Deutsche Bank
Research

Generative AI and ChatGPT 101

#PositiveImpact

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What is generative AI? | How does it work? | How can you use chatbots? | What does generative AI mean for the future?

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IMPORTANT RESEARCH DISCLOSURES AND ANALYST CERTIFICATIONS ARE LOCATED IN APPENDIX 1. MCI (P) 097/10/2022. UNTIL 19th MARCH 2021 INCOMPLETE DISCLOSURE INFORMATION MAY HAVE BEEN DISPLAYED, PLEASE SEE APPENDIX 1 FOR FURTHER DETAILS.

Image by DALL-E

Six months of hype, chat and fears

Next week will mark six months since the launch of ChatGPT, the chatbot based on OpenAI's GPT-3.5 large language model.

There has been an extraordinary flurry of launches, hype and activity since then. Even in the past week, OpenAI, Google and Meta announced fresh products, OpenAI's CEO testified in Congress, and the G7 called for "guardrails" on AI, among many other developments.

Whether you agree with the researchers who say the underlying technology has "sparks of Artificial General Intelligence" or you think it is just a "stochastic parrot", it is vital to understand how it works and what it could mean.

This is the latest in our 101 series for generalists, aiming to give a clear overview of generative AI, addressing what it is, how it works, how to use it, and what it means for jobs, the economy and society. It is also part of an ongoing series starting this week looking more deeply into the topic.

In the meantime, one thing seems certain. Amara's law, that "we tend to overestimate the effect of a technology in the short run and underestimate the effect in the long run," could have been written for (or indeed by) ChatGPT.

1950: Alan Turing proposes a learning machine

1966 First chatbot ELIZA developed

1980s Early development of neural networks

2011 Apple releases first iPhone with AI assistant Siri

2012 AlexNet takes leap forward in image recognition

2017 "Attention is all you need" paper announces transformers

2018 Google introduces BERT large language model

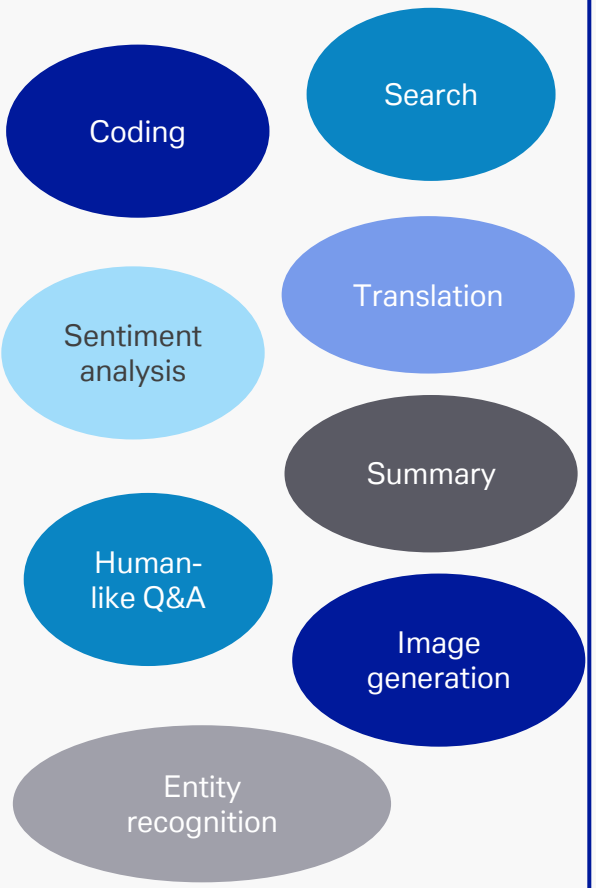
2019 OpenAI creates GPT-2 LLM with 1.2bn parameters

Nov 30, 2022: OpenAI launches ChatGPT chatbot

What is special about generative AI?

Almost anyone with internet access can right now operate a chatbot based on a large language model (LLM) at little cost and with little or no training

1. General (multi-purpose) tech

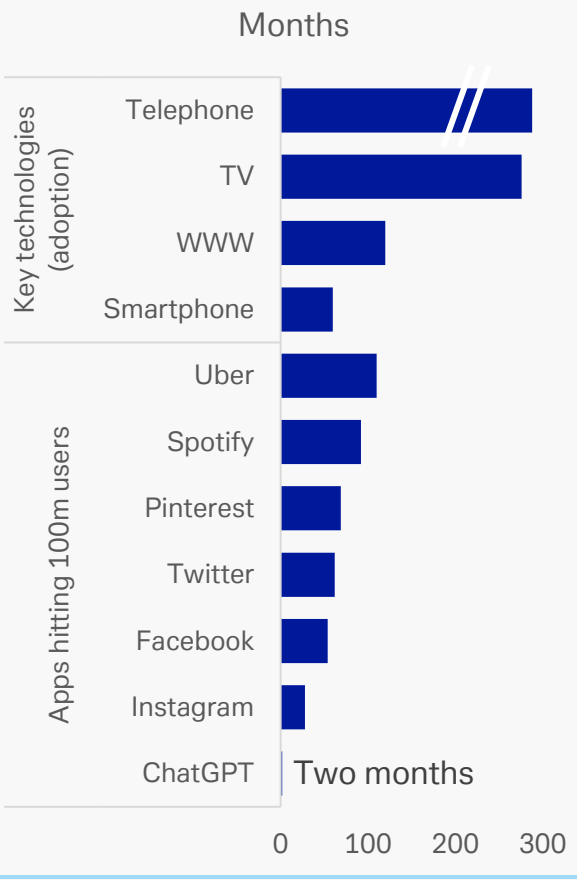


2. Ease of use

Tell me how to access and use ChatGPT in a six-line rhyming poem

To access ChatGPT, heed this rhyme,
Visit websites where it's prime.
In the chatbox, type your quest,
Hit send, put it to the test.
Read responses as they show,
Keep chatting, watch the knowledge flow.

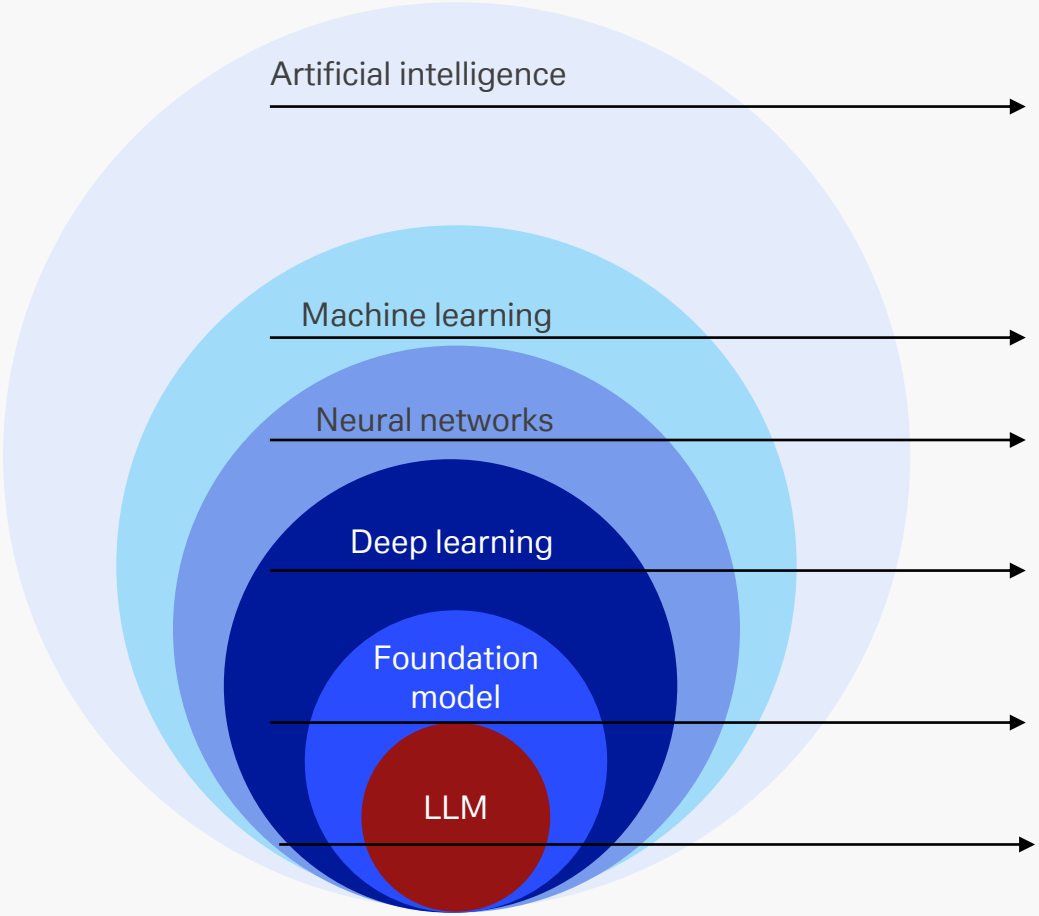
3. Rapid adoption



Source: Deutsche Bank, company reports, media headlines; ChatGPT content written with ChatGPT

What is a large language model (LLM) and where does it fit into AI?

GPT-4 is the underlying technology for ChatGPT and is currently the most high-profile LLM, an AI model trained on a vast amount of data, capable of understanding and generating human-like text



Machines/software capable of intelligent behaviour: three levels
1. Narrow AI: performs limited tasks
2. Artificial General Intelligence (AGI)
3. Superintelligence

Learning and acting on data without explicit instructions

Models inspired by the human brain

Uses multiple hidden layers of artificial neural networks to enhance performance

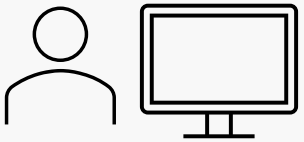
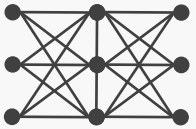
Understands and generates text and/or images, code etc; need a lot of data for training

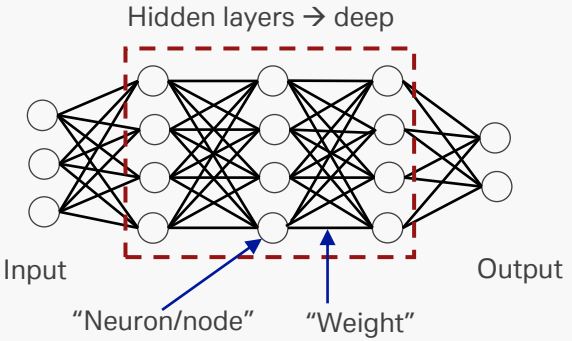
Focused on language tasks

Source: Deutsche Bank.

What is the underlying deep learning technology for LLMs?

An image classification example

	Input	Feature extraction	Classification	Output
Traditional machine learning: Experts input structured data				CAT NOT CAT

	Input	Feature extraction + Classification	Output
Deep learning with neural networks: Can learn far more complex structures and relationships (eg pixels) without needing human help to identify relevant features			CAT NOT CAT

Source: Deutsche Bank.

What are the key neural networks and what are they made of?

Neural networks have become increasingly sophisticated over the past decade, particularly with the breakthrough of Convolutional Neural Networks in 2012 and Transformers in 2017

Key neural network models:
(Approximately ranked from simple to complex)

1. **Feedforward**: one-directional, no looping/feedback

2. **Recurrent (includes Long Short-Term Memory, LSTMs)**: good for sequential data like text; have a feedback connection, enabling them to "remember" previous inputs

3. **Convolutional**: layers "convolve" the input, making them particularly good at handling images

4. **Generative Adversarial Networks**: consist of two networks that compete and can generate new data

5. **Autoencoders**: unsupervised, used for data compression

6. **Transformers**: best for natural language processing (NLP):
   - Process all pair-relationships between input tokens
   - Use "self attention" to weigh the relevance of, for example, different words in a sentence and capture long-range dependencies in data
   - Form basis for models like OpenAI's GPT, Google's BERT and PaLM, Meta's LLaMA and DeepMind's Chinchilla

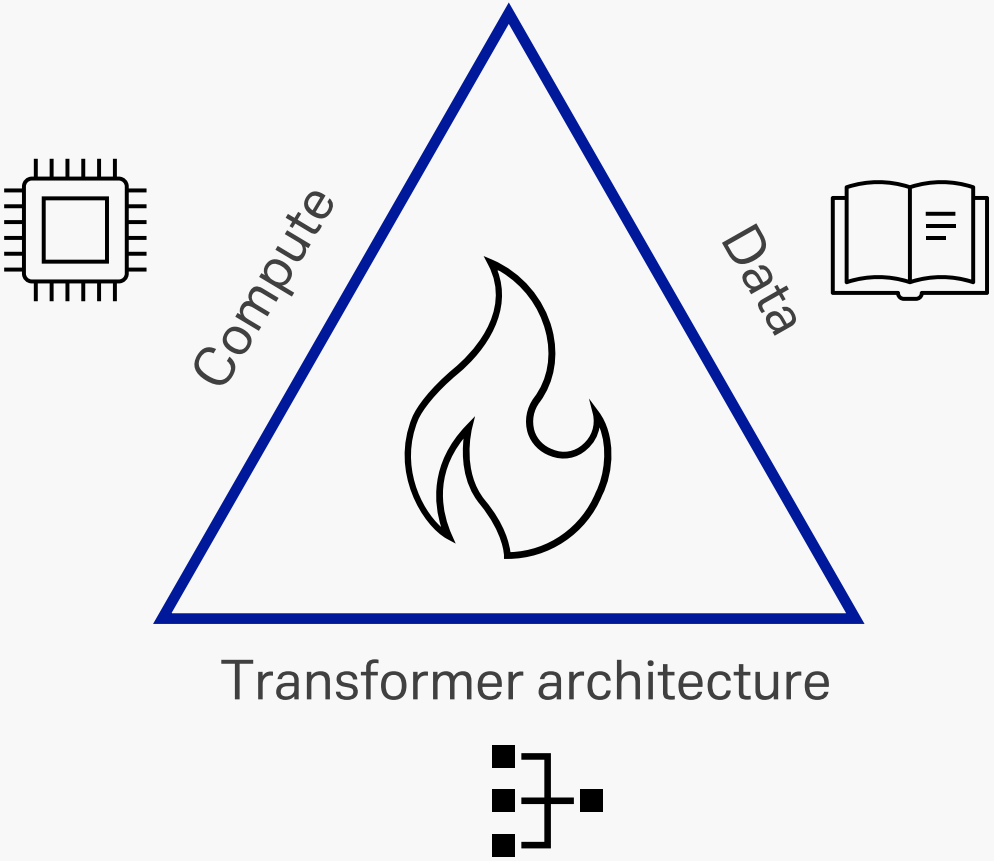
Common components:

- **Input layer** – takes in the data, e.g. text, and feeds it into the next layer
- **Hidden layers** – in between input and output layers, responsible for data computation and transformation
- **Output layer** – the final result, the form depends on the initial task – e.g. classification, next word prediction etc
- **Neurons** – the nodes within layers where weights, activation functions and biases are applied to inputs
  - **Parameters (weights and biases)** are learned during training
  - **Activation functions** decide whether a neuron should be activated or not, adding non-linearity
- **Tokens** – unit of text, such as a word or subword, that is an input to a language model

Source: Deutsche Bank.

What was the tipping point for generative AI?

Massive computing power, data and the invention of the transformer model are the oxygen, fuel and heat that have enabled generative AI to catch fire



Source: Deutsche Bank.

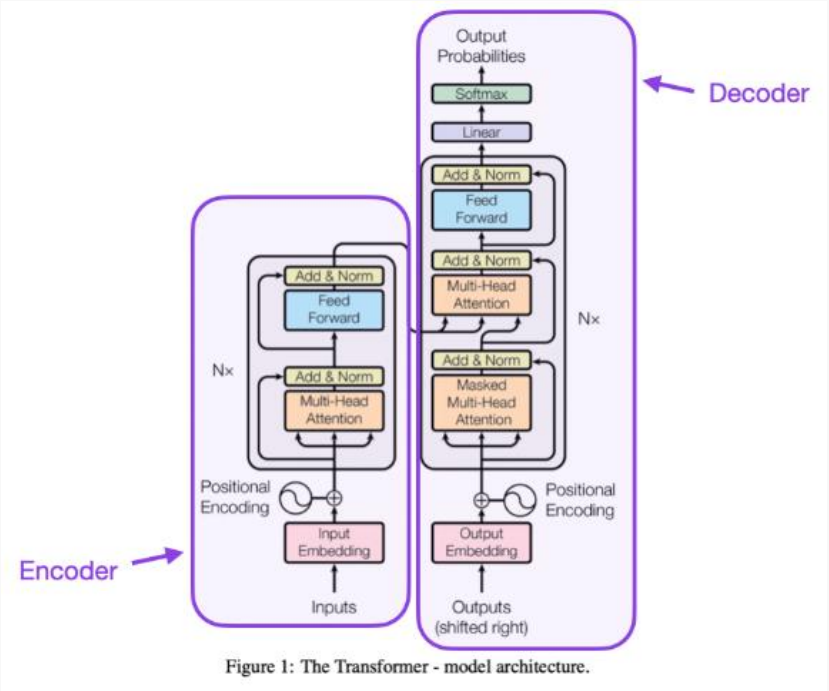


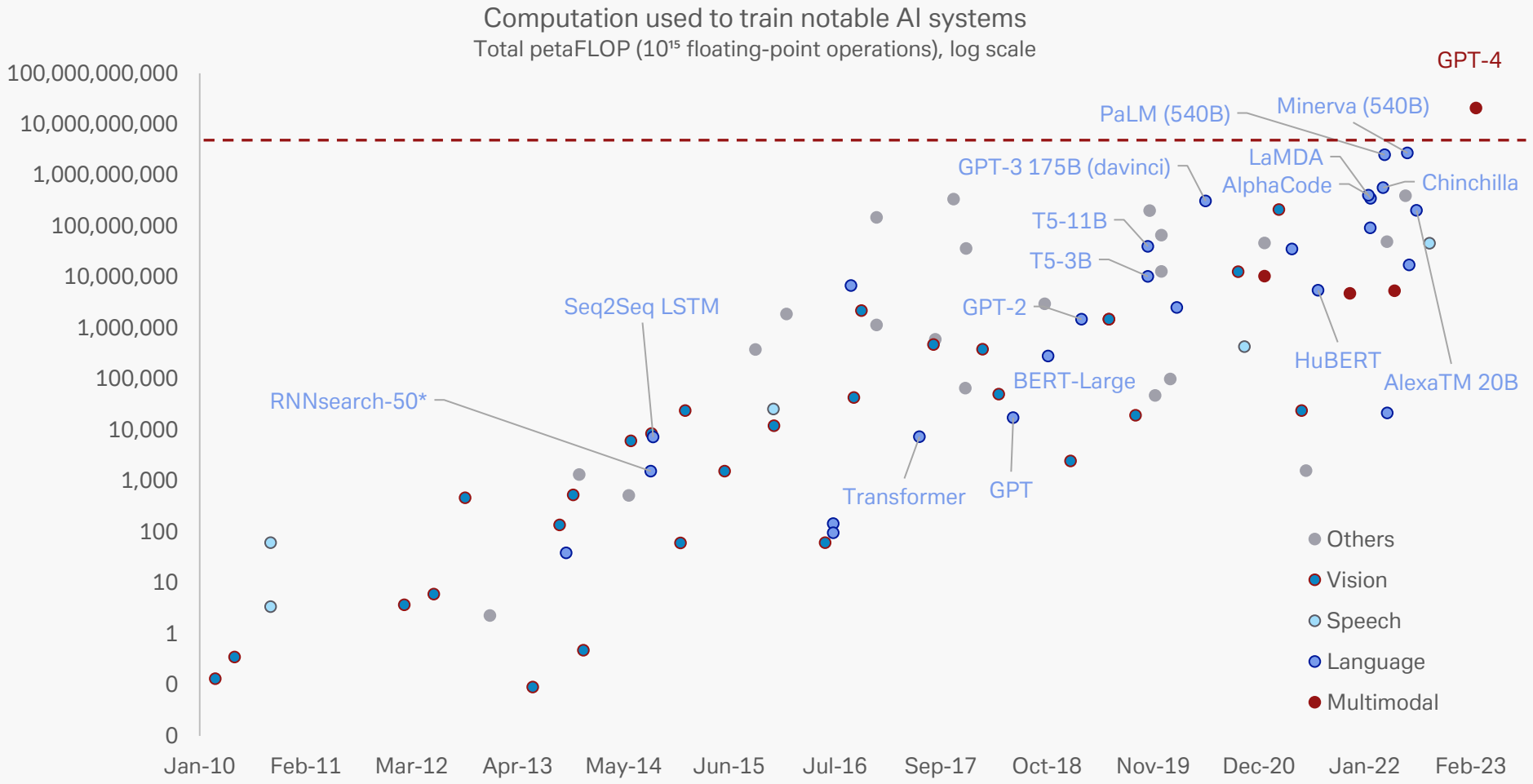
Figure 1: The Transformer - model architecture.

Transformer model: the Rosetta Stone of SOTA (State of the Art) large language models

From "Attention Is All You Need", Vaswani et al, 2017

How large was the advance in computing power to get us here?

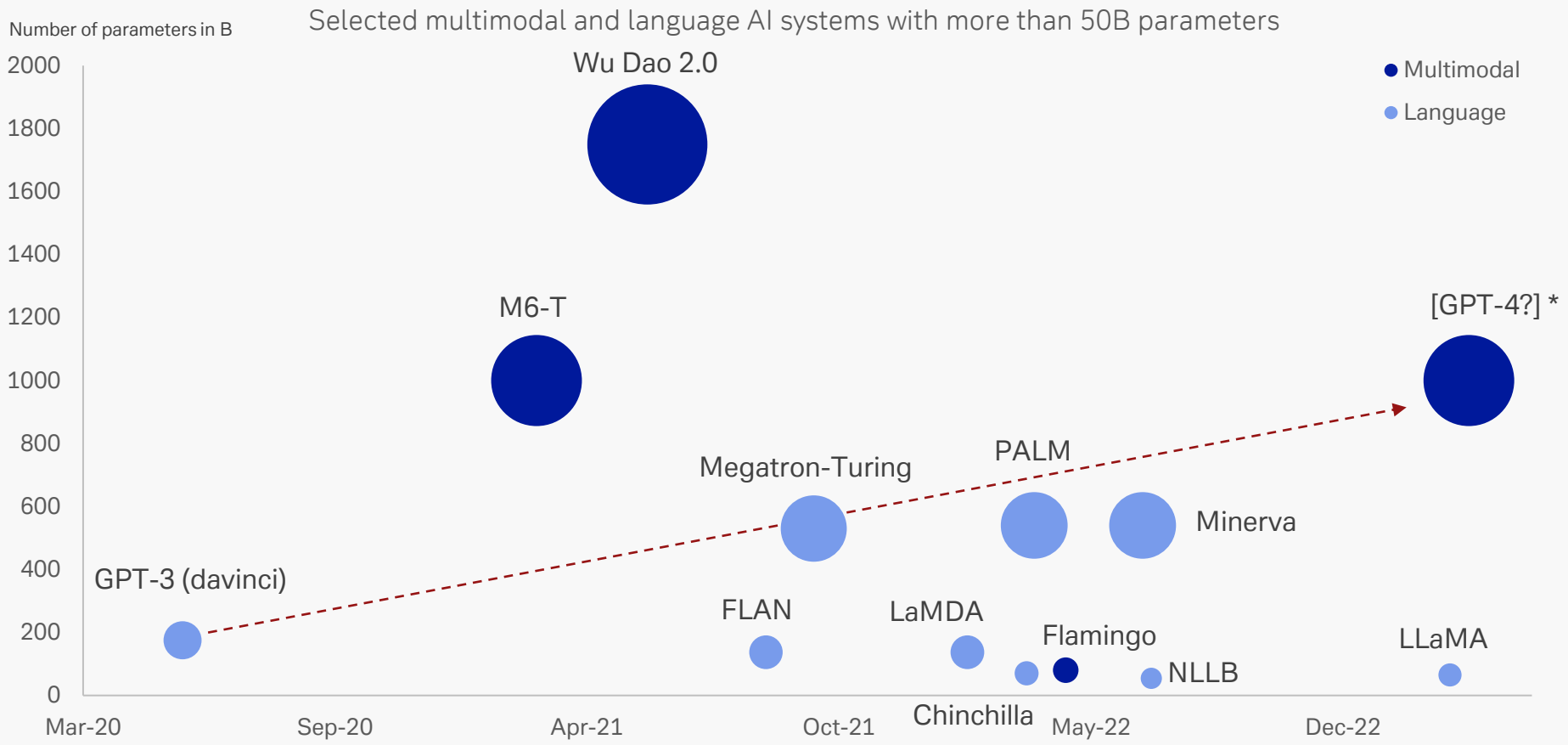
Recent models use several orders of magnitude more processing power, or "compute", than past models, with more parameters and more complex model architectures



Source: Sevilla et al. (2023), Our World in Data, Deutsche Bank. Note: Computation is estimated based on published results in the AI literature and comes with some uncertainty. The Authors of the study expect the estimates to be correct within a factor of 2.

How many parameters do LLMs have now?

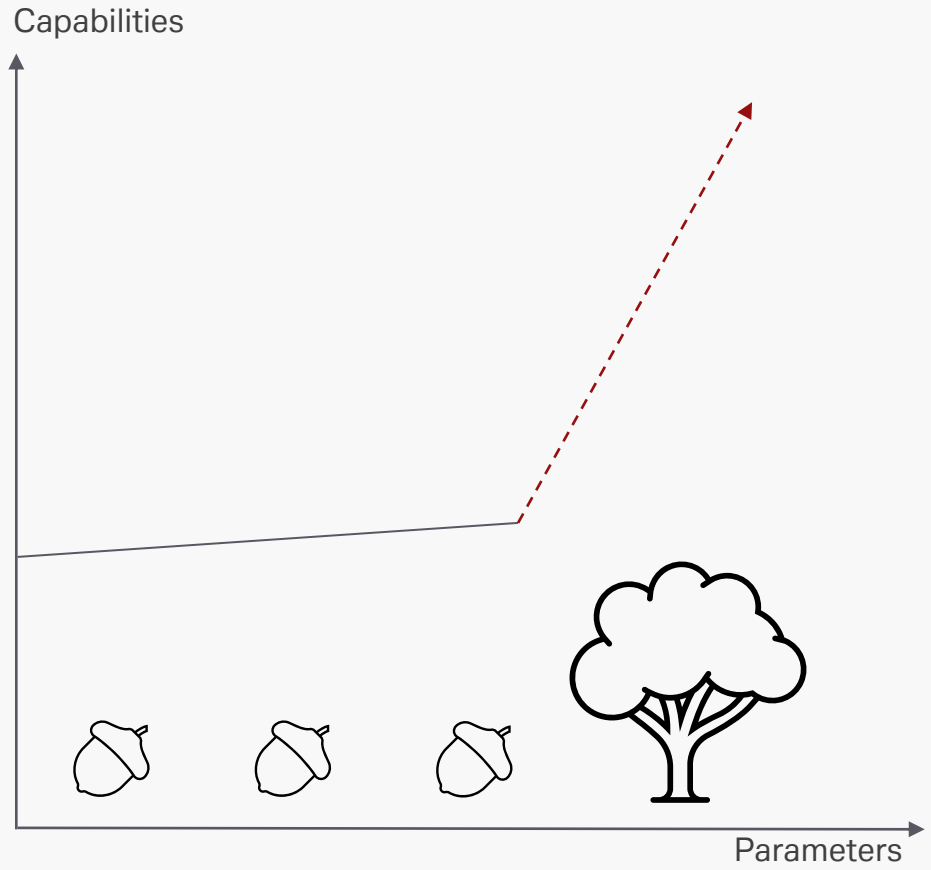
The number of parameters in LLMs, a key measure of size, has surged in the past five years. Even if estimates are true, GPT-4 will not be the first 1tn parameter model. China's multimodal Wu Dao 2.0 reportedly has 1.75tn parameters



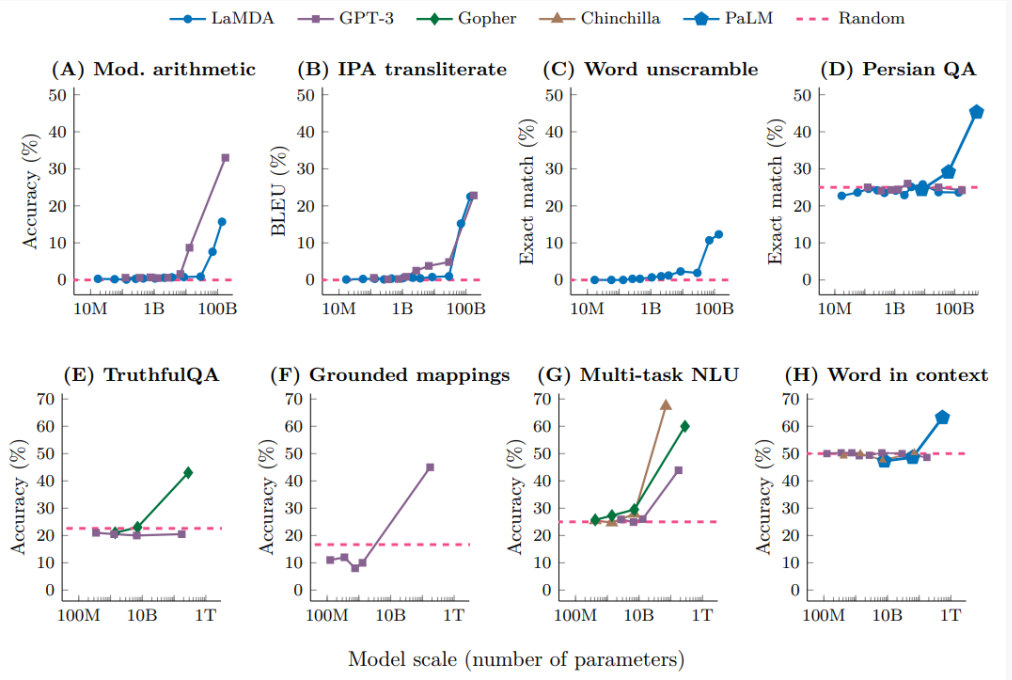
*Source: Sevilla et al. (2023), Our World in Data, Deutsche Bank. *Note GPT-4 parameter count has not been announced; industry estimates that it is around 1 trillion parameters. Parameters are estimated based on published results in the AI literature and come with some uncertainty. The authors of the study expect the estimates to be correct within a factor of 10.*

Why do more parameters matter?

LLMs show emergent abilities, where capabilities suddenly (and often unexpectedly) appear when the model reaches a certain size



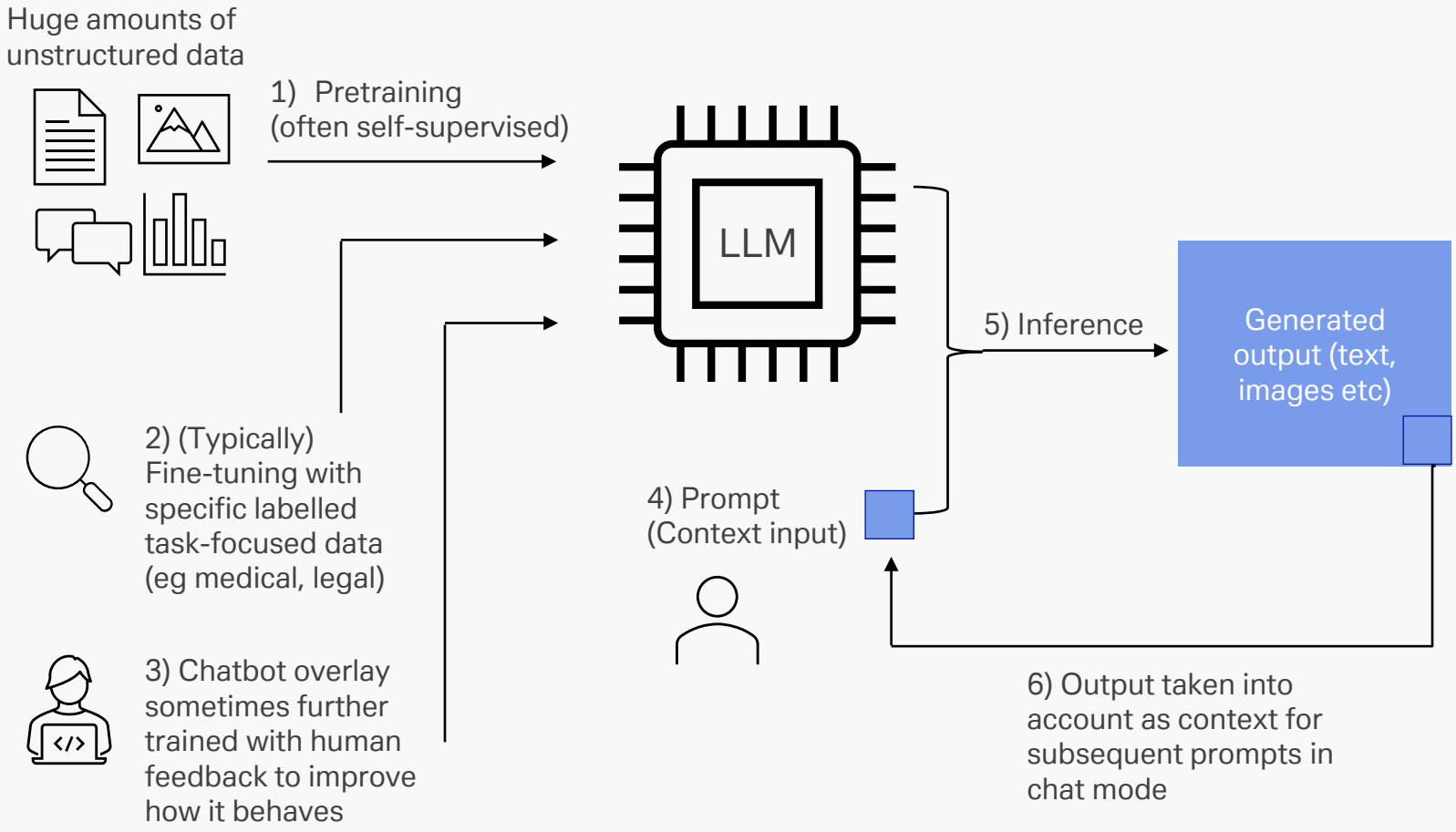
Examples of emergent abilities in the few-shot prompting setting



Source: Deutsche Bank, "Emergent Abilities of Large Language Models", Wei et al. (2022); IPA is International Phonetic Alphabet, NLU is Natural Language Understanding

What are the steps in preparing and using an LLM?

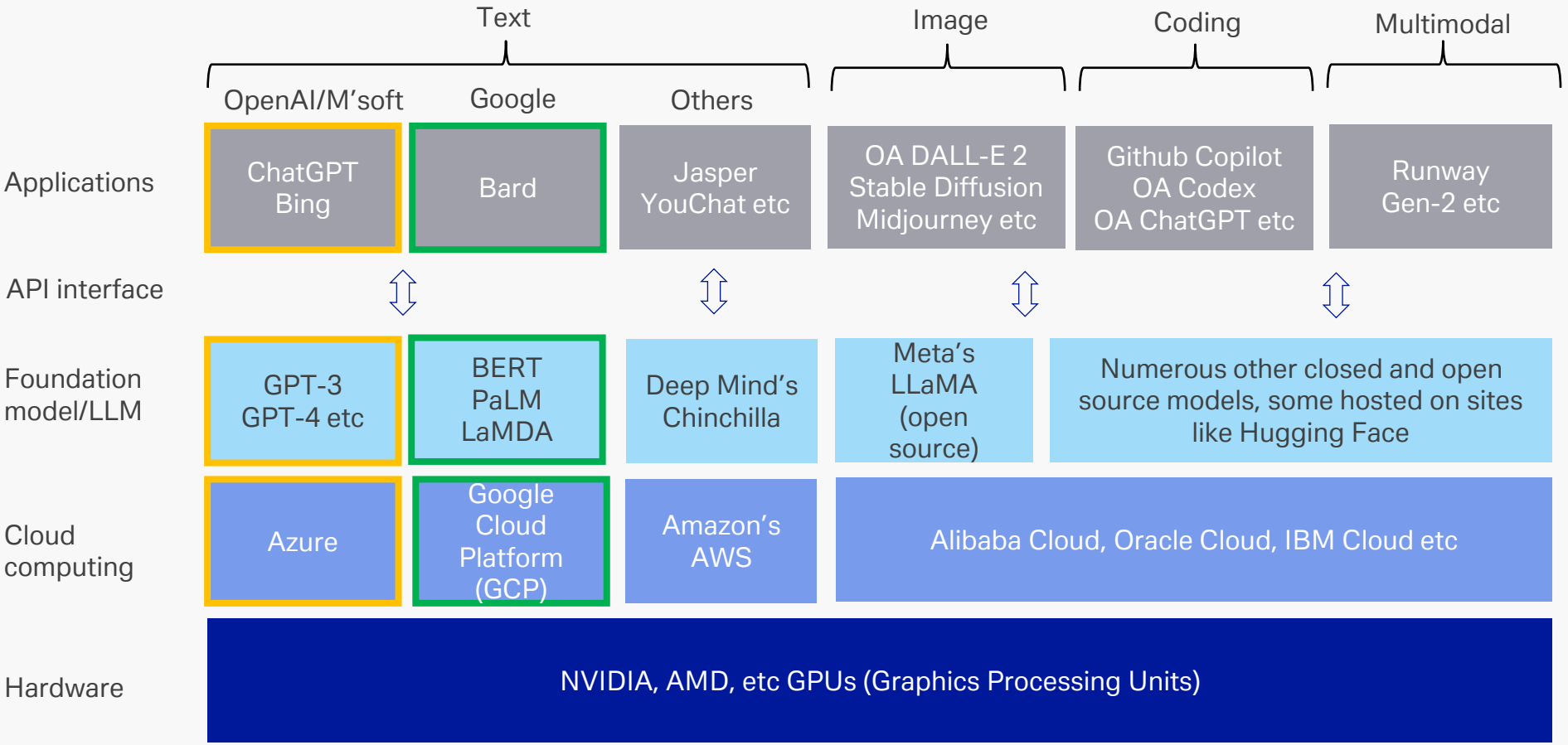
LLMs are pretrained then often fine-tuned on data to acquire a skillset before the user prompts them to perform a task



Source: Deutsche Bank.

Where do LLMs fit in with other technology?

The "tech stack" is built on hardware and cloud computing. LLMs can often support multiple applications which interact with them via APIs (Application Programming Interfaces). Apps can also be given extra skills with "plug-ins"



Source: Deutsche Bank.

How do you use a chatbot?

ChatGPT and its competitors look and feel like search engines but it is more effective to interact with them like speaking with a human, giving lots of context, and expecting that answers may be more creative than factual

Basic approach

1. Ask like you're having a conversation with a person
2. Give context: more is better, inc goal, tone of voice etc; you can paste in relevant text and data (the amount it can handle depends on the model)
3. Rephrase, correct and clarify if you don't get the answer you want – you don't need to restate the whole context

Useful points to include

"Act as a [ROLE]": doctor, teacher, legal expert, sales manager…
"Addressing an [AUDIENCE]": university student, 7-year-old…
"In a [FORMAT]": 500-word essay, sales pitch, analogy, rhyming poem, social media post, table, code, in the style of Mary Shelley…

Digging deeper

1. Specify steps: use chained prompting for complex tasks: ie write an article starting with the outline… [Output]… Now write three key messages for each subheading… etc
2. Give sample answers in your question (ie "one-/few-shot prompt") instead of an open-ended "zero-shot prompt"
3. Ask the chatbot to suggest prompts to achieve your task

Shortened example prompts for various use cases

Business

- Identify 10 ways a finance company can use AI…
- You are a customer service rep. Write an apology for…
- Take this data [eg pasted table] and identify themes…
- Use this job description and cv to write a cover letter…
- Tell me which angel investors have invested in [name], give their email addresses and draft emails asking for…
- Write a business plan and slogan for a business that…

Education

- Summarise War and Peace in 500 words for kids…
- Teach me basic calculus with analogies and a quiz…

Code

- Write code to convert a video file into a smaller format…
- Explain the security flaw in this code snippet…

General text and reasoning

- Write a humorous poem welcoming wedding guests…
- I have this [list] in the fridge… Give me a healthy recipe…
- Parrot crosses a road. Complete this joke… Why funny?
- Compose a song about a fund manager inc chords…
- Why might my dog be sick? It has these symptoms…
- Write a five-day itinerary in a table format for a 30-year-old wheelchair user visiting Berlin for the first time…

Source: Deutsche Bank.

What are the immediate limitations and concerns?

LLMs are not search engines, though some can be paired with search engines for greater accuracy. Their output reflects the limitations and biases of their training data, encompassing billions of words and images on the internet

Five limitations and concerns about generative AI and the risks for enterprises

1. Hallucinations	→	Libel risk
2. Bias	→	Reputational risk
3. Data privacy	→	Security, confidentiality risk
4. Unclear sourcing	→	Legal risk, IP/copyright
5. Deliberate misuse	→	Operational risk

Australian mayor readies world's first defamation lawsuit over ChatGPT content

OpenAI Chatbot Spits Out Biased Musings, Despite Guardrails

Samsung Bans Staff's AI Use After Spotting ChatGPT Data Leak

Getty Images is suing the creators of AI art tool Stable Diffusion for scraping its content

How AI is being used to spread misinformation

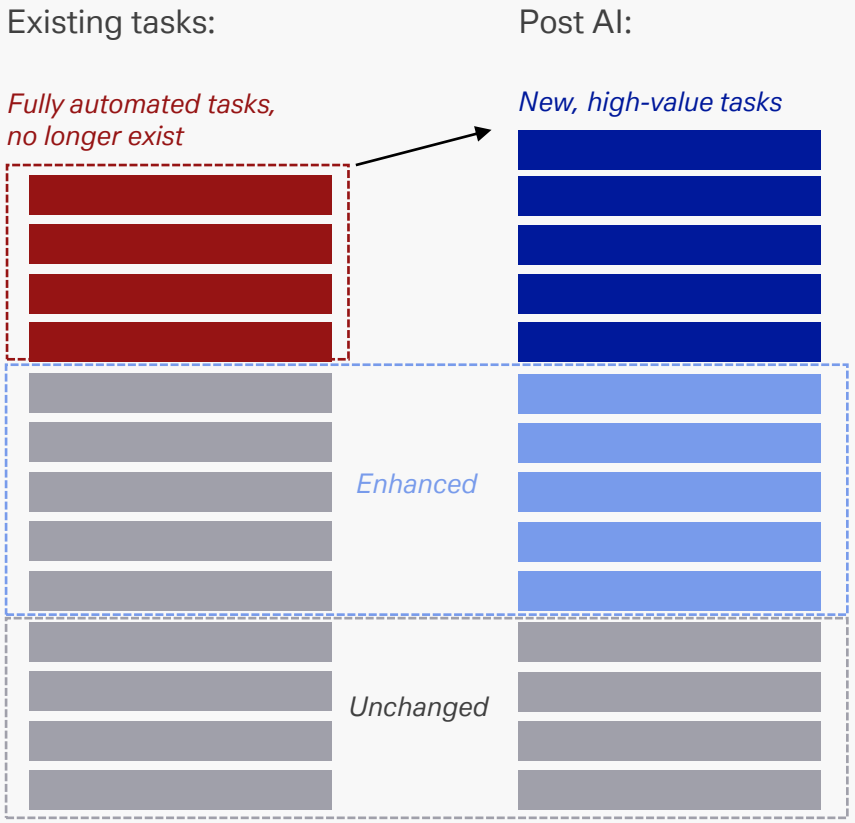
Additionally: Limited range of training data, eg GPT-4's "knowledge cutoff" is Sept 2021

Source: Deutsche Bank, media headlines

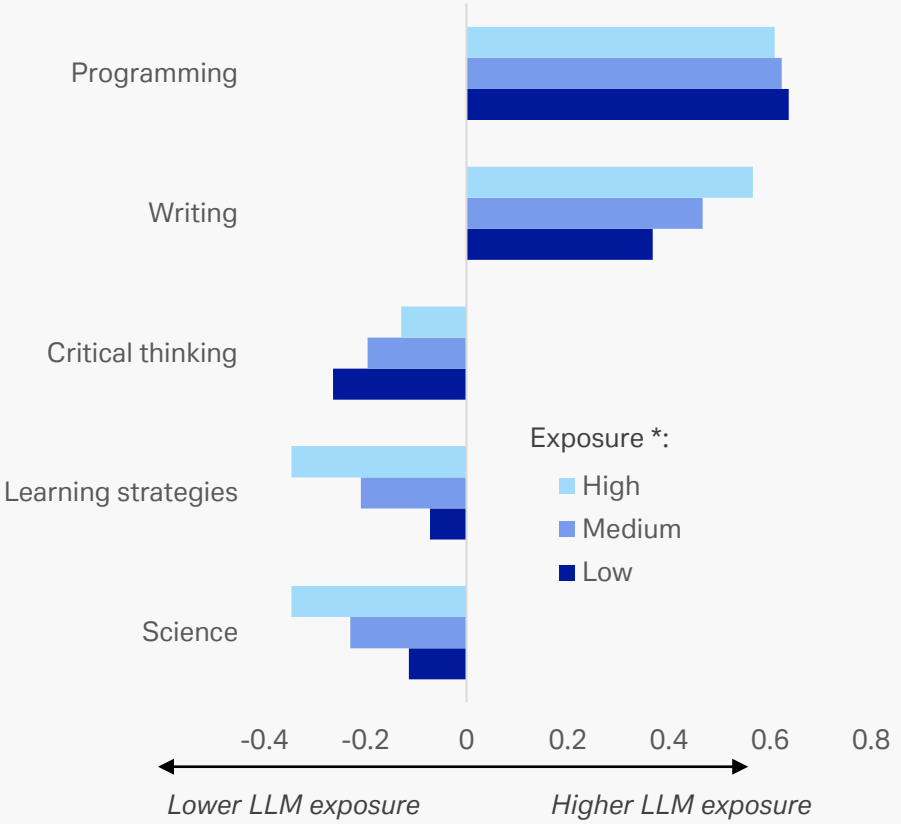
What job tasks will be most affected?

Roles will be "unbundled" with a net effect of new work tasks, many higher value; occupations requiring science and critical skills are less likely to be impacted by LLMs while programming and writing roles are more likely to be impacted

Effect of AI on 13 main tasks performed by customer service agents



Regression of occupation-level, human-annotated exposure to GPTs on skill importance



Source: Customer service example: "Radically Human", Paul Daugherty, H. James Wilson (2022); "GPTs are GPTs: An Early Look at the Labor Market Impact Potential of Large Language Models", Eloundou et al. (2023), Deutsche Bank. Note: Low exposure (alpha in the original study) - lower bound of the share of exposed tasks within a role; medium (beta)– exposure when using the technology via additional tools and applications needs additional investment; high (zeta) – upper bound of exposure to LLMs. See the paper for in-depth description.

How are corporates beginning to use generative AI?

Early adopters have often been individuals doing creative tasks and coding; big tech is now integrating AI into existing products; companies may delay rolling out pure AI solutions until they can ensure quality, reliability and governance

Six busy months of AI announcements and launches

Nov 2022
30: Open AI launches ChatGPT, built on the GPT-3.5 LLM

Jan 2023
23: Microsoft makes reported $10bn investment in OpenAI

Feb 2023
7: Microsoft launches new GPT-powered Bing search engine
24: Meta announces launch of lightweight LLaMA LLMs for researchers; it leaks a few days later and rapidly becomes the basis for numerous open-source uses

March 2023
14: OpenAI launches GPT-4, said in research to show sparks of Artificial General Intelligence; Anthropic launches Claude
21: Google begins widespread rollout of new Bard chatbot
21: Microsoft adds Image Creator to Bing

May 2023
2: Amazon said to be bringing AI chat capabilities to Alexa
10: Google presents AI-powered tools for Workspace inc "Help me write" for emails and image generation for Slides

Businesses that say they are using chatbots

Instacart: biggest US online delivery company
- Adding ChatGPT to shopping app, so customers can ask for recommendations for recipes, healthy food etc

WPP: world's largest marketing services company
- AI is "fundamental" to future business, used to create ad campaigns and develop personalised advertisements

Allen & Overy: one of London's "magic circle" law firms
- Using Harvey, built using OpenAI's GPT tech, to help come up with first drafts of legal documents

Zurich Insurance: Swiss insurance company
- Investigating using ChatGPT to extract data from claims descriptions and write code for statistical models

Duolingo: language learning app
- Launched Duolingo Max offering tailored language lessons and features to roleplay and explain answers

Salesforce: software-as-a-service pioneer
- Introducing ChatGPT to Slack platform to summarise conversations, answer questions and draft responses

Snap: maker of Snapchat app
- Launched My AI, a customised ChatGPT, for users

Mattel: US toymaker, owner of Barbie and Hot Wheels
- Using DALL-E 2 image generator to design new toys

Source: Media reports, company announcements, Deutsche Bank.

How fast will things change?

AI text may match the best human writing soonest, followed by code and images, with video games and movies potentially becoming "personalised dreams" by the end of the decade

	PRE-2020	2020	2022	2023?	2025?	2030?
TEXT	Spam detection Translation Basic Q&A	Basic copy writing First drafts	Longer form Second drafts	Vertical fine tuning gets good (scientific papers, etc)	Final drafts better than the human average	Final drafts better than professional writers
CODE	1-line auto-complete	Multi-line generation	Longer form Better accuracy	More languages More verticals	Text to product (draft)	Text to product (final), better than full-time developers
IMAGES			Art Logos Photography	Mock-ups (product design, architecture, etc.)	Final drafts (product design, architecture, etc.)	Final drafts better than professional artists, designers, photographers)
VIDEO / 3D / GAMING			First attempts at 3D/video models	Basic / first draft videos and 3D files	Second drafts	AI Roblox Video games and movies are personalized dreams

Large model availability: First attempts | Almost there | Ready for prime time

Source: Sequoia Capital blog post: "A timeline for how we might expect to see fundamental models progress and the associated applications that become possible. 2025 and beyond is just a guess"

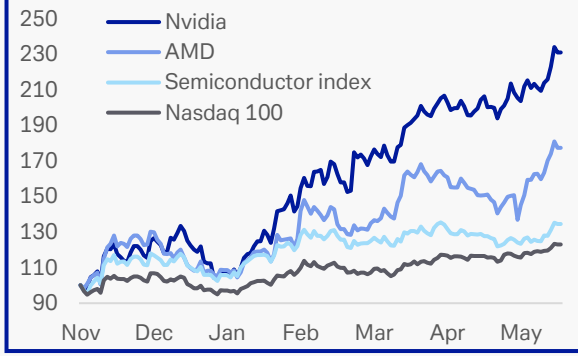
What are potential bottlenecks to AI development right now?

Some experts say that growth will slow as costs spiral and raw materials such as data and hardware become scarce

1. Access to GPUs

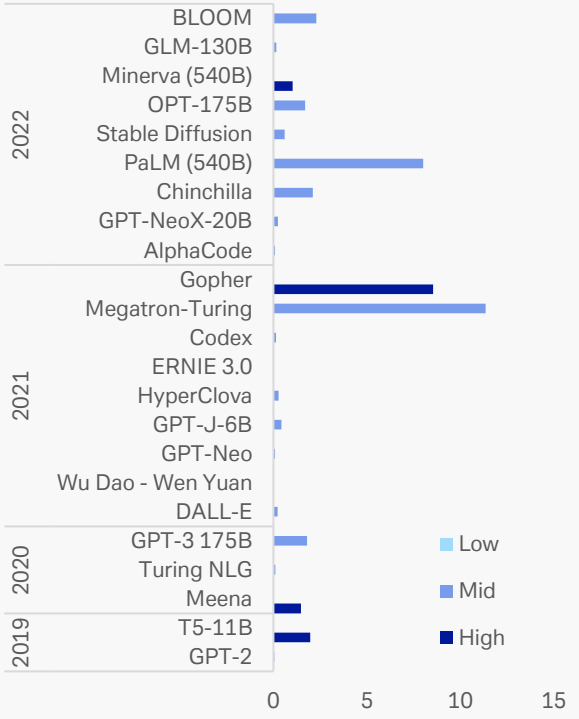
There is an acute shortage of GPUs, almost all of which are made by Nvidia, for supercomputers used to train LLMs. Lead times are at least nine months and more usually 18 months for the new H100 chip. The OpenAI supercomputer used to train GPT-4 reportedly uses 10,000 of the older Nvidia A100 GPUs.
H100s have a retail price of around $10k but can trade on the grey market for as much as $40k

Nvidia's stock has almost doubled since ChatGPT launch



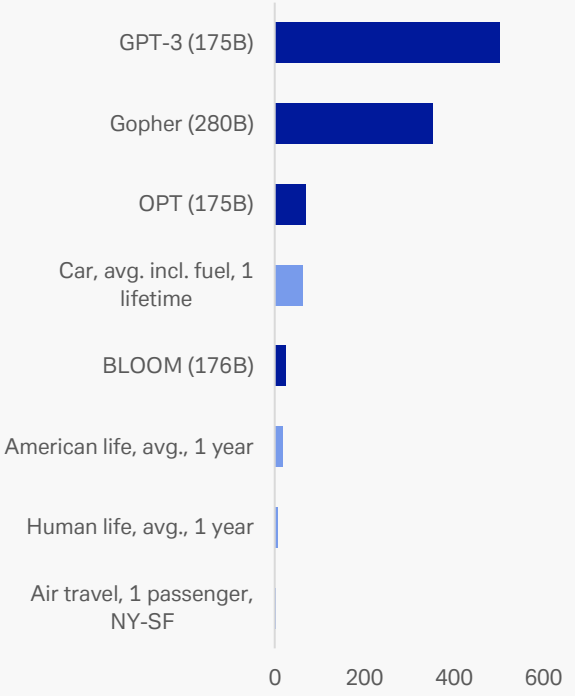
2. Cost of training

Estimated training cost of select large language and multimodal models, $mn *



3. Environmental costs

CO2 equivalent emissions (tonnes) by selected machine learnings models and real life examples, 2022

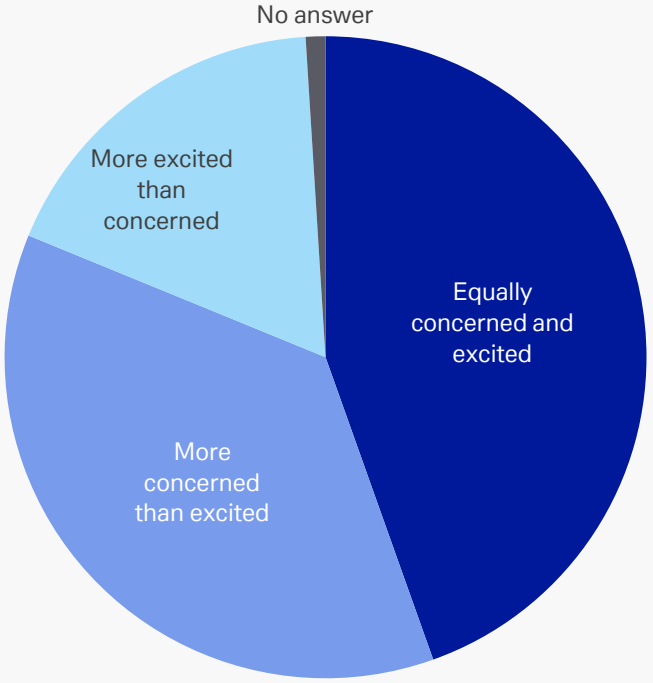


*Source: Bloomberg Finance LP; 2023 AI Index Report; Luccioni et al., 2022; Strubell et al., 2019; Deutsche Bank. * Note: low refers to potential underestimate, mid refers to what is believed to be a mid-level estimate and high refers to a potential overestimate.*

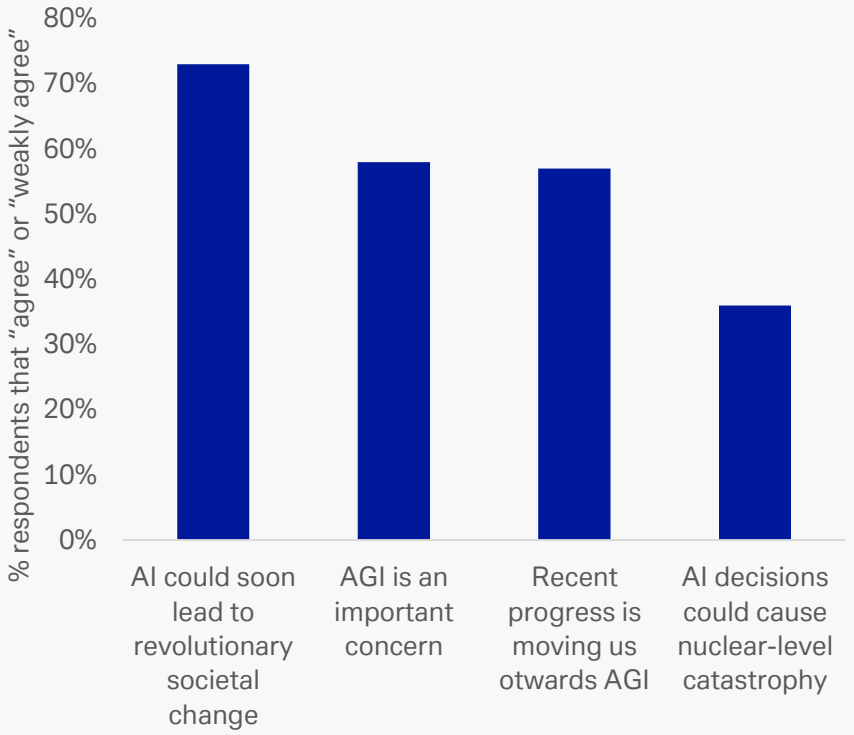
How do the general public and experts feel about AI?

Concerns outweighed excitement even before the launch of ChatGPT last November

Americans' feelings toward increased use of AI programs in daily life, 2022



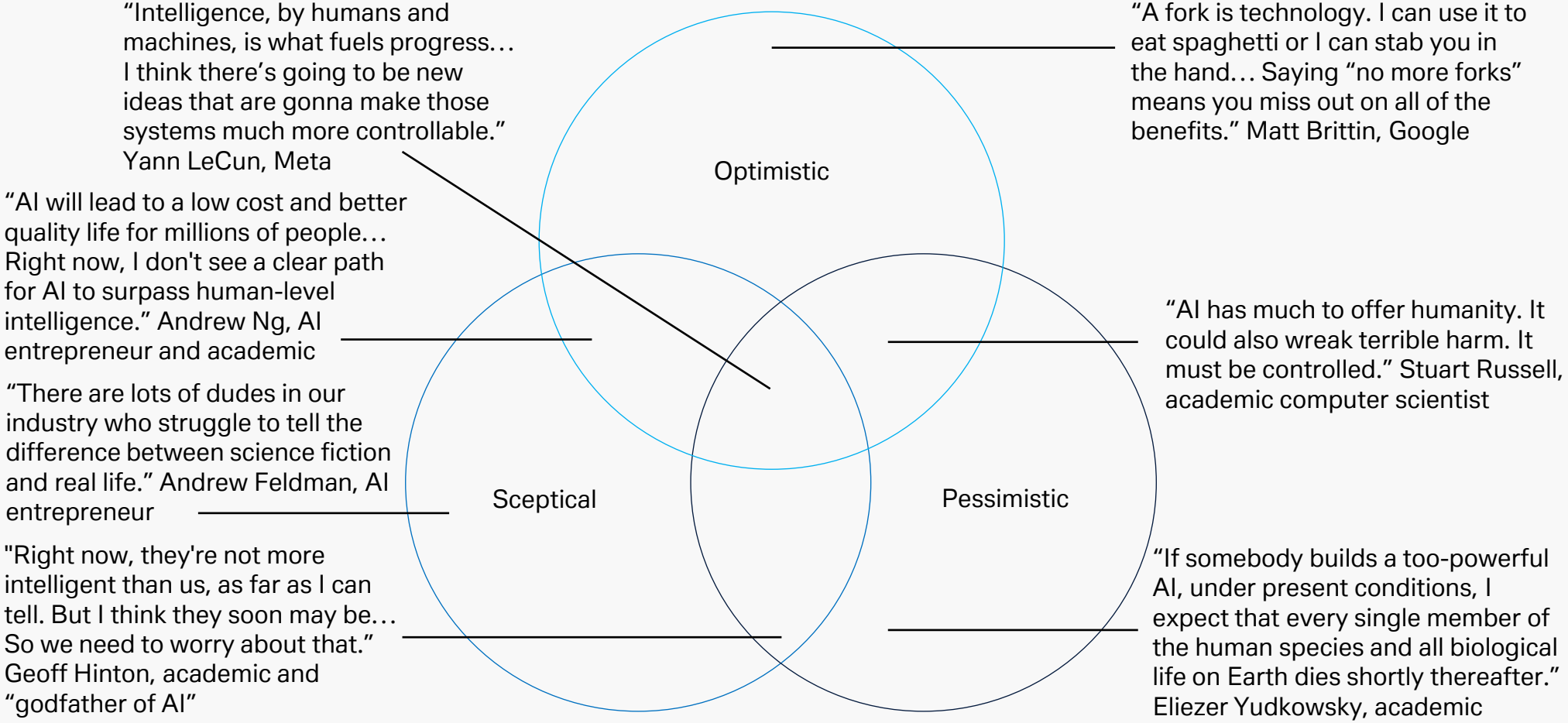
Artificial General Intelligence (AGI) and major risks, according to the natural language processing (NLP) community, 2022



Source: Pew Research, 2022; Michael et al. 2022; 2023 AI Index Report; Deutsche Bank.

Are we on the brink of Artificial General Intelligence? And is that good?

Experts differ widely between sceptics, who say AI is still rudimentary, despite appearances, and may never match human intelligence, and those who say AGI is imminent, for better or worse; there are also many overlaps



Source: Media reports, Deutsche Bank: NB: Categories are rough and flexible, for indicative purposes only. They reflect emphasis of specific quotes and may not fully reflect views of the speakers.

What are policymakers doing?

Governments and regulators are playing catchup with fast-evolving AI to set "guardrails" to regulate and oversee it without discouraging investment and innovation and losing a competitive advantage

Challenges

"Like trying to nail Jell-O to the wall." Bill Clinton, US President, 2000, on China's attempts to crack down on the internet

1) Technology still emerging

- Hard to predict future risk and benefits; new laws may be obsolete by the time are enacted

2) Lack of deep understanding

- Asymmetry between lawmakers/ public and industry/academia

3) Cross-sectoral application

- AI affects multiple industries with varying risks and impacts

Divergent approaches emerging

US/UK

- Light touch, risk-based regulation
- Applying existing regulations
- No new regulatory bodies
- Sector-specific, focusing on use of AI rather than the technology itself

European Union

- Multifaceted inc specific legislation
- Proposed AI Act in legislative process is detailed and prescriptive, eg classifying AI uses by degrees of risk; minimum requirements for AI systems; new national/EU bodies
- Builds on tech rules such as GDPR

China

- Piecemeal approach
- Focus on security, eg: mandatory security assessment for new products; must meet China's values

Notable developments

Jan

- US Dept of Commerce releases voluntary AI risk framework

March

- More than 1,000 tech leaders inc Elon Musk publish letter calling for "pause" in AI development
- Italy temporarily bans ChatGPT
- UK publishes AI policy paper calling for "pro-innovation approach"

April

- China's internet regulator proposes new rules applying to generative AI
- Reports that US Senator Schumer is developing AI regulation plan

May

- OpenAI CEO Sam Altman appears at US Senate hearing
- G7 leaders call for AI "guardrails"

Upcoming…

- Late 2023: EU AI Act set to pass

Source: Government and regulatory announcements, media reports, Deutsche Bank.

What happens next?

The rapid pace of eye-catching launches is likely to slow as the focus turns to refining and integrating the new tech into infrastructure, governance and culture; industry and governments will need to work together to avoid a backlash

Users

- Individuals: rapid adoption for personal/semi-professional use
- Companies: FOMO (fear of missing out) balanced by governance concerns; increasing use in customer services, data retrieval, content creation, coding
- General: increasingly sophisticated use of tech (eg plugins) and techniques (eg chained prompts through eg AutoGPT for complex multi-step tasks)

App developers

- Explosion in new applications built on top of LLMs
- Trying out of open-source models, fine-tuned and stacked for specific tasks

LLM developers

- Race to offer integrated enterprise solutions with reliable, ringfenced data
- Further advances in 1-trillion+ parameter multimodal LLMs, notably GPT-5, rumoured to finish training by year-end and to have video capabilities
- Parallel advances in open-source lightweight alternative LLMs that offer similar performance to large models, trained more efficiently and cheaply with pruned datasets, and that users can run on their own hardware

Hardware

- Ongoing pressure on supplies of key GPUs and networking equipment

Regulators and society

Widening anxiety threatening a potential backlash with concerns about:

- Jobs: some white-collar jobs will be enhanced while others may be at risk
- Education: eg UK teacher coalition warned in May of "severe" threat
- Privacy: Spain, Canada and others have considered or started probes
- Truth: US presidential election in 2024 will be a litmus test of AI-enabled hyper-personalised campaigning and potential misinformation by "bad actors"
- Ethics: "alignment" to human values

Pressure to legislate and retrain

- Policymakers caught between desire for popular precautions and a "race to the bottom" to encourage home-grown development and use
- Governments will be urged to provide financial and educational safety nets for those displaced by AI to mitigate social upheaval

Source: Deutsche Bank.

Appendix 1
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*Other information available upon request

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Adrian Cox, Jim Reid, Galina Pozdnyakova

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