# AI as Innovation in the Method of Innovation: Implications for Productivity Growth

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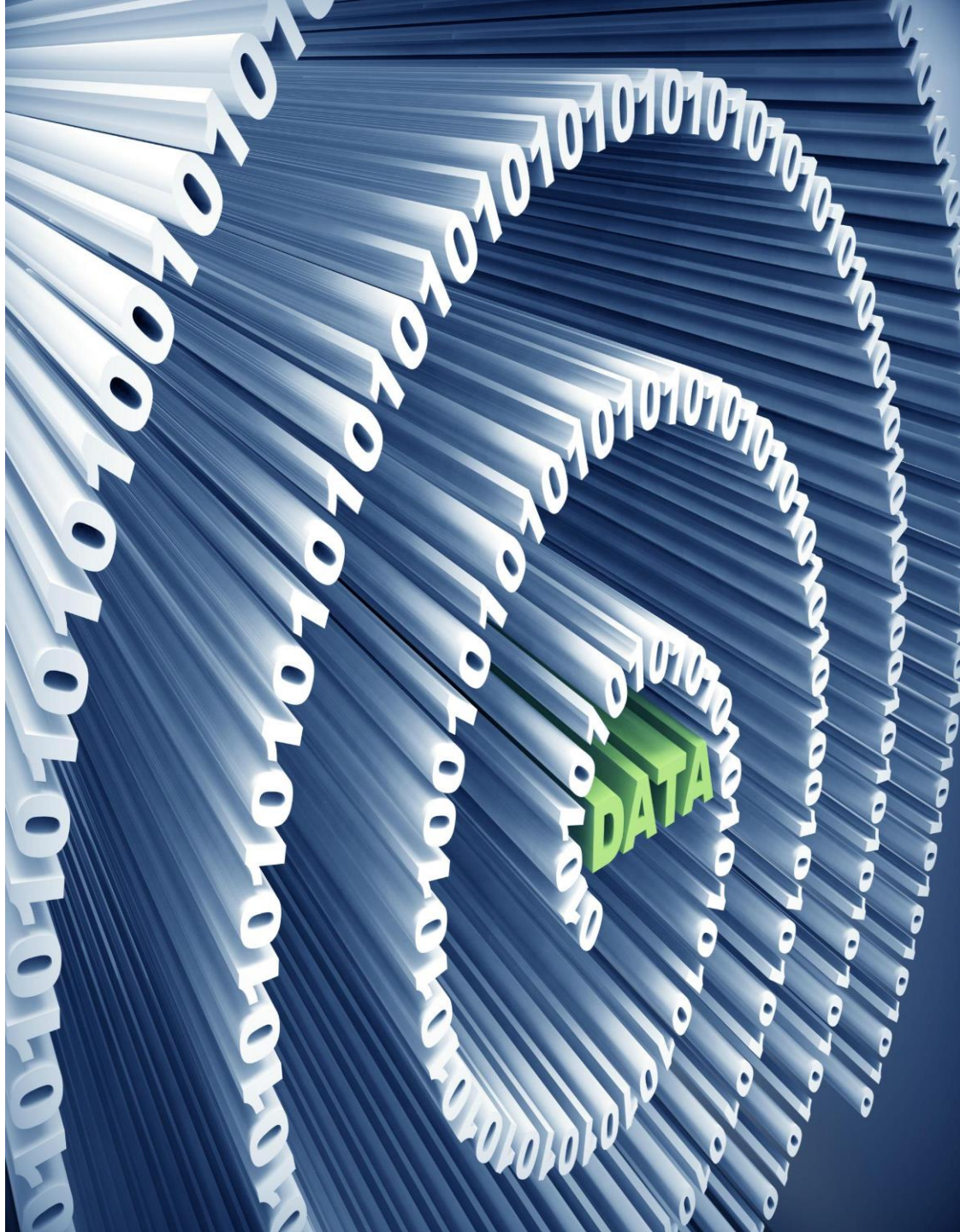
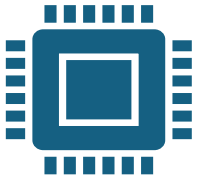
***AEA Session "AI and productivity: Is this time different?"***
*ASSA Meetings, Marriott Hotel, Philadelphia, Pa.*
*Saturday, 2:30 pm, Jan 3, 2025*



# What I'll be talking about



**What approach to use to estimate impact of AI on productivity growth?**

Existing literature is not dispositive

AI is a powerful research tool, which suggests using an approach that captures AI as an IMI … as well as a GPT

GPTs lead to systemic change in production structures, which suggests using an approach that looks at changes in composition of investment

**The intangibles-augmented growth accounting approach meets these needs:**

Features the capture of **business investments** in innovation

Amenable to **modeling AI as an IMI as well as a GPT**

Can be taken to the **existing** data.

**Results and robustness**

Results suggest **AI** contributed significantly to US labor productivity growth since 2017---1 percentage point annually

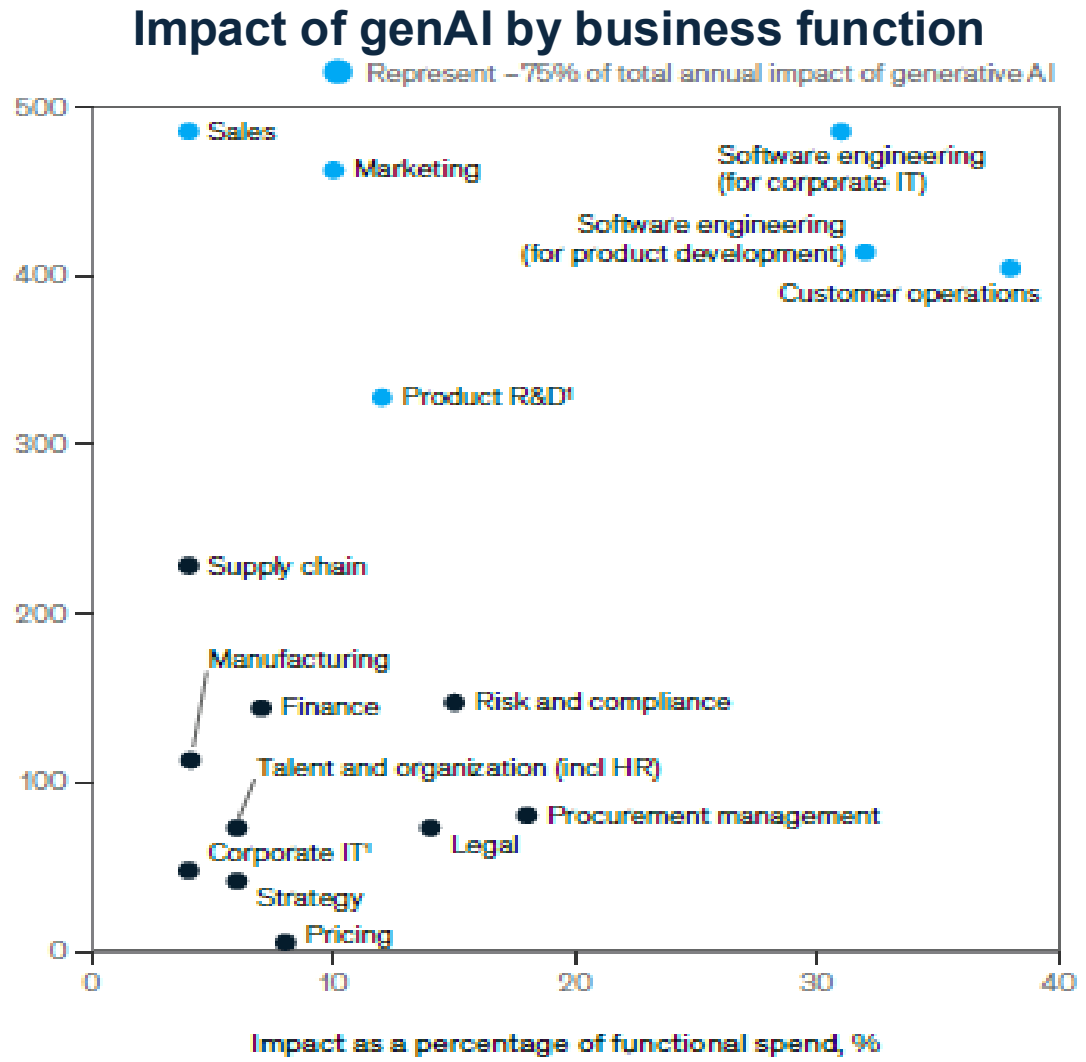
Not as large as ICT (yet). Still early days.

Is AI all a bubble? No, in terms of productivity growth, it seems that this time IS different.

# AI as innovation in innovation: Evidence from business functions

McKinsey survey evidence on the impact of genAI through the lens of business functions:

- Suggests AI is broader than automation…
  - AI affects many (mostly intangible) business functions
  - AI especially helps with product R&D and marketing/customer facing functions
- **Consistent with AI as an IMI as well as a GPT**



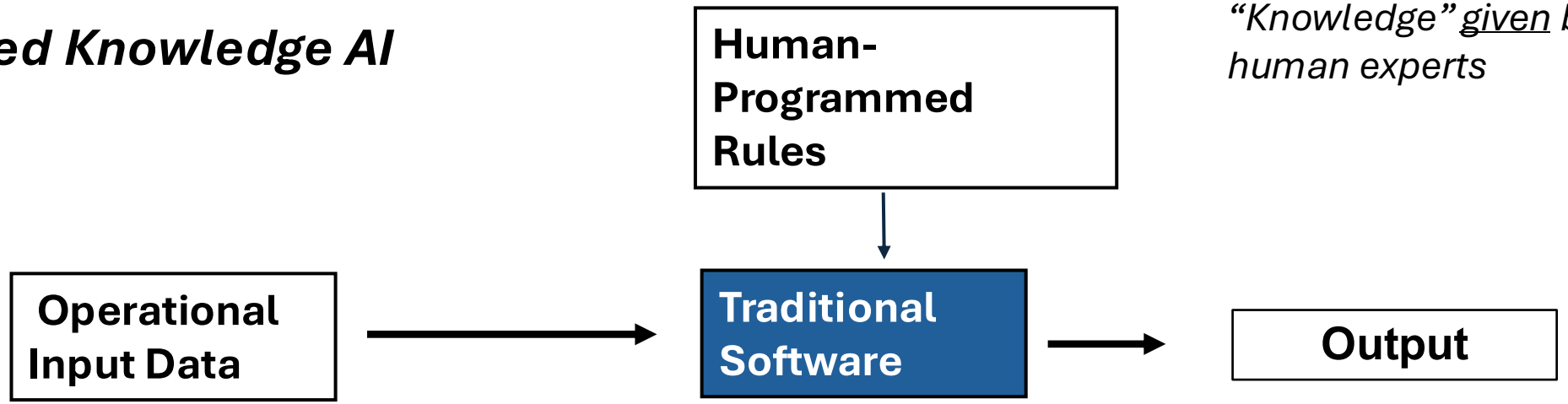

*Source for chart. McKinsey (Chui et al. 2023)*

# Modeling AI as an IMI and a GPT

- Multi-sector approach
  - There is an **upstream**, **knowledge-producing** sector that generates long-lasting commercially valuable knowledge (intangible capital)
  - Other **downstream, knowledge-using** sector produce tangible capital and consumption goods
- The mechanism for treating AI as an IMI is that the upstream sector **uses AI technologies** to produce both AI-enabled intangibles and AI-enabled "brains" for tangible capital goods, e.g., autonomous vehicles
  - The upstream sector does not necessarily represent a collection of firms
  - Rather it mainly represents the business functions within firms that engage in knowledge production (R&D and/or product development departments, marketing teams, strategy teams, etc.)

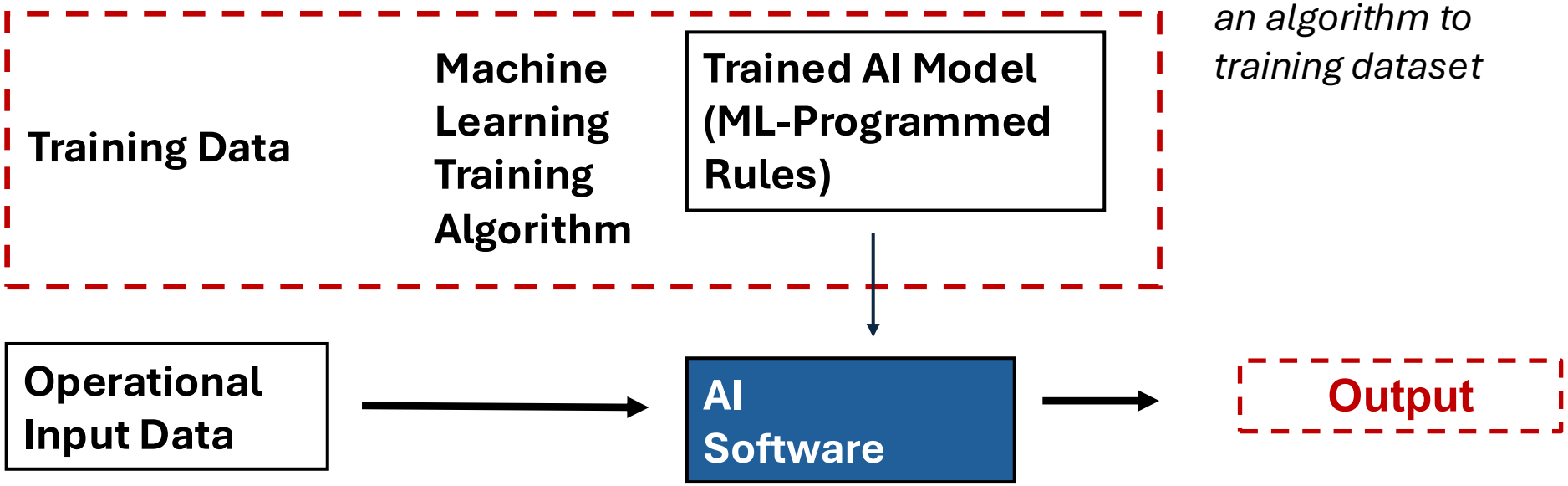

https://share.google/epUUiBDagSMIREbhv

## *Handcrafted Knowledge AI*




*"Knowledge" given by human experts*

## *Machine Learning AI*




*"Knowledge" learned by applying an algorithm to training dataset*

Source: Adapted from Allen (2020).

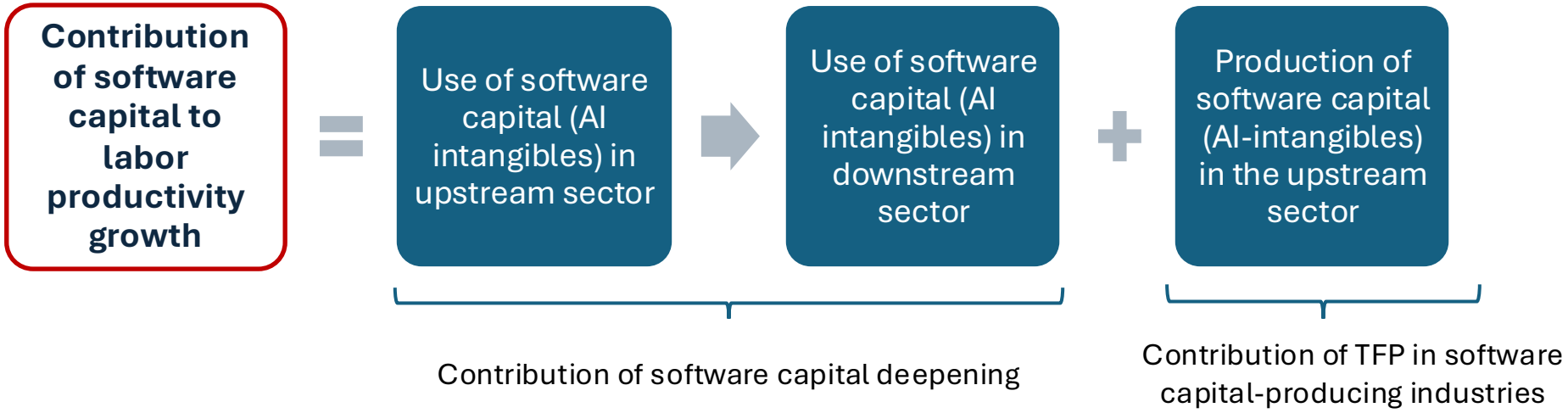
# Bringing the upstream/downstream model to the data

**Intangibles-augmented growth accounting**

## Focus on AI as software capital

- Production **(2017 NAICS 511, 518-9, and 5415)**: Software publishing, Internet publishing computing infrastructure and data services, custom programming services and systems design; also includes legacy print media and excludes own production outside of these industries (data limitations prevent these adjustments).
- Use: Two asset types. **(A)** Software products acquired or internally developed by businesses; internal production of databases. **(B)** Software product R&D and embedded software R&D within other R&D activities.

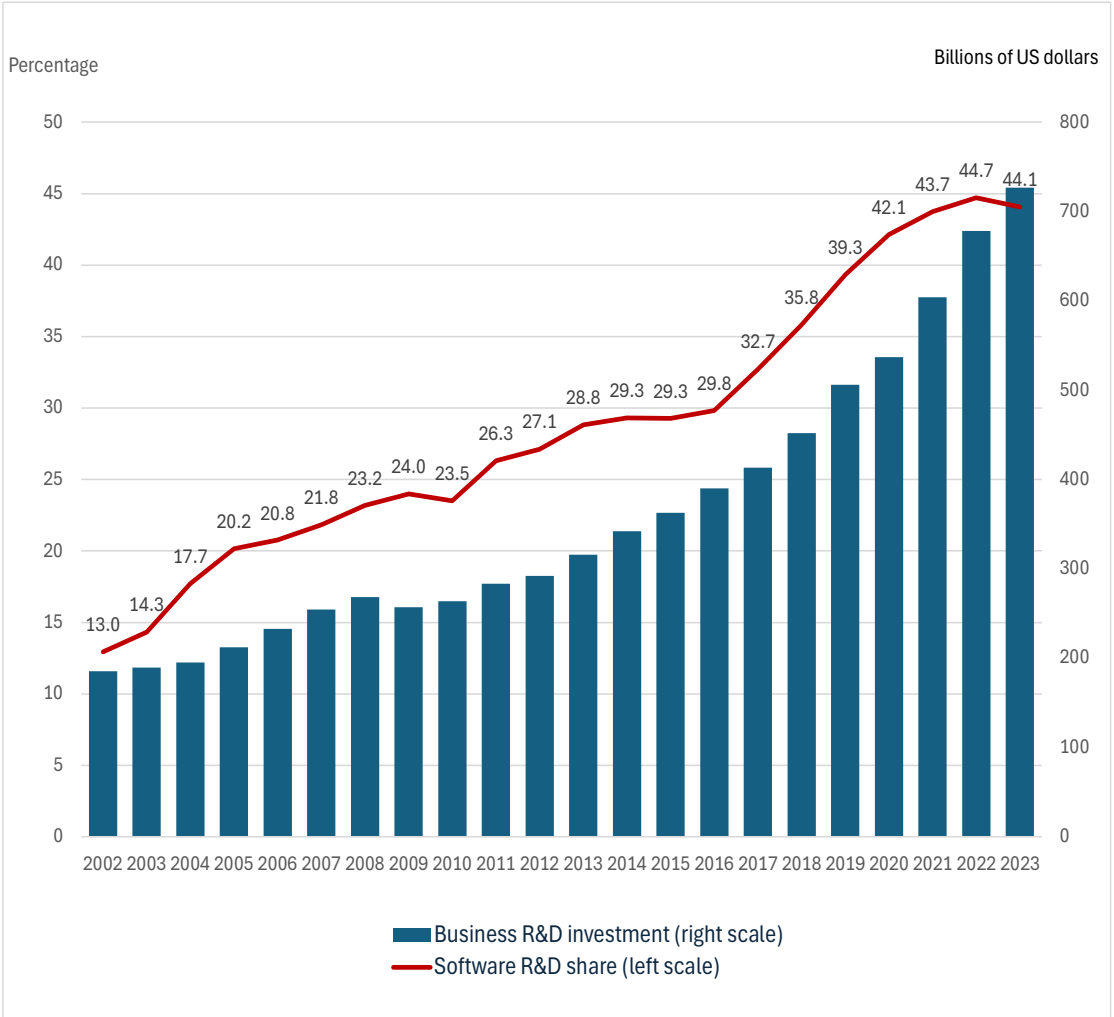
## Calculations exclude spillovers



# Software capital: Where to find software R&D?

- Software R&D is an area of technology
- Its conduct (or use) is not confined to software industries.
  - e.g., R&D for autonomous vehicles “brains” may appear as motor vehicle industry R&D in the usual data—but rather is (embedded) software R&D.
- US R&D surveys have collected data by technology focus since 2001.
  - Estimates on national accounts basis developed for this paper.
- **US Software R&D grew very rapidly from 2017 to 2022.**

Software R&D: Estimate consistent with national accounts



# Software capital and US productivity growth

**Table 1.** Productivity Growth and Software: Summary

| US Nonfarm Business Sector | 2012 to 2017 (1) | 2017 to 2024 (2) | Acceleration (3) |
|---|---|---|---|
| 1. Labor productivity growth (LPG)[1,2] | .8 | 2.0 | 1.2 |
| 2. Contribution of software production and use[2,3] | .4 | 1.0 | .6 |
| 2a. *(percentage share of line 1)* | .50 | .51 | .51 |
| of which: | | | |
| 3. Contribution of software industries | .2 | .6 | .4 |
| 3a. *(percentage share of line 1)* | .28 | .30 | .30 |
| 4. *Total factor productivity growth (TFPG)*[1,3] | .4 | .9 | .5 |
| of which: | | | |
| 5. Contribution of software industries | .1 | .4 | .2 |
| 5a. *(percentage share of line 4)* | .30 | .37 | .43 |

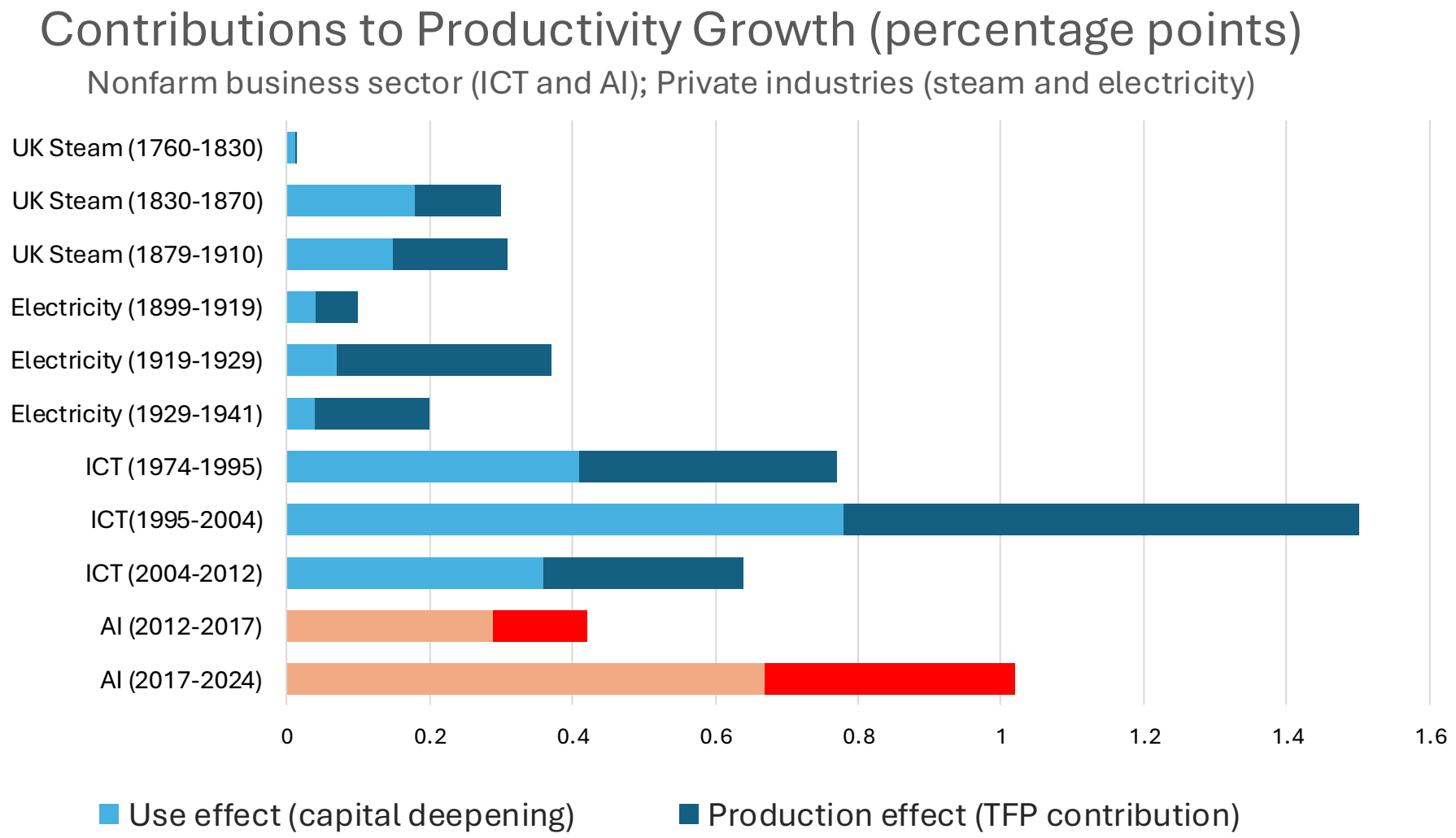
**Notes.** Software industries are the 2017 NAICS 511, 518-9, and 5415 industries. Software capital is the software component of Intellectual Property Products (IPP) and software product and embedded software R&D component of Business R&D.

1. Percent change
2. Percentage points
3. Based on natural log differences/points

**Sources.** Authors' elaboration of BLS productivity data files and NSF/NCSES BERD Survey data.

Taking the production and use of software capital as a reflection of the impact of AI technologies, their combined contributions indicate that AI has already had a significant impact on US productivity growth.

# Results in context of earlier technologies: AI still in early days




*Source for blue bars: Crafts (2021, table 1); electricity includes spillovers. Source for red bars, this paper..*

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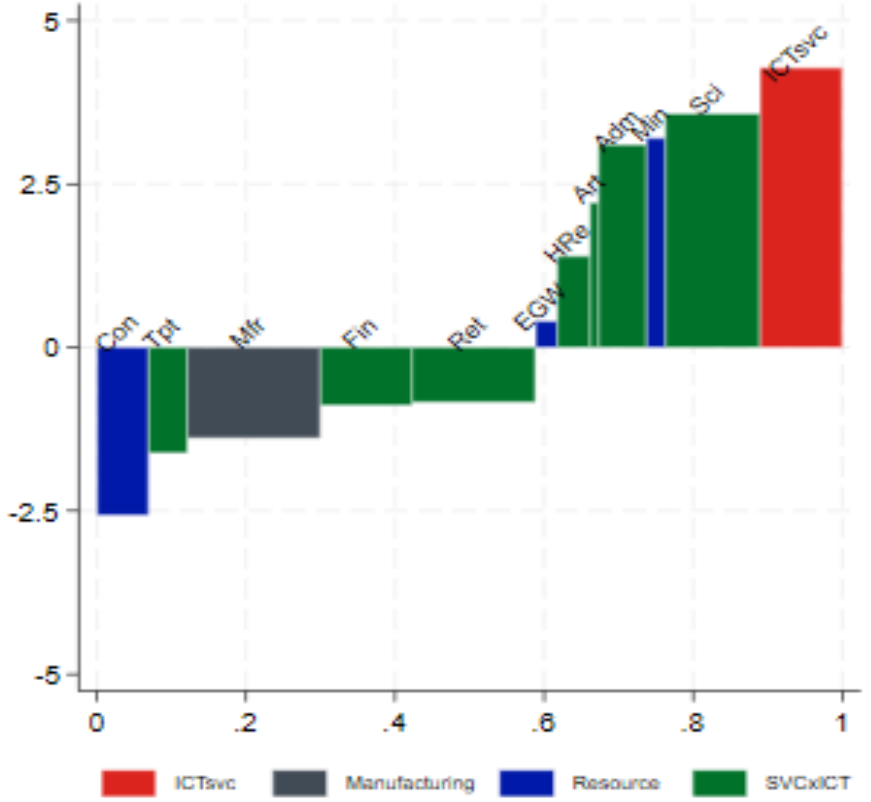
# TFP results in an industry context: N**ot** a bubble

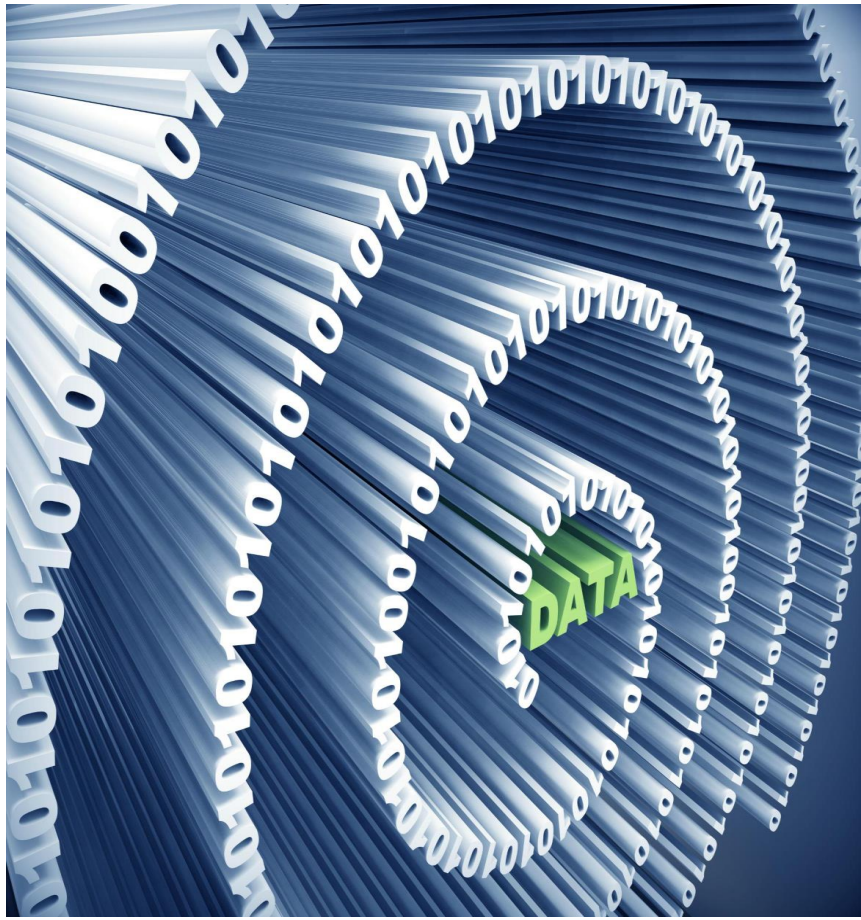
- Chart to the right shows industry-level TFP growth, where the width of each sector reflects the sector's production share
- Shows that the US digital sector (red bar) is a key driver of TFP growth
- … and that US economy is **not** entirely dependent on its digital economy
- The large finance, retail, and manufacturing sectors are negative contributors to TFP growth
- … but these 3 sectors are among **the 6 leading sectoral adopters of AI software** (according to IDC's AI software spending data)

**US TFP growth 2018 to 2023**



# Summary

- AI is a breakthrough in the capabilities of software
  - Significant R&D resources have been devoted to developing knowledge-creating software and tools with intelligent capabilities in the United States
- Impact of AI is visible in ***existing*** US data
  - The contribution of software accounts both for 50% of labor productivity growth since 2012 and more than 40 percent of the acceleration in TFP growth from 2017 to 2024.
- Digitally-driven productivity growth in the US and elsewhere is not new, and likely to stay.



# Thankyou.

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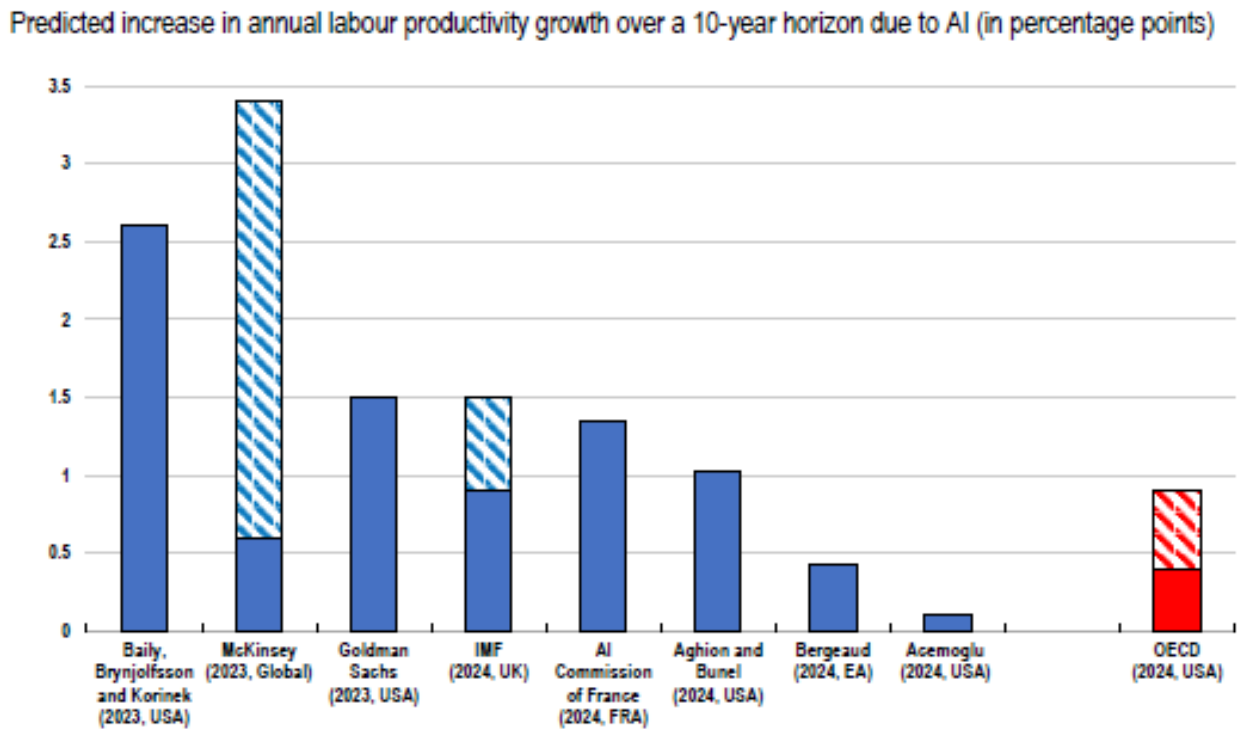
(backup slides follow)

# Labor productivity…Wide estimates of the effect of AI




Notes: joint effect of boost to TFP and induced capital deepening. Shaded areas in bars indicate bounds.
Source: Fillippucci, Gall, Schief, 2024, Figure A10.

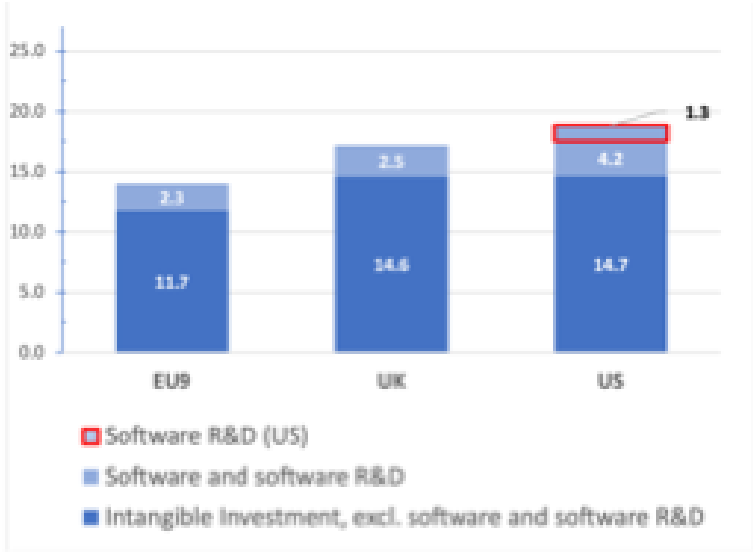
- Example calculation:
  - Acemoglu (2025)= 0.064pppa gains to TFP => gain to Lab prod growth = 0.12pppa with induced cap deepening
  - Fillippucci, Gall, Schief, 2024 = 0.14-0.38pppa gains to TFP = > gains to Lab prod 0.36-0.93pa with induced cap deepening

# AI, GPTs and IMIs

- **GPT**: definition: "…pervasive use in a wide range of sectors and … technological dynamism." (Bresnahan, Trajtenberg, 1995)
  - Steam and electric motors generated more and cheaper power … but also led to redesign of transportation equipment and factories
- **IMI** = "invention in the method of invention" (Alfred North Whitehead, 1925)
  - Hybrid corn (Griliches 1957)
  - AI as an IMI suggested in Cockburn, Stern, and Henderson (2019), Crafts (2021), Baily, Byrne, Kane, and Soto (2025).
- Note: Task accounting studies based on AI as a GPT
  - Acemoglu (2025) "I … do not discuss how AI can have revolutionary effects by changing the process of science"
  - Fillippucci, Gall, Schief (2024) "We do not model the implications of an AI-driven acceleration of innovation, research or technological progress "

# What about the future? Suppose most intangibles are driven by AI agents…

Intangible Investment as a share of market sector GVA, 2019




Note. GVA is adjusted to include non-national accounts intangibles.

Faster upstream TFPG induces more downstream capital deepening

Contributions of AI as an IMI to labor productivity in steady growth

| | Production and income share | Contributions | Upstream Productivity Advantage (percentage points) | | | |
|---|---|---|---|---|---|---|
| | | | **.05** | **1** | **2.5** | **5** |
| | | | (1) | (2) | (3) | (4) |
| 1. | **.05** | Production | .03 | .05 | .13 | .25 |
| 2. | | Use | .04 | .08 | .21 | .42 |
| 3. | | **Total** | **.07** | **.13** | **.33** | **.67** |
| 4. | **.10** | Production | .05 | .10 | .25 | .50 |
| 5. | | Use | .08 | .17 | .42 | .83 |
| 6. | | **Total** | **.13** | **.27** | **.67** | **1.33** |
| 7. | **.15** | Production | .08 | .15 | .38 | .75 |
| 8. | | Use | .13 | .25 | .63 | 1.25 |
| 9. | | **Total** | **.20** | **.40** | **1.00** | **2.00** |

**Note.** Totals may not add to components due to rounding. Figures constructed assuming the labor share is .60.