Thematic Investing

Me, Myself and AI - Artificial Intelligence Primer

Thematic Investing

This is a redaction of a 97 page report published on February 28, 2023.

'If data is the new oil, then AI is the new electricity'

More data is created per hour today than in an entire year just two decades ago, and global data is expected to double every 2 years. We are entering the age of the Yottabyte, but still, only 1% of global data is being captured, stored and used. This is about to change. We are at a defining moment – like the internet in the '90s – where Artificial Intelligence (AI) is moving towards mass adoption, with large language models like ChatGPT finally enabling us to fully capitalize on the data revolution.

The iPhone moment for AI

Until now AI could only read and write but could not understand content. Generative AI models like ChatGPT has changed this, enabling machines to understand natural language, and produce human-like dialogue and content. 4 reasons why this could be the 'iPhone moment' for AI: (1) democratization of data; (2) unprecedented mass adoption; (3) warp-speed technological development; and (4) abundance of commercial use cases.

Democratization of data. ChatGPT empowering people.

Large language model (LLM) based chatbots like ChatGPT democratize data and make it accessible to all without the need for training or experience. Thus, mass adoption is unprecedented. It took ChatGPT just 5 days to reach 1 million users, 1 billion cumulative visits in 3 months and an adoption rate which is 3x TikTok's and 10x Instagram's. The technology is developing exponentially. In the last decade, computing power to train the AI datasets doubled every 3 months, outpacing Moore's Law by a factor of 6x. In the past 4 years the number of parameters for large language models grew 1,900x. And within a decade, AI models could be 1 million times more powerful than ChatGPT today.

$15.7tn for GDP, $900bn market, $8tn mcap enablers

By better capitalizing on data, AI could boost the world economy by up to $15.7tn by 2030 (PwC). Furthermore, the global AI market, which includes software, hardware and services, could reach $900bn by 2026E (IDC). Every sector will be impacted, but the immediate beneficiaries include tech hardware (semis, GPUs, data centres), software (cloud, analytics) and cyber (phishing).

Challenges: ESG

What's not to like? Training a single AI model could emit as much as 5x the lifetime emissions of an average car. Concerns also remain on ethics, copyright, accuracy, and 'hallucination'. Heavy text and service-based industries' unemployment could also increase inequality.

Artificial Intelligence in 4 Charts

Exhibit 1: Everything you wanted to know about AI in 4 charts
We are entering the fifth industrial revolution with the global AI market expected to grow to $900bn by 2026E and total private investments doubling between 2020-21. The number of large language model parameters have grown nearly 2000x in the past 4 years and since its launch ChatGPT has had over 1 billion cumulative web visits
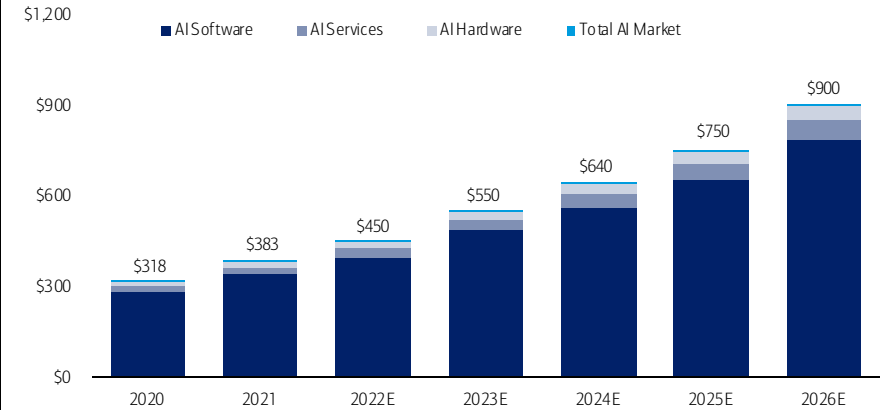
The fifth industrial revolution involves the combination of humans and machines at work
The five waves of industrial revolution
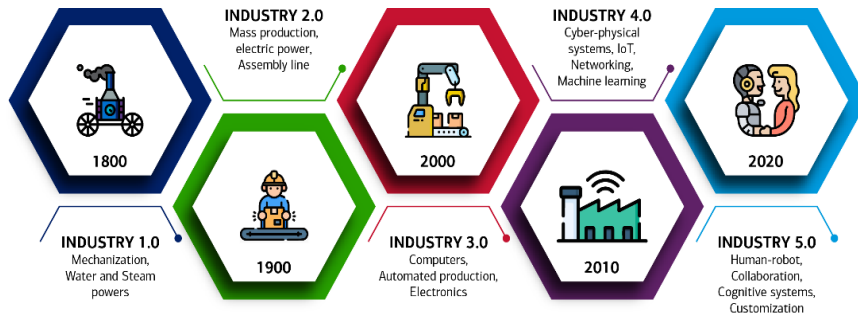
Global AI market is expected to grow at 19% CAGR to reach US$900bn by 2026E
Global AI market size (US$ bn)

Since its launch on 11/30/22, ChatGPT had over 1bn cumulative web visits up to and including 2/5/23.
Daily total visits to ChatGPT
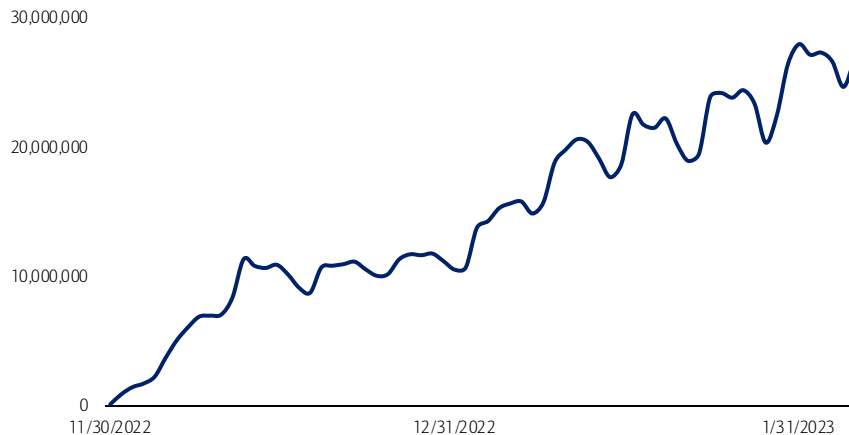
Global private investment in AI totalled US$93.5bn in 2021, more than double the total private investment in 2020
Global corporate investment in AI by activity type, 2013-21 (US$ bn)
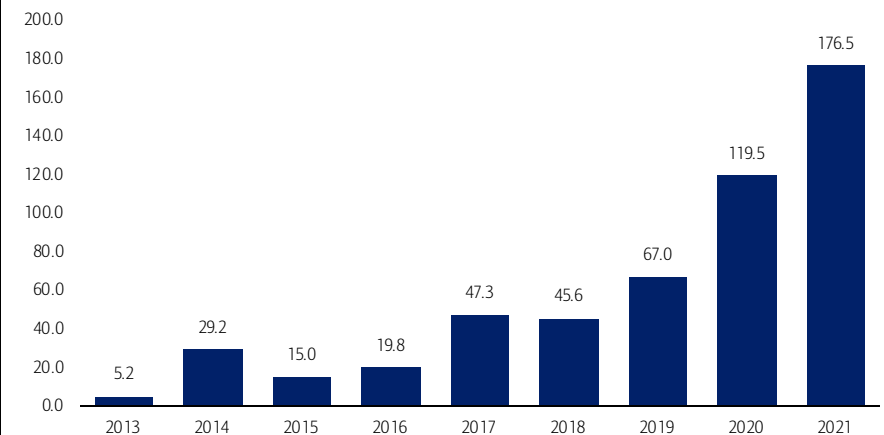
Source: 1) BofA Global Research, KnowHow; 2) BofA Global Research, IDC; 3) SimilarWeb; 4) NetBase Quid, 2021 and 2022 AI Index Report

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ChatGPT FOMO – BofA Proprietary Data

Exhibit 2: 5 days from launch ChatGPT reaches 1mn users vs 14 days for TikTok
Daily unique visits to ChatGPT and cumulative TikTok downloads after their launches

Source: BofA Global Research, *Similarweb, **SensorTower

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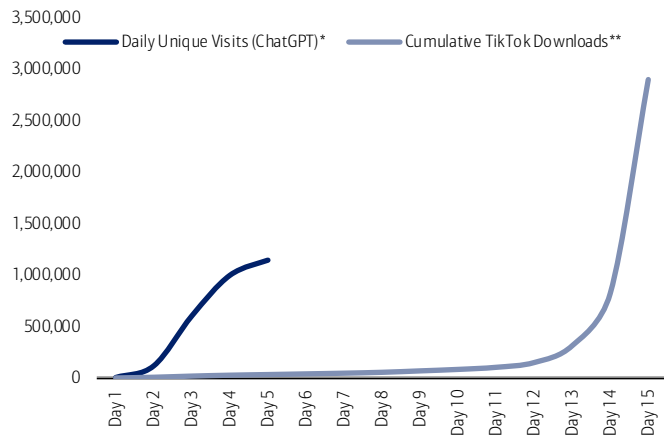
Exhibit 3: Conversations about ChatGPT have overtaken those on inflation on Twitter by 53%
Seven day moving average of the phrases 'inflation'/'#inflation' and 'chatgpt'/'#chatgpt' on Twitter
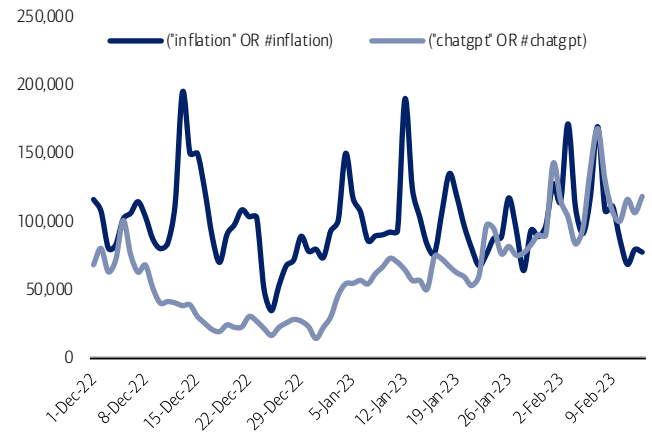
Source: BofA Global Research, ListenFirst

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Exhibit 4: Subscriber numbers have increased 191x since 4 December 2022
Subscribers on Reddit (r/chatgpt)
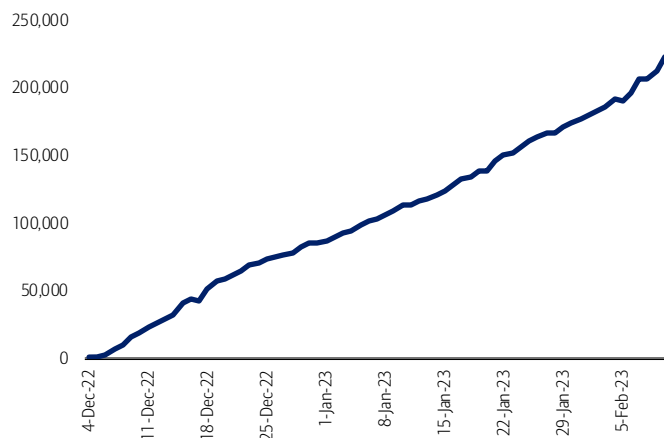
Source: BofA Global Research, ListenFirst

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Exhibit 5: The US takes the largest market share of web traffic to ChatGPT of 12.3%
Market share of web traffic to ChatGPT (chat.openai.com)

Source: BofA Global Research, SimilarWeb

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How will AI impact industry?

Exhibit 6: Likely key winners and losers from Artificial Intelligence/Machine Learning/Large Language Models
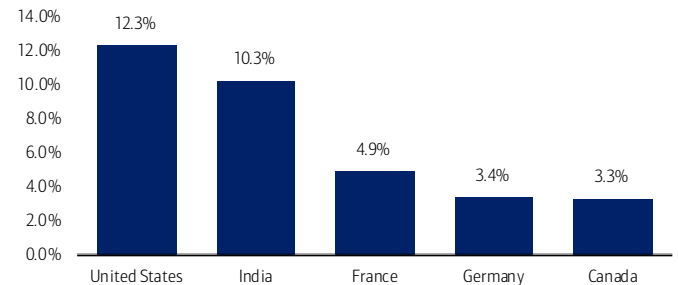An analysis of how AI/ML/LLMs will likely impact industry

Industry	Impact	Comments
IT		
Software development	++	AI or large language models (LLMs) can help developers write code for program applications and software. It can also debug code and suggest improvements.
Semiconductors	++	The emergence of AI and LLMs could represent one of the strongest upcoming drivers of semis. Computational requirements for running AI models are increasing due to the processing power needed to train them.
Data centres	++	As data continues to grow at an exponential rate, more data centres are required to store that data.
Cybersecurity	++	With the emergence of LLMs like ChatGPT, it is easier for threat actors with limited programming skills to generate code for cyberattacks e.g., legitimate-sounding phishing emails. Hence, ChatGPT and similar models are likely to have broad-based implications on the cybersecurity sector in terms of email security, identity security, and threat detection.
Search engines	++	Traditional search engines could be replaced by chatbot applications like ChatGPT, however, it is likely that search engines are going to be used in conjunction with generative AI to improve the user experience.
Communication services		
Education	++	LLMs could drive online learning, writing textbooks and providing online learning modules.
Media	++	LLMs can be used for content generation e.g., writing news articles, social media posts, marketing content, story-writing, summarising text, media planning and advertising.
Music	++	AI and LLMs can be used to transpose music, generate melodies, chord progressions and lyrics. It can even analyse music and generate reviews and comparisons.
Legal	++	LLMs can write legal documents and summarise legal cases. ChatGPT is even capable of writing legal essays that passed law exams.
Healthcare		
Telemedicine	++	AI can help doctors make more data-driven decisions that improve the patient experience. It can be used for remote patient monitoring, population health management using predictive analytics, reminding patients of health appointments, training junior doctors and providing more accurate patient diagnoses.
Pharmaceuticals	++	AI can help with the initial screening of drug compounds to predict its success rate. It can further identify the right candidates for trials based on their medical history.
Financials		
Banks	++	AI can help analyse the data that banks, diversified financials and insurance companies have to conduct predictive analysis. AI could analyse an individual's credit history and calculate the likelihood of default. These companies can also retain customers for longer by providing additional services based on their spending and financial activities.
Fintech	++	AI can help fintech companies automate the credit risk assessment process, detect bank fraud, increase safety, automate the customer service experience and analyse user behaviour.
Capital Goods		
Aerospace	+	Aerospace companies can use AI to improve fuel efficiency by using recorded data and optimising fuel consumption.
Defence	+	AI-powered weapons could be the focus point of the next arms race. In addition, image and video recognition could be used for surveillance. This could increase national general security while reducing human intervention.

Source: BofA Global Research estimates. NOTE: *++ large positive impact; +positive impact

Executive summary – all the answers you need

Key acronyms

- AI = Artificial Intelligence

- ML = Machine Learning

- DL = Deep Learning

- LLM = Large Language Model

- NLP = Natural Language Processing

- GPT = Generative Pretrained Transformer

- GPU = Graphics Processing Unit

- TPU = Tensor Processing Unit

Q: What is Artificial Intelligence and what are the key technologies?

Artificial Intelligence (AI) leverages large data sets and uses algorithms to find underlying relationships, which can be used to drive new or better business outcomes. Some of the key AI technologies include machine learning, deep learning, predictive analytics, natural language processing and machine vision.

Q: Algorithms, Machine Learning, Deep learning. What is the key difference?

A: Algorithms (= set of instructions) can be used for machine and deep learning

An algorithm is a finite set of instructions that is used to solve a well-defined computational problem. Algorithms can be used to carry out machine and deep learning. Linear regressions and logistic regressions are some examples of machine learning algorithms.

Machine learning is a subdivision of AI that uses computerised mathematical algorithms, which can learn from the data and teaches itself to progress as the data keeps fluctuating. Put differently, rather than having humans write programmes, computers themselves determine programme functions from the data. Machine learning algorithms automatically apply mathematical calculations to big data to learn from past data to produce repeatable and reliable decisions and results, e.g., improved video suggestions based on past video viewing activity. In general, with machine learning, if the data is of the same type, then increasing the amount of data will result in an improvement in the accuracy of output.

Deep learning is the subset of machine learning and includes algorithms inspired by the function and structure of the brain called artificial neural networks. Deep learning's strength stems from the system's ability to ascertain additional data relationships that are difficult to identify. After sufficient training, the network of algorithms constantly improves predictions or interpretations, e.g., improved product rankings based on relationships of data that humans cannot easily identify.

Q: What is the economic potential of AI?

A: Up to US$15.7tn by 2030

AI could contribute up to US$15.7tn to the global economy by 2030 (source: PwC), while open data (data that anyone can access, use and share) has the potential to unlock US$3.2-5.4tn in economic value annually via, for example, reducing emissions, increasing productivity, and improving healthcare (source: McKinsey). According to IDC, global revenues for the AI market, including software, hardware, and service sales, will grow at a CAGR (2022E-26E) of 19% to reach US$900bn by 2026. Big Data and AI could double

the gross value added (GVA) growth rates of developed markets by 2035E and add 0.8-1.4ppt to global productivity growth in the long run. The Big Data ecosystem will have tremendous positive impacts on society and over half the benefits could be captured as consumer surplus and public benefits rather than corporate profits.

Q: How much funding is there for generative AI?

A: A lot! Investor and corporate funding, government support, and Gen C

Investor funding increased 71% YoY in 2022 from US$1.5bn to US$2.6bn. Even global private investment in AI increased 48% YoY in 2021 to US$93.5bn, more than double the total private investment in 2020. In February 2023, Google announced a US$300mn investment in the AI startup, Anthropic. Governments around the world are increasingly seeking to promote and provide funding for AI development and innovation e.g., in 2020, the US passed the IOGAN ACT (Identifying Outputs of Generative Adversarial Networks Act), which directed the National Science Foundation to support research on generative adversarial networks and other relevant technology.

As the population ages and Gen Zs and Gen Cs make up a larger portion of the population, AI adoption should increase too because these two generations, particularly Gen C, will be unable to live without tech in most aspects of their lives. By the end of 2021, Gen C numbered 700mn, or c.9% of the world's population. They are estimated to reach up to 2bn by 2025 or c.20% but will be smaller in size than Gen Z due to declining birth rates (source: Kinetics). In the case of ChatGPT and Bard, younger generations are more aware of them and see them in a more favourable light: 18% of Gen Zs know of them compared to only 6% of Boomers. Similarly, 15% of Gen Zs have a positive opinion about them compared to only 4% of Boomers.

Q: Large Language Models (LLMs): the next generation?

A: LLMs have become more advanced at processing human language

Large language models are models that use deep learning in natural language processing (NLP) uses. An LLM is a transformer-based neural network which predicts the text that is likely to come next. The performance of the model can be judged on how many parameters it has (i.e., the number of factors it considers when generating output).

Natural language processing (NLP) is the AI technology that enables machines to understand human language including slang, contractions, and pronunciations, and consecutively produce human-like dialogue and text. Natural Language Processing entails applying different algorithms to identify and extract natural language rules to convert the unstructured language data into a form that computers can interpret. A real-world example is improved results for voice search queries.

Since 2020, natural language systems have become more advanced at processing human language, particularly in terms of sentiment and intent. They can generate human-like text, and express understanding about an image through language (visual understanding).

Q: What is ChatGPT and why is it such a hot topic among investors?

A: ChatGPT is a chatbot that amassed 1mn users in just 5 days after its launch

ChatGPT is a chatbot, that can generate coherent human-like text. It is the first application of its kind that is openly available to a wide audience. Until now AI could only read and write but could not understand content. Generative AI models like ChatGPT changed that, enabling machines to understand human language, and consecutively produce human-like dialogue and content. Since its launch on 30 November 2022, ChatGPT has gained significant traction, amassing one million users after merely five days.

Q: What is the technology behind ChatGPT and why is it so ground-breaking?

A: Generative AI, LLM with 20bn parameters, built from scale and RLHF

The technology underpinning ChatGPT is a language model that uses machine learning and natural language processing to predict the next word in a sentence based on previous entries. Hence, ChatGPT is classified as a form of generative AI. ChatGPT is a variation of GPT-3, a large language model (LLM)

The second key differentiator is that this model is trained using reinforcement learning from human feedback (RLHF). This is where the model generates outputs that are labelled and calculated for some reward objective, such as to represent human preferences for how a task should be done or things to avoid (e.g., harmfulness).

Q: How can ChatGPT be used? What are the drawbacks to its capabilities?

A: Content generation, data extraction, but can produce incorrect answers

Since ChatGPT can generate human-like text, it can be used for content generation (e.g., writing essays, news articles, social media posts, marketing content, stories, music, emails), data extraction, summarising text, optimising web browsers, language translation and computer programming. Programmers are already using this technology for program generation (platforms that can give suggestions as one writes code e.g., GitHub Copilot) or to explain code or concepts.

However, ChatGPT can hallucinate (i.e., generate an incorrect answer with confidence). Furthermore, it is not able to make decisions or deal with too much memory/generation.

Q: What are the wider risks of this technology?

A: Automation in the workplace, cyberattacks, emissions, data misuse, IP

Since ChatGPT can generate human-like content, it is possible to introduce automation in sectors that are based on idea generation e.g., advertising, art and design, entertainment, music, media and legal. This would help drive the fifth wave of industrial revolution – the coexistence of humans and machines.

ChatGPT can respond to harmful instructions. Therefore, it could lower the barrier to entry for threat actors because it opens the door for more malware, phishing, and identity-based ransomware attacks. Cybercriminals have already found ways around ChatGPT's content filters and policies, which are meant to prevent malware-based code generation. ChatGPT can quickly produce authentic-looking emails to target an end-user's identity credentials. ChatGPT has broad-based implications for cybersecurity, particularly for email security, identity security, and threat detection.

To train models based on ever-increasing parameters, LLMs require a significant amount of energy and computing power. Training an AI model creates more 57x more CO2 emissions than a human generates in a year (source: College of Information and Computer Science at the University of Massachusetts Amherst).

The model could accidently reveal sensitive information and the output can be misused e.g., tracking individuals. If data is misused, then it could be the case that the model violates privacy laws e.g., the EU's GDPR.

Intellectual property is often overlooked before public release and is difficult to incorporate. It is currently a grey area, as there is currently nothing stopping companies from using AI-generated content beyond compliance. There are legal challenges between AI companies and stock photo companies, for instance, meaning that the regulation and permissions for citing content may change. Partnerships could arise between generative AI applications and traditional content generating platforms. Some large technology companies like Google have developed responsible AI principles to avoid unfair bias in AI models. However, incorporating fairness and preventing bias becomes difficult when training models with billions of parameters.

Q: Which areas are likely to be the most positively impacted by this technology?

A: Semiconductors, data centres, cybersecurity, software

Firstly, semiconductors are a likely beneficiary because the training of these LLMs requires significant computing power. Secondly, as data continues to grow at an exponential rate, more data centres are needed to store that data. Thirdly, since cyberattacks are more likely, the cybersecurity sector is likely to benefit, particularly email security, identity security and threat detection. Finally, software companies are likely to benefit due to the increased need to develop ChatGPT-like technology to support new products.

Q: Which sectors are likely to be disrupted by this technology?

A: Sectors using text data are likely to incorporate this tech to increase productivity

Any industry that uses text data might be affected by this technology e.g., call centres, legal searches, document writing, authoring, jobs involving spreadsheets, insurance and healthcare are areas that involve a large amount of text data.

It is important to bear in mind that AI and machine learning are *enabling* technologies. AI must be coupled with something to be useful. Hence, whilst these advanced language models could be disruptive to these sectors in terms of replacing jobs that involve relatively routine tasks, jobs in these sectors will not disappear altogether. They are likely to *incorporate* AI, allowing for greater productivity potential.

Search engines could become more conversational, embedded with language models. This would be a new user interface within search engines rather than a disruption of the search engine market in general.

Q: How can developers keep the data used to train these models up to date?

A: Linking the LLMs to external databases

Over time, language models can be linked to external databases, making them easier to update over time. WebGPT is an example which can use internet information to update the model and would need retraining only periodically. Data volume could be a constraint to LLMs where they could exhaust all public data, code, and text.

Q: How is the technology going to evolve?

A: Towards multimodality

This technology is likely to evolve beyond single applications (e.g., text and images) towards multimodality – for instance, using text, images, voice recordings as prompts to generate a response from the AI system. More proficient language model deployment could proliferate conversational tools into (e.g.) word processors, virtual video meetings and email systems to enable their onboarding for more users to interact via speech. Another application is that this technology could be used to generate entire programming applications rather than just being able to suggest or explain code.

There is debate on the competencies of AI chatbot systems; whether they could be applied to any industry vertical in their current capabilities and parameters, or whether they need to be verticalized to become more commercially useful. In the long term, LLMs may be general enough so that verticalization is no longer needed. However, in the short-term, LLMs may need to be domain-specific to achieve an increase in performance in the industries that intend to use them.

Q: What is the key differentiator between these LLM models?

A: Quality and size of underlying data

There is no technical difference in how technology companies are approaching LLMs. The key differentiating factor between these AI models is the quality and size of the underlying data used to train the models. Google DeepMind's Chinchilla research paper

suggests that more data is required and up to 5x more training of models to realise the benefits of their size.

Q: What are the barriers to entry?

A: Operating costs, computing power, talent, data implies large tech companies
Sectors that can combine computing power, data, and talent to enable AI could capitalise on the commercial opportunities. Operating costs (e.g., semiconductors, staff) could present a large barrier to entry. As the parameter size increases, costs increase too. A single search query in a GPT-like system can cost two to three US cents. This could be challenging to absorb when such models perform billions of queries a day. For this technology to be more viable, we would likely need a 10-20x improvement in efficiency, otherwise it would be too costly for entrants to deploy them commercially.

Reinforcement Learning from Human Feedback involves difficult engineering, as companies need to build their own. This problem is compounded by scarce talent: a small number of people know how to do this and work for a small number of companies.

Artificial Intelligence 101

AI – the fifth wave of IT-driven productivity growth

We believe that Big Data and AI (artificial intelligence) are propelling the fifth wave of IT-driven productivity growth (Exhibit 7).

Exhibit 7: The fifth industrial revolution involves the combination of humans and machines at work
The five waves of industrial revolution
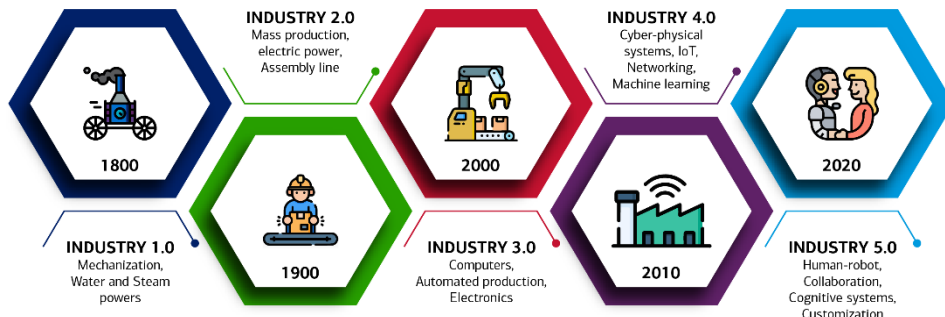
Source: KnowHow

According to IDC, global revenues for the AI market, including software, hardware and service sales, will increase at a CAGR (2022E-26E) of 19% to reach US$900bn by 2026 (Exhibit 8).

Exhibit 8: Global AI market is expected to grow at 19% CAGR to reach US$900bn by 2026E
Global AI market size (US$ bn)
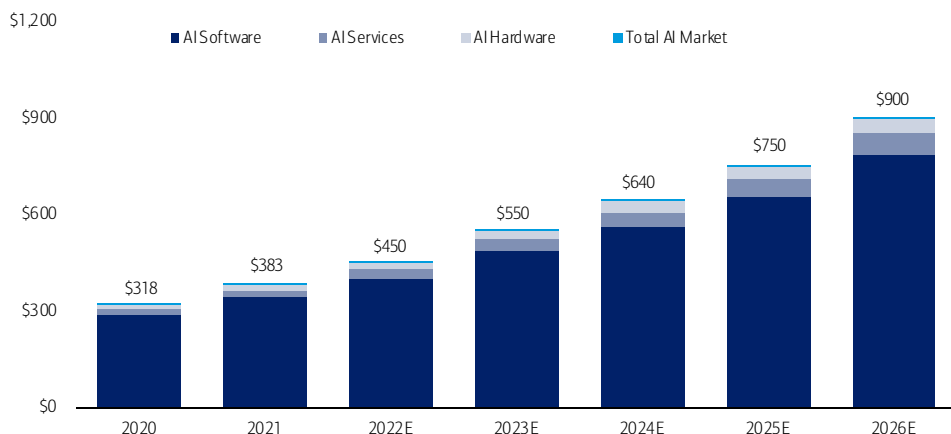
Source: BofA Global Research, IDC

Big Data and AI could double the gross value-added (GVA) growth rates of developed markets by 2035E and add 0.8-1.4ppt to global productivity growth in the long run. AI could contribute up to US$15.7tn to the global economy by 2030 (source: PwC), while open data (data that anyone can access, use and share) has the potential to unlock US$3.2-5.4tn in economic value annually via, for example, reducing emissions, increasing productivity, and improving healthcare (source: McKinsey).

The Big Data revolution needs to be analysed in tandem with AI since both form a virtuous circle. The rising size and complexity of datasets have posed challenges for traditional analytical approaches, and new tools such as AI play a vital role in helping us to derive new insights from the data. In turn, data-thirsty AI-based algorithms, such as machine learning and deep learning, are made "smarter" using large amounts of data to learn from. Big Data is being driven by a mutually reinforcing ecosystem of ubiquitous connectivity, cheaper storage, and faster compute, in combination with smarter algorithms.

AI +$15.7tn to global GDP by 2030

Positive economic potential

Most studies conclude that AI will have a significant positive economic impact.

Exhibit 9: Studies generally conclude that AI is likely to have a positive economic impact on GDP

Comparison of other studies assessing the impact of AI

	PwC	**McKinsey Global Institute**	**Accenture**
Global GDP	+14% in 2030 from 2018	growth +0.8% to +1.4%	growth doubled by 2035: US growth rate at 4.6% with AI instead of 2.6%
Channel of impact	Productivity (replacement and augmentation) Consumption	Labour substitution gains	Intelligent automation Labour and capital augmentation Innovation diffusion

Source: PwC, McKinsey Global Institute, Accenture

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According to Accenture, AI could double annual global economic growth rates by 2035. AI is likely to drive this in three different ways: firstly, AI will lead to a strong increase in labour productivity (by up to 40%) due to automation. Secondly, AI will be capable of solving problems and self-learning. Thirdly, the economy will benefit from the diffusion of innovation.

A study by PwC estimates that global GDP may increase by up to 14% by 2030 (or US$15.7tn) due to AI adoption via productivity gains in the manufacturing and transportation sectors, and due to businesses complementing their workforce with AI technology. This would enable the workforce to perform tasks better.

McKinsey estimates that AI may deliver an additional economic output of c.US$13tn by 2030, increasing global GDP by 1.2% per year. This is to come from the substitution of labour by automation and increased innovation in products and services. AI is likely to create a negative externality in the labour market whereby there is a loss of domestic consumption due to unemployment.

Channels of AI impact

We discuss ways (ITU, 2018; PwC, 2018) in which AI could impact the economy via production, externalities, and demand.

Production channels:

- **Augmentation:** AI may change the *Future of Work*, reshape existing jobs and augment human capabilities enabling workers to be more productive.

- **Substitution:** AI could substitute factors of production e.g., labour since repetitive tasks can be automated.

- **Innovation:** Investment in AI can produce economic output through developing new products and services.

Externality channels:

- **Economic gains from increased global flows:** digital data is a large proportion of international flows in the form of knowledge and information exchange. AI can facilitate more efficient cross-border commerce. Gartner (2017) estimates that AI-based recommendation engines can contribute c.30-40% of sales in leading e-commerce players.

- **Wealth creation and reinvestment:** increased output from efficiency gains and innovation can be passed on to workers in the form of higher wages and to firms in the form of profits. Wealth generation could create spillover effects that increase economic growth.

- **Transition and implementation costs:** AI adoption may incur costs e.g., severance pay, integration costs, hiring new workers to operate AI.

- **Negative externalities:** AI could displace workers; hence the increased economic activity may cause decline in labour share which puts pressure on employment and wages and could decrease consumption. Furthermore, government support for affected workers may be required.

Of these seven channels of impact, according to ITU (2018) three stand out. The **substitution of labour** could add c.11% or c.US$9tn to global GDP by 2030. **Innovation in products and services** could deliver c.7% or c.US$6tn of potential GDP by 2030. **Negative externalities** could reduce the gross GDP impact by c.9ppts or c.US$7tn.

Demand channels:

- **Consumption:** increased consumer demand resulting from the availability of higher quality AI-enhanced products and services. PwC (2018) finds that c.58% of the 2030 GDP impact (or US$9.1tn) is likely to come from the consumption impact.

- **Product personalisation:** AI can enable more efficient discovery of consumer preferences by gathering more data and analysing it. Increased product personalisation can increase the marginal utility of consumption for a given product and increase the variety of products available for consumers.

- **Product quality:** In facilitating better product personalisation, the value of the product can increase too.

- **Time:** AI and AI-enabled products could save consumers time and lead to greater consumption. Gartner predicts that in 2018, half a billion users will save two hours a day due to AI.

Global GDP could by up to 14% higher in 2030 (+US$15.7tn) vs 2018 due to AI (source: PwC Analysis). Looking at a breakdown of this increase, demand-side effects are more delayed but increase significantly over time. This is due to the longer transmission mechanism from product enhancements to consumption. 58% of all GDP gains in 2030 will come from consumption-side impacts.

North America and China, the expected key winners

North America and China could see the biggest economic gain in percentage terms from AI (source: PwC, 2018). PwC estimates that AI will enhance GDP by 26.1% in China and 14.5% in North America in 2030, which accounts for c.70% of the global impact. This is because North America has advanced technological and consumer readiness for AI which enables a faster effect of AI on productivity and overall, a larger effect by 2030. For China, this is because productivity and product enhancements GDP effects are higher than other regions.

All sectors of economy to experience gains from AI

Across the board, there are GDP gains associated with productivity and product enhancements. The services industry (health, education, public services and recreation which is labelled as 'Other public and personal services') is set to gain the most (GDP +21% by 2030). Transport and logistics, and financial and professional services are estimated to see smaller GDP gains of 10% each due to AI.

The services industry is the sector that stands to gain the most. This is mainly due to the healthcare sector, which should see greater personalisation and quality improvement in the medical advice. Healthcare professionals could improve the patient experience by using virtual assistants and camera-based healthcare apps in diagnosing medical conditions.

The distribution of impact across sectors remains consistent across different regions.

What is the outlook for AI?

Government support of artificial intelligence: legislation and initiatives

Governments around the world are increasingly seeking to promote and provide funding for AI development and innovation. The US is dominating the list of countries with 13 AI-related bills passed into law between 2016 and 2021 (Exhibit 10), but the UK is taking the lead in terms of number of mentions Exhibit 11.

For example, in 2020, the US passed the IOGAN ACT (Identifying Outputs of Generative Adversarial Networks Act), which directed the National Science Foundation to support research on generative adversarial networks and other relevant technology. As another example, in 2020, the UK passed a provision (c.13) of the Supply and Appropriation (Main Estimates) Act 2020. This provision authorised the Office of Qualifications and Examination Regulation to explore the opportunities for AI to improve marking for important qualifications.

Exhibit 10: The US has taken the lead in the number of AI-related bills passed into law
Number of AI-related bills passed into law, 2016-21 (aggregate)
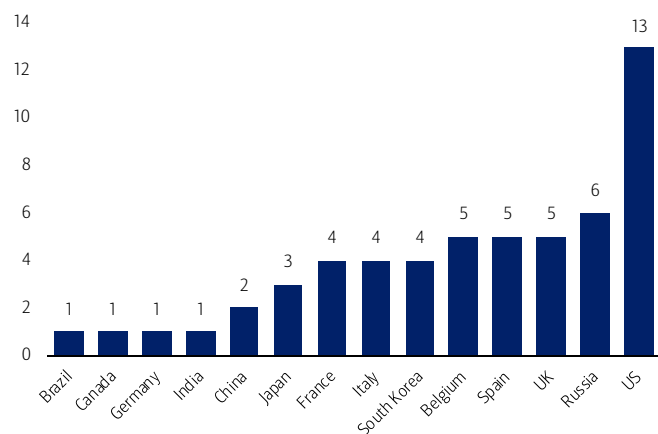
Source: 2022 AI Index Report

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Exhibit 11: The UK has had the highest number of mentions in legislative proceedings in recent years
Total mentions of AI in legislative proceedings, 2016-21 (aggregate)
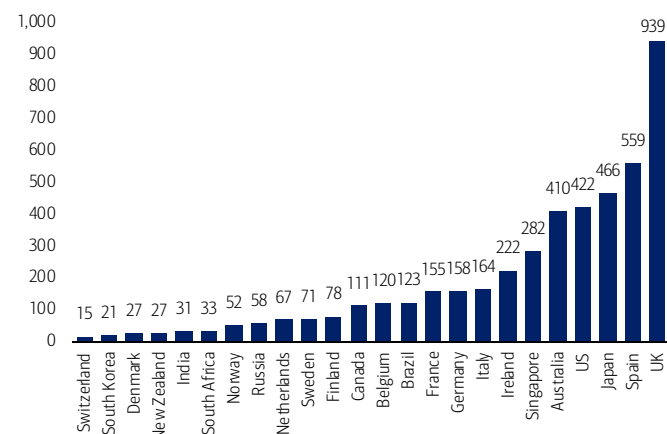
Source: AI Index, 2021

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Examples of governmental initiatives that support the development of AI:

- **USA:** The White House is launched a partnership with India on 31 January 2023 which Biden hopes will help both countries compete against China on military equipment, semiconductors and artificial intelligence.

- **China:** The Chinese government's policies on AI include 'Made in China 2025', 'Action Outline for Promoting the Development of Big Data', 'Next Generation Artificial Intelligence Development Plan', *inter alia*. China aims for its core AI industry to have surpassed RMB400bn (c.US$59bn), with AI-related fields exceeding RMB5tn (c.US$740bn).

- **UK:** The UK's National AI Strategy published on 18 December 2022 outlines the government's 10-year plan to make Britain a global AI superpower. The UK government has invested more than £2.3bn into AI across many different initiatives since 2014. For example, investments include:

  o contributing to The Alan Turing Institute and over £46mn to support the Turing AI Fellowships to develop the next generation of top AI talent.

  o opening 16 new AI Centres for Doctoral Training at universities across the UK, backed by up to £100mn and delivering 1,000 PhDs over five years.

      o   £250mn to develop the NHS AI Lab at NHSX for the safe adoption of AI in healthcare.

- **India:** The Indian Government has published the National Strategy for Artificial Intelligence which aims to develop an eco-system for the research and adoption of AI.

Growing Gen C could speed up AI adoption

As the population ages and Gen Zs and Gen Cs make up a larger portion of the population, AI adoption should increase too because these two generations, particularly Gen C, will be unable to live without tech in most aspects of their lives. Even 40% of Gen Z social interaction is online.

By the end of 2021, Gen C numbered 700m, or c.9% of the world's population, estimated to reach up to 2bn by 2025 or c.20%, but will be smaller in size than Gen Z due to declining birth rates (source: Kinetics).

Exhibit 12: A third of the global population is Gen Z and 9% is Gen C
Share of the global population by generation
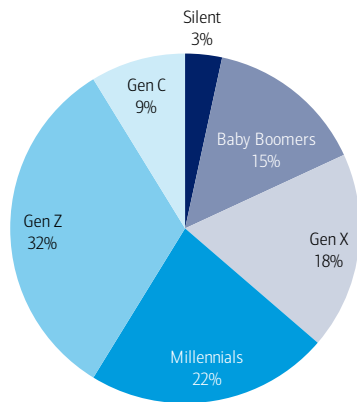
Source: UN

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Exhibit 13: Gen C accounts for 700mn people
Global population (millions)
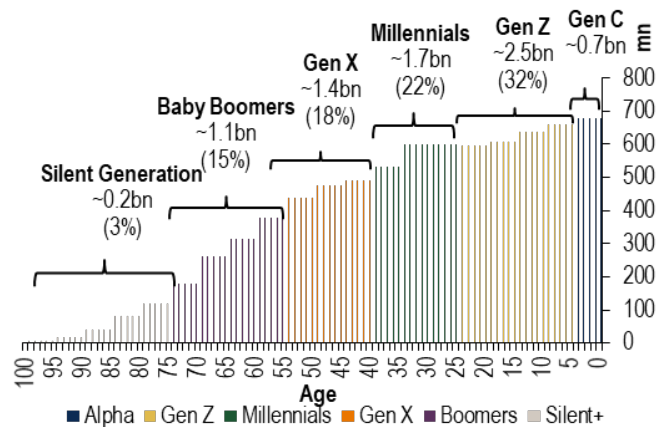
Source: UN

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Gen Z and Gen C will be more open to AI adoption compared to older generations. Even in the case of ChatGPT and Bard, younger generations are more aware of them and see them in a more favourable light: 18% of Gen Zs are aware of the two compared to only 6% of Boomers. Similarly, 15% of Gen Zs have a positive opinion about them compared to only 4% of Boomers.

Wider risks: automation, cyberattacks, ethical concerns, emissions

Unclear overall impact on labour: creation vs automation

Don't underestimate humans' ability to one up technology

There are areas where humans can beat machines. In the future, we believe there will likely be an increasing premium for jobs within occupational groups that require social intelligence, creativity and complex problem solving as opposed to repetitive, low dexterity skills. For instance, an event planner requires more social intelligence than a dishwasher in hospitality, fashion designers require more creativity than a seamstress in apparel, and a medical surgeon requires greater perception and manipulation of tasks than a clinic receptionist within healthcare. Furthermore, a recent study by McKinsey flags that ultimately it is *activities* rather than *jobs* that are being automated where US$2tn in wages or 45% of work activities in the US could already be automated with existing technologies.

Sectors with more routine/manual tasks and limited training/education required more at risk of automation

PwC estimates that 326mn jobs will be impacted by AI in 2030 where 67% of these jobs are likely to be 'unskilled' jobs. In terms of sectors, Transport and Logistics is a sector that is likely to see the largest percentage of jobs at risk: averaging c.39% across all regions. On the other hand, other public and personal services have the lowest percentage of jobs at risk (average of c.15% across all regions). The two key factors driving this result is 1) the proportion of time spent on routine and manual tasks and 2) the amount of training and education required for jobs in those sectors. The Transport and Logistics sector could have relatively more day-to-day tasks that can be automated e.g., conducting document checks at customs to ensure a smoother process. In contrast, the Other public and personal services category includes healthcare which involves a relatively larger amount of human judgement e.g., performing surgery and diagnosing patients.

....but don't disregard the risk from robots either

COVID has hastened the adoption of technologies such as AI, chatbots, robot process automation (RPA) in white collar roles and industrial robots in blue collar jobs – all of which we estimate could displace 2 billion jobs by 2030. Up to 47% of US jobs could be at risk over the next 20 years from computerization. And in Emerging Markets, this figure could reach 85%.

Machines have their limits: premium for jobs with intelligence and creativity

Workers should look towards tasks with skillsets that robots and computers cannot easily accomplish in the next 10 to 20 years. For instance, dexterity is something that current robot hardware technologies have not yet mastered. There will likely be an increasing premium for jobs that require social intelligence, creativity, and complex problem-solving.

New jobs are likely to come from health, STEM and managerial roles

AI could also create new jobs, particularly with regard to training and maintaining the AI technology. The net result on the labour market depends on the number of jobs created versus the number that are automated.

Job market: automation

Since ChatGPT can generate human-like content, it is possible to automate tasks, hence displacing certain tasks. It could impact the advertising, art and design and entertainment sectors. Health and Science are least likely to experience automation but Manufacturing and Transportation the most.

The differences in impact across sectors can be explained by the potential incremental value from AI over other analytics techniques. The more science-based sectors like Aerospace and Defense, Semis, Pharmaceuticals and Healthcare could see relatively some of the lowest potential incremental values from AI. Hence, these sectors are less likely to experience job displacement by ChatGPT or similar generative AI programs.

In more than two-thirds of use cases, AI can improve performance beyond that provided by any other analytics techniques, which explains why on average, sectors are likely to experience job displacement.

Cyberattacks: could be used to generate malware

ChatGPT may lower the barrier to entry for cybercriminals

ChatGPT lowers the barrier to entry for threat actors and opens the door to more malware, phishing, and identity-based ransomware attacks. Cybercriminals have already found ways around ChatGPT's content filters and policies, which are meant to prevent malware-based code generation. Phishing attacks are another key attack vector in focus, as ChatGPT can quickly produce authentic-looking emails to target an end-user's identity credentials.

Implications for the cybersecurity sector

Human-written defensive software may not be enough to combat AI-generated malware which has drastic implications for cybersecurity. Our US Aerospace and Defense Electronics colleagues have a negative outlook for ChatGPT in terms of cybersecurity: The weakest link in the cybersecurity chain, regardless of how much companies spend, are the human users. Forbes reported cybercriminal have already caught on to these use cases and showcased malicious code written by ChatGPT which can be used to exploit victims.

AI: Did You Know?

Artificial Intelligence...is intelligent!

- The intensity of just one day's worth of AI training is equal to 150 years of gaming training for a human.

- 44% of UK adults do not properly understand how AI works...[2]

- ...but 51% of Europeans would like to replace their politicians with AI...[3]

- ...and 49% of people prefer interactions with AI based chatbots, rather than other humans.[4]

- The human brain operates at 1 exaFLOP, which has the equivalent processing power of 1 billion*billion calculations per second.[7]

- And the computing power of 1 exaflop is equivalent to every human on Earth doing a calculation per second for 4 years.[4]

- Training a single AI model could emit about 626,000 pounds of carbon dioxide or 5x the lifetime emission of an average car.[8]

- But computing efficiency has actually improved in the past 6 decades where the energy demand for a fixed computational load has halved every 18 months.[9]

- At over 8 billion, there are now more AI digital voice assistants than people on the planet.[12]

- OpenAI Five plays 180 years' worth of video games against itself everyday via self-reinforcement learning.[14]

Sources: [2] Express, [3] IE University, [4] BBC, Stanford University, Microsoft Research, [7] Science ABC, [8] University of Massachusetts, [9] MIT Technology Review, [10] World of Statistics, [11] SimilarWeb, [12] Statista

Big Data: Did You Know?

Big Data…is big!

- By the time you finish reading this sentence, c.231mn emails and 6bn searches on Google and 69mn WhatsApp messages will have been sent and 500 hours of video will have been uploaded on YouTube.[1]

- We will generate more data in the next 2 days than all the data created between the dawn of humanity and 2000.[2]

- … and 90% of global data was created in the last 2 years.[3]

- Every person generates 1.7 megabytes…every second![4]

- Every day we generate 2.5 quintillion (million trillion bytes of data).[5]

- And data creation is doubling every 2 years.[6]

- Each person will generate enough health data in their lifetime to fill 300mn books, or to fill the NY public library 6x.[7]

- Genomic data is the fastest-growing database in the world. By 2025, genomic data will surpass YouTube and Twitter combined.[8]

- Machine-generated data accounted for over 30% of internet data in 2020.[9]

- Cloud data storage around the world will amount to 200+ Zettabytes by 2025.[10]

- If you burned all the data created in just one day onto DVDs, you could stack them on top of each other and reach the moon – twice.[11]

- Today it would take a person approximately 181mn years to download all the data from the internet.[13]

- More data is created every hour today than in an entire year just 20 years ago.[15]

Sources: [1]Oberlo, Domo, [2]Eric Schmidt, [3]Forbes, [4]Domo, [5]Domo, WEF, [6]IDC, [7]KPCB, [8]New Scientist PLoS Biology, [9]Handbook of Research on Cloud Infrastructures for Big Data Analytics, [10]Cybercrime Magazine, [11]Bernard Marr, [13]Unicorn Insights, [15]Seagate Rethink Data Survey by IDC, released in January 2020

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