EC569 Economic Growth
Technology and Efficiency (Lecture 7)

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Technology Production Function

- Last lecture, we assumed technology growth rate is independent of current technology level:

$$\hat{A} = \frac{L_A}{\mu}$$

- However, technology is cumulative: Researchers begin their investigations where those who came before them left off.

Cumulative Nature of Technology Development

- Positive
  - Isaac Newton: If I have seen father than others, it is because I have stood on the shoulders of giants.
  - Larger base of knowledge
  - Larger set of tools
- Negative
  - Fishing out effect: easiest discoveries have already been made
  - More is known today, more effort for a researcher to learn everything required
- 18th and 19th century discoveries: lone scientists and inventors
- late 20th century discoveries: large and well-funded research teams

$$\hat{A} = \frac{L_A}{\mu} A^{-\phi}, \quad 0 < \phi < 1$$

Decreasing Returns to Scale in Technology Production

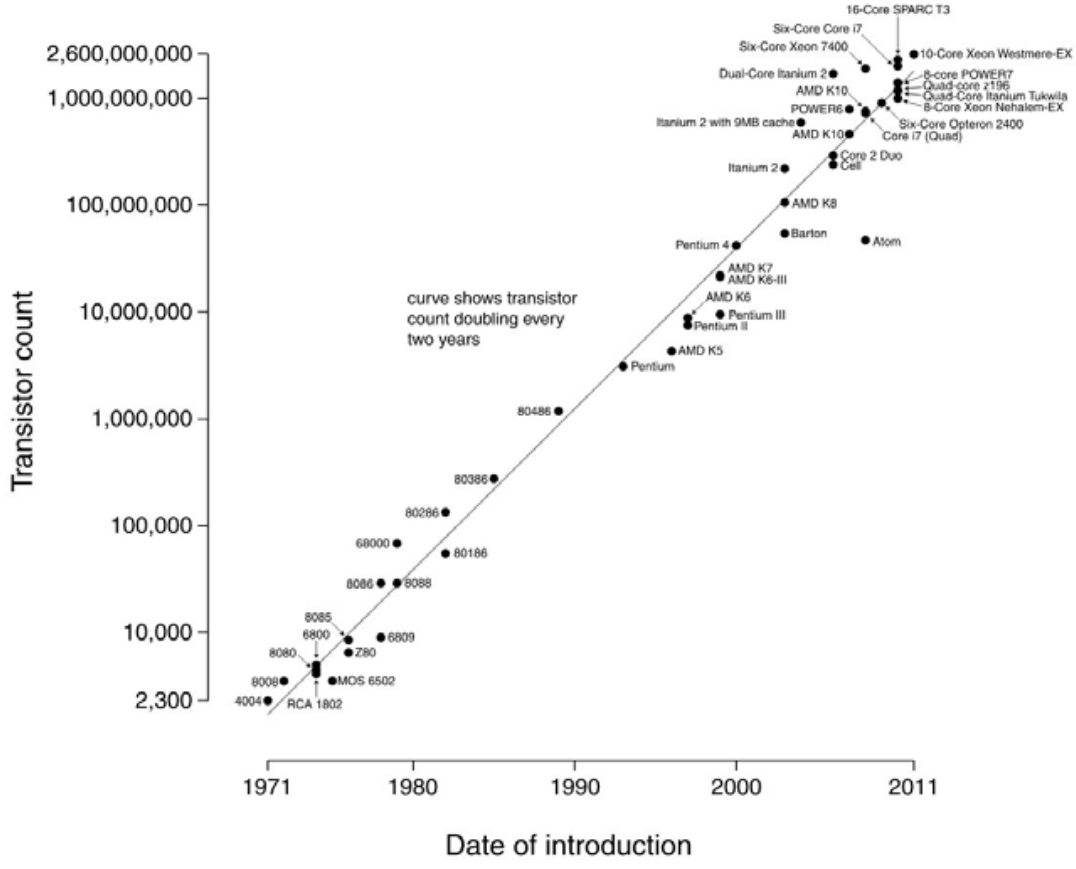
- Non-rivalry of knowledge
- Efforts of most of the researchers will be wasted if many are working at the same project
- Charles Darwin came up earlier with 'natural selection' than Alfred Wallace
- Two teams completed the sequencing of human genome simultaneously

$$\hat{A} = \frac{L_A^{\lambda}}{\mu}, \quad 0 < \lambda < 1$$

Combining with cumulative nature of technology

$$\hat{A} = \frac{1}{\mu} L_A^{\lambda} A^{-\phi}$$

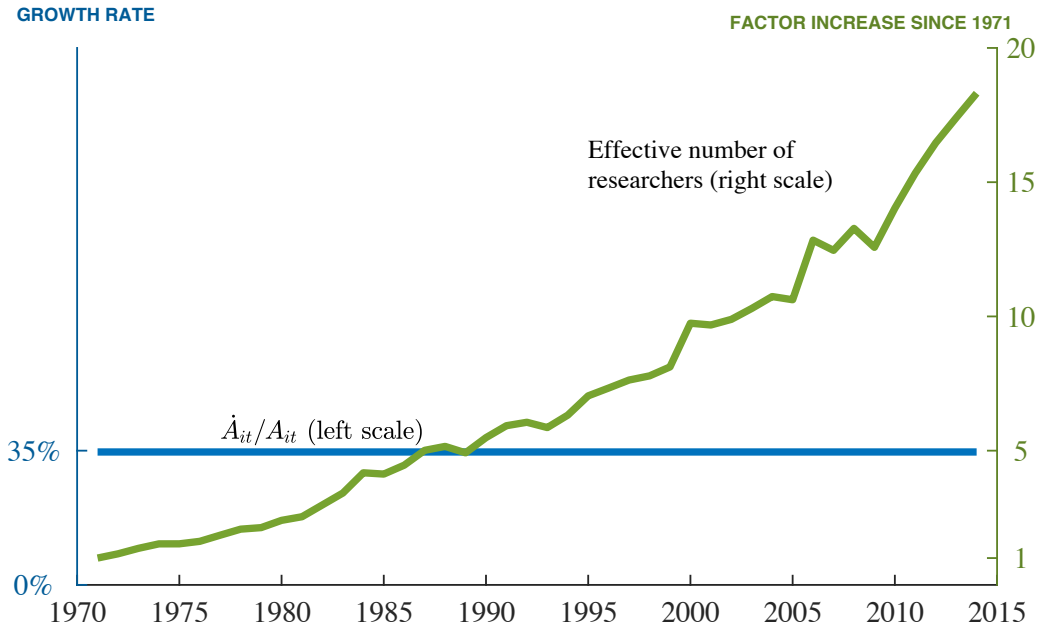
Figure 3: The Steady Exponential Growth of Moore's Law



Source: Wikipedia, https://en.wikipedia.org/wiki/Moores_law.

Source: Bloom, N., Jones, C. I., Van Reenen, J., & Webb, M. (2017). Are ideas getting harder to find? (No. w23782). National Bureau of Economic Research.

Figure 4: Data on Moore's Law



Note: 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. The R&D data includes 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, N., Jones, C. I., Van Reenen, J., & Webb, M. (2017). Are ideas getting harder to find? (No. w23782). National Bureau of Economic Research.

Read the op-ed on the article.

Implications for the Future of Technological Change

- From 1950 to 2007, the number of researchers in the G-5 countries grew from 251K to 3.5M
- The overall labor force could grow
- The fraction of labor force engaged in research could grow
  - In the US, .25% in 1950 to .92% in 2007
- New members could be added to the set of countries doing cutting-edge research

Differential Technological Progress

- So far, we have assumed pace of technological change is same across sectors of a country.
- Some industries radically changed: communications
- Some industries have been created: television, air travel
- Some industries barely changed: barbers, education

Differential Technological Progress, cont'd

- What do these differential rates of technological progress imply for the economic growth?
- Technological progress is more important when it occurs in a larger sector.
- High productivity growth in toothbrush-producing industry vs a small productivity improvement in the automobile industry.
- Average rate of technological progress in the whole economy = weighted average of technological progress in each industry
- Weights = fraction of total output produced in that sector

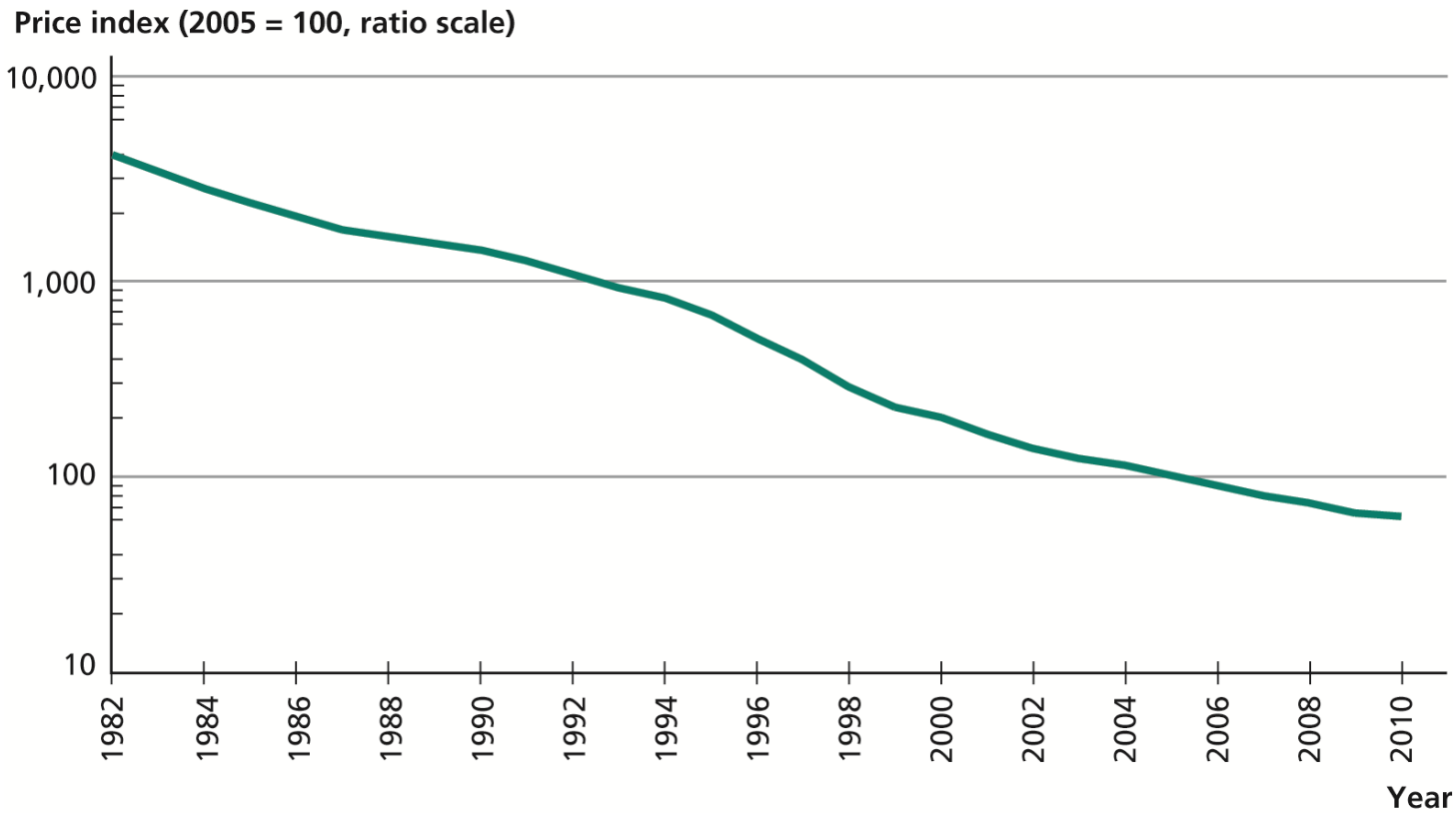
Differential Technological Progress, Theory

- Bread and cheese: perfect complements
  - Movement of factors from high productivity industry (bread) to low productivity industry (cheese)
  - Slowdown in productivity growth
- Butter and margarine: perfect substitute
  - Produce more margarine (high productivity)
  - Growth rate of the economy increases
- Key difference: what happens to share of spending on high productivity sector

Differential Technological Progress, Examples

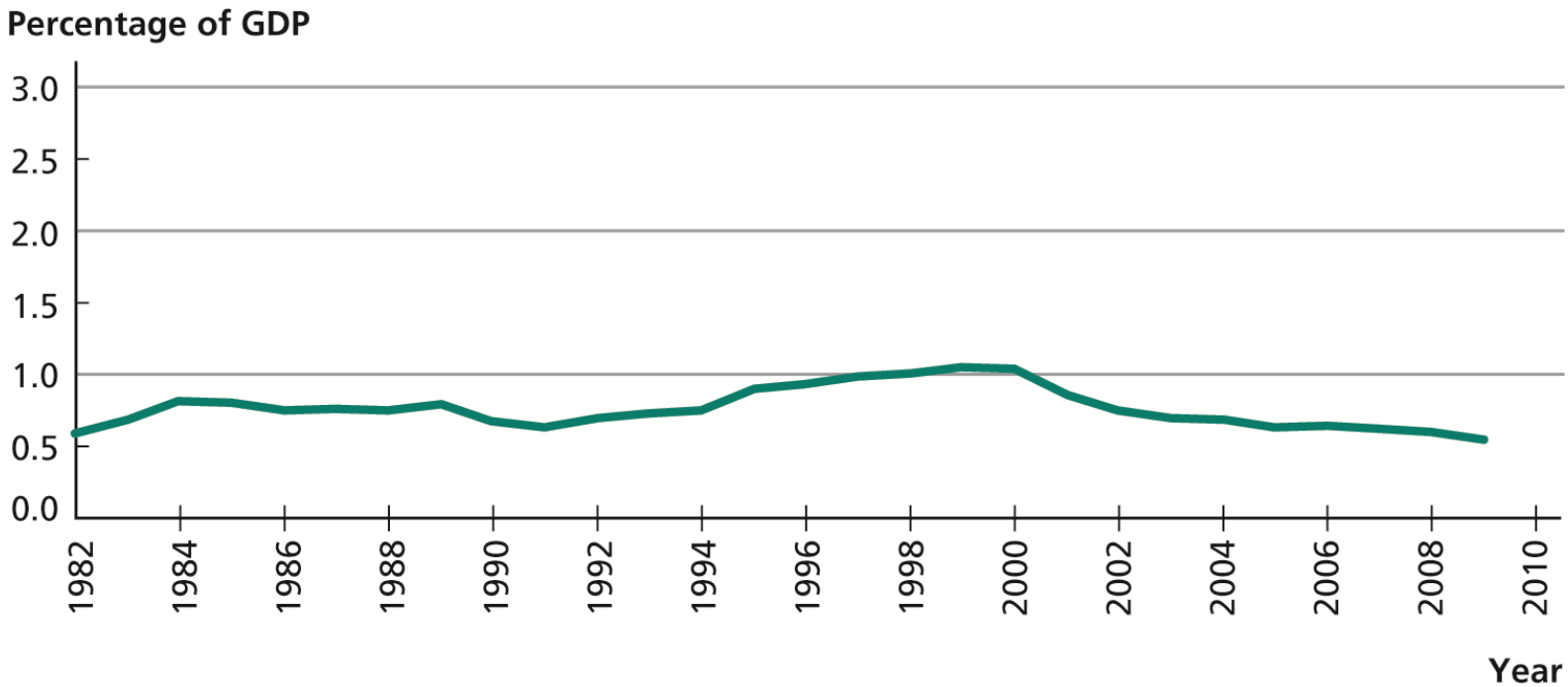
- In 1927, a pair of Levi's jeans cost 13 $\times$ a woman's haircut
- In 2011, a pair of Levi's jeans cost 1.5 $\times$ a woman's haircut
- Service consumption rose from 40% of GDP in 1950 to 67% in 2010.
- Shift to the sector with low productivity growth
- Cost disease: relative costs rise in the sector with slow productivity growth

Figure 9.5: Price of Computers, 1982-2010



Source: U.S. Department of Commerce, National Income and Product Accounts, Table 1.5.4. Includes both computers and peripherals.

Figure 9.6: Investment in Computers as a Percentage of GDP, 1982-2009



Source: U.S. Department of Commerce, National Income and Product Accounts, Table 5.5.5. Includes both computers and peripherals.

Efficiency

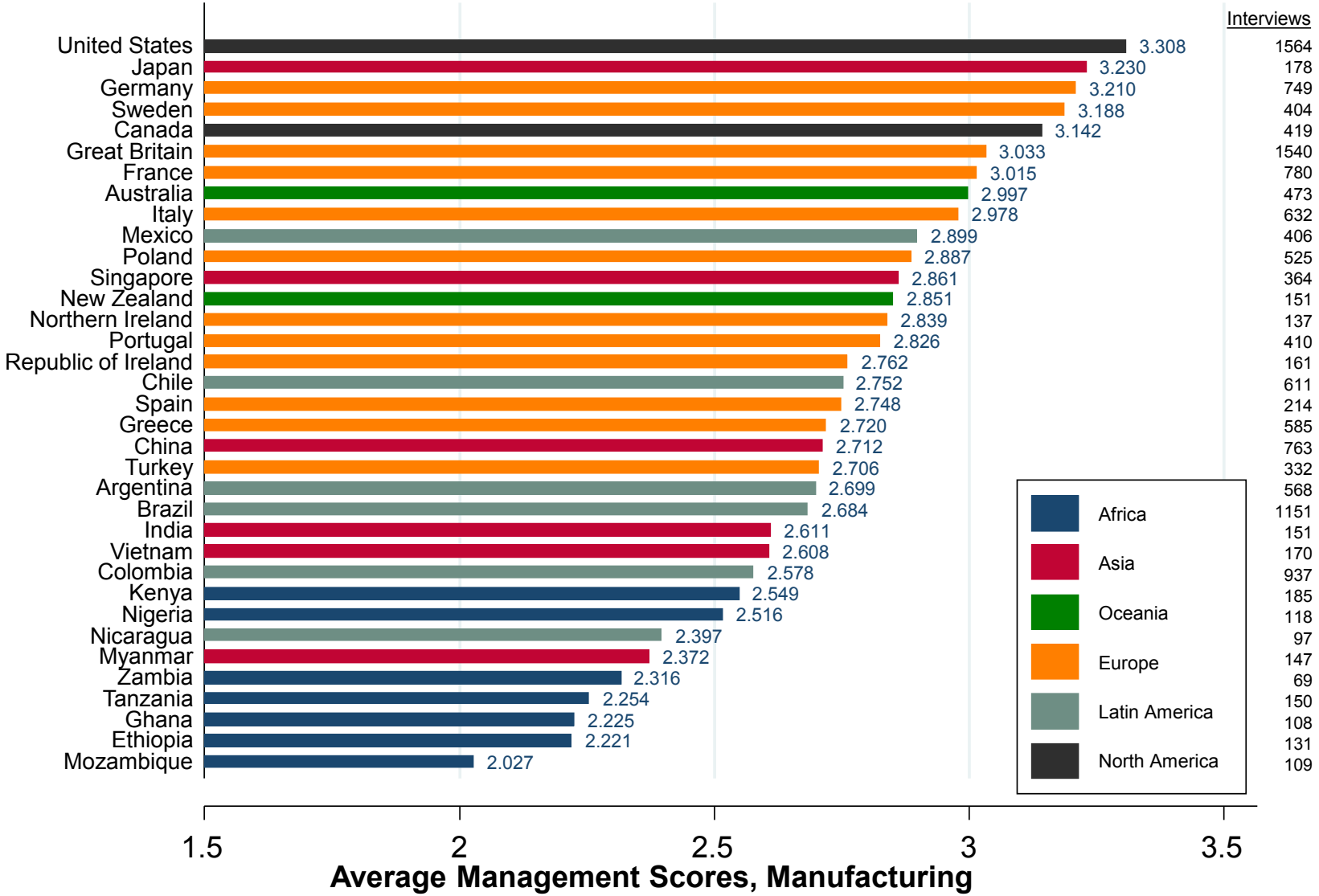
$$A = T \times E$$

- Technology: Knowledge about how factors of production can be combined to produce output
- Efficiency: How effectively given technology and factors of production actually used
- Productivity is much lower in poor countries than in rich countries
- Not obvious the only reason is a gap of technology
- Many of the most advanced technologies are being used in poor countries

Measuring Efficiency

- World Management Survery (Bloom, Sadun, and Van Reenen (2017))
- `http://worldmanagementsurvey.org`
- 12,000 organizations across 34 countries
- Core management practices
  - setting sensible targets
  - providing proper incentives
  - credibly monitoring performance
- Read the op-ed on the article

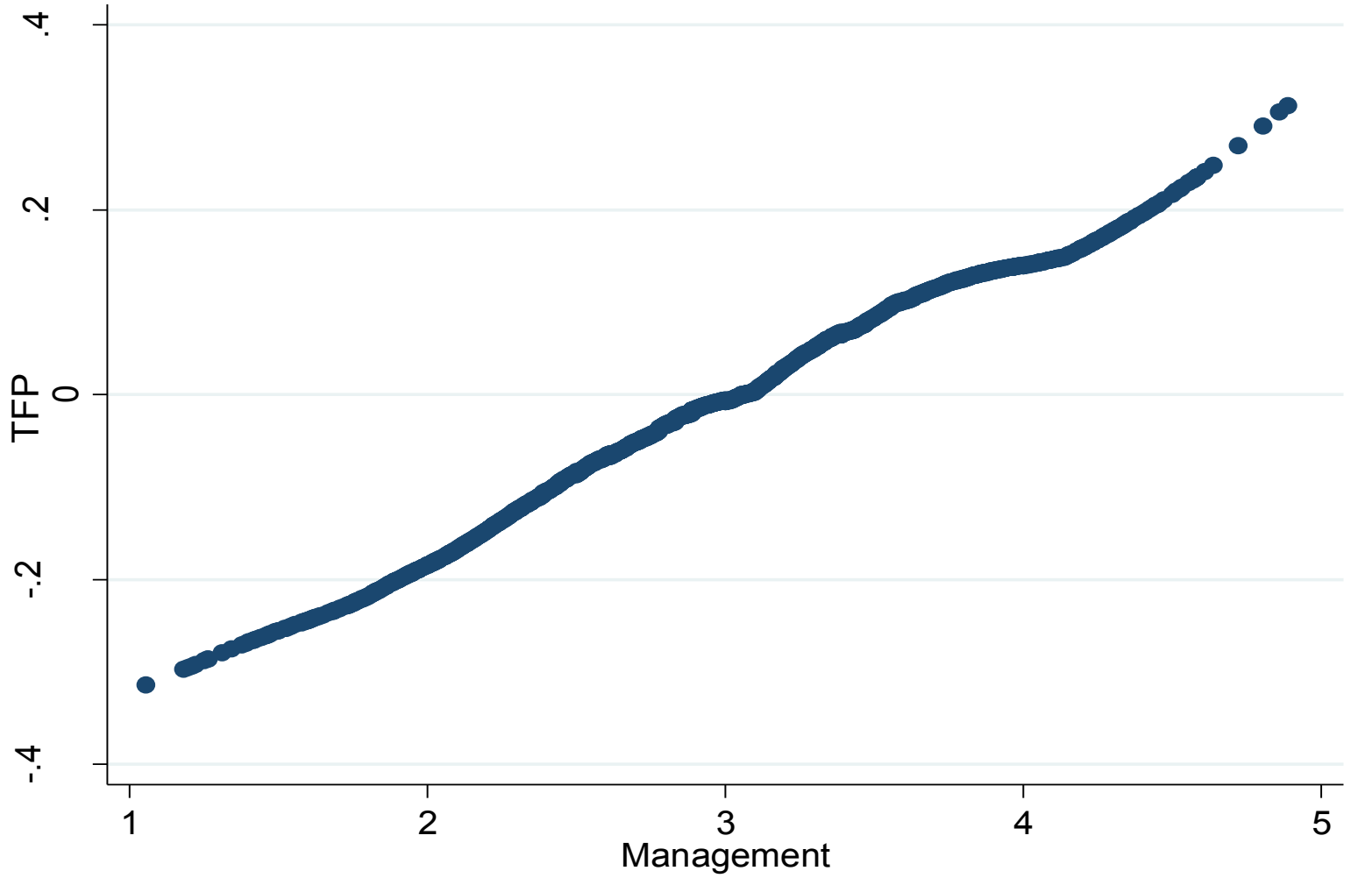
Figure 1: Average Management Scores by Country



Note: Unweighted average management scores; # interviews in right column (total = 15,489); all waves pooled (2004-2014)

Source: Bloom, Sadun, and Van Reenen (2017)

Figure A3: Firm TFP is increasing in management



Notes: This plots the lowess predicted valued of TFP against management (bandwidth=0.5). TFP calculated as residual of regression of ln(sales) on ln(capital) and ln(labor) plus a full set of 3 digit industry, country and year dummies controls. N = 10,900.

Source: Bloom, Sadun, and Van Reenen (2017)

Types of Inefficiency

- Unproductive activities
- Idle resources
- Misallocation among sectors
- Misallocation among firms
- Technology blocking

Unproductive Activities

- rent seeking: involve the use of laws or government institutions to bring private benefits
- Economic rent: payment to a factor of production in excess of what is required to elicit the supply of that factor
- E.g.: quotas to limit the imports of some goods, lobbying, ...
- Costs: a good deal of effort, bright people work in unproductive activities
- Illegal activities: theft, smuggling, kidnapping for ransom, ..

Idle Resources

- Factors of production not used at all
- Unemployment, underemployment
- Factory that sits unused
- Factory running at less than full capacity
- capital hoarding: factory shutdown during recessions
- Example: Air Afrique: 500 employees per airplane, EasyJet: 66 employees per airplane
- 'Fireman' employed in diesel engines of the United States and Canada railroads during the middle of the 20th century

Misallocation Among Sectors

Misallocation among sectors: marginal product of inputs are not equal across sectors

- barriers to mobility
  - geographical isolation
  - wage policy: e.g. sectoral minimum wage
- wages $\neq$ marginal product of labor
  - market segmentation: potentially productive people are unable to work in certain sectors

Figure 10.3: Efficient Allocation of Labor between Sectors

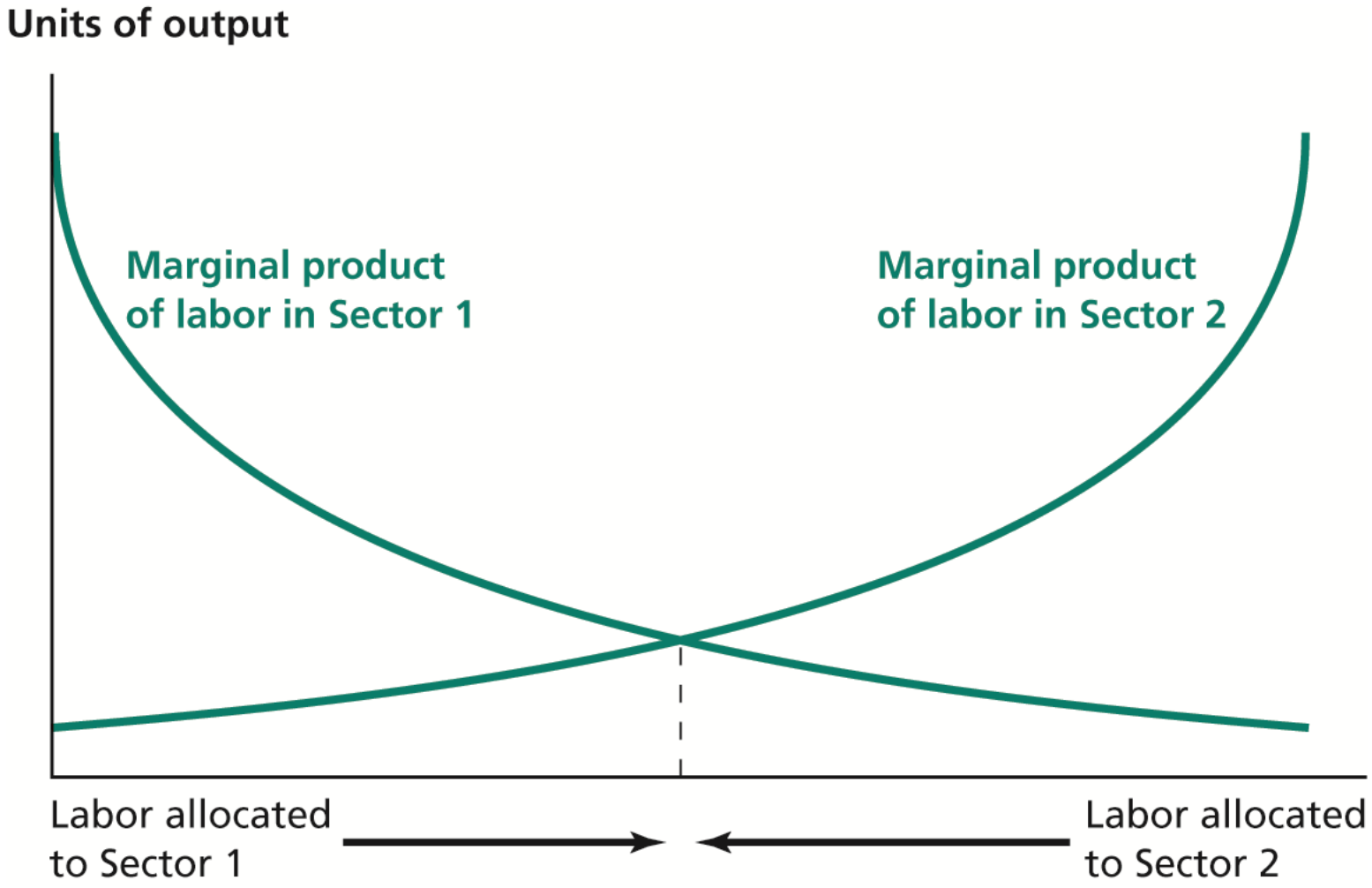


Figure 10.4: Overallocation of Labor to Sector 1

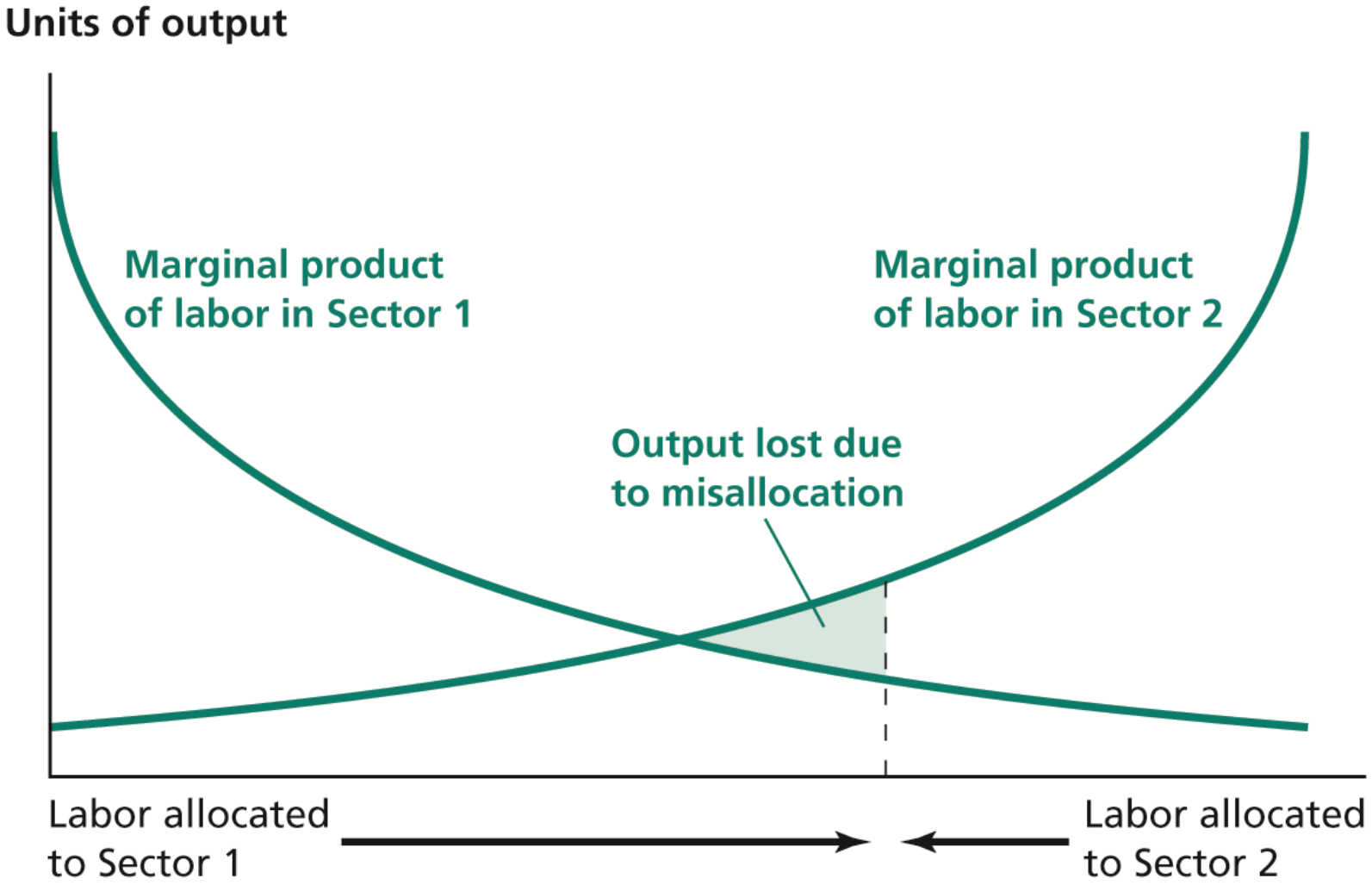
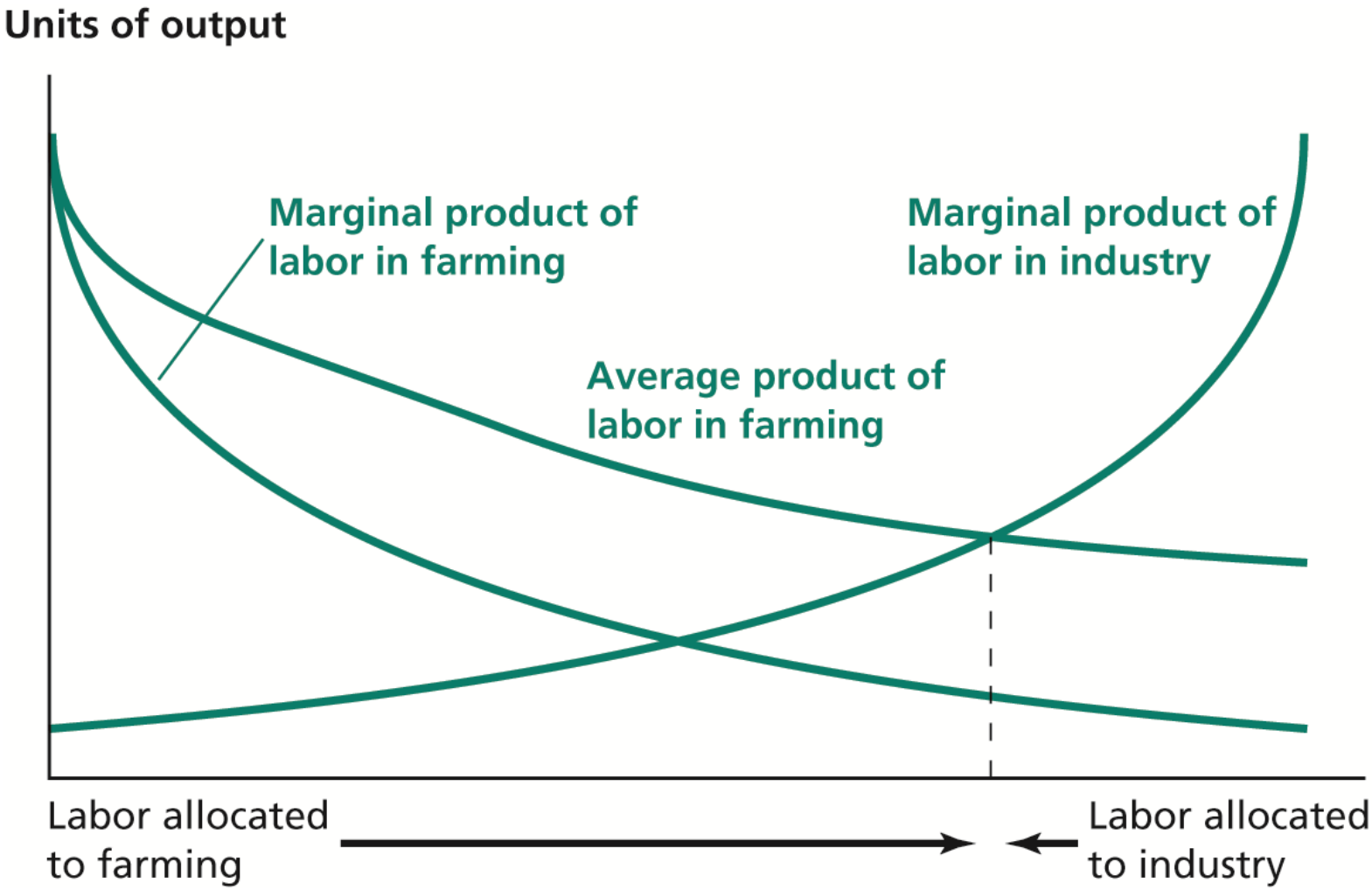


Figure 10.5: Overallocation of Labor to Farming When Farmworkers are Paid Their Average Product



Efficiency Gains from Sectoral Reallocation

Reallocation from agriculture to manufacture

- Taiwan: 0.7% of 5.4% annual growth over 1966-1991
- Korea: 0.7% of 5.7% annual growth over 1960-1990
- US: fraction of agricultural labor 50% to 3% over 1880-1980
- China: fraction of agricultural labor 69% to 40% over 1980-2009

Misallocation Among Firms

Misallocation among firms: marginal product of inputs are not equal across firms

- government-owned firms over-employ: political power
- monopolies under-employ: monopolistic profit
- financial frictions prevent efficient allocation of capital: financial development and growth

Technology Blocking

Agents deliberately prevent the use of technology

- Gutenbergs printing press (1453): scribes
- automated weaving loom (19th century): Luddites
- margarine (late 19th century): dairy farmers
- Netscape browser: Microsoft

Isn't technological progress beneficial to the economy?

- creative destruction and technology blocking
- the success of technology blocking depends on the relative power of the opposer/supporter
- rich countries are more prone to technology blocking
- technology blocking requires a well functioning government