Innovation Policies II: Introduction

NBER Innovation Boot Camp
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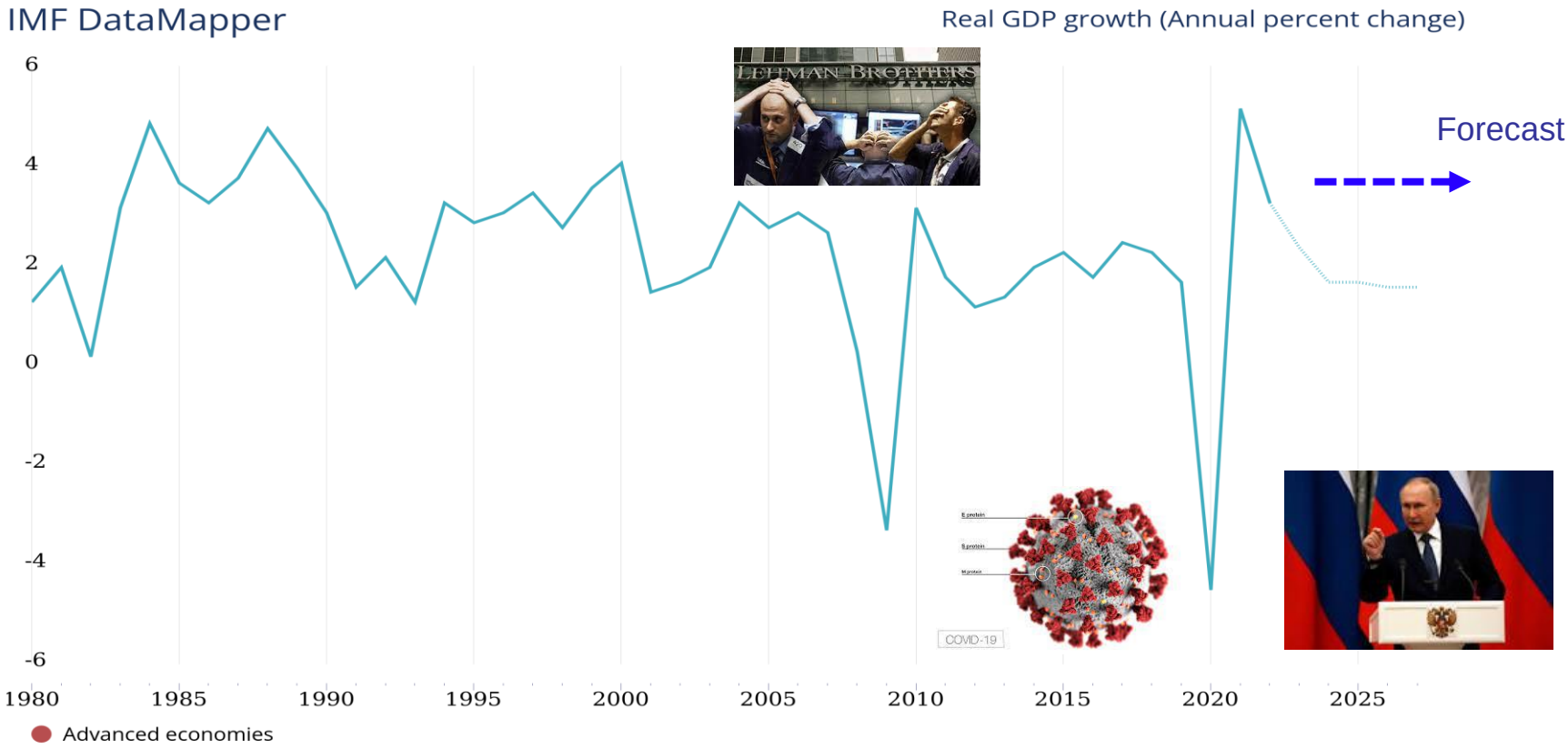
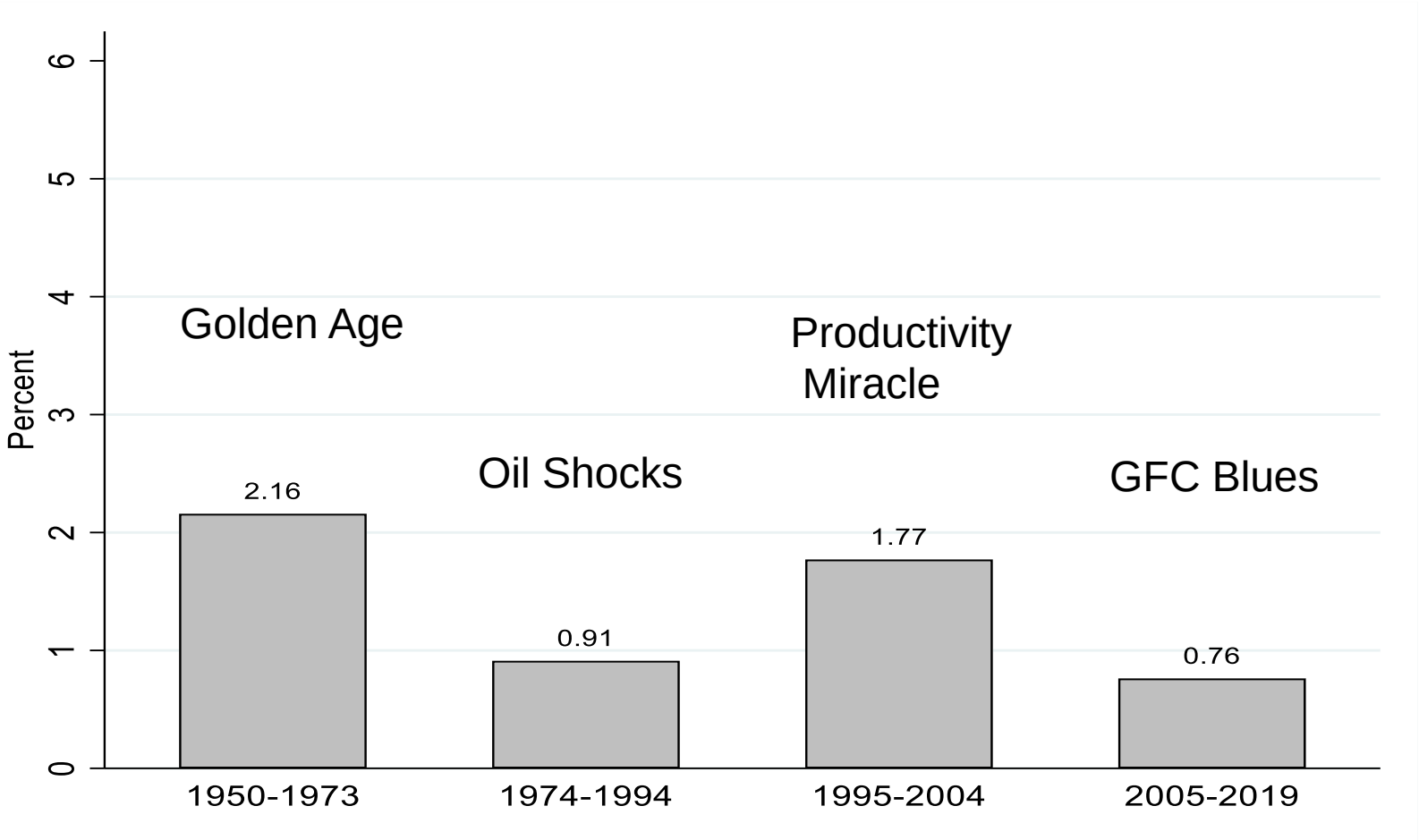
Structure of Lectures

1. Overview
2. Why should governments intervene?
   - Focus on spillovers & their identification
3. How should government intervene?
   - **Innovation policies**
     - *"Demand Side"*
       - Taxation (R&D tax credits & general tax)
       - Direct R&D Grants
     - *"Supply Side"*
       - Human Capital (STEM, University, immigration, Lost Einsteins)
       - (*Other*) Competition & trade
   - **Diffusion policies (focus on management practices)**

The Big Hit: GDP growth in Advanced Economies, 1980-2022



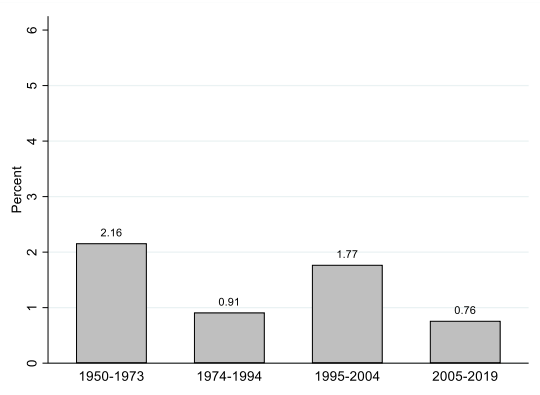
Productivity problems started long before COVID: US Total Factor Productivity (TFP) growth 1950-2019



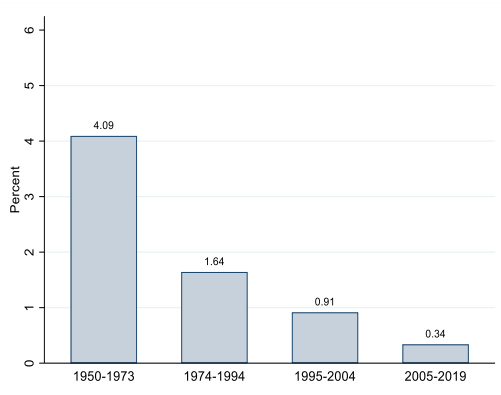
Source: Teichgraber & Van Reenen (2022) Updated data from Bergeaud, Cette, and Lecat (2016). Data publicly available at: http://www.longtermproductivity.com/

Productivity problems started long before COVID: Total Factor Productivity (TFP) growth 1950-2019

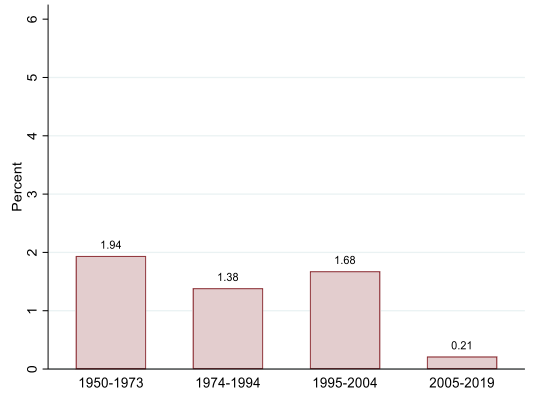
A. United States



B. Euro Area



C. United Kingdom



Source: Teichgraber & Van Reenen (2022) Updated data from Bergeaud, Cette, and Lecat (2016). Data publicly available at: http://www.longtermproductivity.com/
Notes: Average annual TFP growth in the US (panel A), Euro-area (panel B), and UK (panel C). Insufficient data for whole Euro-area so Germany, France, Italy, Spain, Netherlands, and Finland are used.

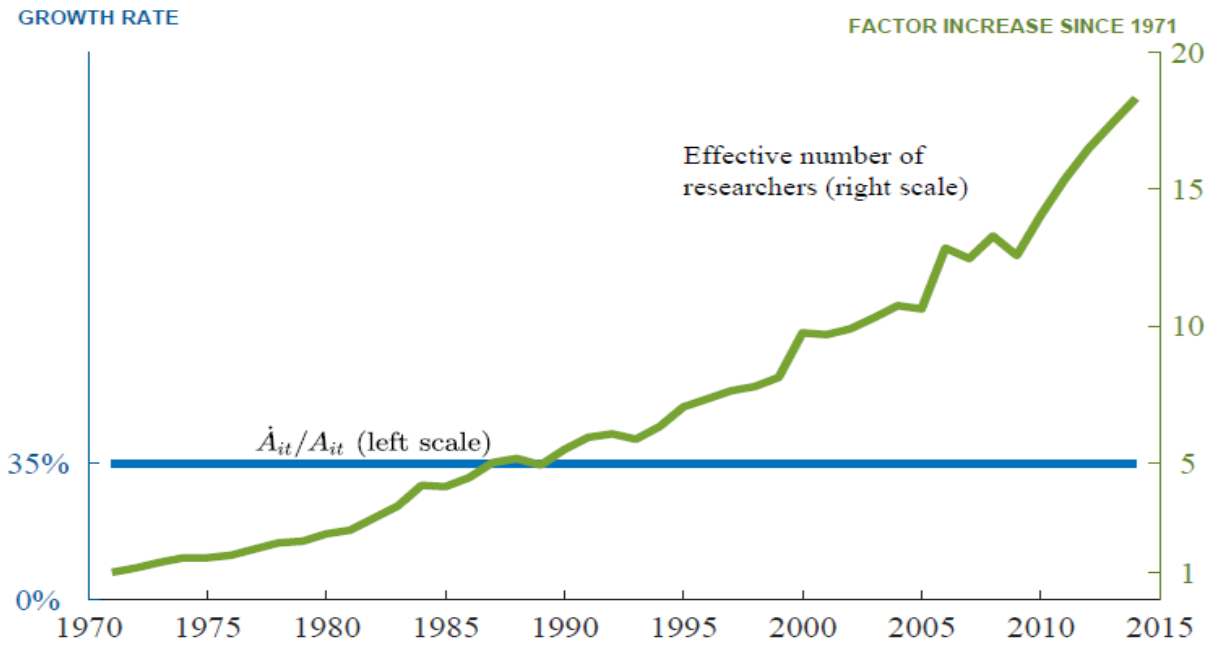
Drivers of Aggregate Productivity

- Pushing out the **technological frontier**
  - Important for economically advanced countries, but not the only thing…

- **Catching Up** to frontier
  - **Diffusion** of technology
  - Reducing **Misallocation**

Ideas Getting Harder to Find? A decline in the productivity of R&D (even in semi-conductors)

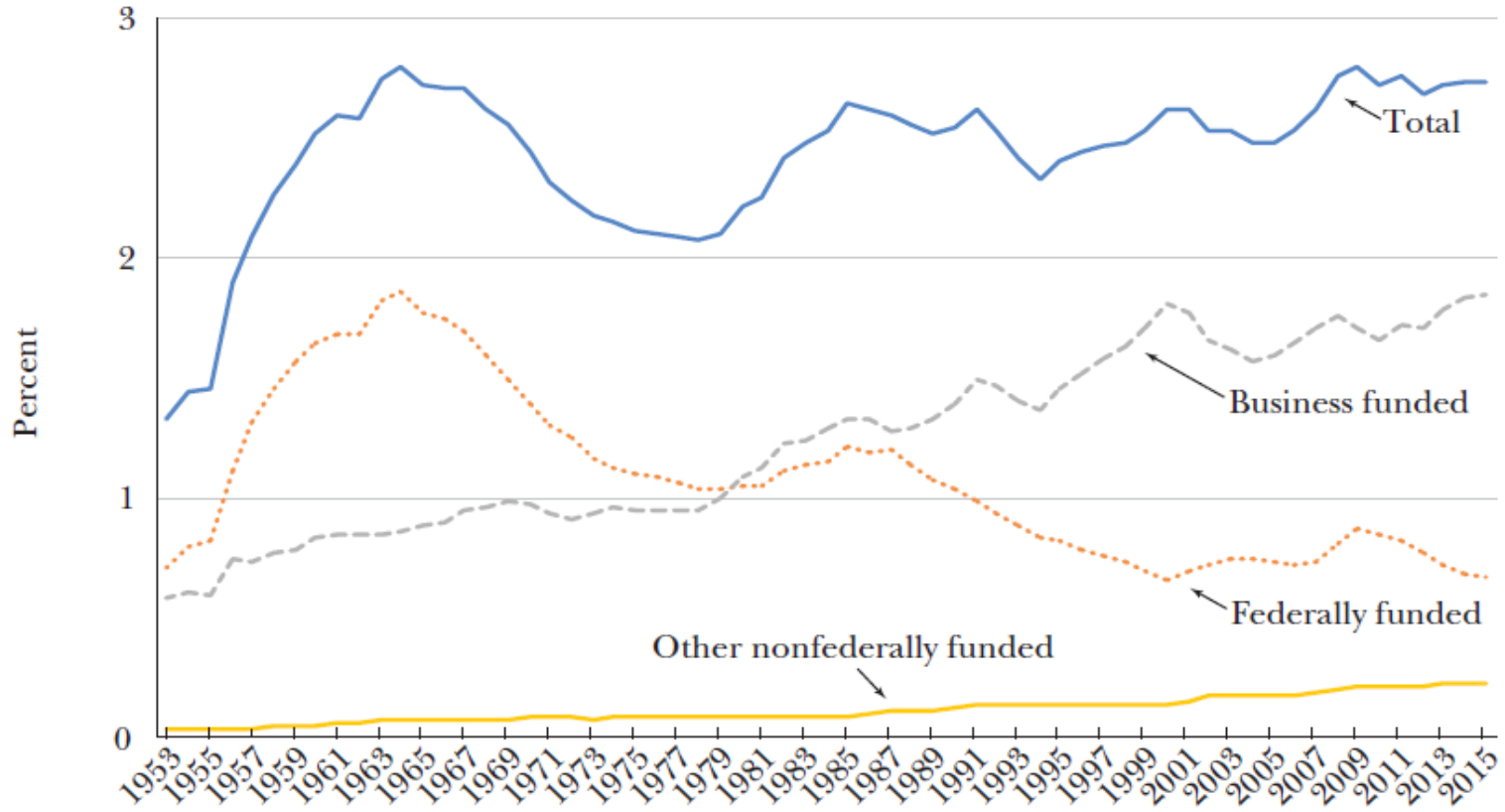
Figure 4: Data on Moore's Law



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, Jones, Van Reenen and Webb (2020, AER)

Decline in US federally funded R&D/GDP since mid 1960s



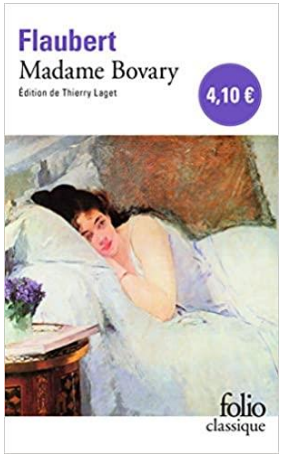
Source: National Science Board (2018)

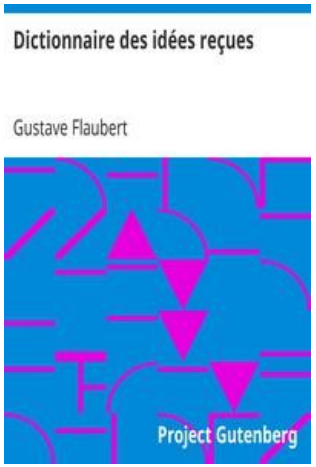
Why should the government subsidize innovation?

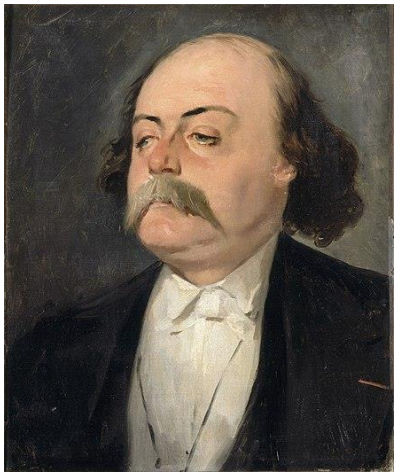
- **Multiple market failures. Main one:**
  - R&D is (partially) non-excludable. “Public good” nature of knowledge means that those who do R&D only get small part of the social benefit.

Le Dictionnaire des idées reçues (“Dictionary of Received Ideas”)

Inventors - “All die in the poor house. Someone else profits from their discoveries, it’s not fair”







Gustave Flaubert (1911)

Why should the government subsidize innovation?

- **Multiple market failures. Main ones:**
  - Non-excludable and non-rival. "public good" nature of knowledge: those who do R&D only get small part of the social benefit.

  - Frictions in other markets.
    - **Example of Finance.** Upfront research costs: Large, uncertain, asymmetric info means that financial markets will tend to under-provide (especially for SMEs)

Multiple types of R&D spillovers

- **Positive**
  - **Imitative:** Copying by other firms
  - **Intertemporal benefits:** "Building on shoulders" as innovators use ideas from previous generation
  - **Users:** Surplus captured by consumers/downstream firms

- **Negative**

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  - **Users:** Surplus captured by consumers/downstream firms

- **Negative**
  - **Business stealing:** market share redistribution (e.g. "me-too" drugs)
  - **Duplicative R&D:** Excess entry/fixed costs
  - **Intertemporal costs:** "Fishing out" of ideas

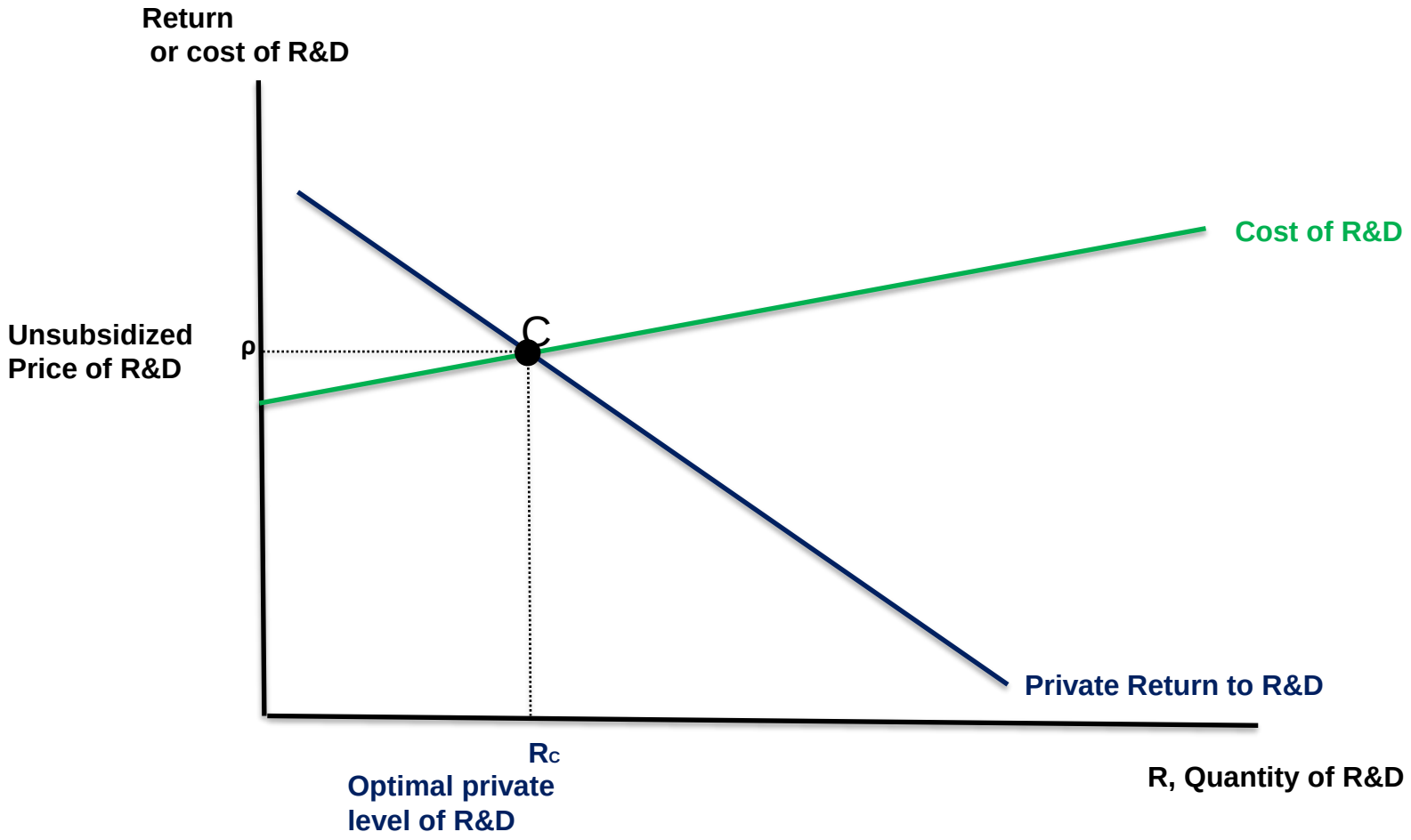
- Which spillover dominates is an empirical issue

Why should the government subsidize innovation?

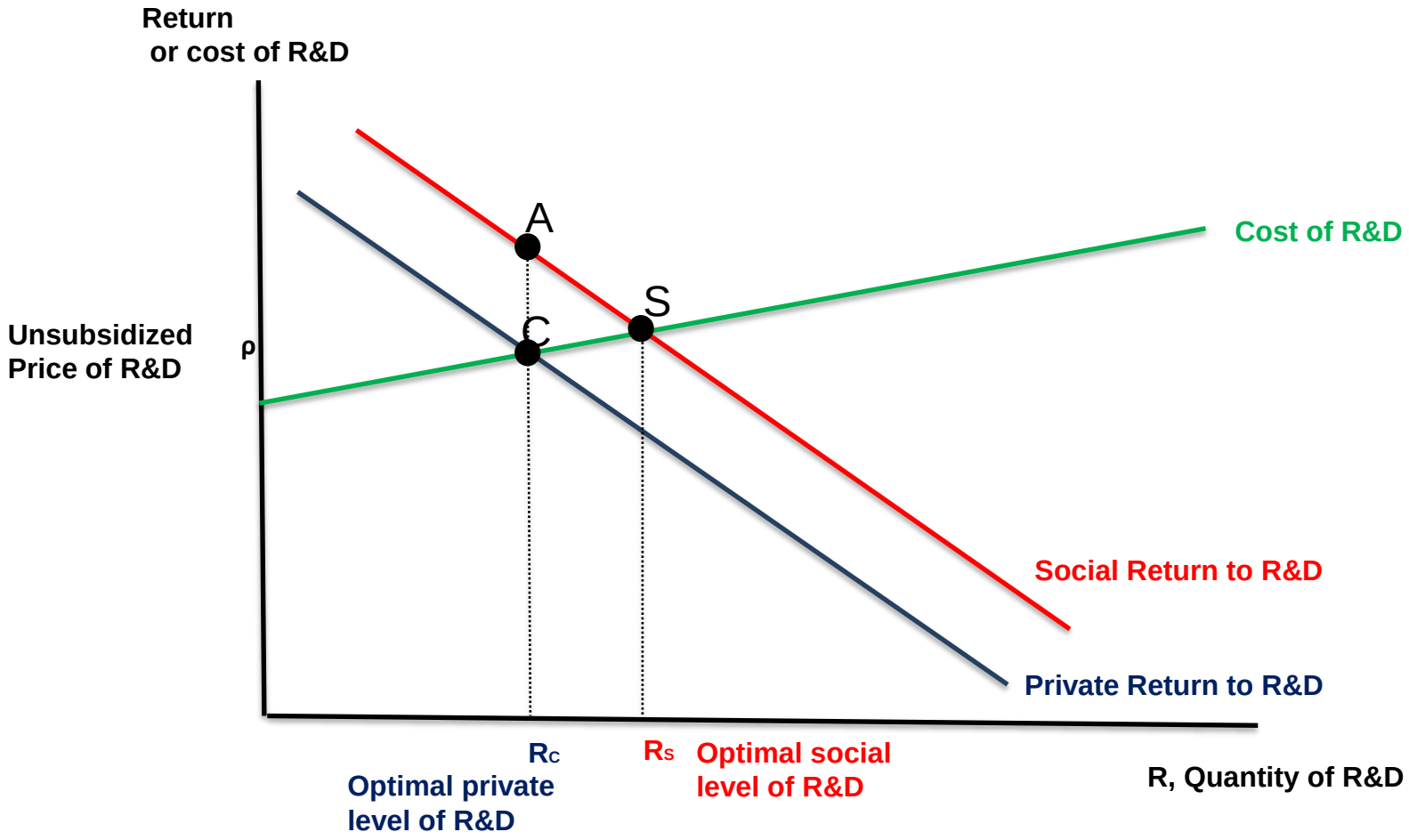
- **Empirical evidence suggests strong role for positive knowledge spillovers.** Examples for US:
  - Bloom, Shankerman & Van Reenen (2013); Lucking, Bloom & Van Reenen (2020); Jones & Summers (2022)
  - Social return to R&D is >3 times as large as the private return. Implies large private under-investment

- Challenge: Why not free ride off other countries?
  - Harder for more advanced countries like US
  - "Two faces of R&D?" (Griffith, Redding and Van Reenen, 2004)

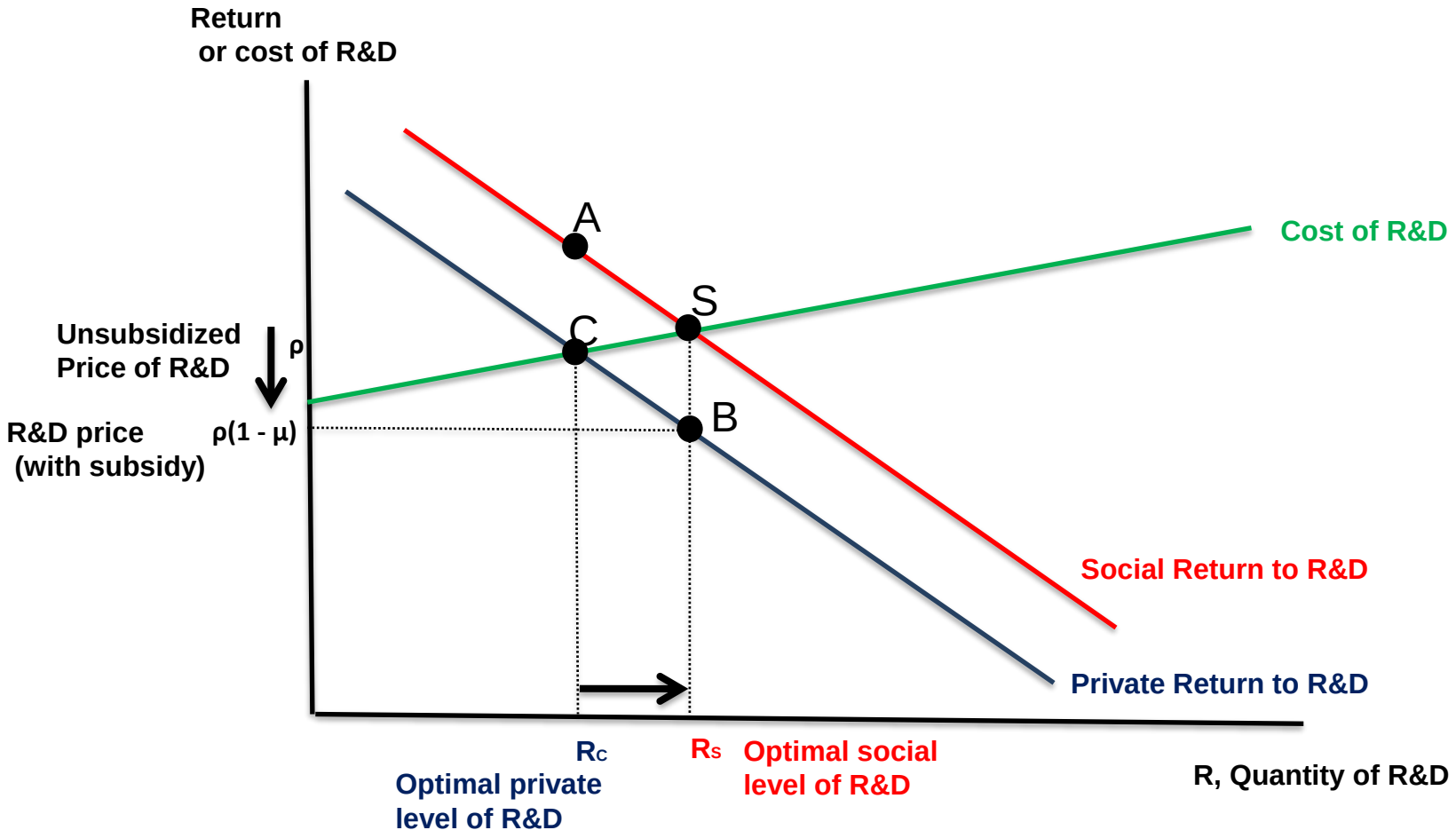
Simplified Model with knowledge spillovers. Decentralized model of R&D spending



Social returns to R&D higher than private returns due to spillovers (A-C)

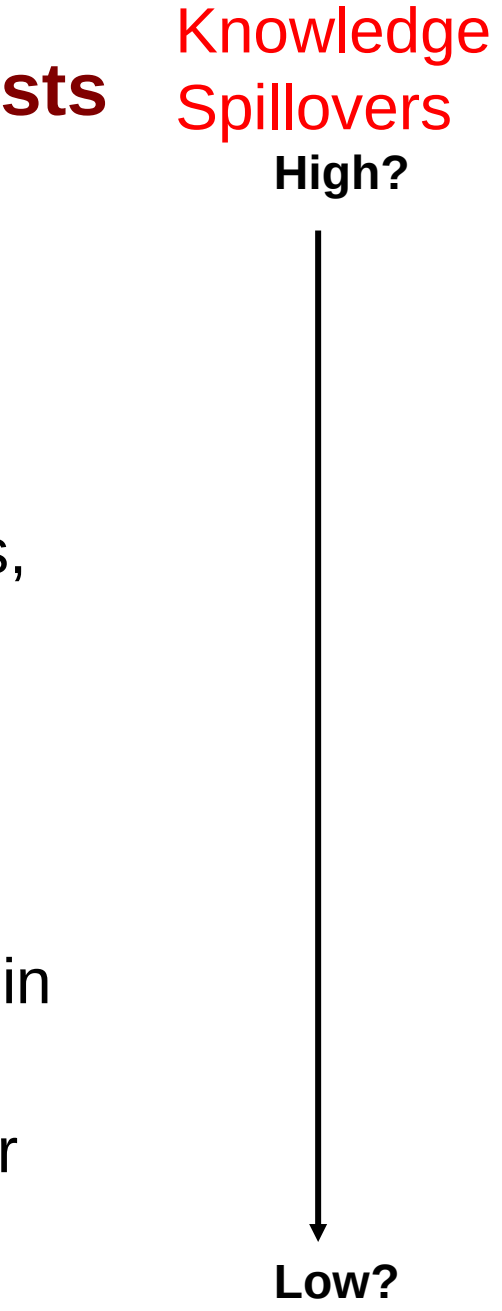


Optimal R&D policy equates social returns with cost via subsidy of μ reducing R&D price to $\rho(1-\mu)$



Components of "Innovation" Costs

- Research
  - Basic
  - Applied
- Development
- Purchase of external IP (patents, copyrights, trademarks and technical know-how)
- Purchase, installation and use of high tech equipment
- Software and database activities
- Training of employees in new processes or in supporting new products
- Marketing associated with the into or new or improved goods & services
- Costs of organizational innovation



Indicators of Innovation (other than TFP growth)

- **R&D** spending
  - Firm accounts (e.g. Compustat)
  - Administrative surveys (e.g. BERD).
  - Tax records (e.g. from R&D credits)

- **Patents** by firms (NBER/Griliches) and by individuals (Lai et al, 2014 disambiguation)
  - Well-known problems (not all patents are innovations and not all innovations are patented)
  - But a lot of empirical focus on this measure because rich information on patent document (future citations, family size, patent texts, etc. to measure quality and type of innovation)

Direct indicators of Innovation (other than TFP)

- **Innovation Surveys** (e.g. EU Community Innovation survey; SPRU; Von Hippel's user-based innovation)

- Shifts of **frontier for specific technologies** (semi-conductors, crop yields, solar panel efficiency, supercomputer performance, etc. – see e.g. Bloom, Jones, Van Reenen & Webb, 2020)

- Academic **Publications**

- **Others:** Venture Capital; Prizes at World Fairs; New Molecular Entities; Medical devices, etc.

Some Econometric Issues

- **Standard problems in policy evaluation**
  - Unobserved heterogeneity
  - Endogeneity
  - Spillovers (SUTVA): big issue for innovation studies

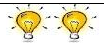
- **Particularly important issues in Innovation Economics**
  - Lots of zeros (real or measurement issue?)
  - Nonlinear outcomes (e.g. counts)
  - Long and uncertain dynamic responses
    - I will not less on these, but has been a focus of some of my work (see “Data and Methodological Issues” on reading list)

Innovation Policy: The “Lightbulb” Table

(1) Policy	(2) Quality of evidence	(3) Conclusiveness of evidence	(4) Benefit - Cost	(5) Time frame:	(6) Effect on inequality

Source: Bloom, Van Reenen and Williams (2019, JEP)

Innovation Policy: The "Lightbulb" Table

(1) Policy	(2) Quality of evidence	(3) Conclusiveness of evidence	(4) Benefit - Cost	(5) Time frame:	(6) Effect on inequality
Direct R&D Grants	Medium	Medium		Medium-Run	↑
R&D tax credits	High	High		Short-Run	↑
Patent Box	Medium	Medium	Negative	n/a	↑

"Demand"

Source: Bloom, Van Reenen and Williams (2019, JEP)

Innovation Policy: The "Lightbulb" Table

(1) Policy	(2) Quality of evidence	(3) Conclusiveness of evidence	(4) Benefit - Cost	(5) Time frame:	(6) Effect on inequality
Direct R&D Grants	Medium	Medium	💡💡	Medium-Run	↑
R&D tax credits	High	High	💡💡💡	Short-Run	↑
Patent Box	Medium	Medium	Negative	n/a	↑
Skilled Immigration	High	High	💡💡💡	Short to Medium-Run	↓
Universities: incentives	Medium	Low	💡	Medium-Run	↑
Universities: STEM Supply	Medium	Medium	💡💡	Long-Run	↓
Exposure Policies	Medium	Low	💡💡	Long-run	↓
Trade and competition	High	Medium	💡💡	Medium-Run	↑

"Demand"

"Supply"

Source: Bloom, Van Reenen and Williams (2019, JEP)

Other Innovation Policies (that I won't focus on)

- **Patent** and IP system (Heidi Williams covers)
- **Science funding**/Grants to academics (Azoulay covers)
- Research Joint Ventures/**collaborations** (e.g. Sematech)
- **Prizes** and Forward Commitments (e.g. Vaccines)
- Many **policies/institutions with indirect effects** on innovation (e.g. regulation; unions; minimum wages)
- **Finance**: Venture Capital, angels, etc. (Lerner, 2022)
- **Place-based policies** (MNE literature, agglomeration, etc.)
- General policies towards productivity
- My focus is innovation - things that **shift the global technological frontier outwards** (new to world not just to firm/industry/country). But some diffusion of management

Other Innovation Policy Approaches

- My focus on econometric analysis of policies, mostly on micro data
- Alternative is to build explicit model and consider optimal policies (with some calibration or structural estimation)
- Example of Akcigit, Hanley and Stantcheva (2022) in notes

- See “Macro Approaches” on reading list for more like:
  - Acemoglu, Akcigit, Alp, Kerr and Bloom (2018)
  - Acemoglu, Akcigit, Hanley and Kerr (2016)
  - Aghion, Bergeaud and Van Reenen (2022)
  - Atkeson, Andrew, and Ariel Burstein (2019)
  - Liu, Ernest and Song Ma (2022)

Back Up

Akcigit, Hanley and Stantcheva (2022)

- Dynamic Mechanism Design model with
  - Knowledge spillovers (needs Pigouvian tax correction)
  - Imperfect Competition (monopoly distortion)
  - Heterogeneous R&D productivity (& changes over time)
  - Asymmetric info (govt. does not observe heterogeneity; wants to screen “good” firms from “bad” firms)
- Optimal policies vary tax nonlinearly with profits & R&D levels

Akcigit, Hanley and Stantcheva (2022)

- Key parameter turns out to be complementarity between:
  1. R&D investment & R&D effort (observable and unobservable innovation inputs)
     - Implies want higher optimal R&D subsidies
  2. R&D investment & R&D productivity
     - Implies lower optimal R&D subsidies as productive firms can just take rents
- They claim (2) is empirically strong, so allocate subsidies away from low productivity firms (otherwise high productivity firms will imitate them)
- Can get close to first best with simple policies that have lower marginal corporate tax rates for more profitable firms and lower marginal subsidies at high R&D investment levels (latter is main thing)

Issues

- Most important primitive elasticities are very hard to observe
  - Could relate to management literature on complementarity
- Profits are very hard to directly observe
- Model is very stylized, how seriously should we take it?

Introduction

- TFP main factor in macro (growth over time & differences across countries) & micro (differences across firms) heterogeneity

- Conventional view was that technical change was exogenous, but endogenous growth theory revolutionized ways of thinking of this

- Policy makers seek to affect innovation in many ways, directly (e.g. R&D grants) and accidentally (e.g. regulation)

Some Indicators of Diffusion

- Diffusion of other specific innovations (robots, Information & Communication Technology - ICT, hybrid corn, seeds, etc.).
- Diego Comin's historical datasets (CHAT): telephone, steam, rail, etc.
- Why are seemingly superior technologies not adopted?
  - Big issue in development economics. Usually agricultural, but Atkin et al (2015) on a manufacturing technology (soccer balls in Pakistan)
  - In developed economies, lots of discussion over ICT diffusion. Discuss later impact of management & complementarities with technology

Policies towards diffusion

1. Adoption of specific technologies (e.g. Broadband)

2. Information provision (e.g. Small Business services)

3. Technology transfer (e.g. FDI support or export credits)

4. University-business linkages (Technology Licensing Offices, 1980 Bayh-Dole Act)

TABLE 4—ROBUSTNESS OF ESTIMATES TO UNRESTRICTED CURVATURE

Technology	Invention year ($\underline{v}_\tau$)	Percentage H_0 not rejected*	Correlation between Estimated adoption lags
Steam- and motorships	1788	65	.99
Railways - Passengers	1825	67	.89
Railways - Freight	1825	62	.97
Cars	1885	75	.82
Trucks	1885	81	.81
Aviation - Passengers	1903	66	.93
Aviation - Freight	1903	77	.83
Telegraph	1835	59	.95
Telephone	1876	80	.94
Cellphones	1973	67	.70
PCs	1973	59	.41
Internet users	1983	100	.59
MRIs	1977	92	.56
Blast Oxygen Steel	1950	72	.73
Electricity	1882	41	.91
Total		69	.80**

Note: All results are for plausible and precise estimates under restricted specification.
* At 5 percent significance level. ** Correlation is weighted average of correlations across technologies.

Source: Comin & Hobijn (2010, AER)

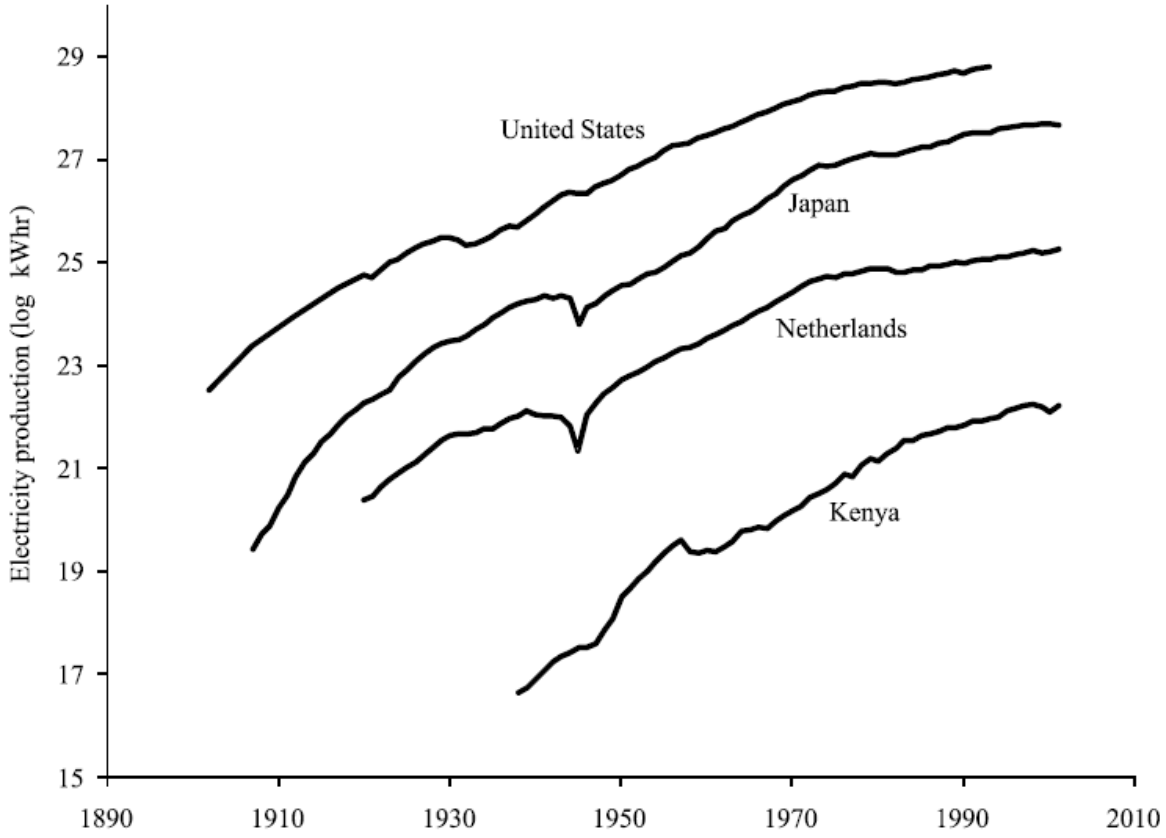


FIGURE 1. ELECTRICITY PRODUCTION IN FOUR COUNTRIES.

Source: Comin & Hobijn (2010, AER)