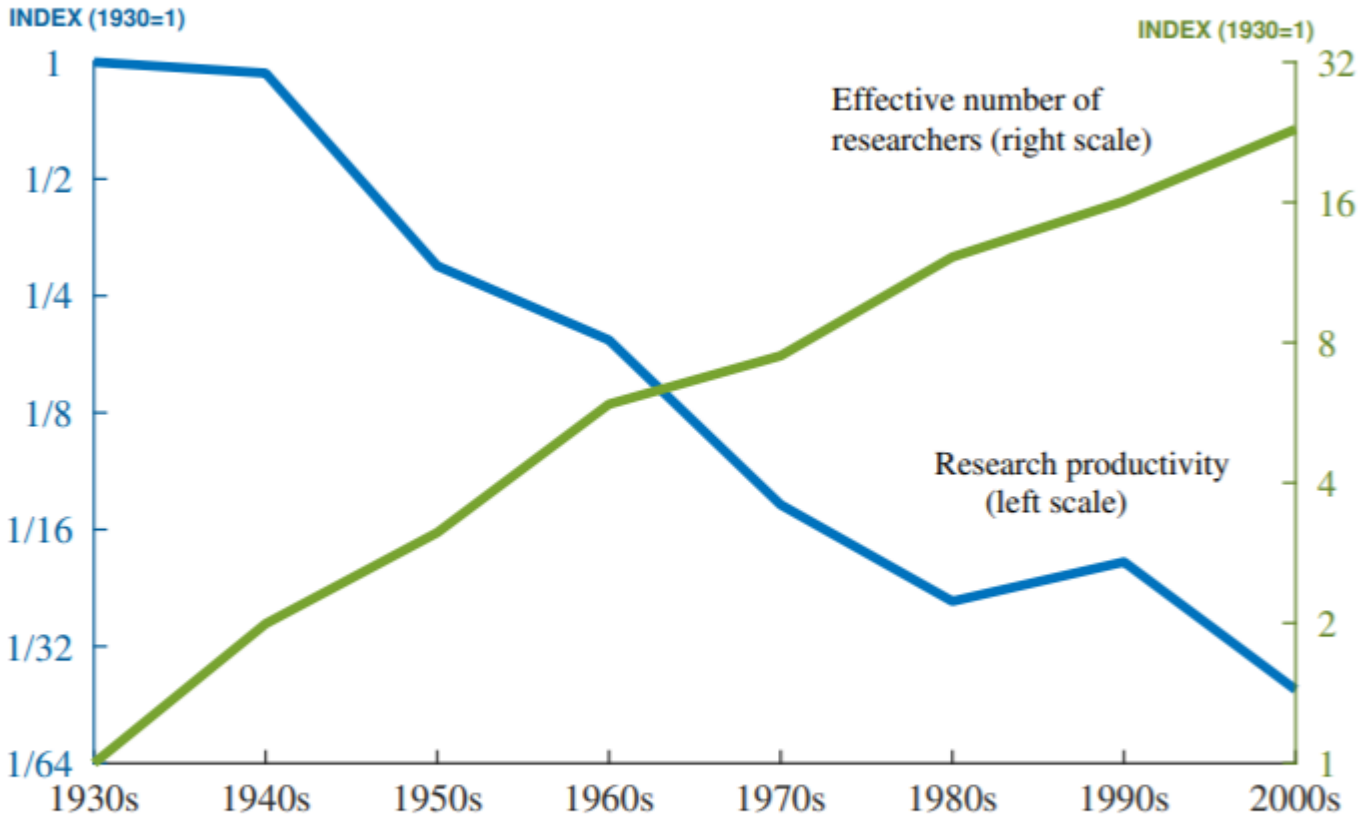
Figure 1: Aggregate Data on Growth and Research Effort




Note: The idea output measure is TFP growth, by decade (and for 2000-2014 for the latest observation). For the years since 1950, this measure is the BLS Private Business Sector multifactor productivity growth series, adding back in the contributions from R&D and IPP. For the 1930s and 1940s, we use the measure from Robert Gordon (2016). The idea input measure — "Effective number of researchers" — is gross domestic investment in intellectual property products from the National Income and Product Accounts, deflated by a measure of the nominal wage for high-skilled workers.

- More and more researchers are working to find new ideas.
- However, research outcome, measured by TFP growth, does not seem to increase much.

Figure 2: Aggregate Evidence on Research Productivity




Note: Research productivity is the ratio of idea output, measured as TFP growth, to the effective number of researchers. See notes to Figure 1 and the online appendix. Both research productivity and research effort are normalized to the value of 1 in the 1930s.

- In other words, research productivity ↓.

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# A Toolkit of Policies to promote Innovation

- “Innovation is the only way for the most developed countries too secure sustainable long-run productivity growth.”
- “For countries such as these (the US, Japan, and the nations of Western Europe), what are the most effective policies for stimulating technological innovations?”

- Bloom, Nicholas, John Van Reenen, and Heidi Williams (2019), “A Toolkit of Policies to Promote Innovation,” *Journal of Economic Perspectives* 33(3), 163-184.

# Why should government promote innovation?

- “Knowledge spillovers are the central market failure on which economists have focused when justifying government intervention in innovation.”

- Private agents do not fully incorporate social benefit when they create new ideas.
- Knowledge may spill over to and benefit other firms.

# What can governments do?

1. Research and Development (R&D) tax credits: When firms raise R&D spending, the govt reduces the corporate income taxes.
2. Government research grants: Governments may want to promote specific types of research, for example, basic R&D by directly providing grants.
3. Patent boxes: A special, low tax rates may be applied to revenues linked to patents relative to other commercial revenues.
   - Firms, particularly multinational ones, manipulate stated revenues from patents to minimize their global tax burden. Thus, less effective than the above two policies.

# What can governments do? (cont'd)

4. Human capital supply: Increasing the supply of human capital through expanded university programs and/or relaxed immigration rules is likely to be an effective innovation policy.
   - By supplying more high-skilled workers, this policy may lower their wages and reduce income inequality.
5. Intellectual property: Introduce patents, copyrights, and other instruments such as trademarks.
   - In principle, patents should be awarded to novel, nonobvious, and useful inventions. In practice, determining whether an invention is novel, nonobvious, and useful is not straightforward.

# What can governments do? (cont’d)

- There are also other possible tools. Interested students may refer to Bloom, Van Reenen, and Williams (2019) directly.

# In the next class…

- The final review