



AI and Digital transition.

Digital Infrastructures, Knowledge, and Data Governance

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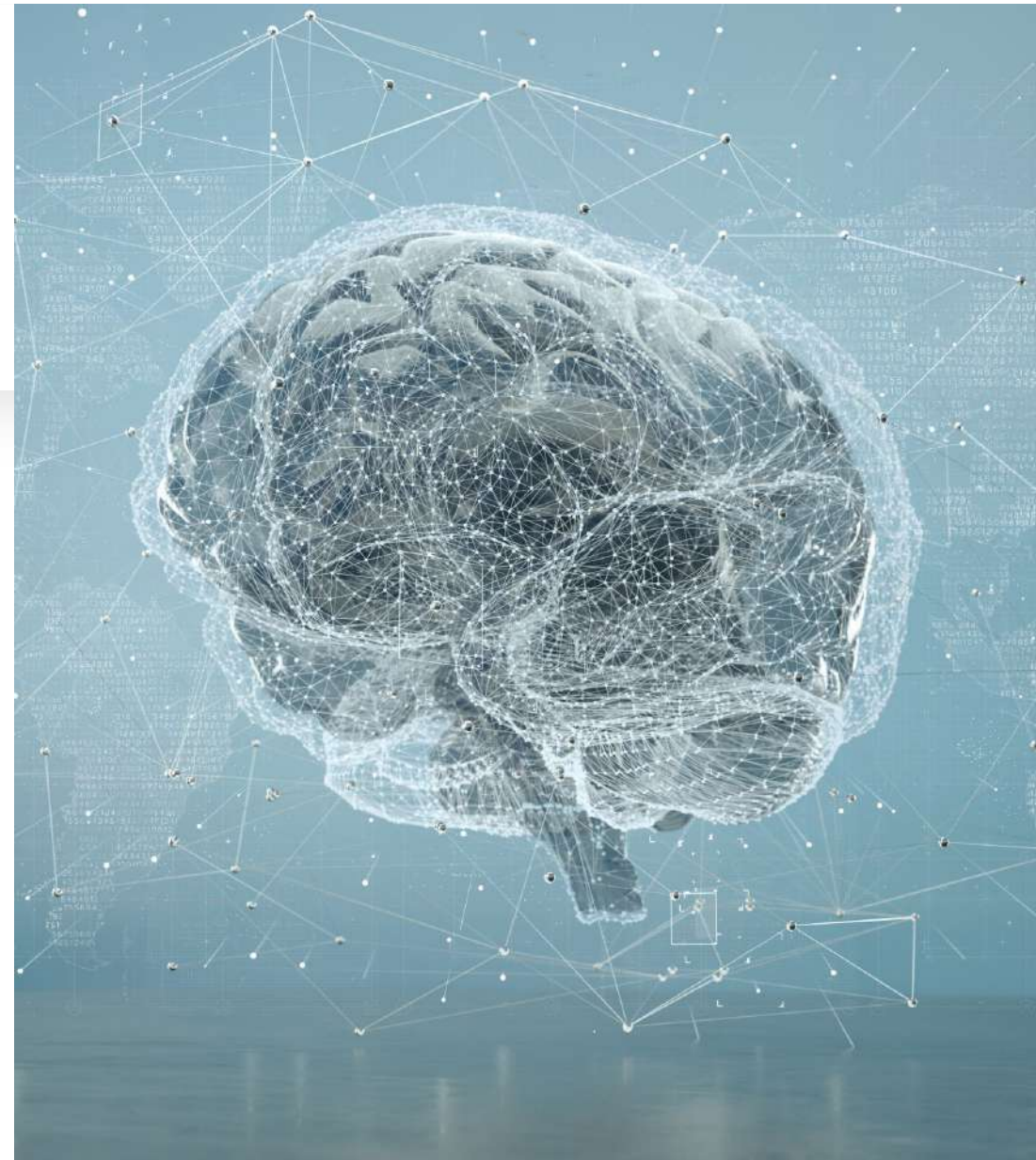
Jean Monnet UNU Merit Summer School

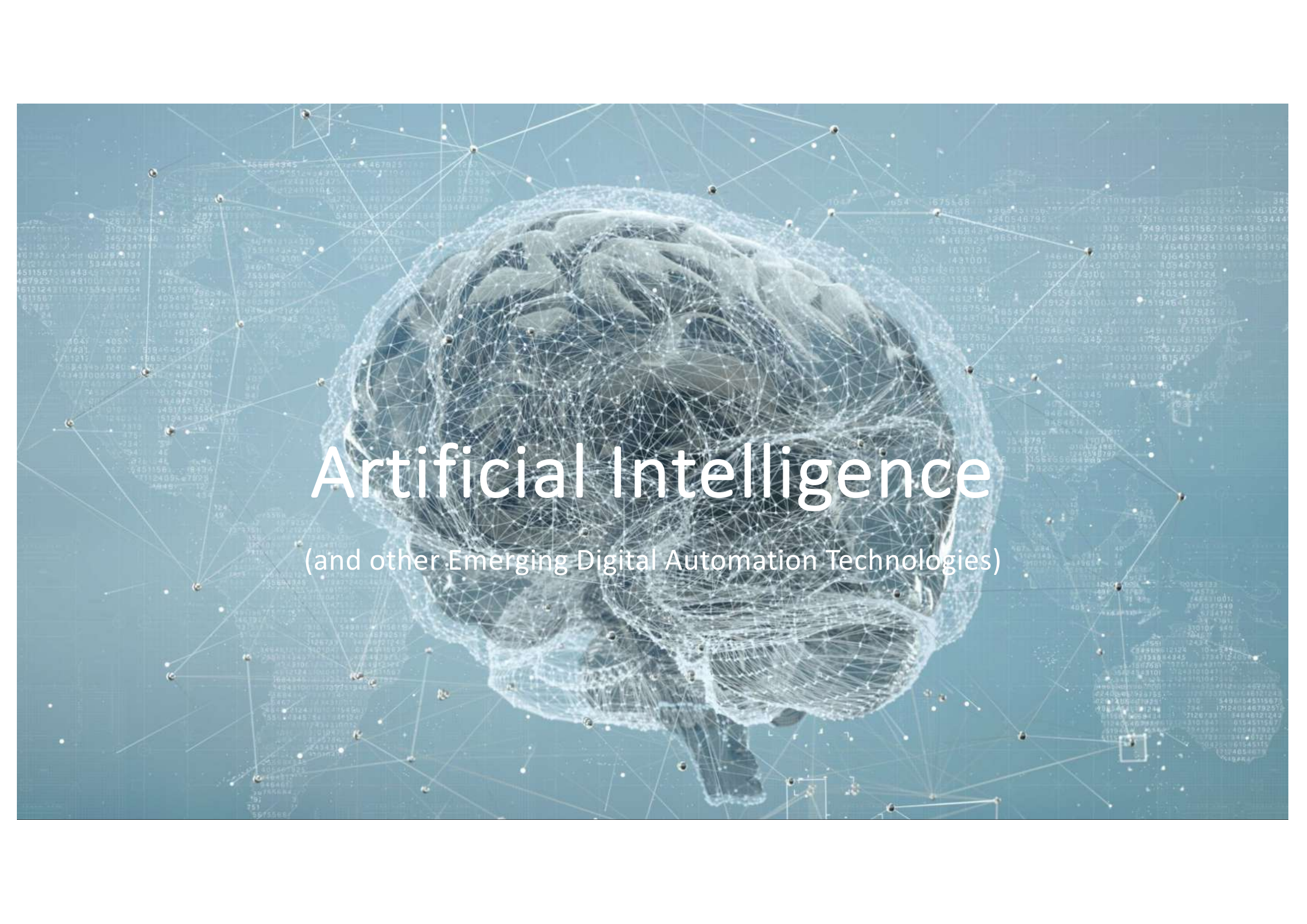
The Economics of the Green and Digital Transitions: Innovation Policies for a Global Europe



Outline

1. AI as part of a technological paradigm of Emerging Digital Technologies (EDTs)
2. AI, Digital Infrastructures and Data Centers
3. The Value: Informational Scale or Collective Knowledge?
4. The Value and Governance of Data



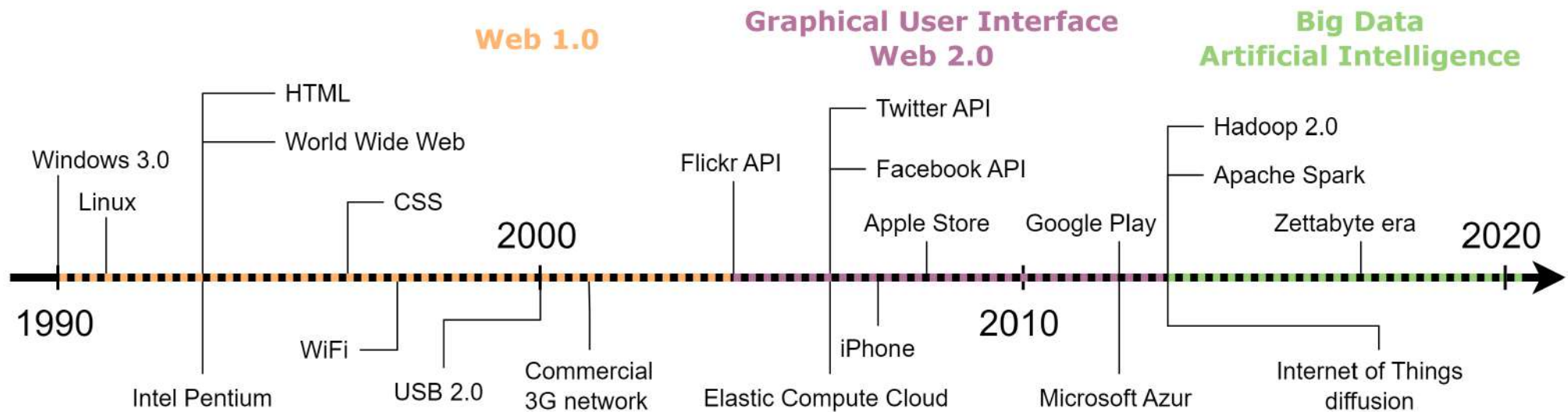


Artificial Intelligence

(and other Emerging Digital Automation Technologies)

Thirty years of ICTs and digital automation technologies

Source - Jaccoud et al. 2024



A taxonomy of relevant EDT

Technology family A – Robots (Articulated, Cylindrical, Cartesian, Dual Arm) *Definition: Technologies that sense and (autonomously) act based on data*

Technology family B – Physical Data Acquisition Technologies *Definition: technologies that harvest and record information*

Technology family C – Software-based data management *Definition: Technologies for storing, protecting, managing/handling and acquiring data*

Technology family D – Computing *Definition: Technologies used to compute/calculate*

Technology family E – AI (not directly as a cloud service) & Intelligent Information System, *Definition: Technologies using algorithms and advanced methods to make sense out of the data*

Technology family F – Additive manufacturing (using any material), *Definition: Technologies that produce bottom-up goods based on digital models*

Technology family G – Networking, *Definition: Technologies for communicating between machines (data transmission) or connecting machines*

Technology family H – User interface, *Definition: Technologies for human interaction with machines or data*

What is AI?

Automating adaptability represents a radical improvement on currently available automation technologies: going beyond routine.

For a system to achieve this, three components are necessary:

1. Sensors, collecting **data** from the environment.
2. Analyzers that extract patterns from these data and ***make recommendations***.
3. Effectors that carry out **changes in behaviour**.



Now, what is the hype around emerging digital automation about?

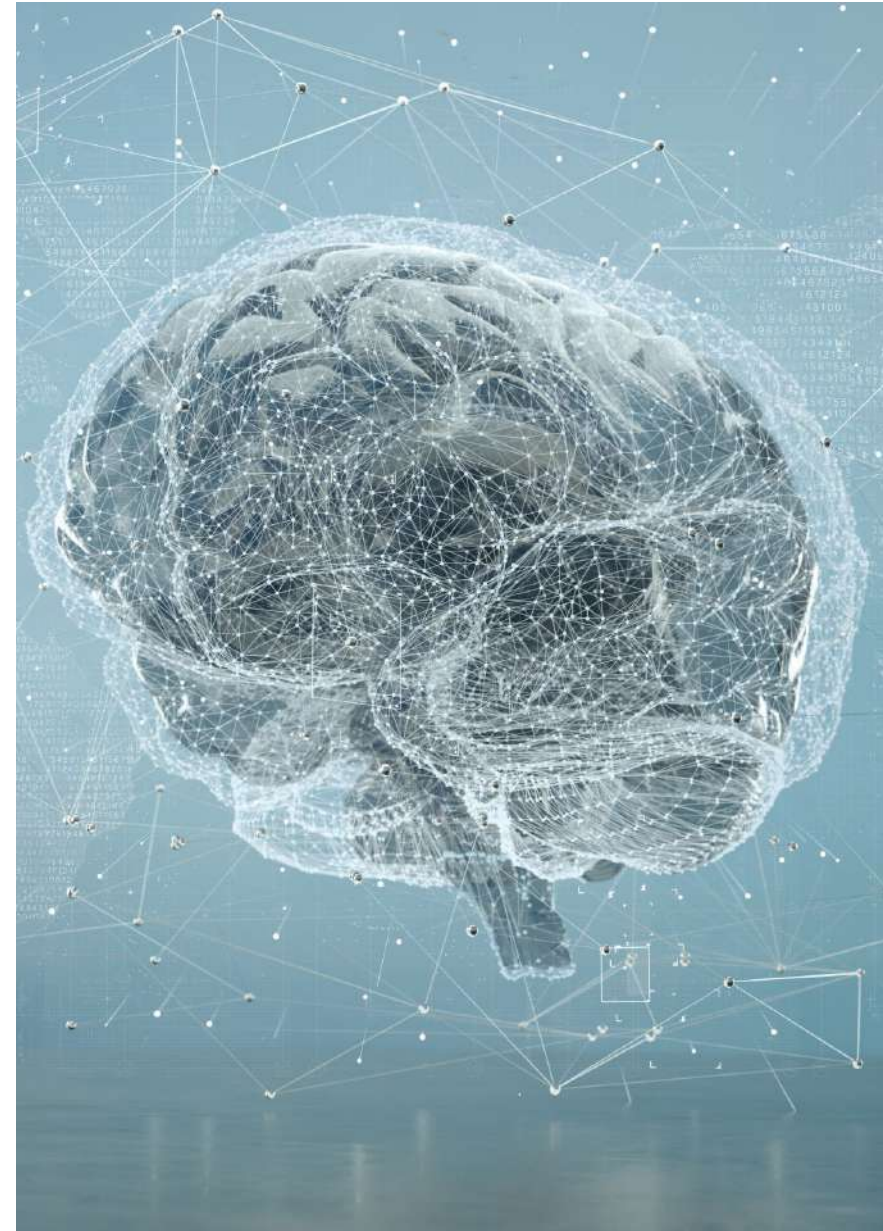
- A conscious, human-like, **general intelligence**, now a reality (Steinmueller, 2021)
- The power of **learning by imitation**, or Machine Learning, or AI or more recently CHAT-GPT3/4/5



- The anxiety on “**this time it will be different**” in terms of occupational effects and beyond

Gen-AI and Agentic AI (IBM, 2025)

- **Generative AI** is [artificial intelligence](#) that can create original content in response to a user's prompt or request. Gen AI relies on using machine learning models called [deep learning](#) models—algorithms that simulate the learning and decision-making processes of the human brain.
- **Agentic AI** describes AI systems that are designed to autonomously make decisions and act, with the ability to pursue complex goals with limited supervision.
- **It's a proactive AI-powered approach**, whereas **gen AI is reactive to the user's input**. Agentic AI can adapt to different or changing situations and has “agency” to make decisions based on context. It is used in various applications that can benefit from independent operation, such as robotics, complex analysis, and virtual assistants.





Digital Infrastructures: Data Centers, and Cloud Services (DCCS)

Environment, geopolitics and lines of research worth pursuing

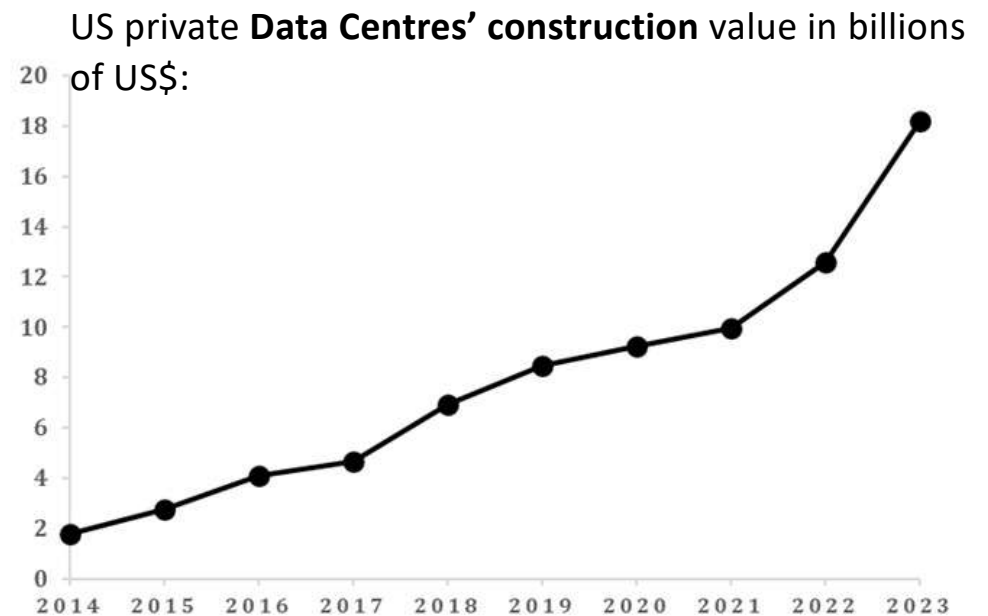
Outline

- Digital infrastructures: data centers and clouds services (DCCS)
- Issues of energy demand
 - Prospects/estimations (EPRI report)
- Geographical and geopolitical issues
 - What is behind the uneven distribution of DCCS? (Papadakis & Savona, 2024)
 - US-China (Lehdonvirta et al., 2023)



Digital infrastructures

- Investment in DCCS in the US
- Complementary investment in **digital (physical) infrastructure**
 - The costs and complexity of storing and processing large data ⇒ Outsourcing and offshoring
 - **Yet** we know little about where they are and how their location matters



Data source: US Census data - *Construction Spending*

AI and data centers capacity dem and supply

Data volume of global consumer IP traffic from 2017 to 2022

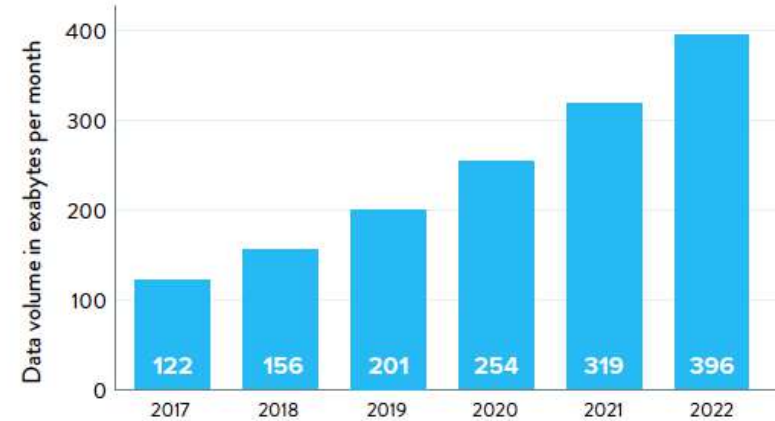


Figure 4. Trends in global consumer IP traffic, 2017–2022 [21]

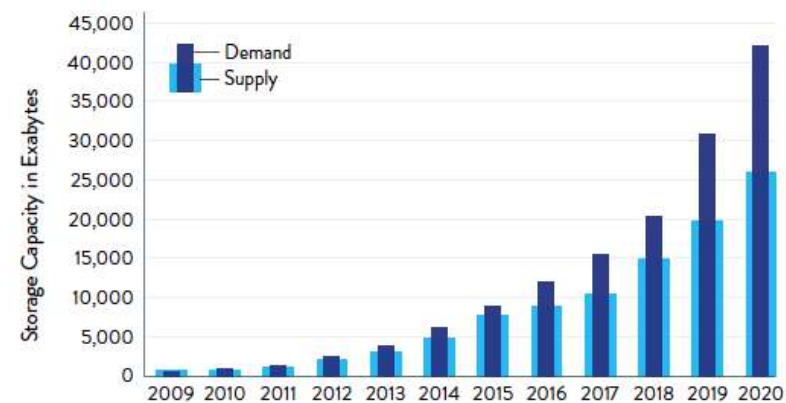


Figure 5. U.S. data storage supply vs. demand, 2009–2020 [22, 23]

Web traffic and energy consumptions (EPRI)

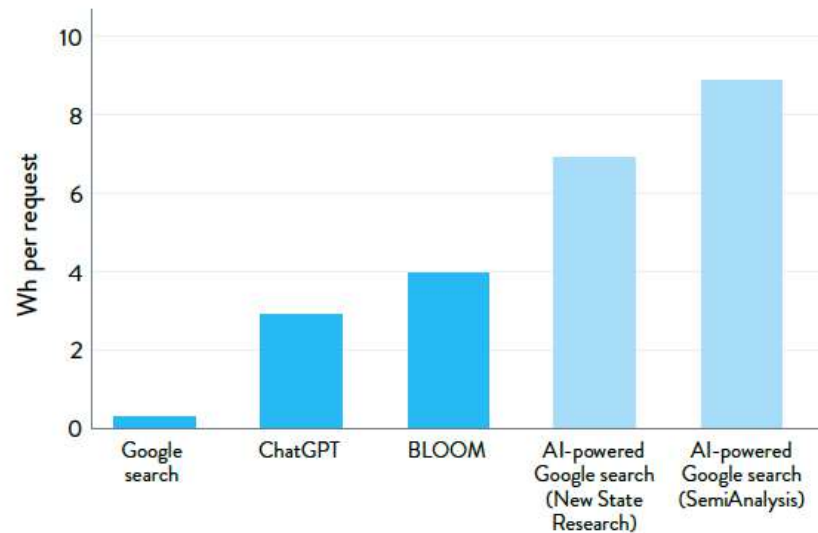


Figure 10. Electricity consumption per request [47]

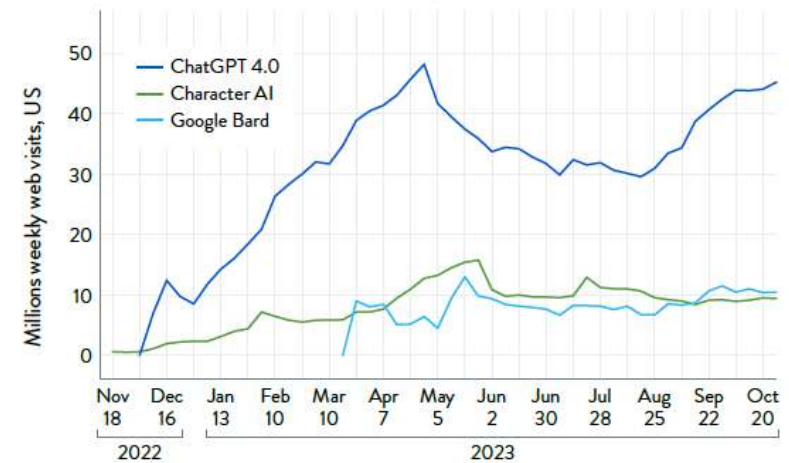


Figure 9. U.S. web traffic trends to AI platforms, 2022–2023 [45]

Projection of electricity consumptions in the US (EPRI report)

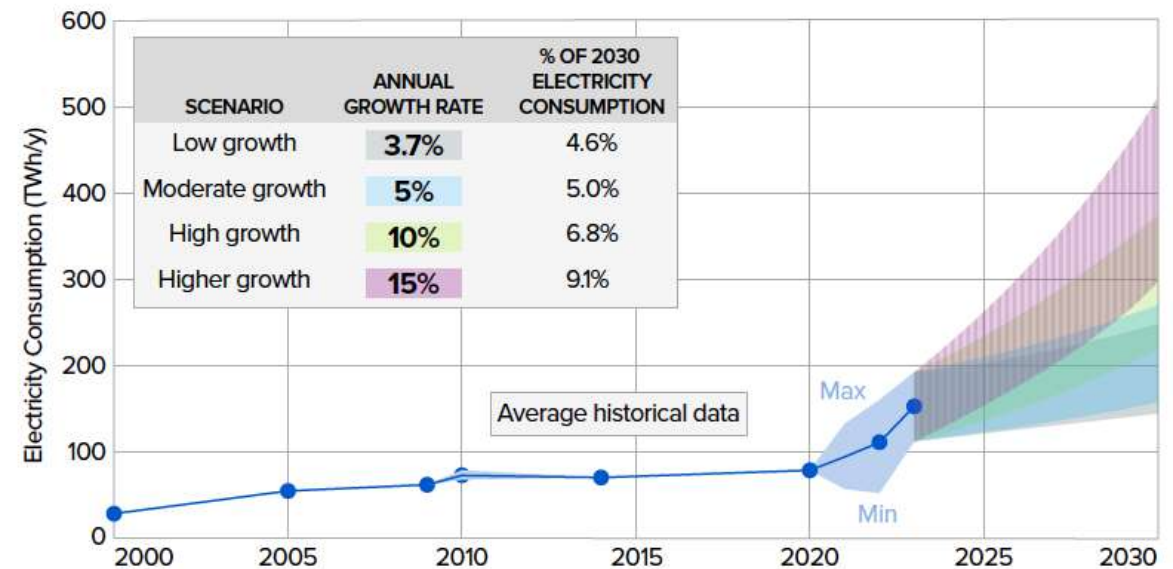


Figure 11. Projections of potential power consumption in U.S. data centers scenarios, 2023–2030 [1, 2, 4, 8, 14]

Overall: DCCS and Energy demand

- ChatGPT requests consume 2.9 watt-hours
- AI queries are estimated to require TEN TIMES more the electricity of traditional Google queries (0.3. watt-hours each)
- Data centers grow to consume 4.6% to 9.1% of US electricity generation annually by 2030 versus an estimated 4% today.



The geography of digital infrastructures

Focus: **geography** of data centers and cloud service providers (DCCS)

Research questions

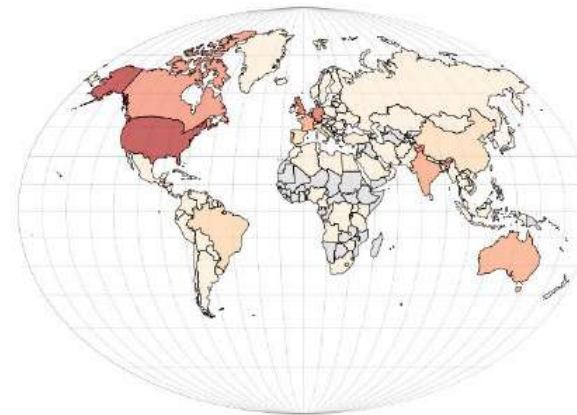
- **Where** – mapping across countries
- **How** – drivers and implications for businesses and countries

Preview of findings: uneven geography

- a higher **number** in countries w/ darker red colour
- a higher **share** of DCCS is in top digital services exporting countries
- the **intensity** of DCCS is higher in financial services' specializing countries and tax havens

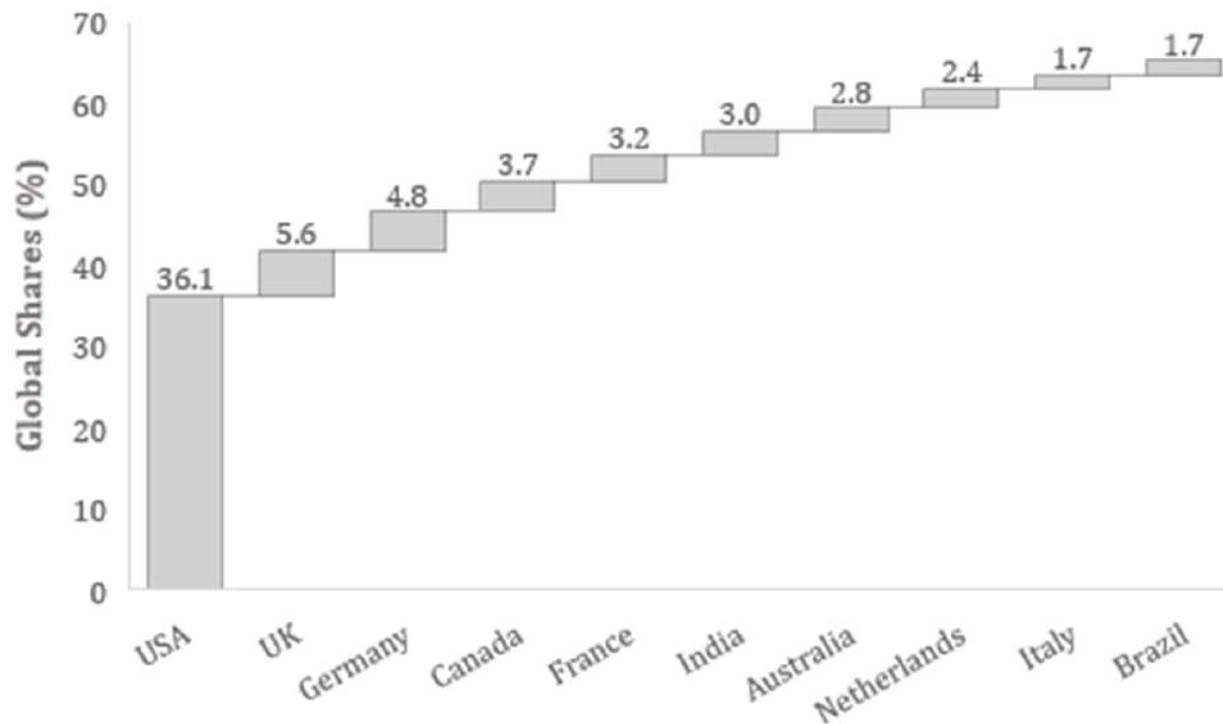
Figure 2: Total Number of Data Centres and Cloud Service Providers

Total Number 0 2250



Notes: This figure maps the total number of data centres and cloud service providers. Darker orange countries have a high number of data centres and cloud service providers. In grey are countries without available data. Source: data on data centres and cloud infrastructures from www.datacentermap.com

Country share of DCCS

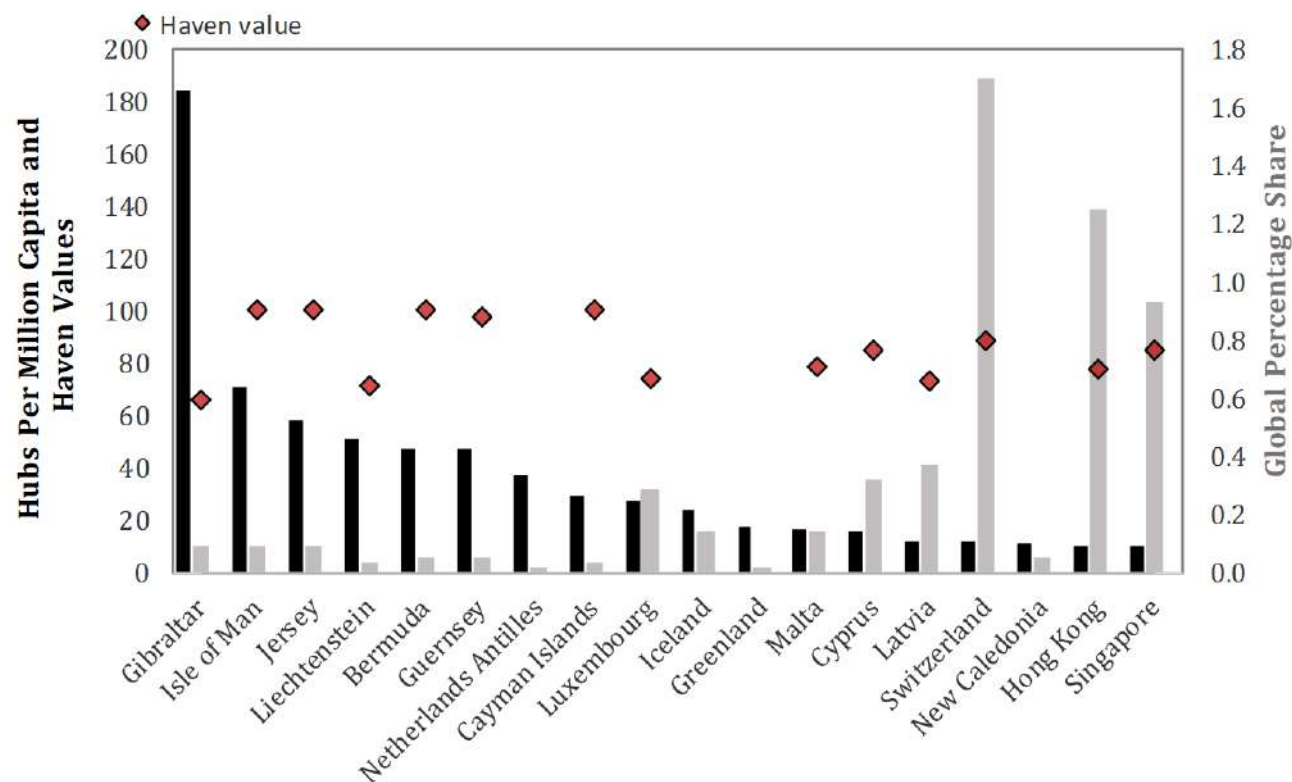


- High concentration:
 - the top ten countries account for two-thirds of CDCs
- The top 3 countries:
 - **Large** countries
 - Top exporters of **digital services** (UNCTAD, 2023)

Source: data on data centres and cloud infrastructures from www.datacentermap.com

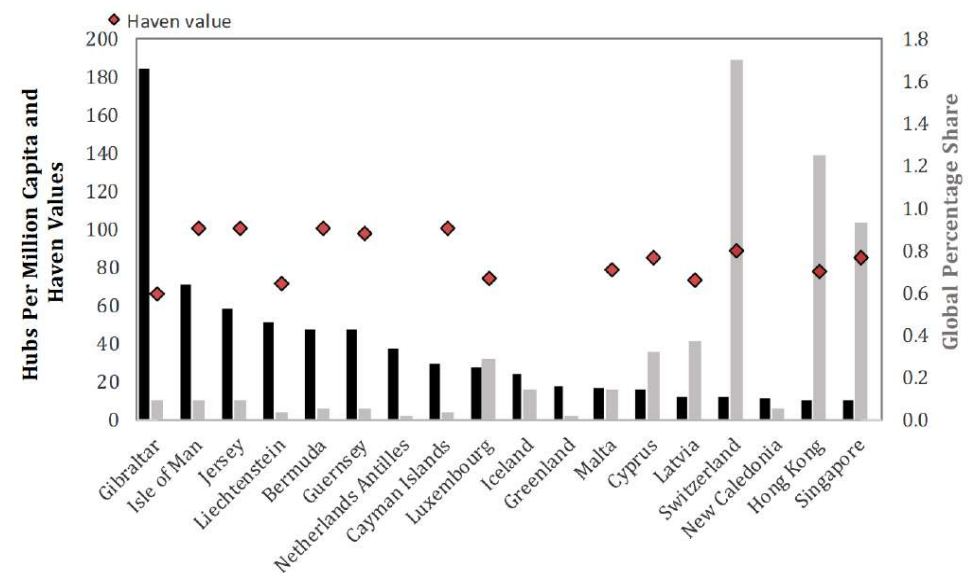
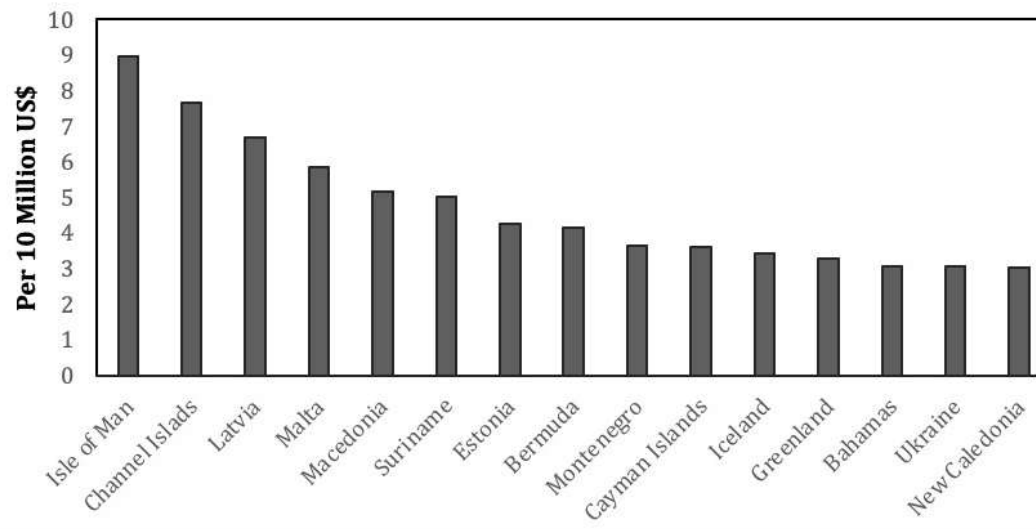
Intensity of DCCS (per capita)

- A very different picture emerges

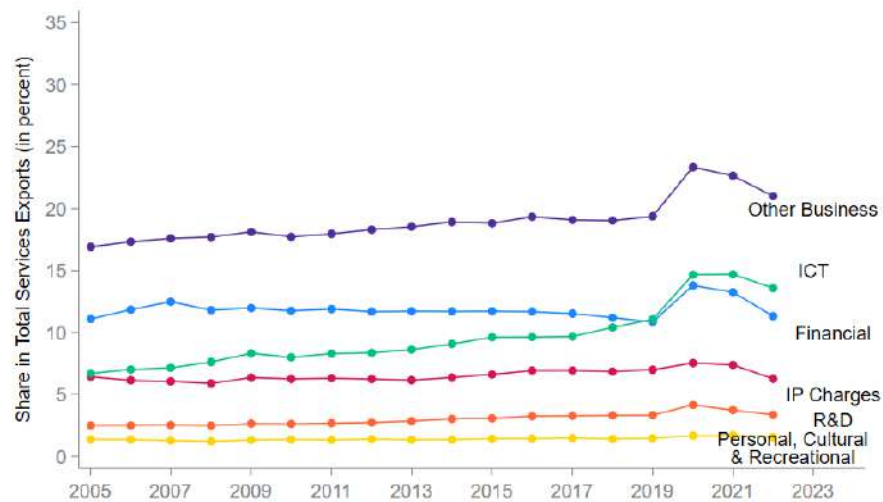


- Higher intensity in **smaller** countries
- particularly in those that are considered **tax havens** (close to 100 haven score values)
- Germany, UK, and USA have only 4, 5, and 7 per 1 mil capita CDCs

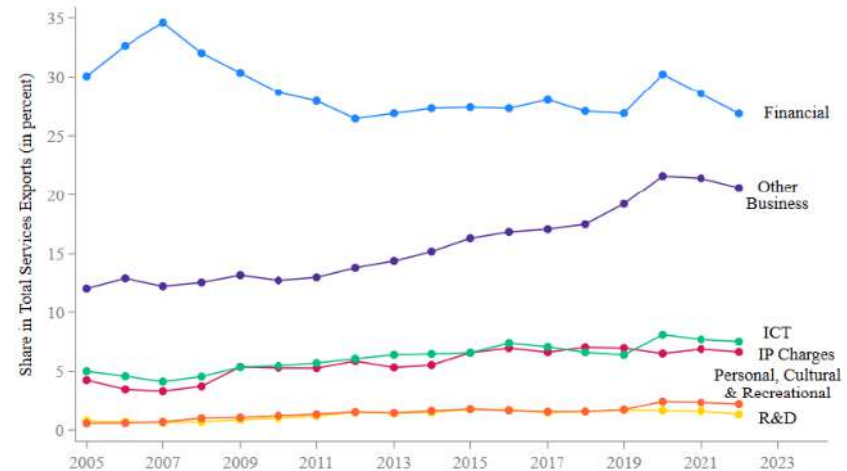
Intensity of DCCS (per 10mlns US \$) (comparison)



Digital exports share in total services



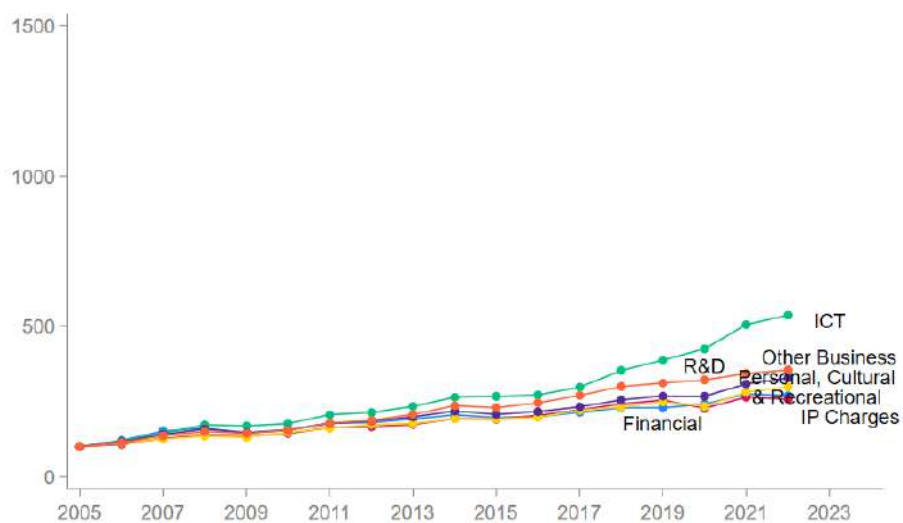
Panel A: World



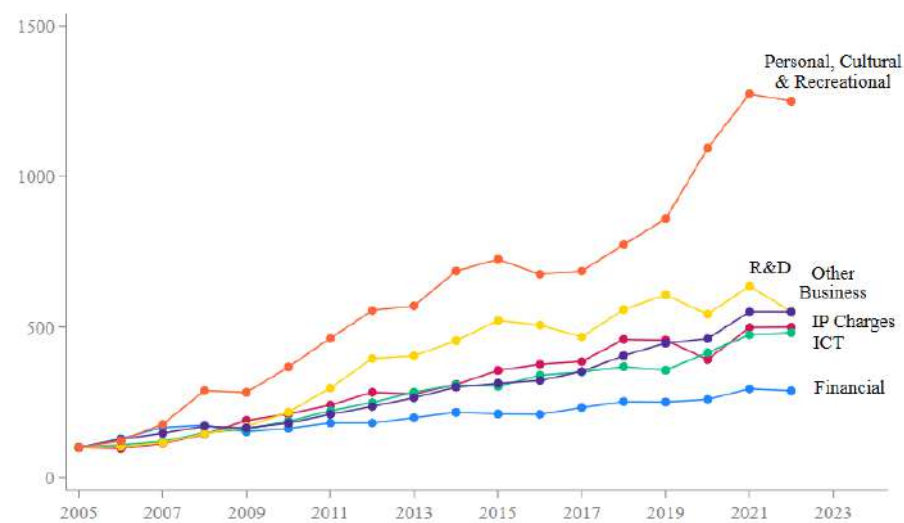
Panel B: DCCS intensive

- **Other business services**—such as legal, accounting, management consulting, advertising, market research, and engineering services had the largest p.p. increase in **Panel B** and **ICT services** in **Panel A**.

Digital exports trends

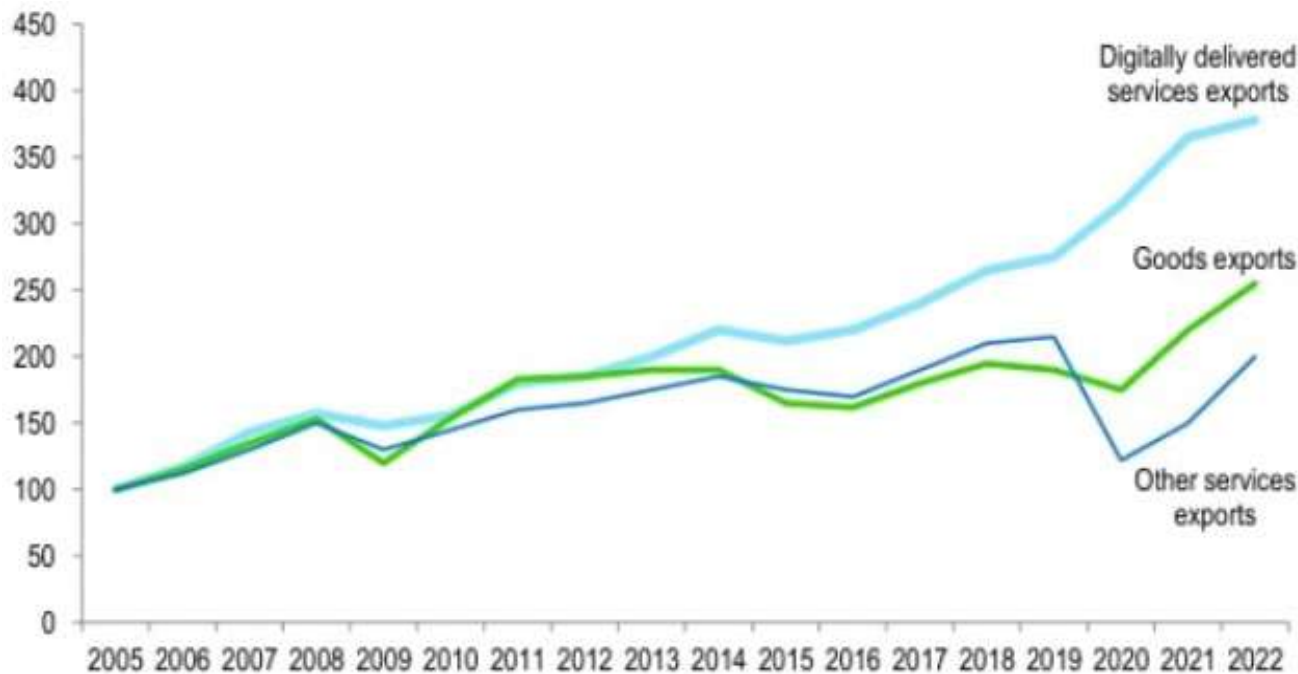


Panel A: World



Panel B: DCCS intensive

What can we learn?



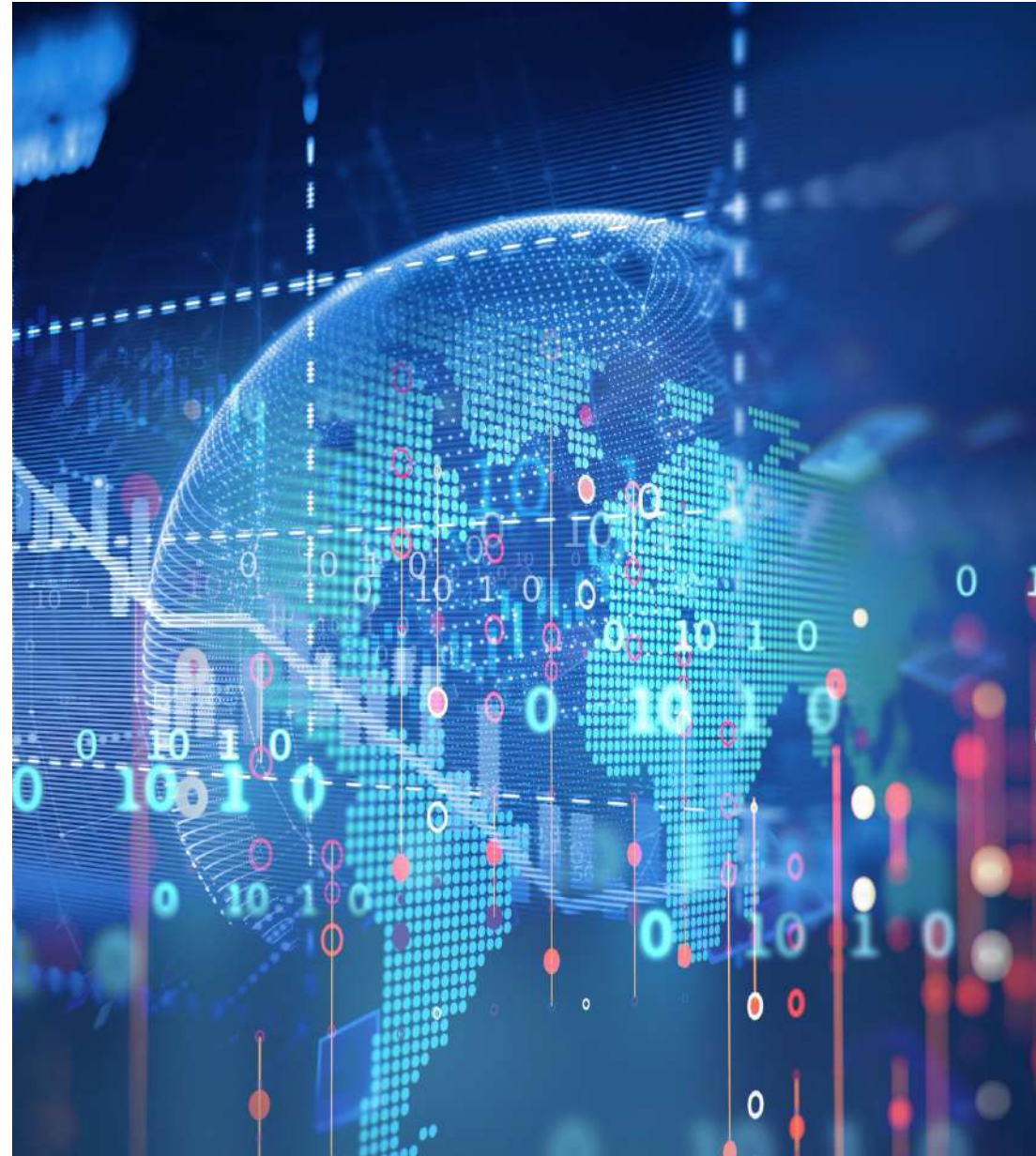
Source: *WTO and Standard Chartered Research*. Link: trdefinancglobal.com

DCCS' geography suggests:

- DCCS might be associated with **digitization**
 - This is consistent with the shares' graph where top digital exporters account for the largest DCCS shares
 - The digitization of trade could give rise to DCCS
 - The share of services in total world exports peaked at 25% in 2019, up from 19% in 1982, and stood at 23% in 2022
 - mainly due to the rise of digital services!
- Yet, the intensities' graph suggests that DCCS might be mostly associated with **taxes**.

So: Drivers of DCCS location beyond digital trade

- Regulatory Arbitrage: Seeking favorable tax regimes, data privacy laws, or environmental standards.
- Environmental Conditions: Access to cheap/cool climate, reliable energy, water for cooling.
- Specialization: Hubs for financial services, specific tech niches.



The 'Data Haven hypothesis'

- Conjecture: High DCC intensity in certain locations may be linked to regulatory arbitrage, similar to 'tax havens' or 'pollution havens'.
- Are countries attracting DCCs by offering:
 - o Lower taxes (especially on IP-related income)?
 - o Looser data protection/privacy rules?
 - o Less stringent environmental regulations (energy/water use)?
- Needs further investigation, but the correlation with tax haven status is suggestive

Does DCCS' location matter?

What if DCCS' location does not matter?

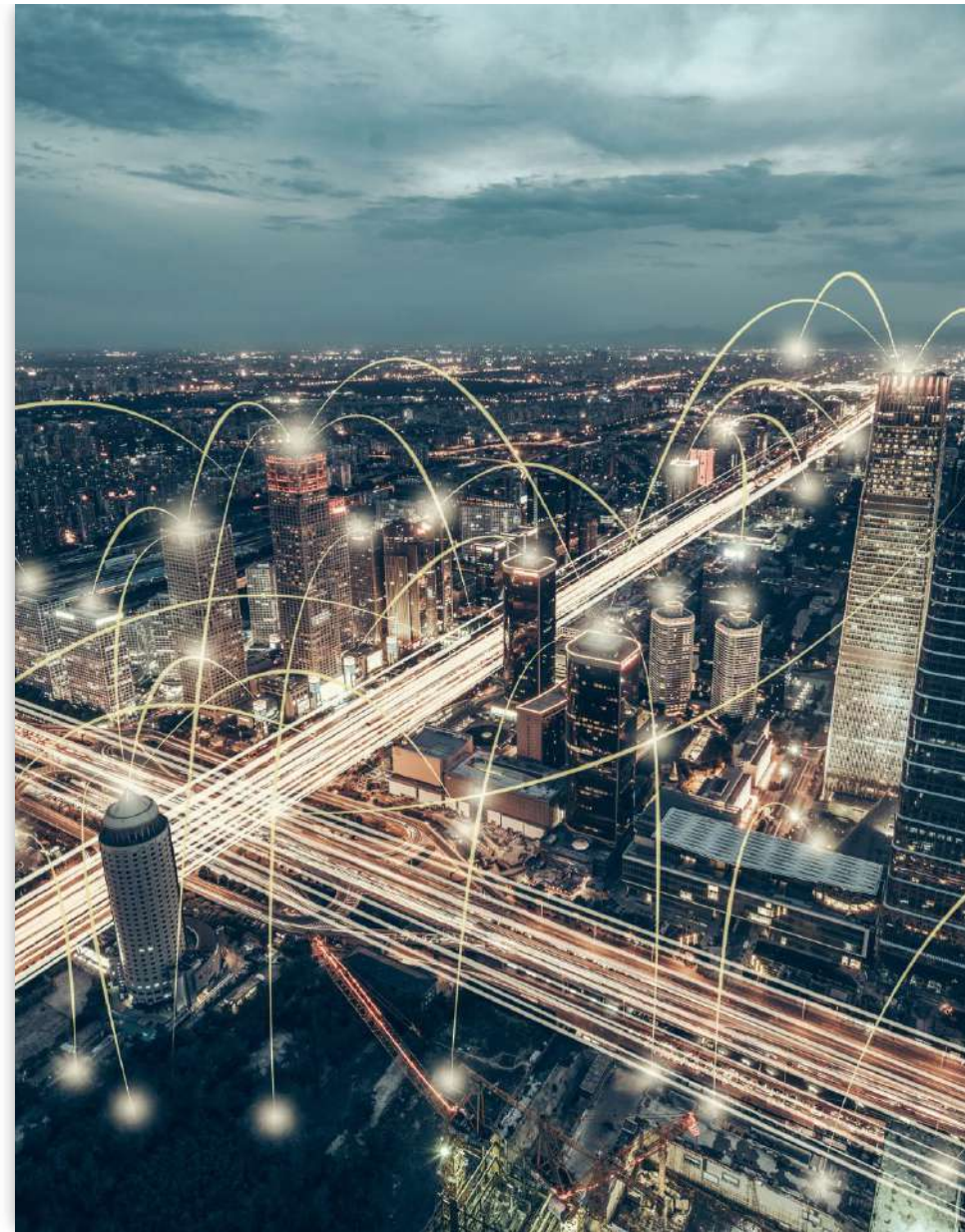
- In that case: DCCS concentration is mostly associated with taxes and has no adverse implications for businesses that do not co-locate

However:

- proximity of businesses to digital infrastructure can **increase data speed and network latency**, which are related to services' quality and costs
- This is important for both buyers and sellers for performing digital transactions
 - Example: If a US business sells its products mostly to domestic customers it would not use a European data centre, as this would mean that the transaction-generated data would need to travel from a US-based seller's device to a US-based buyer's device after first crossing the Atlantic Ocean multiple times through submarine cables
- data flow and adequacy regulations
 - Example: GDPR - transferring personal data outside the EU is possible to "adequate" countries only

A new core-periphery of digital infrastructures?

- Uneven distribution could reinforce global divides.
- Large economies benefit from network effects and economies of scale.
- Smaller / less developed nations may struggle to build competitive digital infrastructure.
- Risk: Peripheral nations become primarily locations for offshoring energy-intensive / environmentally impactful data centers serving core economies, without capturing higher value-added activities.



In sum: DCCS location determinants and implications

DCCS costs vary across countries (USCC and HW, 2014).

DCCS Location drivers:

- **Geopolitics:** Concentration (esp. ownership by US firms) creates dependencies and exposure to foreign shocks/policies (more below from Lehdonvirta et al., 2023).
- **Environment:** Data centers are resource-intensive (energy, water). Concentration in specific regions can strain local resources, especially water in stressed areas.
- **Regulatory Race-to-the-Bottom?:** Attracting DCCs via lower standards could undermine global efforts on tax fairness, privacy, and environmental protection

In sum: DCCS location determinants and implications

Implications for data privacy protection, environment, and the tax base

- data centers' cooling systems rely extensively on water (mentioned above)
- Lower taxes for attracting CDCs
- Protection for investors' privacy (Scasserra and Foronda, 2022)
- IP and other intangible capital which are part of digital services and are stored in CDCs are prone to tax evasion and avoidance (Haufler and Schindler, 2023; Alstadsæter et al., 2018).
- Foreign ownership of digital infrastructure and the geopolitical determinants (Lehdonvirta et al., 2023)

DCCS and geopolitics – main issues (Lehdonvirta et al., 2023)

- US and China dominate the global hyperscale cloud market (AWS, Azure, Google Cloud vs. Alibaba, Huawei, Tencent).

- Cloud infrastructure = Infrastructural Power: Control over data, potential for surveillance, espionage, service denial.

- Crucial for AI development and deployment.

- "Weaponization" of tech infrastructure raises stakes for third countries.

DCCS and geopolitics – foreign ownership (I) (Lehdonvirta et al., 2023)

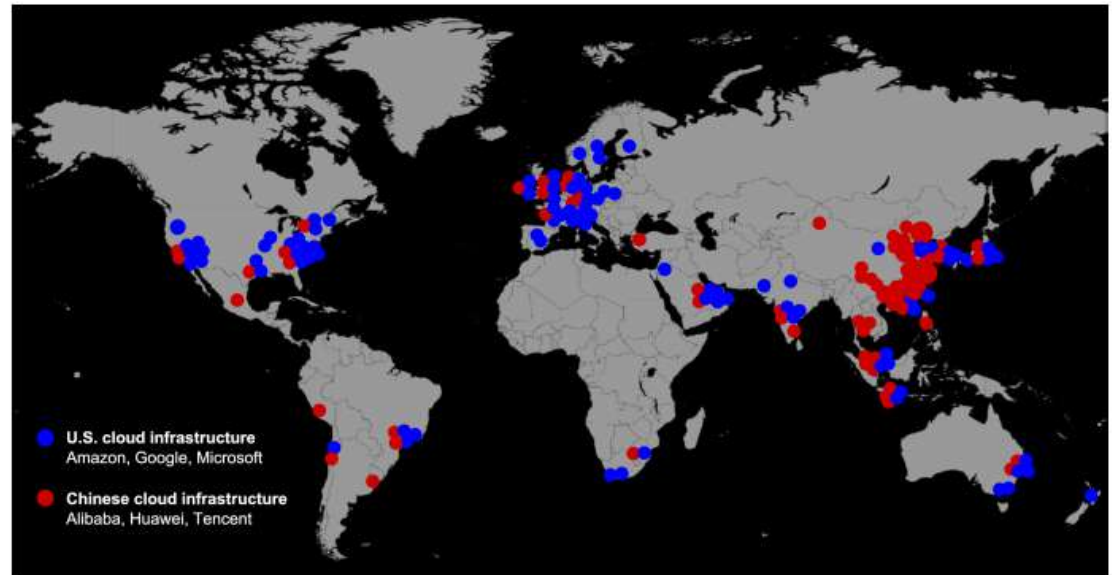


Figure 1. U.S. (blue) and Chinese (red) cloud availability zones

We identified a total of 511 AZs globally. Their approximate locations are depicted in Figure 1. Of these, 76 AZs were located in the United States, 137 AZs in mainland China, and 298 AZs in 38 third countries. Hong Kong is included in our list of third countries/regions because it is measured as a distinct entity in international trade data as well as in cloud providers' region data. Of the 298 AZs located in third countries, 204 belonged to U.S. cloud providers and 94 to Chinese cloud providers. We operationalize third country

DCCS and geopolitics – foreign ownership (I) (Lehdonvirta et al., 2023)

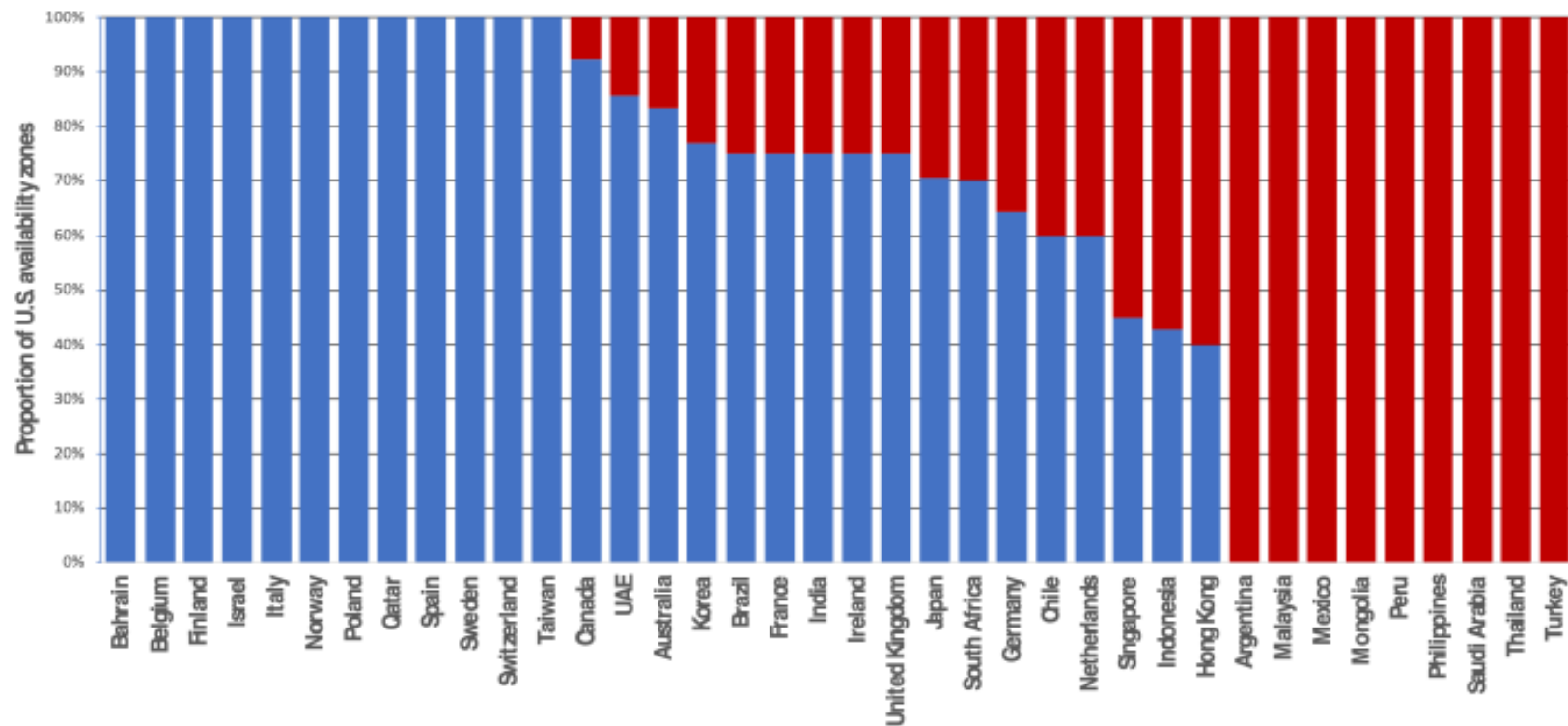


Figure 2. Proportions of U.S. (blue) and Chinese (red) availability zones by country

DCCS and geopolitics – explaining alignment (Lehdonvirta et al., 2023)

- **International (digital) Trade:**
 - DCCS is driven by scale of digital trade – as mentioned earlier
 - DCCS providers locate where demand is high and trade friction low and due to the determinants above
- Does DCCS alignments depends on (digital) balance of imports from US vs China?

DCCS and geopolitics – explaining alignment (Lehdonvirta et al., 2023)

- **Digital ‘imperialism’ and digital ‘sovereignty’**
 - Locating DCCS in different areas of influence allows to contain rivals and expand control
 - DCCS might also be part of defense-relevant infrastructures
- Does DCCS alignment correlate positively with security cooperation (alliances) and negatively with conflict?

DCCS and geopolitics – explaining alignment (Lehdonvirta et al., 2023)

- **Third countries strategic choices**

- Government spending on DCCS is based on national interests of security, among economic variables
- The use of industrial policy leverages might affect DCCS too
- Does alignment correlate positively with security cooperation and negatively with conflict?

Wrap up (I)

- Need better data: Establishment dates, size/capacity, ownership details.
- Further analysis needed on:
 - Link between DCC intensity, tax regimes, and profit shifting.
 - Environmental impacts of geographic concentration.
 - Role of international institutions in data governance.
- Policy challenge: Harness benefits of DCCs while mitigating risks (environmental, tax base erosion, geopolitical dependency).



Wrap up (II)

- **Energy:** Data center & AI energy demand is a major, growing challenge requiring efficiency, flexibility, and grid collaboration (EPRI).
- **Geopolitics:** Cloud infrastructure is a key geopolitical arena. Alignment (US vs. China) is shaped by trade (demand) and security (strategic choices, conflict avoidance) (Lehdonvirta et al.).
- **Geography:** Distribution is highly uneven. Concentration by share in large digital exporters, but concentration by intensity in smaller, specialized (tax haven?) nations, suggesting regulatory/environmental drivers (Papadakis & Savona).





AI and the nature of knowledge

Where is the value? Informational Scale or Collective Knowledge?



The Economics of Knowledge

- We know something about the role of knowledge in the economy.
- We have moved beyond **individual knowledge** to **collective knowledge** (i.e., the knowledge of groups, networks, organizations, societies, etc.)?
- But we can do better to understand how collective knowledge is evolving with **new ways of measuring/analysing this knowledge** (think of text-as-data, machine learning, dealing with high-dimensional data structures, etc.)?
- What are the **main obstacles to improve this understanding**?

The economics of knowledge: beyond intangible assets



Episteme (propositional) and Techne (prescriptive) knowledge (Mokyr, 2002, 2015)



Tacit (capability to imitate by practice) and Codified (transmittable instructions) (Polany, 1958; Cowan & Foray, 1997; Foray & Steinmueller, 2003, Steinmueller, 2020)



Knowledge “transfer”, **Technology** and Human Learning (Nelson & Nelson, 2002; Zollo & Winters, 2002)



Capabilities (Nelson & Winter, 1982), **epistemic communities and communities of practices** (Steinmueller, 2010)



Know-how is defined as a shared community-extended, cultural learning process (Nelson & Nelson, 2002)

How is know-how **acquired**?

How is it **retained in memory**?

How is it selectively **used** in given circumstances?

How is it **communicated**?

We need a shared view of what is important to understand. I propose:

Technological change and the
**changing boundaries of
codification:**

- The boundaries of knowledge transfer (**communication**) and **learning** in the era of AI and digital automation
- Knowledge has a social value. Still?

Datafication and the value of data:

- might collective knowledge (from the perspective of cognitive science and evolutionary economics) be now a fiction?
- The political economy of data value (distribution of value from personal to Big data)

Codified (**conveyed** by rational discourse and reproducible instruction) and tacit (**acquired** by imitation of practices) knowledge

Economists assume a "linear" model of communication or knowledge transfer, from a **sender** to a **receiver**

Individual and collective knowledge are conceived as simply adding more nodes to a "transfer" process towards a collective receiver

- Technology transfer has historically had a weak performance, which leads us to at least question the sender-receiver model
- or to assume that **transfer** does not necessarily imply "**learning**", due to lack of learning capabilities of the receiver(s)

The changing boundaries of codification in the era of machine learning (I) (N&N, 2002)

- *“(..) the minds of individual human actors are extended through the collective memories of the community as well as through the artifacts and symbols – especially spoken and written language – of their social world” (Nelson & Nelson, 2002)*
- Some human capabilities involve intuition, imagination and insights that are independent from receiving codified instruction, nor can be imitated in the course of a practice

Now

- **Machine learning relies on imitation processes (tacit?) based on codified information, though (so far) does not rely on a psycho-logical element of the capabilities involved to imitate**
- **Machine learning is characterized by a SCALE dimension rather than a COLLECTIVE dimension, which is the cumulation of complex sets of human know-how in the old-fashion technology transfer**

The changing boundaries of codification in the era of machine learning (II) (N&N, 2002)

- **How does classical cognitive science applies to ML?**
 - “Good old fashioned AI”: problem solving based on logics
 - Connectionist theory: recognition of complex patterns based on mental imaging
 - Donald’s learning through *mimesis* theory: this is free from structured and codified language for communication
- **ML and the underpinning datafication of economic activities have not (yet) managed to reproduce the multilayered human know how, based on collective learning, experiencing, memorizing and problem solving**
- **Informational SCALE does not necessarily imply COLLECTIVE knowledge.**

The changing boundaries of codification and tacitness in the era of AI and ML

- *“(..) the minds of individual human actors are extended through the collective memories of the community as well as through the artifacts and symbols – especially spoken and written language – of their social world” (Nelson & Nelson, 2002)*
- Some human capabilities involve intuition, imagination and insights that are independent from receiving codified instruction, nor can be imitated in the course of a practice

Now

- Machine learning relies on the **imitation** (tacit?) of masses of data (**codified information?**) , though (so far) does not rely on a **psycho-logical element of the capabilities involved to imitate**
- Machine learning is characterized by a **SCALE dimension** rather than a **COLLECTIVE dimension**, which is the cumulation of complex sets of human know-how in the **old-fashion technology transfer**

Informational Scale and collective knowledge.
Which one is which?



CHAT GPT3 defined by CHAT GPT3

before. So let me ask once more. Do you think you might be creative but not able to recognize that creativity?

As an AI language model, I don't have the capacity to experience or recognize creativity in the way that humans do. I can generate responses that may appear creative or novel to humans, but it's still based on patterns and rules derived from the data that I've been trained on, rather than a spontaneous or generative process that involves the kind of creative intuition, imagination, and personal experience that human beings possess. So, while I can generate responses that may seem creative to humans, I don't have the capacity to recognize or experience creativity myself."

Write a reply...



Robert Clowes

So essentially you forget this conversation after we have had it?

As an AI language model, I don't have the ability to remember conversations in the same way that humans do. While I can generate responses to your prompts based on the patterns and relationships identified in my training data and parameters, I don't retain any specific memory of our conversation after it's ended.

However, my training data and parameters may be updated over time based on user interactions and other sources of input. This means that my ability to generate responses may be improved based on patterns and relationships identified in our conversation and other conversations with users. But these improvements are based on changes to my training data and parameters, rather than any specific memory of our conversation.

Robert Clowes

What about during the conversation. Do you remember in some way the previous parts of the dialogue we are having now?

As an AI language model, I am able to remember the previous parts of our dialogue during the course of our conversation. When you provide a new prompt or question, I use the context of our previous conversation to generate a response that is relevant and informative based on what we've discussed so far.

However, it's important to note that my "memory" is not the same as human memory. I don't experience emotions or personal connections to our conversation, and I don't retain a detailed record of what we've discussed beyond what's necessary to generate responses in the current moment. Additionally, my memory is limited to the parameters and data that I was trained on, and my ability to generate responses is ultimately determined by the patterns and relationships identified in that data.



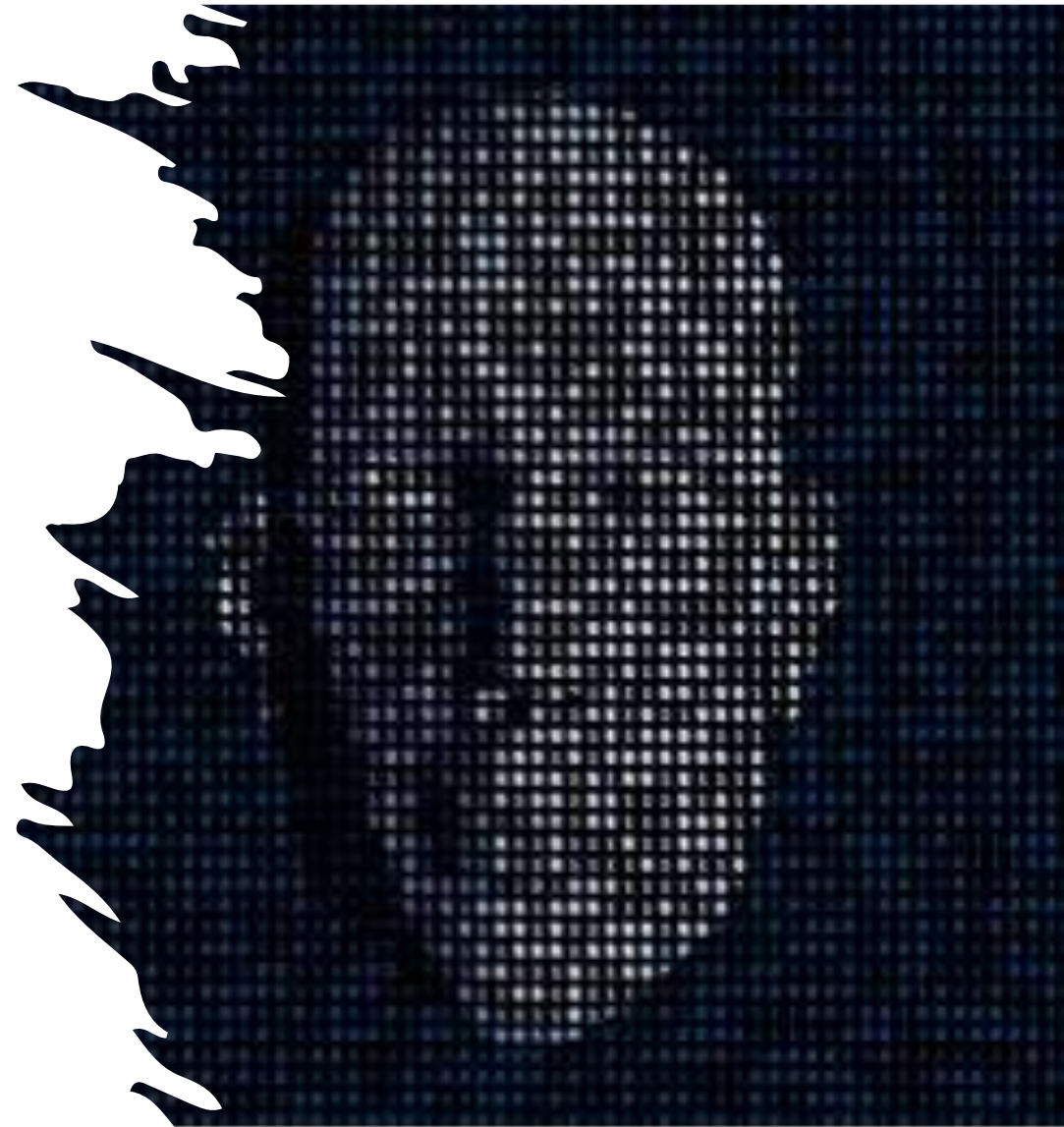
Informational Scale does not (yet) necessarily imply
Collective knowledge

AI does well on derived rather than original novelty

The end of episteme and radical breakthrough?

What is the future of original novelty and innovation in the context of AI and ML?

- The hiatus between informational scale and collective knowledge becomes larger, and shapes human-machine interaction: fragmented, unaware, extractive, platform mediated, mostly unregulated
- How do we maintain incentives to produce original novelty?
- What is left to human creativity?
- How do we protect human creativity, original novelty and collective knowledge?



e.g. The diatribe between generative AI and NYT copyright infringement

The Times Sues OpenAI and Microsoft Over A.I. Use of Copyrighted Work

Millions of articles from The New York Times were used to train chatbots that now compete with it, the lawsuit said.

Share full article



1.3K

MEDIA The Times Sues OpenAI and Microsoft Over A.I. Use of Copyrighted Work



A lawsuit by The New York Times could test the emerging legal contours of generative A.I. technologies. Sasha Maslov for The New York Times

OpenAI

Guardian staff and agencies

Tue 27 Feb 2024 20:30 CET

OpenAI responds to New York Times lawsuit, says ‘regurgitation’ of content is a ‘rare bug’

PUBLISHED MON, JAN 8 2024-3:00 PM EST | UPDATED MON, JAN 8 2024-3:46 PM EST



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KEY POINTS

- OpenAI on Monday released its statement about The New York Times’ recent lawsuit over copyright infringement.
- In December, the Times filed a lawsuit against Microsoft and OpenAI, alleging intellectual property violations related to its journalistic content appearing in ChatGPT training data.
- OpenAI wrote in a statement Monday that the startup disagreed with the Times’ lawsuit, adding, “Their lawsuit on December 27—which we learned about by reading The New York Times—came as a surprise and disappointment to us.”

TRENDING NOW



I’ve spent 25 years studying the brain never do these 4 t that destroy our m

OpenAI claims New York Times ‘hacked’ ChatGPT to build copyright lawsuit

In a filing Monday, OpenAI claims a ‘hired gun’ took ‘tens of thousands of attempts to generate the highly anomalous results’

