Deutsche Bank
Research

Artificial intelligence: in earnings calls, AI is everything, everywhere

ChatGPT hype sparks hopes and fears around AI

AI stocks surge as investors bet on growth prospects

AI & The Five Ws: Why, What, Who, When, Where?

#PositiveImpact

OpenAI Makes ChatGPT Available for Companies to Integrate in Apps

Microsoft targets Google's search dominance with AI-powered Bing

Google's Plan to Catch ChatGPT Is to Stuff AI Into Everything

AI start-ups: funding buzz passes from Web3 to artificial intelligence

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DISCLOSURES AND ANALYST CERTIFICATIONS ARE LOCATED IN APPENDIX 1. MCI (P) 051/04/2022. UNTIL 19th MARCH 2022 INCOMPLETE DISCLOSURE INFORMATION MAY HAVE BEEN DISPLAYED, PLEASE SEE APPENDIX 1 FOR FURTHER DETAILS.

Chartbook: AI & The Five Ws: Why, What, Who, When, Where?

Artificial Intelligence suddenly came to life for the general population with the release of the accessible chatbot ChatGPT three months ago, but the technology and opportunities are still a mystery to many.

Following the release of GPT-4 on March 14, an update to the technology underlying ChatGPT, we publish a new Chartbook on *Artificial Intelligence* and address the five Ws: Why, What, Who, When, and Where.

Part 1 – What is artificial intelligence is. We take a look at "what" and "why" of artificial intelligence: its genesis, the different types of AI and the skills someone needs to work in the field.

Part 2 – Today's artificial intelligence landscape. We take a look at today's artificial intelligence landscape, including the rapid growth of its capabilities and investment into the field.

Part 3 – What the opportunities for corporates are. We show how corporates are becoming increasingly interested in the development of artificial intelligence, and how smaller corporates may be swept up in an upspring of innovation after OpenAI released its API.

Part 4 – Capabilities: Where we are today and where we are moving to. We illustrate how artificial intelligence has become faster, more affordable, but has placed increasing demands on technological capabilities. We examine the sustainability of artificial intelligence technology, before analysing the nature of regulation on the sector.

…All in an easy-to-read PowerPoint format.

Open AI's ChatGPT and GPT-4: A quick overview

What are ChatGPT and GPT-4?

- ChatGPT is a chat interface built by OpenAI that allows the public to interact with its AI model, GPT-3.5. It was released on Nov. 30, 2022.
- GPT-4 is OpenAI's latest AI model, released on March 14, 2023, and the update to GPT-3.5.
    - It is available on subscribers to ChatGPT Plus and as an Application Programming Interface (API) for developers to build applications and services.
- The models are "trained" using huge volumes of data and generate text and code based on the relative probability of what should come next

What is the difference between the two models?

- GPT-4 is multi-modal, using deep learning to digest not just text but also images, and to respond with text. That includes suggesting a recipe from a photo of ingredients and correctly interpreting the humour in a photo of a phone with an old-fashioned plug.
- It outperforms ChatGPT on creative and reasoning metrics, according to OpenAI.
    - It is 82% less likely to respond to requests for disallowed content and 40% more likely to produce factual responses. It can take in and generate around 25,000 words of text, around eight times more than ChatGPT.
    - GPT-4 scores above ChatGPT in common tests, reaching the 90th percentile in the Uniform Bar Exam, compared with the 10th.

Where do they fit into the market?

- After the launch of ChatGPT, Microsoft stepped up its financial and computing power support for OpenAI. A wave of other AI model announcements is taking place, with Google saying earlier on March 14 it will open new generative AI tools to some clients and Google-backed Anthropic launching its Claude chatbot. Microsoft is expected to give details on how it will roll out AI features for Office software later in the week.

Capabilities of Large Language Models

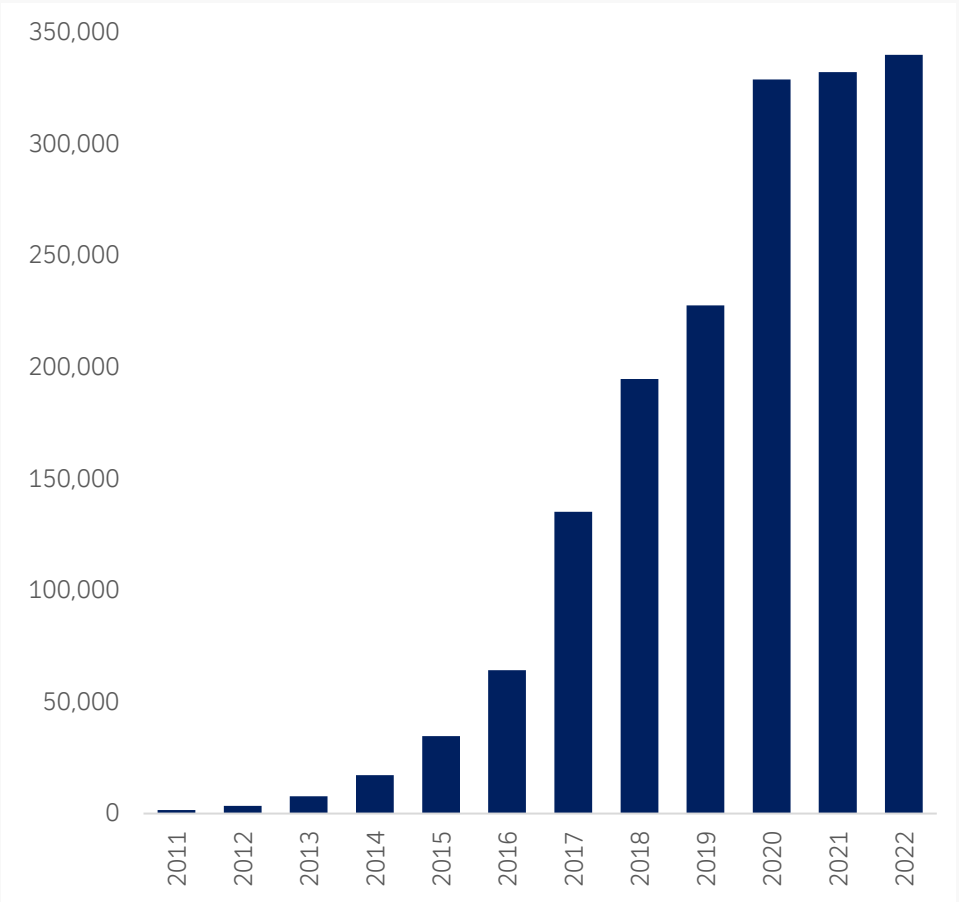
- Retrieve and format information
- Classify sentiment, common topics and indicators of risk from data
- Engage in Q&A
- Analyse and summarise text
- Translate text
- Generate text, computer code, images, music etc

Limitations

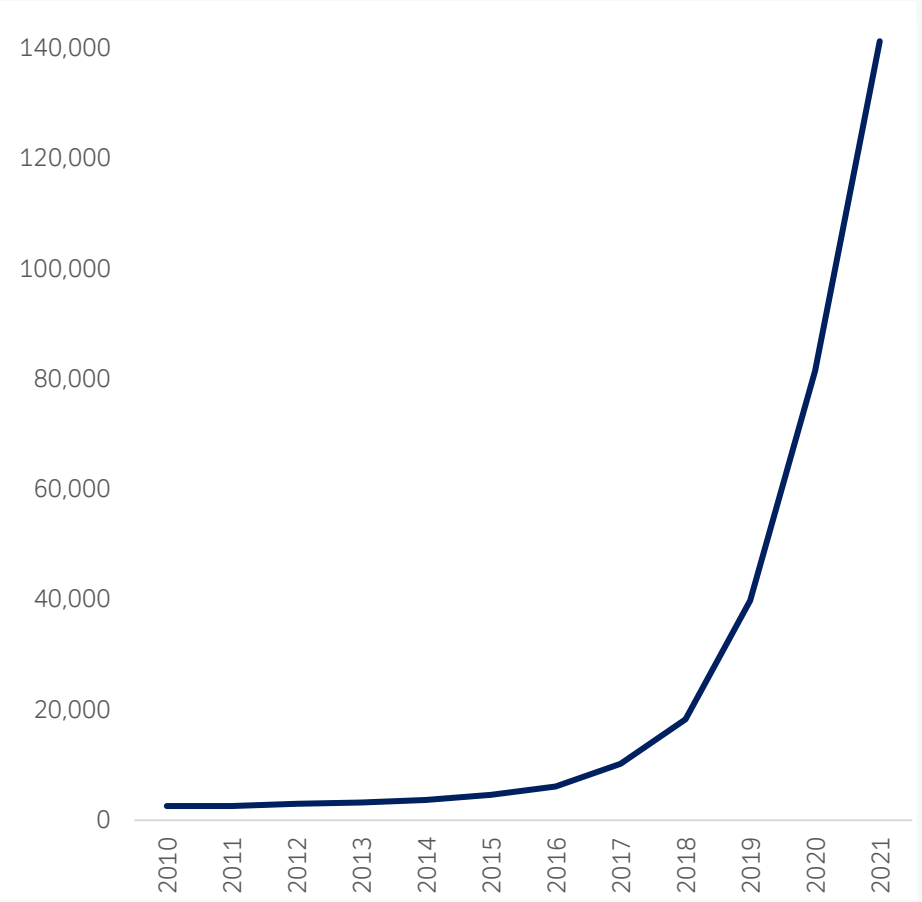
- Social biases, based on the data they "learn" from
- "Hallucinations" in the form of invented facts
- Data limitations, eg ChatGPT/GPT-4 data set largely stops in 2021

INTEREST: The number of AI public projects and annual patent fillings has exploded since 2015

Number of public AI projects



Annual number of patent filings for AI technologies

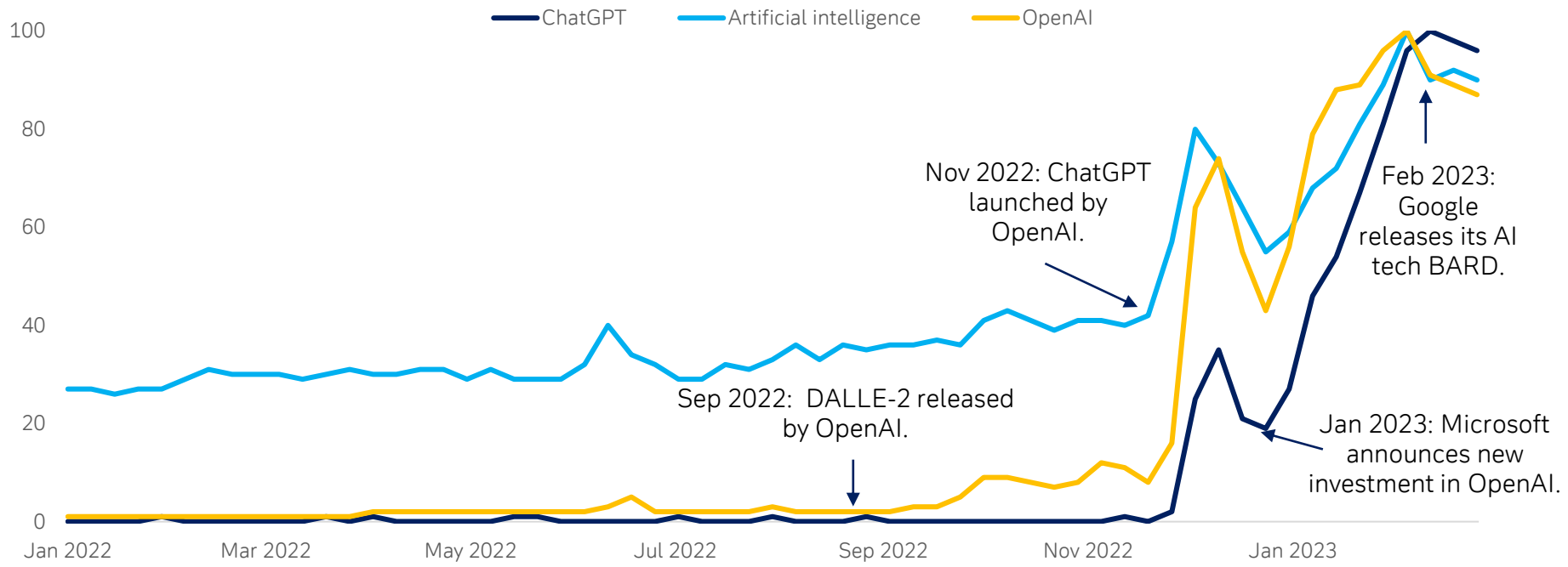


Source: Deutsche Bank, OECD.AI.

INTEREST: People have recently increased searches on these topics

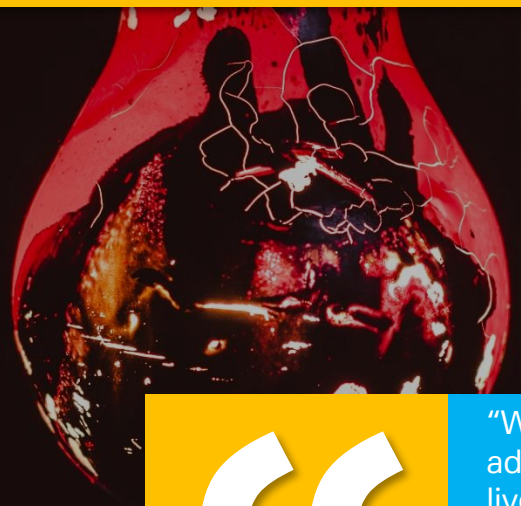
– Google searches for “artificial intelligence” skyrocketed in November 2022, following the release of OpenAI’s ChatGPT.

Google trends, worldwide web searches



Source: Deutsche Bank, Google Trends. Updated 8 March 2023.

1. What is AI

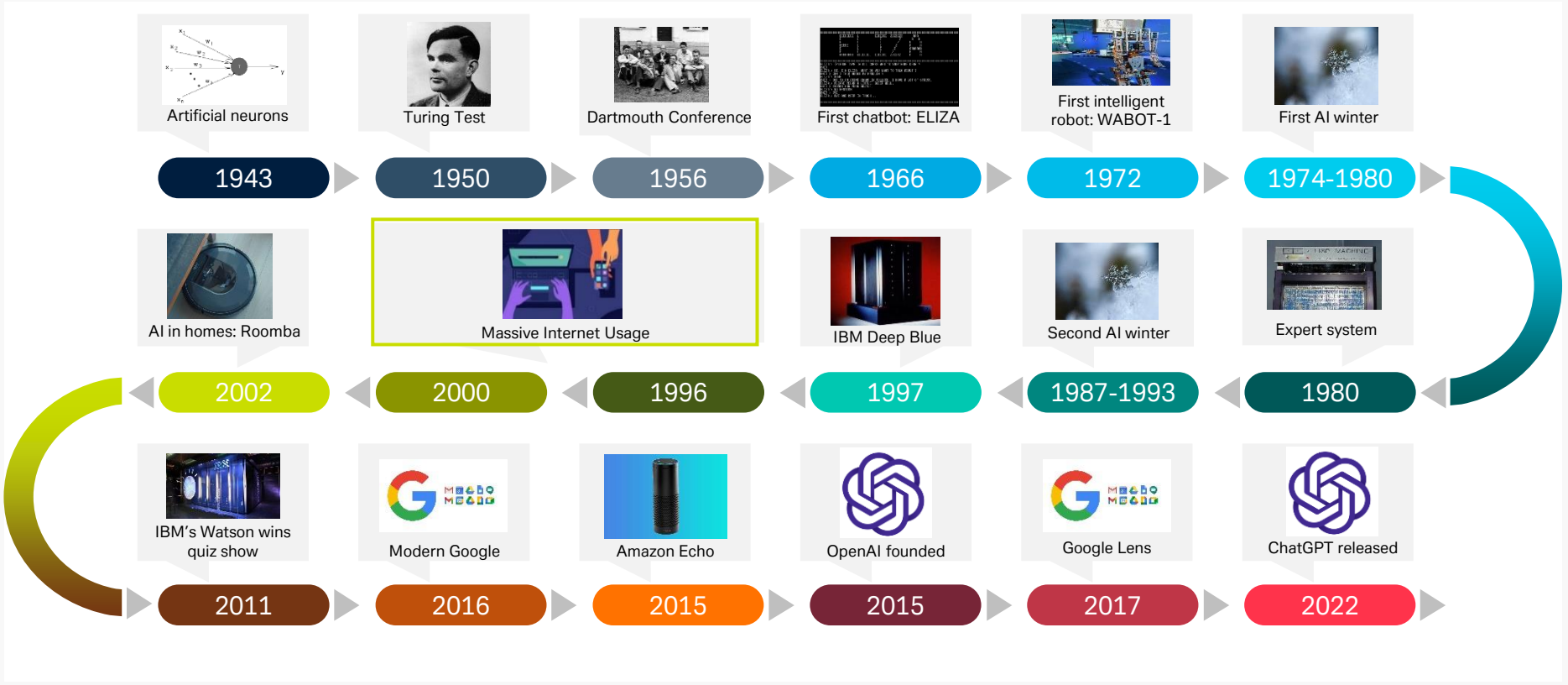


"We're at the beginning of a golden age of AI. Recent advancements have already led to inventions that previously lived in the realm of science fiction — and we've only scratched the surface of what's possible."

- Jeff Bezos, founder of Amazon

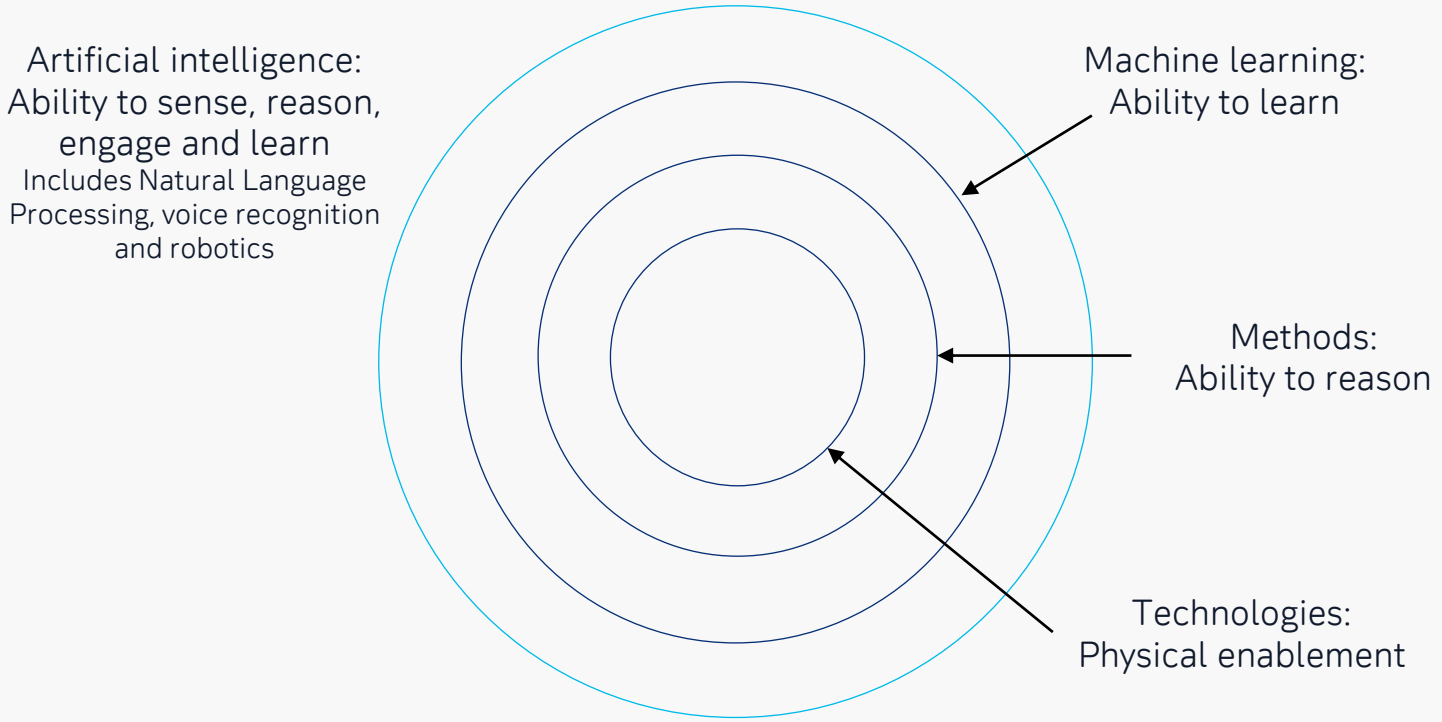
HISTORY: The genesis of artificial intelligence

- The concept of artificially intelligent beings and machines has been around since the 19th century, with Mary Shelley's 1818 *Frankenstein,* Samuel Butler's 1972 *Erewhon* and the Maschinenmensch in Fritz Lang's *Metropolis* in the early 20th century.
- AI in the field of science came to life with Alan Turing's 1950 paper on Computing Machinery and Intelligence, solidifying its place in the history of science with the 1956 Dartmouth Conference, where the term 'artificial intelligence' was coined.



AI DEFINITION: Computer systems that can perform tasks that require advanced, often human-like, intelligence

- OECD definition: 'machine-based system that can, for a given set of human-defined objectives, make predictions, recommendations or decisions influencing real or virtual environments'.
- AI located and accessed in several ways: (i) centrally in data centres; (ii) centrally in the cloud; (iii) decentralised devices.



Source: Deutsche Bank, Deloitte.

4 TYPES OF AI based on memory; social and emotional intelligence; self-aware; big picture vs. task specific

	Reactive AI	Limited memory	Theory of mind	Self-awareness
Description	No memory and are task specific, with no learning capabilities. They produce output based on the input they receive.	Have memory capabilities, so they can use past experiences and previous input to inform future decisions and to make better predictions.	The system would have the social intelligence to understand emotions. This type of AI would be able to infer human intentions and predict behaviour, a necessary skill for AI systems to become integral members of human teams.	AI systems that possess a sense of self, which gives them consciousness. Machines with self-awareness understand their own current state in a way similar to how the human brain functions.
Examples	Deep Blue, the IBM chess program that beat Garry Kasparov in the 1990s. Deep Blue can identify pieces on the chessboard and make predictions but, because it has no memory, it cannot use past experiences to inform future ones.	Some of the decision-making functions in self-driving cars are designed this way.	Self-driving cars may in future have the capability to infer and react to changing emotions of their human occupants, as well as drivers and pedestrians around them.	This type of AI does not yet exist, but there have been cases of semi-sentient robots, for example, in 2020 at Columbia University a robot arm was able to build a model of its own body without prior knowledge.

Source: Deutsche Bank, OECD, OECD Legal Instruments.

AI SKILLS

AI Skill	Description	Use-cases
Machine learning	Where algorithms use historical data as input to predict new output values without being explicitly programmed to do so.	Recommendation engines; business process automation
Deep learning	A subset of machine learning, where a neural network attempts to simulate human knowledge acquisition by processing large amounts of data.	Automated driving; detecting cancer cells; automated hearing and speech translation
Data structures	Specialised format through which to store, organize, process and retrieve data in memory.	For other types of AI innovation; implement computer programs
Pandas	An open-source Python package used for data analysis and machine learning tasks.	For other types of AI innovation; computer programming
Computer vision	Extraction of meaningful information from digital images by computers trained to understand and interpret visual input.	Automated driving; analysing x-rays; smart stores; road traffic analysis
TensorFlow	A free, open-source software library developed by Google for machine learning and AI.	For other types of AI innovation; computer programming; Facebook's image recognition system; Apple's Siri
Natural language processing	Programming computers to understand and respond to text or voice data, including to writer's intent and sentiment.	Request for information; translation; autocorrect; automatic text summarising; chatbot
Scikit-Learn	A free, open-source machine learning library for Python.	For other types of AI innovation; computer programming
PyTorch	A free, open-source machine learning framework based on the Torch library, part of the Linux Foundation umbrella.	For other types of AI innovation; computer programming
Neural networks	Artificial neural networks mimic the human brain as programmed by a set of algorithms. Three neural networks makes a deep learning algorithm.	Deep learning; marketing; search engine functionality

Source: Deutsche Bank, IBM, OECD.AI. Note: Skills are the 10 most prevalent AI skills among LinkedIn members worldwide, 2015-2022, as identified by the OECD.AI. Similar/repetitive skills have been removed for succinctness.

> "I believe there is no deep difference between what can be achieved by a biological brain and what can be achieved by a computer. It therefore follows that computers can, in theory, emulate human intelligence — and exceed it."
>
> - Prof. Stephen Hawking, theoretical physicist

2. Today's AI landscape

CAPABILITIES: Today's top AI areas to watch

Machine learning

- Machine learning involves building algorithms that learn from experience without being explicitly programmed to do so.
- Publications in machine learning have more than doubled from 2015 to 2021
- Artificial intelligence / machine learning is the most popular speciality in US computer science PhDs, accounting for 21% of total graduates in 2020.

Deep learning

- A subset of machine learning, where a neural network attempts to simulate human knowledge acquisition.
- Deep learning can make machine learning algorithms more efficient by eliminating some data pre-processing as deep learning algorithms are able to process unstructured data
- Examples include virtual assistants like Amazon's Alexa or Apple's Siri, chatbots, as well as medical purposes. At UCLA, deep learning helped researchers detect cancer cells in blood.

Generative AI

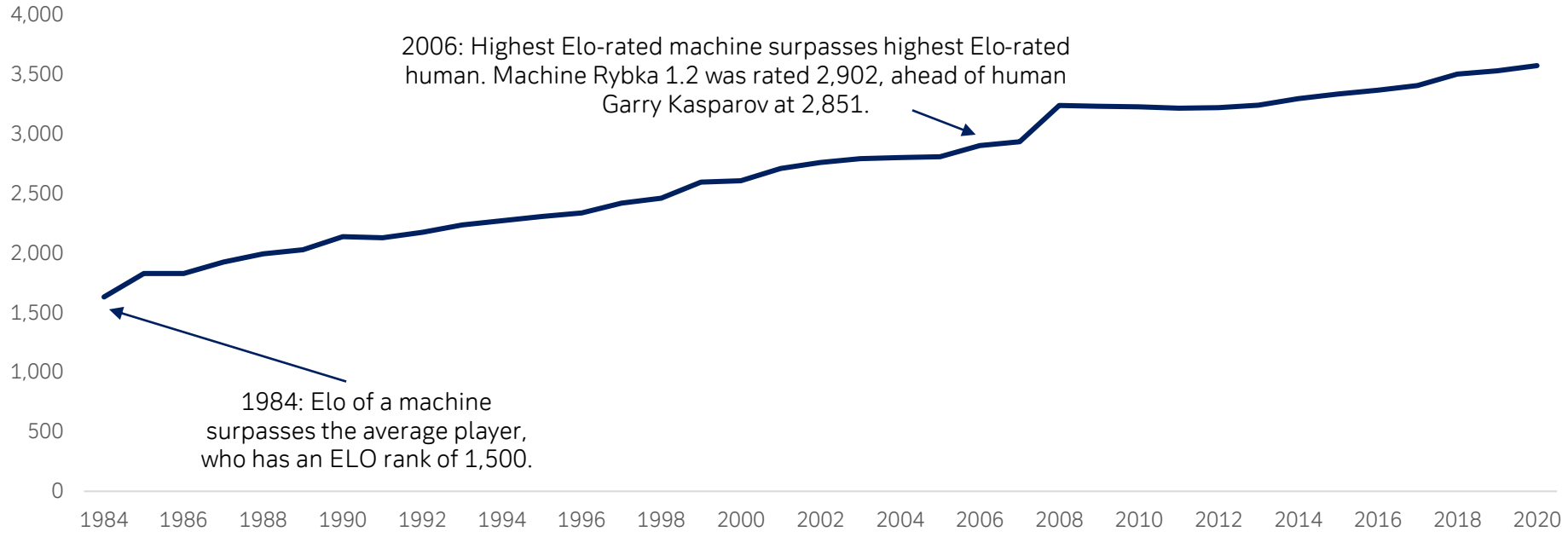
- Algorithms that generate new outputs like images, text, audio, based on the data they have been trained on and uses a type of deep learning called generative adversarial networks.
- Generative AI has been a buzzword following the boom in popularity of ChatGPT and DALLE-2. Other examples include MidJourney and Codex.
- Generative AI has seen significant adoption in US by the marketing and advertising industry (37%) and technology (35%).

Sources: Deutsche Bank, World Economic Forum, OECD.AI, Statista, Our World in Data, IBM.

CAPABILITIES: Machines are edging closer and closer to superhuman capabilities

- Machines have far surpassed even the greatest human chess champions, beating the highest Elo-rated human in 2006, and have since continued to improve to superhuman levels.
- AI has not yet mastered complex language tasks, but the difference is closing fast, with humans performing only 1 percentage point better in abductive natural language inference in 2019.

ELO rankings of best machine in chess (1984-2020)

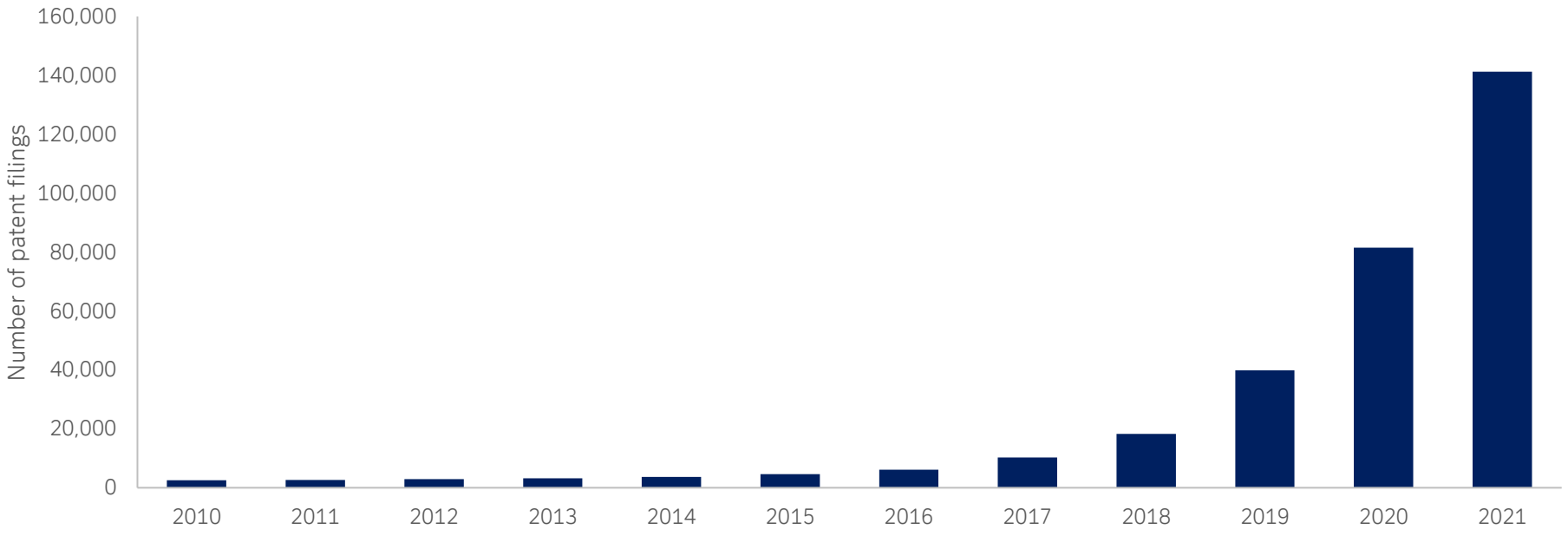


Source: Deutsche Bank, Swedish Chess Computer Association. Note: The Elo rating system is a method for calculating the relative skill levels of players in games such as chess.

GROWTH: The number of global patent filings for AI technologies has grown over 50-fold since 2010

- Since AI emerged in the 1950s, over 340,000 AI-related invention applications have been filed.
- But patents and inventions have accelerated in the last decade, rising from 2,560 patents in 2010 to over 140,000 in 2021.
- The ratio of scientific papers to inventions has also decreased, from 8:1 to under 3:1 from 2016 onwards, indicating a new interest in creating commercial products rather than developing theoretical research.

Annual number of patents filed for AI technologies

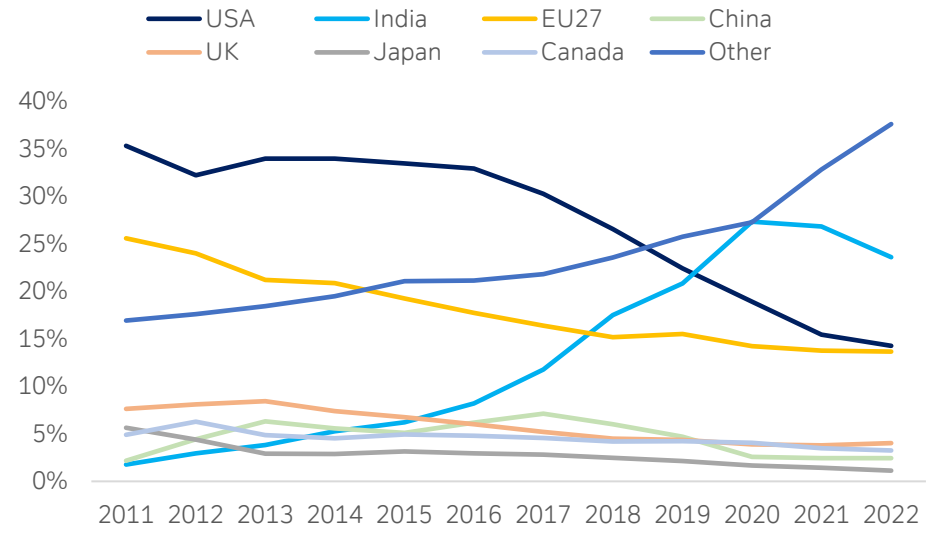


Source: Deutsche Bank, Our World in Data, WIPO.

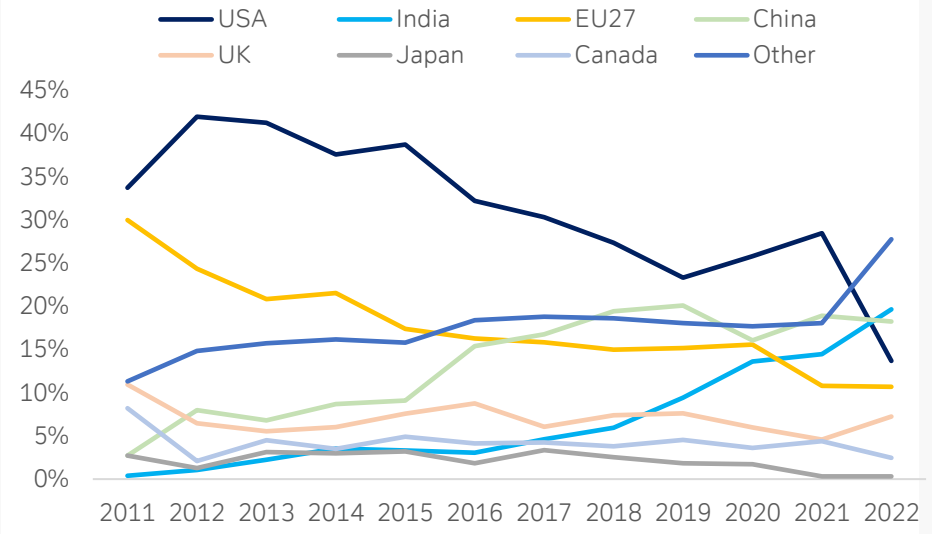
GROWTH: China and India have seen significant advances in their artificial intelligence capabilities

- The US has historically led in AI research and software development, but has been losing ground as China and India have rapidly advanced their research capabilities.
- China has now closed the gap with the US in terms of contributions to very high impact public AI projects, producing 18% of all high impact contributions, vs 14% for the US. India now leads high impact contributions, producing 20% of the total.
- China has improved its AI capabilities by become a world leader in AI publications, the quality of its AI research, its increases in R&D spending in software and computing, and its development of supercomputers. China now possess 162 of the fastest supercomputers, and the US has 127, as ranked by Top500.

Contributions to all public AI projects



Contributions to very high impact public AI projects*

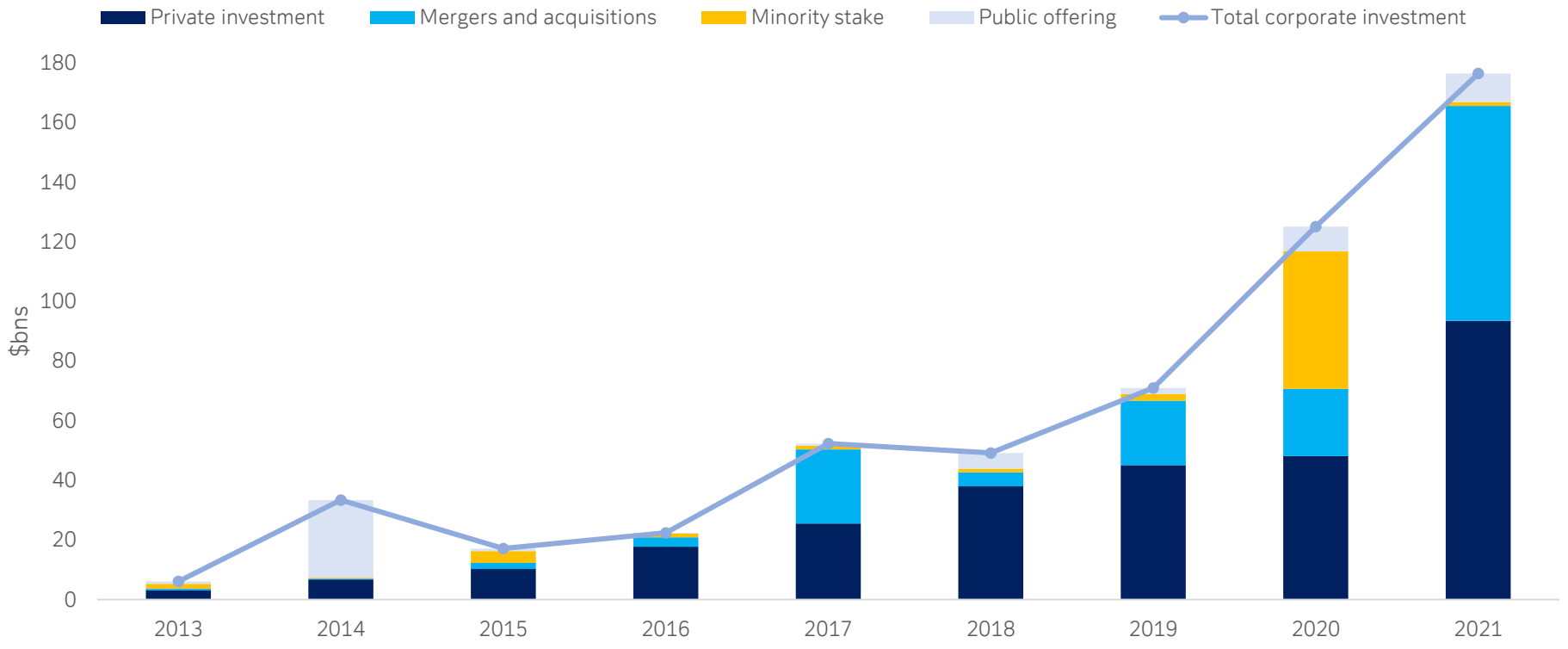


Source: Deutsche Bank, OECD.AI, Top500. *Very high impact are contributions with over 100 forks. Note: this chart shows the share of contributions (i.e., "commits") made to AI projects (i.e. AI-related GitHub "repositories") by country and over time. AI project impact is given by the number of managed copies (i.e., "forks") made of that project.

GROWTH: And investment on the ground has been booming, driven by private investment and mergers and acquisitions

- There is a global investment boom into AI, with total global corporate investment into AI up 150% since 2019, and nearly 30-fold since 2013.

Annual global corporate investment into artificial intelligence by category ($bn)

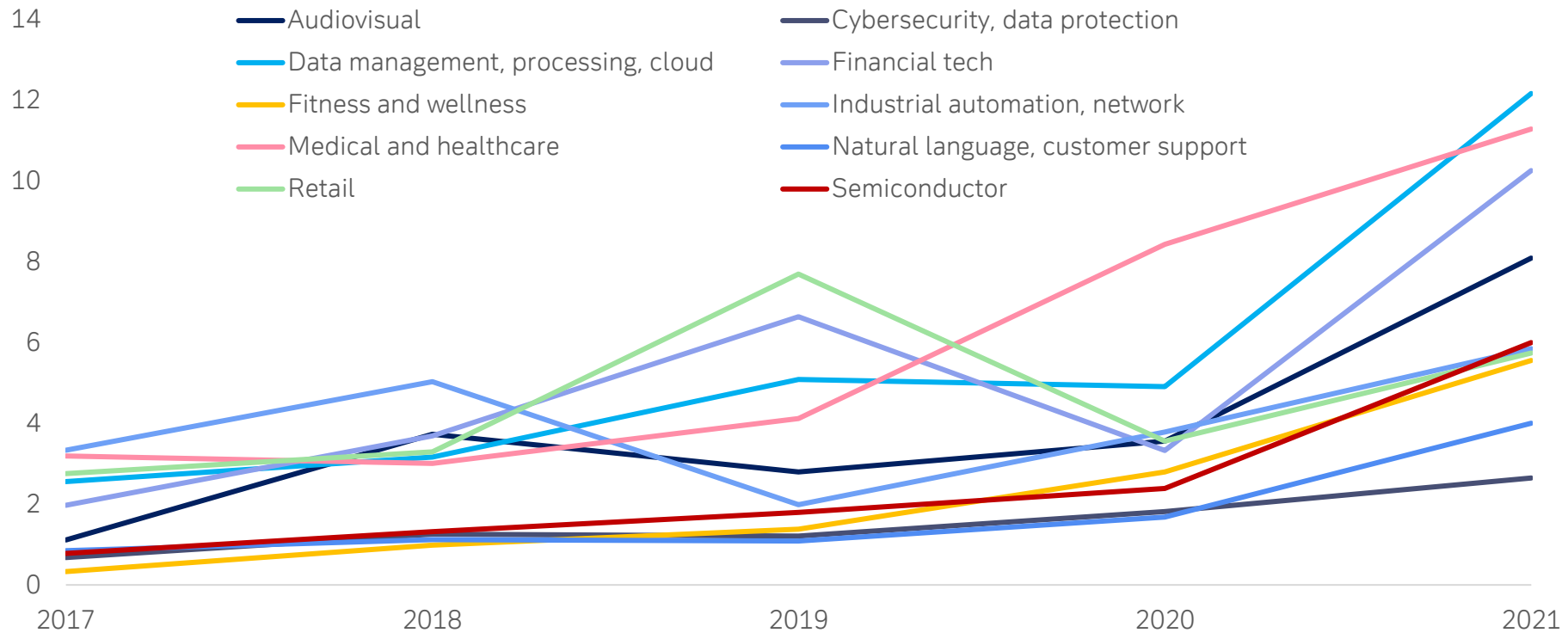


Source: Deutsche Bank, Our World in Data. Note: Data for chart is expressed in constant 2021 US$. Inflation adjustment is based on the US CPI.

GROWTH: Private investment has surged, focused on (i) data management, processing, cloud; and (ii) medical and healthcare

- This includes companies that received over $1.5m in investment.

Annual global private investment in artificial intelligence, by focus area ($bn)

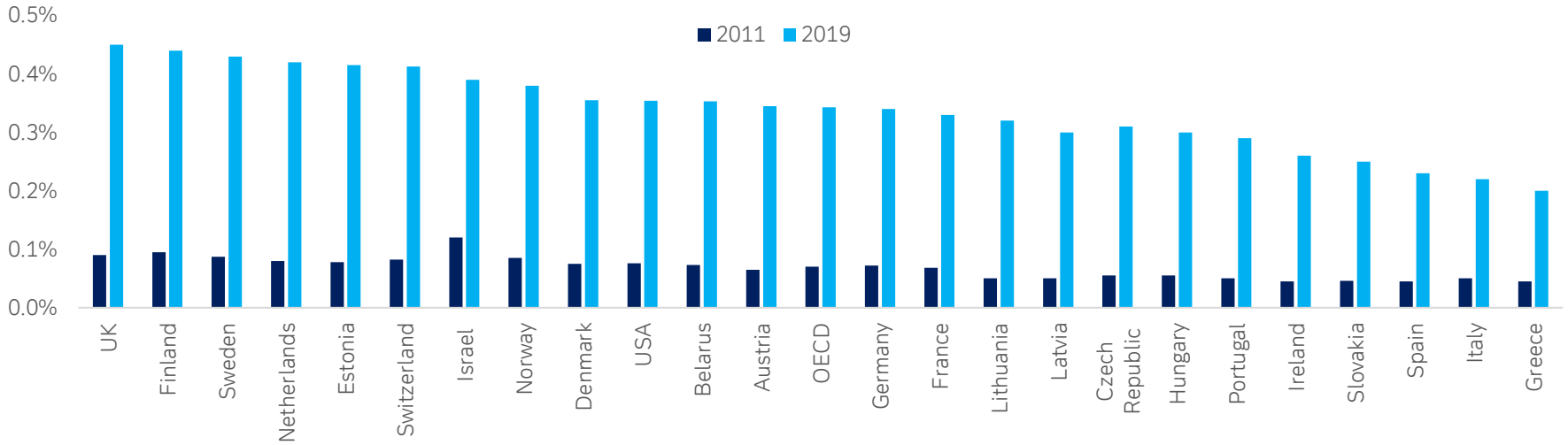


Source: Deutsche Bank, Our World in Data. Note: Data for chart is expressed in constant 2021 US$. Inflation adjustment is based on the US CPI.

LABOUR MARKET: Growth of the AI workforce was 63% from 2017 to 2019 in OECD countries, vs 3% for workers overall

- Across OECD countries, the average share of AI employment is just above 0.3%, ranging from 0.5% in the UK to 0.2% in Greece.
- The AI workforce has grown rapidly from less than 0.1% in 2011 to above 0.3% in 2019 – due to increasing demand for AI skills within occupations, rather than to the growth in occupations demanding AI skills. In other words, across almost all occupations, firms are demanding more workers with AI skills.
- The occupations with the highest share of vacancies demanding AI skills are technical ones: mathematicians, actuaries and statisticians (.52% demanding AI skill); software and application developers (4.9%); information and communication technology managers (4.3%); database and network professionals (3.6%) and electrotechnology engineers (3.2%).

The share of total employment that possesses 'AI skills'



Source: Deutsche Bank, OECD. Note: AI skills are those defined by Alekseeva (2021). Chart comes from OECD analysis of European Labour Force Survey (EU-LFS) for European countries, the Current Population Survey (CPS) for the US, and Lightcast data.

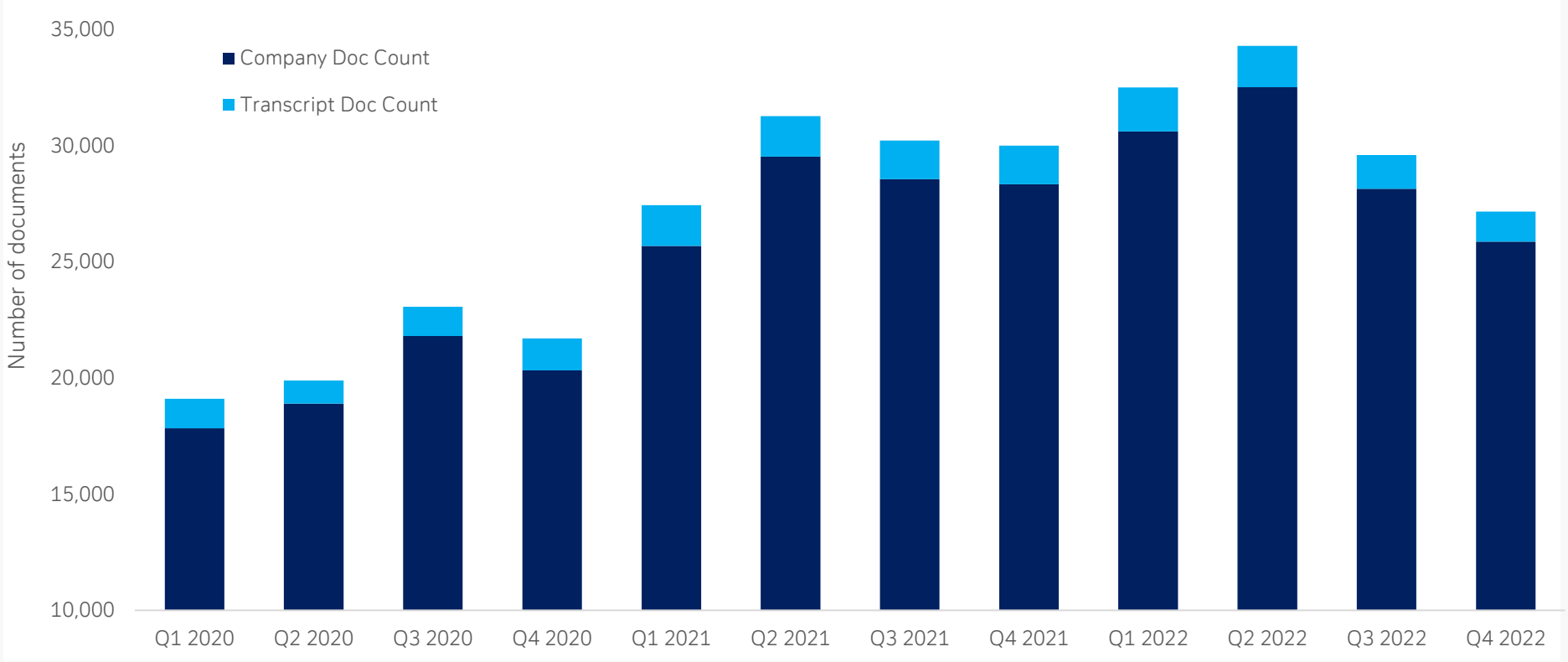
3. What the opportunities are for corporates/banks

> "It's very clear that AI is going to impact every industry. I think that every nation needs to make sure that AI is a part of their national strategy. Every country will be impacted."
>
> -Jensen Huang, CEO of NVIDIA

INNOVATION: Mentions of artificial intelligence in corporate documents surged by nearly 50% from 2020 to 2022

- AI has increasingly become a buzzword for corporates, with companies suggesting AI is being used in a range of sectors, from distribution to medicine.

Number of corporate documents mentioning “artificial intelligence"



Source: Deutsche Bank, AlphaSense.

BUILDING AI: Who? How much?

- The release of ChatGPT last November and Microsoft's $10 billion investment into OpenAI in January have reinvigorated artificial intelligence investments. Recent investments have been made by Google, Salesforce and SK Networks.

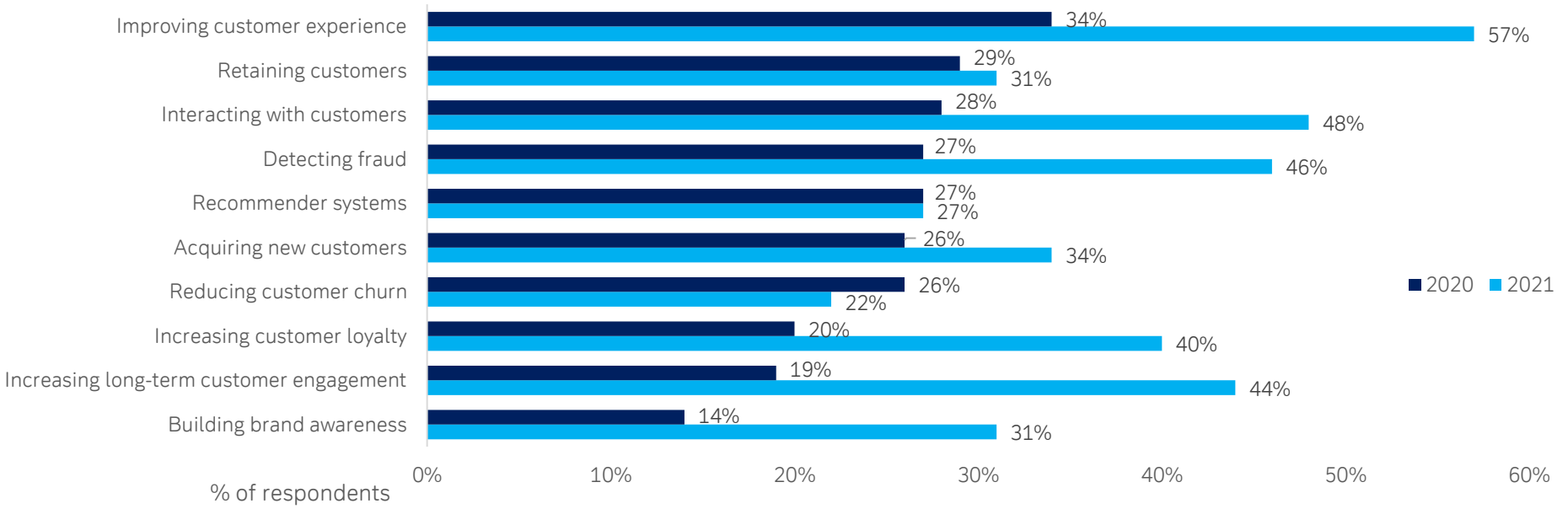
Date	Value	Company	Description
March 2023	$22 million	SK Networks	South Korean firm SK Networks invested $22 million into Humane, an AI powered and software platform, in its Series C funding round. Humane looks to develop the next era of personal mobile computing powered by AI.
March 2023	$25 million	Salesforce Inc	Salesforce Inc's VC capital arm is launching a $250 million fund in generative AI startups.
Feb 2023	$300 million	Google and Anthropic	Google purchased AI startup Anthropic, a generative AI company. Anthropic has developed a rival chatbot called Claude, officially launched on March 14.
Jan 2023	$10 billion	Microsoft and OpenAI	Microsoft has committed investing $10 billion into OpenAI over multiple years. This follows from its $1bn investment in 2019 and in 2021.
2022	$2 billion	IBM	IBM acquired eight companies for $2 billion in 2022, with 30 companies acquired in total since April 2020, to develop its hybrid cloud and artificial intelligence capabilities, including StepZen Inc in Feb 2023. It also invested $2 billion in an AI campus in 2019.

Source: Deutsche Bank, IBM, The Financial Times, Bloomberg Finance LP, PR Newswire.

OPPORTUNITIES in artificial intelligence for corporates

- Use-cases for AI and machine learning are applicable for a broad portfolio of firms, typically used to create efficiencies in existing infrastructure as well as improving customer experience.
- AI and machine learning have seen significant adoption for improving customer experience and interaction, as well as fraud detection.
- In the era of big data, the aggregation and analysis of large swathes of data will become increasingly processed by computers and AI.
    - Even unstructured data can now be processed by deep learning algorithms, and transmute it into something digestible for other machine learning algorithms, as well as for human audiences.

AI and machine learning use-cases for companies worldwide

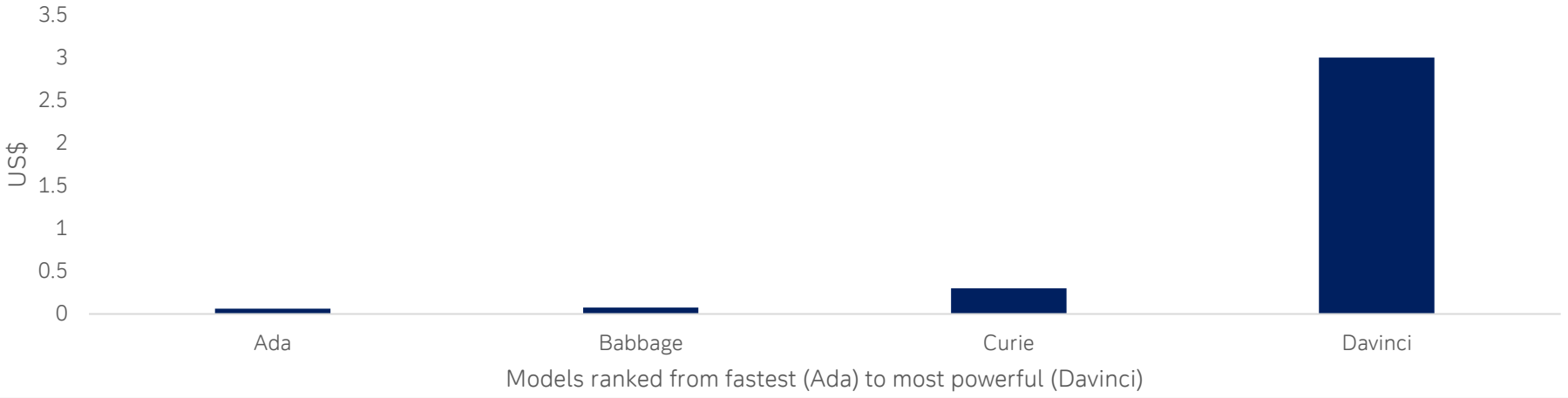


Sources: Deutsche Bank, Statista

OPPORTUNITIES: For smaller corporates, the release of OpenAI's APIs will likely lead to a surge in innovation

- OpenAI's API was released in March including the API to ChatGPT-3.5 and DALL-E. The API to ChatGPT-4 is also now available.
  - For the 32k context model, it costs $0.06/1k tokens, and $0.12/1k tokens for completion, where 1,000 tokens is about 750 words.
- Adding AI capabilities to applications is now more accessible and affordable. Companies may emerge that focus on fine-tuning existing models rather than developing from the ground up. They are underpinned by technologies such as GitHub Copilot and Codex.
- ChatGPT has now changed its data retention policy, only holding users' data for 30 days, and will not use input to train models, reducing risks associated with trusting data to third-parties.
- With the release of the official API, companies can charge for use of their products, and licensing is no longer a grey area.
  - Snapchat, Quizlet, Instacart and Shopify have all begun integrating the API. .

Cost for InstructGPT to process 120,000 words, as much as a typical adult fiction book contains*



Source: Deutsche Bank, OpenAI, Bloomberg Finance LP. *InstructGPT is a model optimised to follow single-turn instructions. Note: Calculations are based on the assumption that one OpenAI token buys approximately 0.75 words.

RISKS: Technology is far from perfect – assistive but not a substitute

- Accuracy: Risk both as creator and consumer of AI generated content – plausible text slipping into real submissions, unchecked and unverified (with no references), and maybe inappropriate for high-stake tasks.
  - AI decisions can be inscrutable and opaque; as they process more data, it becomes more challenging to document its details.
  - Meta launched Galactica, a science specific text generator, but was withdrawn three days later after producing fallacious and even dangerous information.
- Bias: Larger language models are more capable of reflecting bias from their training data, and with greater capabilities, greater potential severity.
  - A 280 billion parameter model developed in 2021 shows a 29% increase in elicited toxicity over a 2018 117 million parameter model.
- Cyclical industry with trend-chasers:
  - Global VC investment into AI has fallen as recessionary forces build, from over $200 billion to $120 billion.
  - Need to separate 'hype' vs meaningful value-add.

Creative AI Is Generating Some Messy Problems

Stack Overflow temporarily bans answers from OpenAI's ChatGPT chatbot

Why Meta's latest large language model survived only three days online

Generative AI is sowing the seeds of doubt in serious science

Disinformation Researchers Raise Alarms About A.I. Chatbots

The Next Cybersecurity Crisis: Poisoned AI

Source: Deutsche Bank Research, OECD.AI, The AI Index Report 2022.

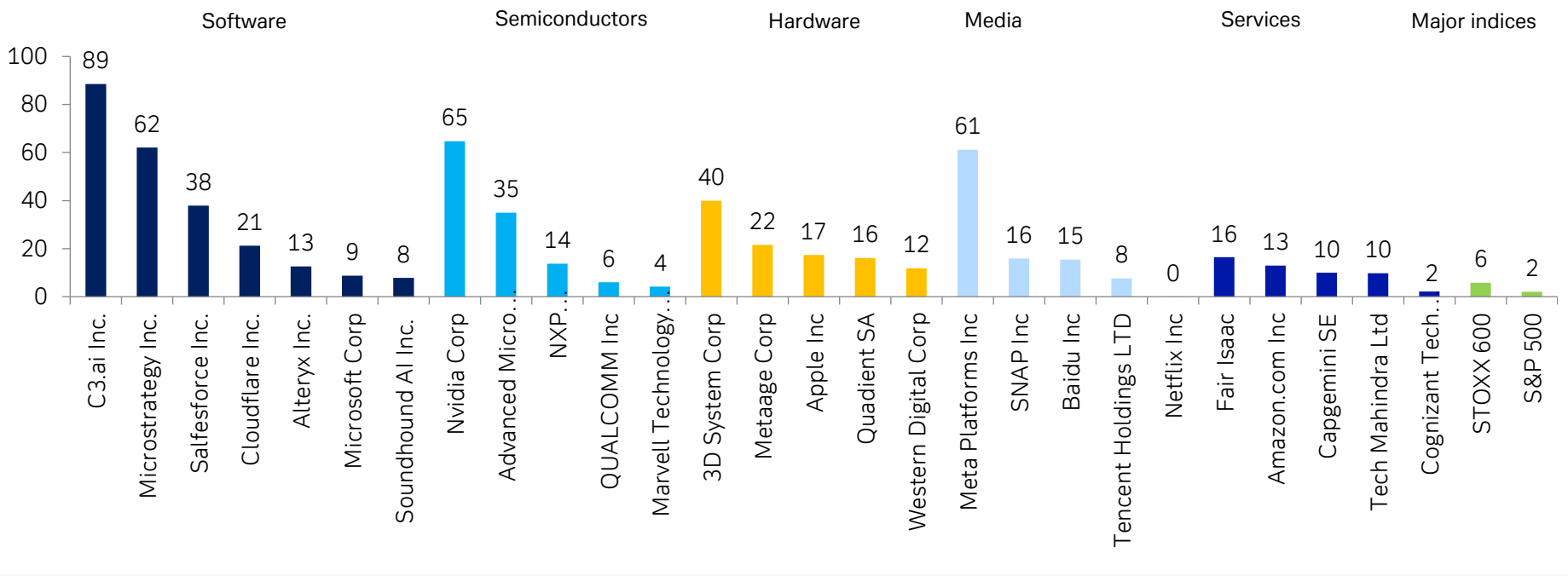
3. Capabilities: Where we are today and where we are moving to

> Machines take me by surprise with great frequency.
>
> -Alan Turing, founding father of modern artificial intelligence and cognitive science

AI related stocks have displayed strong PERFORMANCE since the beginning of 2023, far outperforming major indices

- AI-exposed stocks have outperformed relative to the broader equity market, with players like C3.ai Inc. and NVIDIA Corp seeing returns up 89% and 65% respectively.
- However, some companies have already started to falter as the risk rally ends. Buzzfeed grew 214% from the start to the end of January after announcing plans to utilise AI on its site, but the company has since lost nearly 60% of its value.

Performance of selected AI exposed firms in 2023 YTD

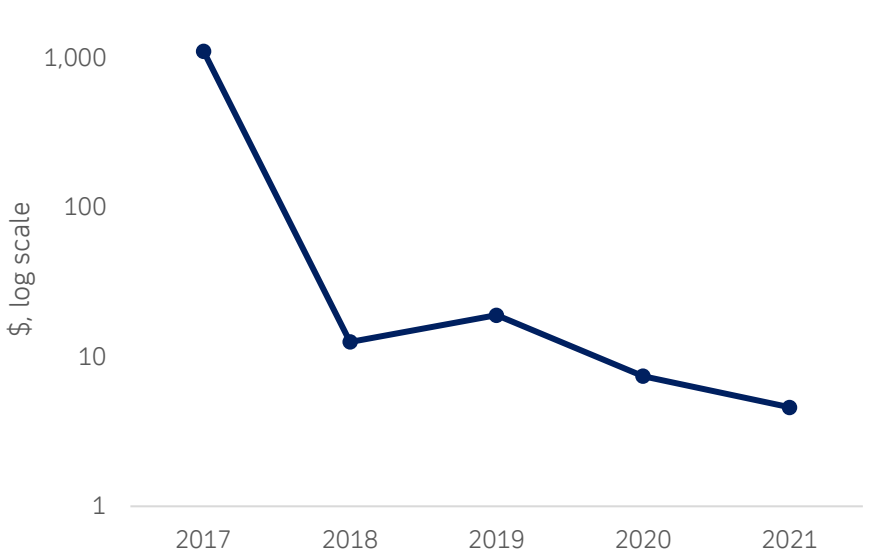


Source: Deutsche Bank, Bloomberg Finance LP. Selected stocks based on Bloomberg Finance LP. *Updated 14 March 2023.

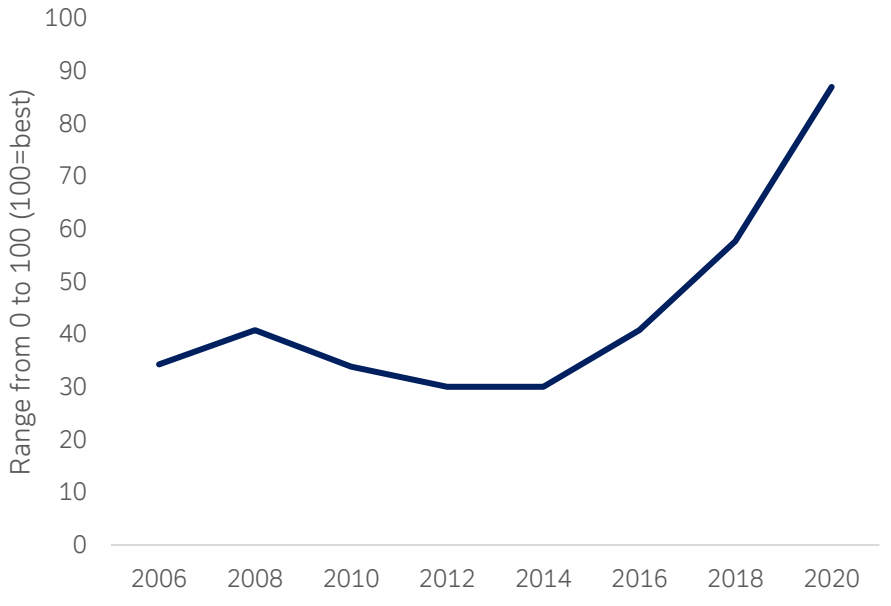
FUTURE INNOVATION: Better, faster and more affordable?

- Since 2018, the cost to train an image classification system has decreased by 63.6%, while training times have improved by 94.4%.
- The median price of robotic arms has decreased by 46.2% in the past five years from $42,000 per arm in 2017 to $22,600 in 2021.
- GPU computational performance per dollar has increased massively since 2006, from 62.42 million FLOP/s/$ with the GeForce 7099 GX2 to 42.59 billion FLOP/s/$ with the GeForce RTX 3080 in 2020.
- This will be favourable for corporates in their commercial adoption of AI.

Imagenet: Training cost (to 93% accuracy)*



Protein folding prediction accuracy

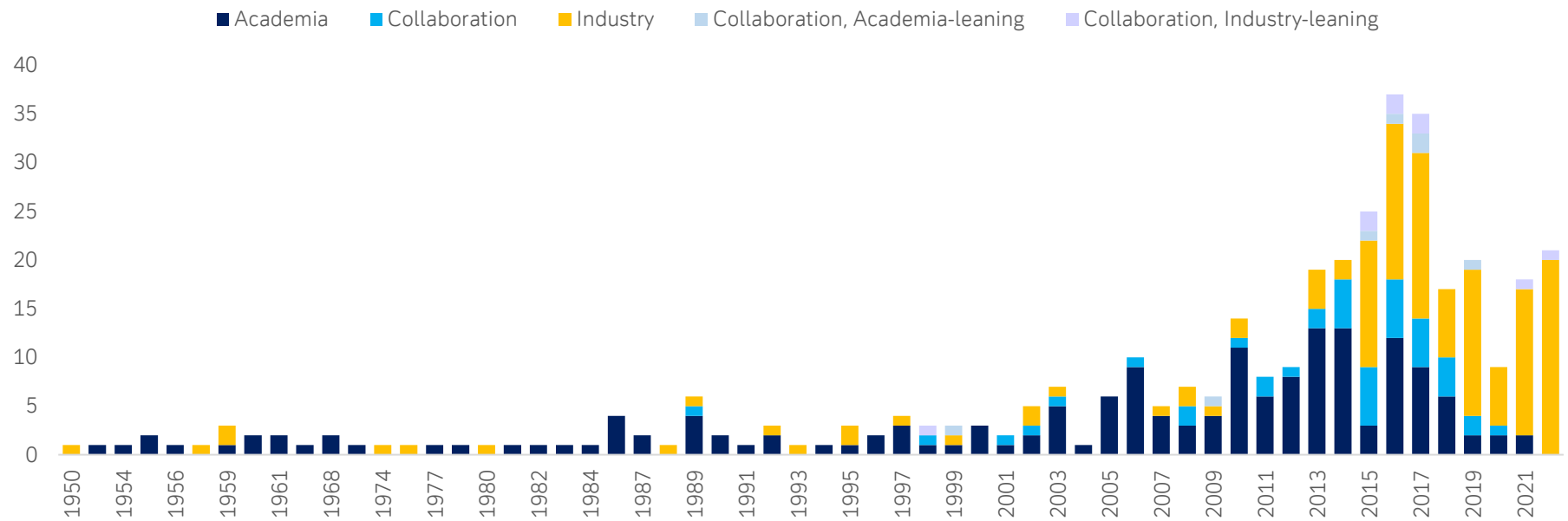


Source: Deutsche Bank, Our World in Data.*Cost in current USD of public cloud computing resources to train an artificial intelligence system to top 5 validation accuracy of 93% or more on ImageNet. ImageNet is a computer vision benchmark that has AI systems label images after interpreting visual input.

INNOVATION: As computing demands grow, AI innovation is increasingly concentrated in industry, not academia

- Intensity and computing demands increased with the prominence of deep learning, which has seen the size of ML systems and compute demands increase, pricing out academic research.
- Has occurred by shifting away from general purpose processors to more specialised hardware as ML systems predominantly train on specialised processors like Graphics processing units (GPUs), Tensor processing units (TPUs) and Neural Processing units (NPUs).
- This may see AI increasingly opaque as backend of algorithms are produced within larger corporates in heated competition.

Affiliation of research involved in the creation and building of 'notable' AI systems

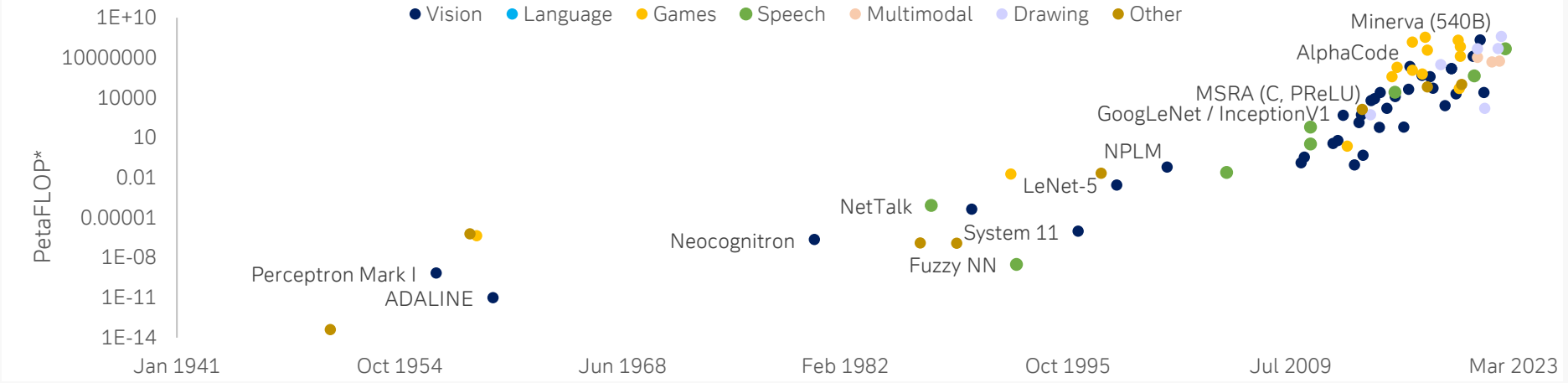


Source: Deutsche Bank, Our World in Data, Sevilla et al (2022). Note: 'notable' when the system is state of the art or of historical importance.

FUTURE INNOVATION: Computational demands are increasingly significant, but talent will remain essential to future development

- On average, employment growth was 63% for the US AI workforce between 2017 and 2019, but just 3% for workers in the overall economy. AI employment had a 22% annual growth rate between 2011 to 2017.
- The OECD argues that future advances in AI development will rely mostly on the human capital of its developers as well as on a dynamic labour market for AI talent.
- The average weekly hours of work for the AI workforce has grown by 0.7% over the sample period compared to a decline in average weekly hours for the economy overall .
- The computational capabilities required to train modern machine learning systems, measured in number of mathematical operations (ie floating point operations per second, FLOPS) has multiplied by hundreds of thousands of times despite algorithmic and software improvements that reduce computing power needs. Increasing demand for specialised AI software, hardware, related infrastructure, as well as AI talent.

Computational power required to train 'notable' AI systems

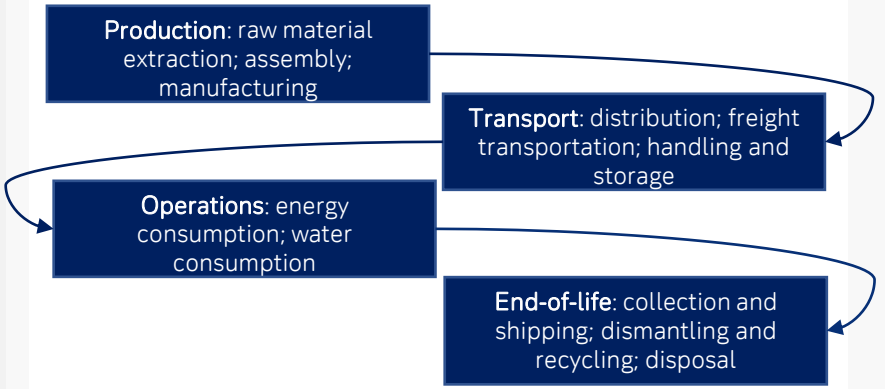


Source: Deutsche Bank, OECD, OECD Digital Economy.

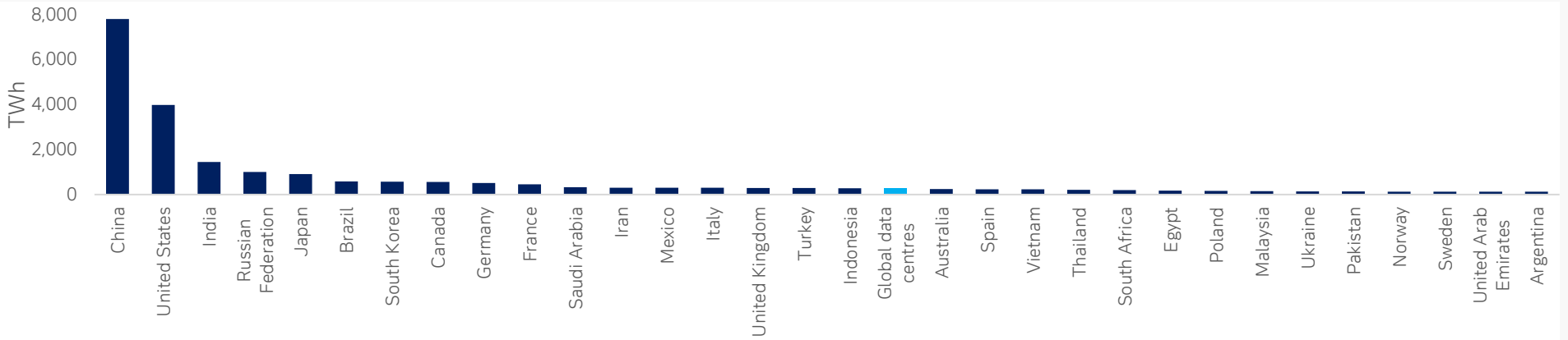
SUSTAINABILITY: To achieve Net Zero, data centre emissions must halve by 2030, but are predicted to more than double

- AI is enabled by 'AI compute', the physical infrastructure, hardware and software required to run AI systems.
- The IEA estimates data centre energy use has remained around 200-250 TWh, 1% of global electricity demand, despite growth in data traffic.*
    - However, growth in AI compute demands has outpaced the performance of current hardware, and it is unclear if this rate of efficiency gains can be maintained.
    - Andrae (2020) estimates data centre global electricity use may account for 783 TWh by 2030, or 2.6% of global electricity use.
- And such a statistic neglects the environmental damage resulting from the mining of necessary rare materials, including that of rare earths, as well as transportation and end-of-life disposal.

Lifecycle of AI compute



Annual electricity consumption for top 30 countries, and global data centres (TWh)**

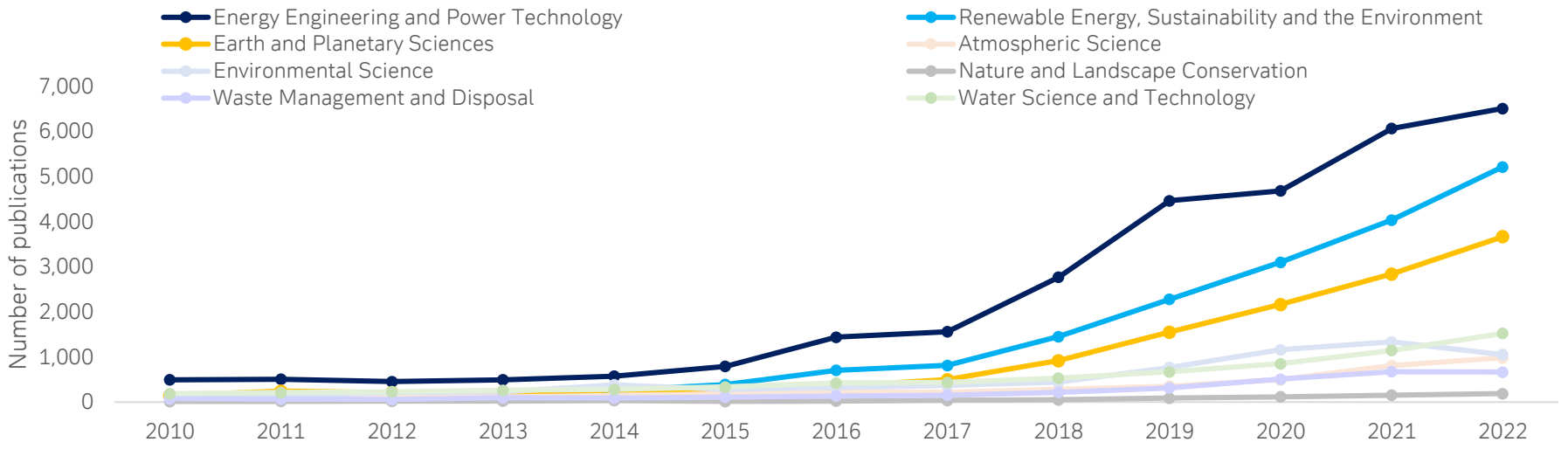


Source: Deutsche Bank, OECD, OECD Digital Economy, International Energy Agency, Cambridge Centre for Alternative Finance. *This does not disaggregate the electricity use of artificial intelligence from broader data centre electricity use. **Data for countries is for 2019, for global data centres is for 2020. ***Global data centre energy use excludes cryptocurrency mining.

SUSTAINABILITY: But AI can be used to improve sustainability

- AI can contribute to environmental action by improving efficiency and optimising the sustainability of existing systems, for example, through climate mitigation and adaption technologies, environmental modelling and forecasting systems and technologies.
- AI applications can also accelerate scientific research in the development of more sustainable technologies applicable to the green transition.
- The number of AI scientific publications on 'Energy Engineering and Power Technology' and 'Renewable Energy, Sustainability and the Environment' have increased around ten-fold and forty-fold respectively.
- The development of hyperscale data centres will also assist in reducing energy use, as they consume proportionally less energy for cooling relative to smaller data centres, according to the IEA.

AI scientific publications related to the environment and energy use, by subject area

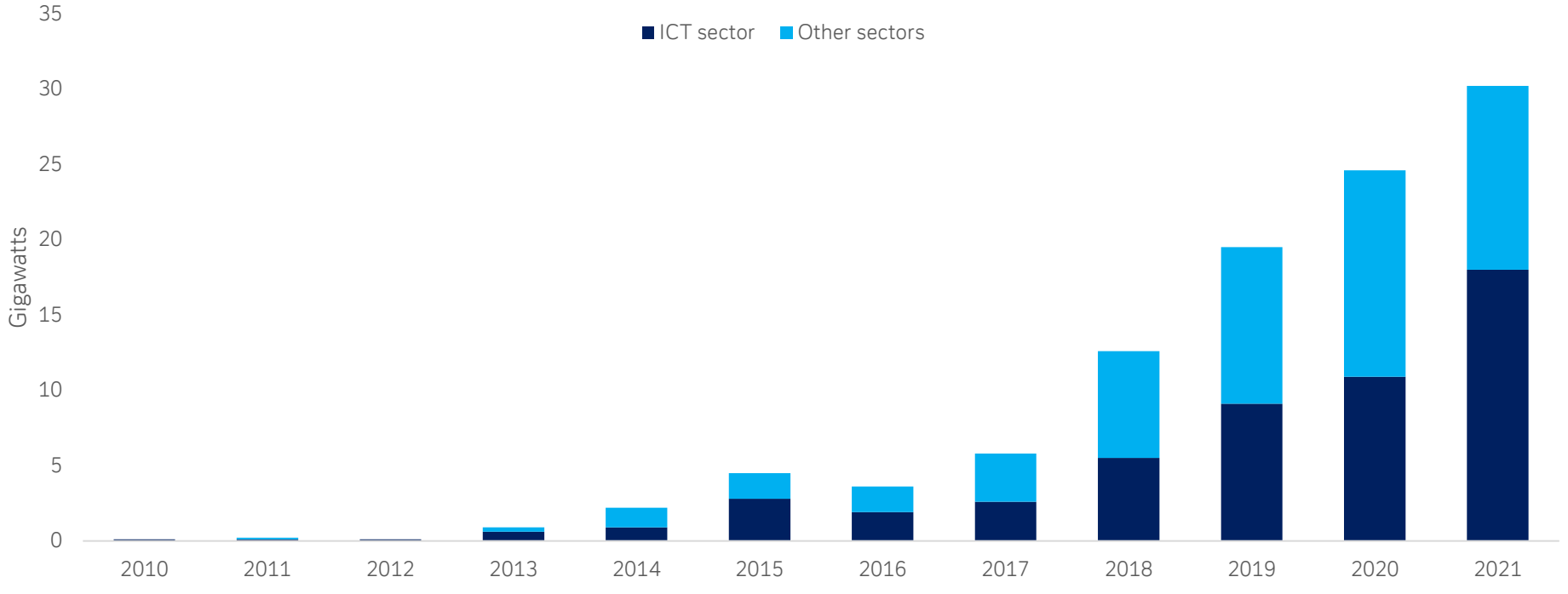


Source: Deutsche Bank, OECD.AI, OECD, IEA.

SUSTAINABILITY: And data centres are now increasingly powered by renewable energy

- ICT companies have increasingly invested in renewables where possible to reduce electricity price volatility and reduce carbon emissions.
- Amazon, Microsoft, Meta and Google are the four largest purchasers of corporate power purchase agreements, having contracted 15 gigawatts in 2021.

Global renewable energy power purchase agreements by sector, 2010-2021

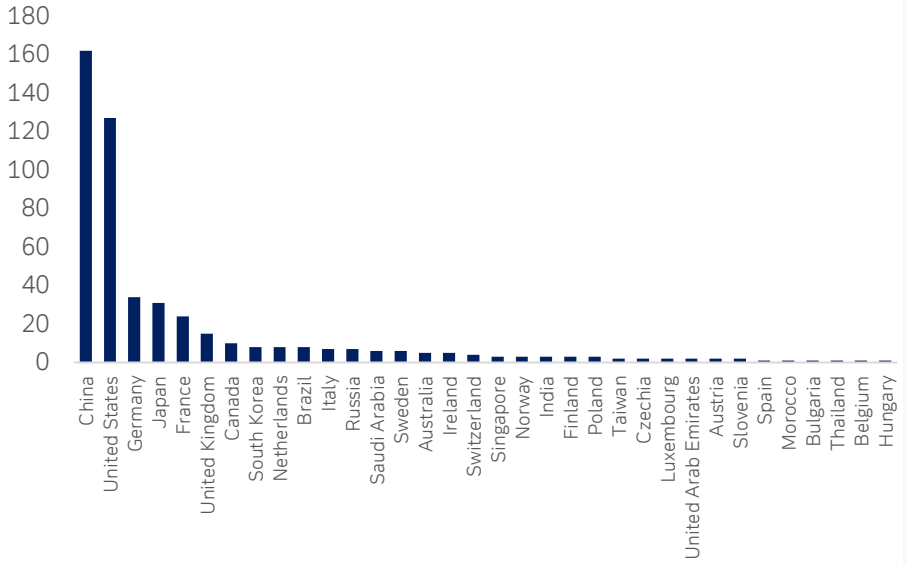


Source: Deutsche Bank, OECD.AI, OECD, IEA.

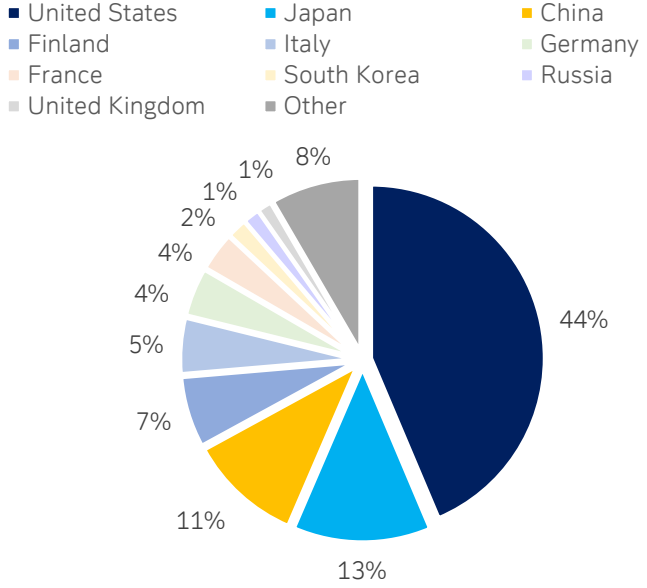
INNOVATIONS: Dividing the world between the haves and have-nots

- An imbalance of computer resources may deepen socioeconomic divides within and between countries, creating further differences in competitive advantage and productivity gains.
- The Top500 list can serve as a proxy measure to observe emerging or deepening compute divides between economies – as supercomputers are increasingly updated to run AI specific workloads, gaps can be observed between those that have the resources to create complex AI models leading to productivity gains, and those that do not.
- This is not merely about possessession, but about matching pace of development – nearly 90% of top supercomputers have been developed in the last 5 years, and their performance has grown 630 times in terms of computation capacity since 2009.

Number of supercomputers by country (Nov, 2022)



Performance of supercomputers by country (Nov, 2022)

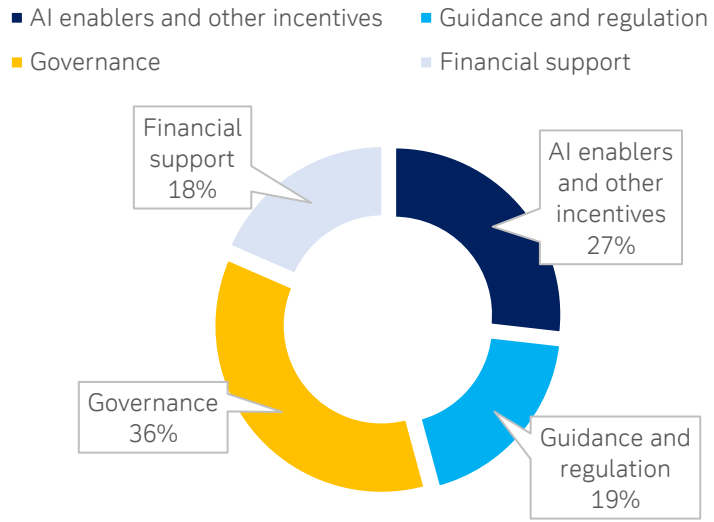


Source: Deutsche Bank, OECD, OECD Digital Economy, Top500.

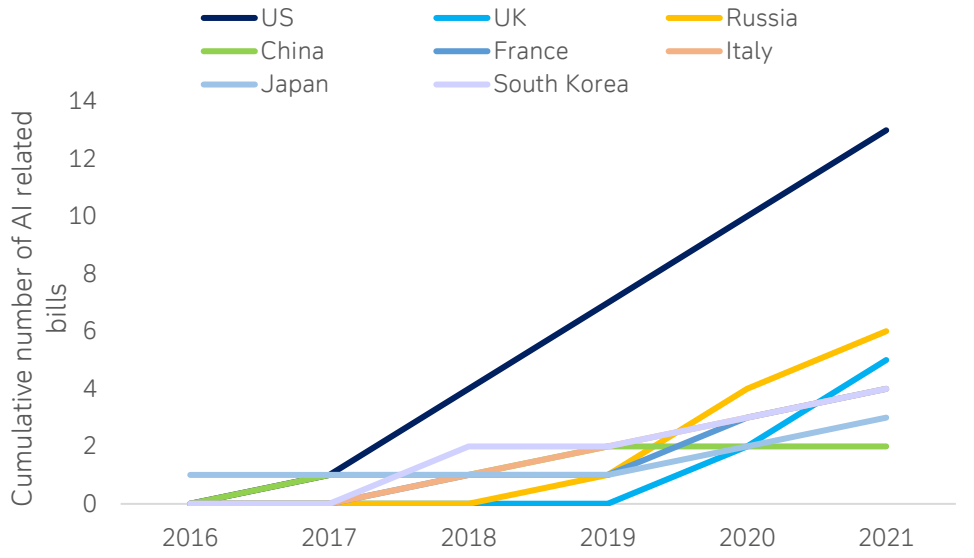
REGULATION: Countries are increasingly introducing governance and regulation on AI, but continue to subsidise innovation

- Examples of AI related policies:
  - i. Scale-up policy – cutting-edge innovation in specific domains (e.g. health, transport and agriculture)
  - ii. Scale-out policy: AI diffusion across sectors of the economy to unlock productivity gains and innovation at scale.
- The EU classifies AI systems into three risk categories:
  - i. Limited-risk: chatbots; gaming; inventory management
  - ii. High-risk: pose risks to health and safety of persons; safety systems; consumer creditworthiness; employment decisions
  - iii. Unacceptable-risk: cause societal harm; real-time, biometric identification used for public law enforcement; social scoring

AI policy instruments, 2021



Cumulative number of AI-related bills (2016-2021)*



Source: Deutsche Bank. OECD.AI, EUR-Lex, Our World In Data. *Countries selected are those with the highest number of AI-related bills as identified by Our World in Data.

REGULATION: Countries have used a mixed portfolio of regulation to both enable AI innovation and to encode principles and ethics

Countries	Approach	Goal
European Union	• Financial support. • Guidance and regulation.	• Coordinated Plan on AI 2018 with a budget of more than EUR 500 million to maximise investments, cooperation. • The European High-Performance Computing Joint Undertaking (EuroHPC) was established in 2018 to share computing resources and coordinate efforts among EU countries and partners, with a 2021 to 2027 budget of EUR 7 billion. To build a European network of National Competence Centres for HPC. • Artificial Intelligence Act pending to promote beneficial development of AI and regulate autonomous weaponry.
United Kingdom	• Governance • Financial support.	• 2021 National AI Strategy on access to finance for innovation, talent, international cooperation, public research capabilities through a National AI Research and Innovation Programme, Advanced Research and Invention Agency, increasing R&D to 2.4% of GDP by 2027. • October 2020, the UK announced launch of its most powerful supercomputer for use by healthcare researchers.
United States	• Governance • Financial support. • Guidance and regulation.	• Executive Order: Maintaining American Leadership in AI 2019 focusing on tech developments, public and private collaboration, technical standards, talent, tech advantage, public trust. • Department of Energy launched the Frontier supercomputer as one of the world's most HPCs for AI applications in 2022. • National Science Foundation invests in next-gen AI R&D supercomputers such as Frontera (deployed in June 2019). • The US National AI Initiative Act of 2020 to make world-class computing resources and datasets available. • Algorithmic Accountability Act of 2022 to improve oversight of software, algorithms and automated systems.
Japan	• Guidance and regulation • Financial support. • Governance	• In 2019, published the Social Principles of Human-Centric AI. • RIKEN Centre for Computational Science and Fujitsu launched top-ranked supercomputer, Fugaku, in 2020. • The National Institute of Advanced Industrial Science and Technology (AIST) develops and operates open AI computing infrastructure, including AI Bridging Cloud Infrastructure to accelerate AI R&D.
China	• Governance • Financial support	• National New Generation AI Plan from 2017 seeks to make China 'world-leading' in some AI fields by 2025, to become the 'primary' centre for AI innovation by 2030 with AI industry worth RMB 1 trillion. • Partnership with national tech companies, and funding a USD 2.1 billion tech park in Beijing.
India	• Governance • Government stimulus	• National Strategy on AI 2018 on proof-of-concept, AI ecosystem, collaboration with public, private and academic. • Centre of Excellence in Artificial Intelligence developing the National Artificial Intelligence Resource Portal. Offering to include a web-based system to search and browse AI resources, including training and cloud-based compute platform.

Source: Deutsche Bank, OECD, OECD.AI, EuroHPC, US Congress, The Federal Register.

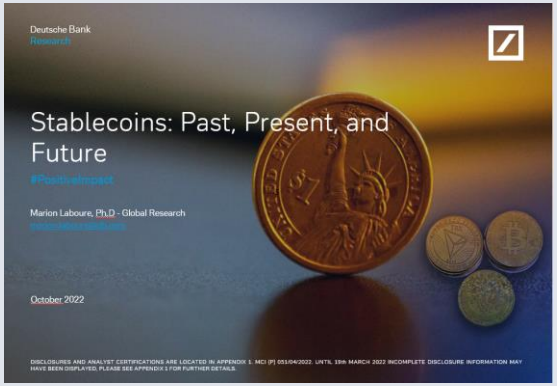
Latest research

Thematic Research: US vs. China: Understanding the semiconductor chip war in 10 charts

Thematic Research: US vs. China: Understanding the rare earth metals tensions in 10 charts

Future Payments: CHARTBOOK - The Future of Money

Future Payments: CHARTBOOK - Stablecoins: Past, Present, and Future



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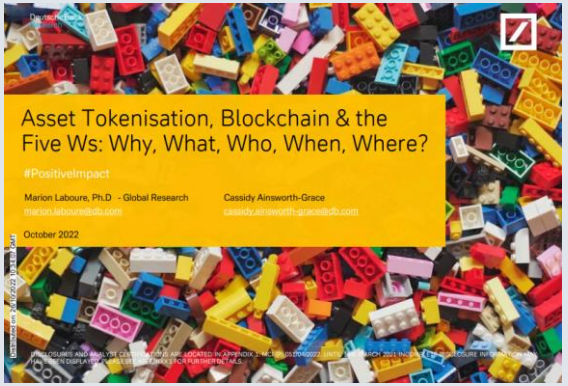

Future Payments: Everything you should know about the (coming) semiconductor chip war

Appendix 1
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I wish to acknowledge the contributions made by Anthony Chaimowitz of dbDIG Primary Research for his invaluable contributions to this report.

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