



February 2023

[www.research.hsbc.com](http://www.research.hsbc.com)

By: Mark McDonald, Davey Jose and Camila Sarmiento

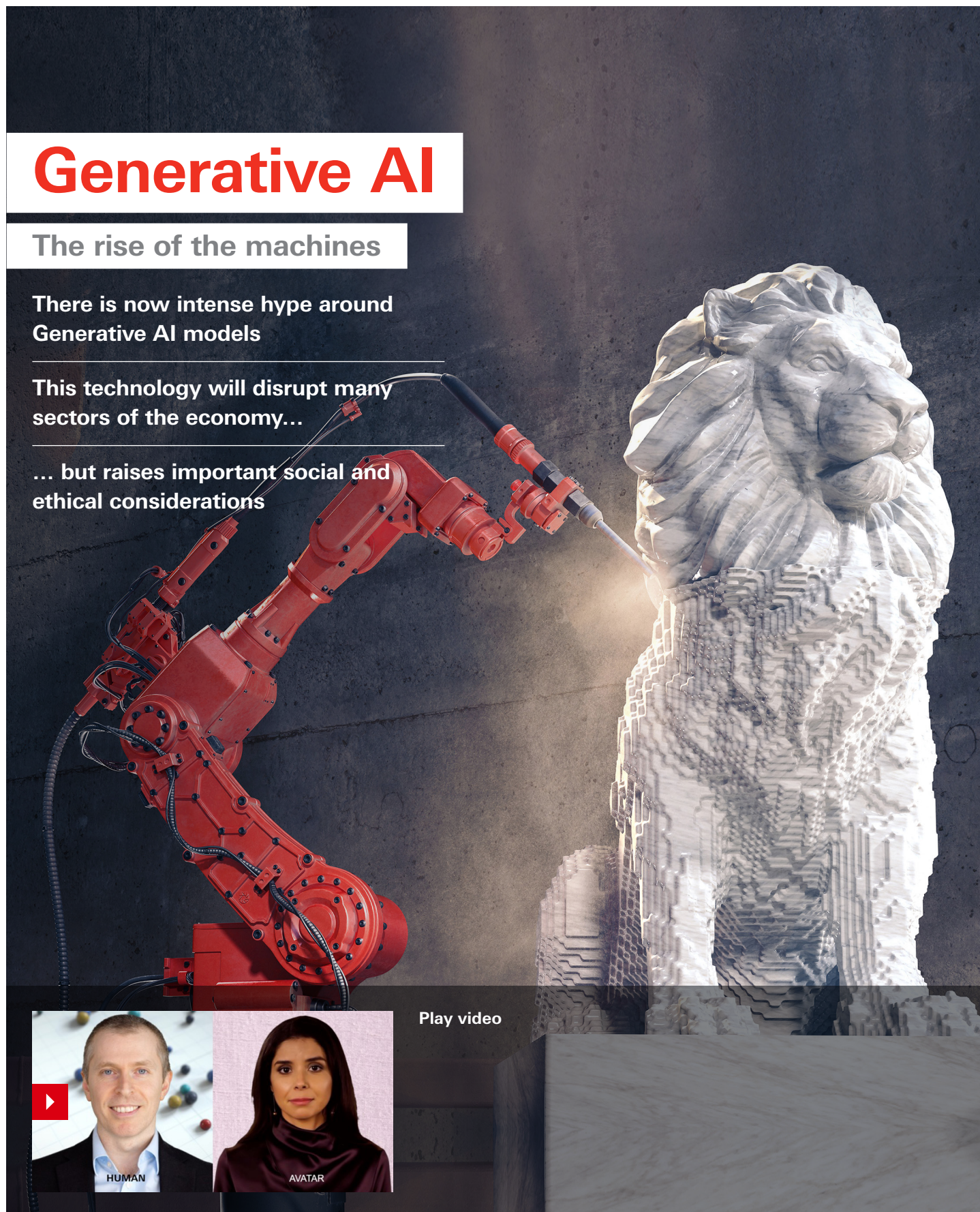
# Generative AI

## The rise of the machines

There is now intense hype around  
Generative AI models

This technology will disrupt many  
sectors of the economy...

... but raises important social and  
ethical considerations



**Disclosures & Disclaimer:** This report must be read with the disclosures and the analyst certifications in the Disclosure appendix, and with the Disclaimer, which forms part of it.

# Contents

|  |           |
|--|-----------|
| <b>Executive Summary</b>                       | <b>2</b>  |
| Generative AI                                  | 2         |
| Significant ethical considerations             | 4         |
| AI-mazing economic opportunities               | 5         |
| <b>Ethical considerations of Generative AI</b> | <b>6</b>  |
| <b>Social considerations</b>                   | <b>7</b>  |
| Reliability and accuracy                       | 8         |
| Disinformation                                 | 8         |
| Biases   | 9         |
| Is it coming for my job?                       | 11        |
| Legal implications                             | 13        |
| Regulations                                    | 13        |
| <b>Thematic and sector implications</b>        | <b>15</b> |
| AI is re-generating for the 2020s              | 15        |
| HSBC Disruption Framework:                     |           |
| Generative AI                                  | 17        |
| Big Tech                                       | 18        |
| Technology                                     | 21        |
| Media  | 22        |
| Education                                      | 23        |
| Healthcare & Pharma                            | 25        |
| Retail   | 29        |
| Consumer Staples                               | 29        |
| Leisure  | 30        |
| Banking  | 31        |
| <b>Here comes the science bit</b>              | <b>32</b> |
| Geek Squad: How do Generative AI models work?  | 32        |
| What can Generative AI do?                     | 37        |
| <b>Disclosure appendix</b>                     | <b>41</b> |
| <b>Disclaimer</b>                              | <b>44</b> |



# Executive Summary

## Generative AI

Generative AI is one of the hottest topics within machine learning at the moment. There is a significant degree of hype surrounding the field and investment flows are pouring into start-up companies trying to commercialise the technology. But what is it, why is it a hot topic now, and what are the implications for investors in public companies?

### What is Generative AI?

Whilst AI (artificial intelligence) has been a hot topic for several years<sup>1</sup>, most of the focus until recently has been on predictive machine learning models. Over the last year there has been a surge in interest in, and a staggering improvement in the performance of, so-called **generative models**. These are machine learning models which can produce new content, something which until recently was considered to be the unique purview of humans.

The variety of Generative AI models is huge: the two models which have made the biggest influence on public awareness are DALL-E, which produces images from text, and ChatGPT, which produces text via a chatbot interface. Both of these models were produced by OpenAI, but many of the major tech companies have built/are building their own equivalent generative models. Increasingly, there are high quality open-source generative models which anyone can use and a wide array of start-ups which are commercialising the output of generative models.

This description barely scratches the surface; the types of content which can be generated by Generative AI models is steadily widening. We discuss the most important model categories in the [What can Generative AI do](#) section on [page 37](#). For those readers who are curious about how it is possible for Machine Learning models, which ultimately need to process numbers, to generate text, image, or audio content, please see the [Geek Squad](#) section on [page 32](#).

### Why is Generative AI a hot topic now?

Generative AI has suddenly captured the popular imagination, with major newspapers writing opinion articles on the technology and social media feeds being inundated with discussions of what is now possible. So why has this happened now?

From a technical perspective, there has been a smooth evolution of what is possible over the past few years. As such, many technologists appear somewhat bemused as to why this technology has suddenly gained such prominence.

Of course, what has really changed in recent months is the ability for the non-technical audience to use this technology. For example, the core technology which powers ChatGPT is a type of machine learning model known as a Large Language Model (LLM). The LLM which ChatGPT uses is not a dramatic improvement on the state of the art technology a year ago, or even two years ago. However, back then these LLMs were only able to be used by people who knew how to code. Whereas now, anyone who knows how to use a website can access ChatGPT.

---

Can a robot turn a canvas  
into a beautiful painting?  
... well they can now

<sup>1</sup> There have been several previous waves of interest in AI, but the current wave really began in 2012 following the success of AlexNet in the 2012 ImageNet Challenge.

---

**Generative AI technology is now widely available to the general public**

This change may seem small to those who are technically adept themselves; it is, however, transformative. These technologies are now easily accessible by any entrepreneur or content creator so we are seeing a dramatic expansion in the use cases being actively explored. As with many other technologies, it is not the invention of the new technology that causes a significant impact; rather, it is when the technology matures and disperses throughout the population.

**What are the implications for investors?**

With any nascent technology it is hard to predict the various ways it will ultimately end up being used productively. However, there is the potential for Generative AI to have a significant impact on several sectors of the economy.

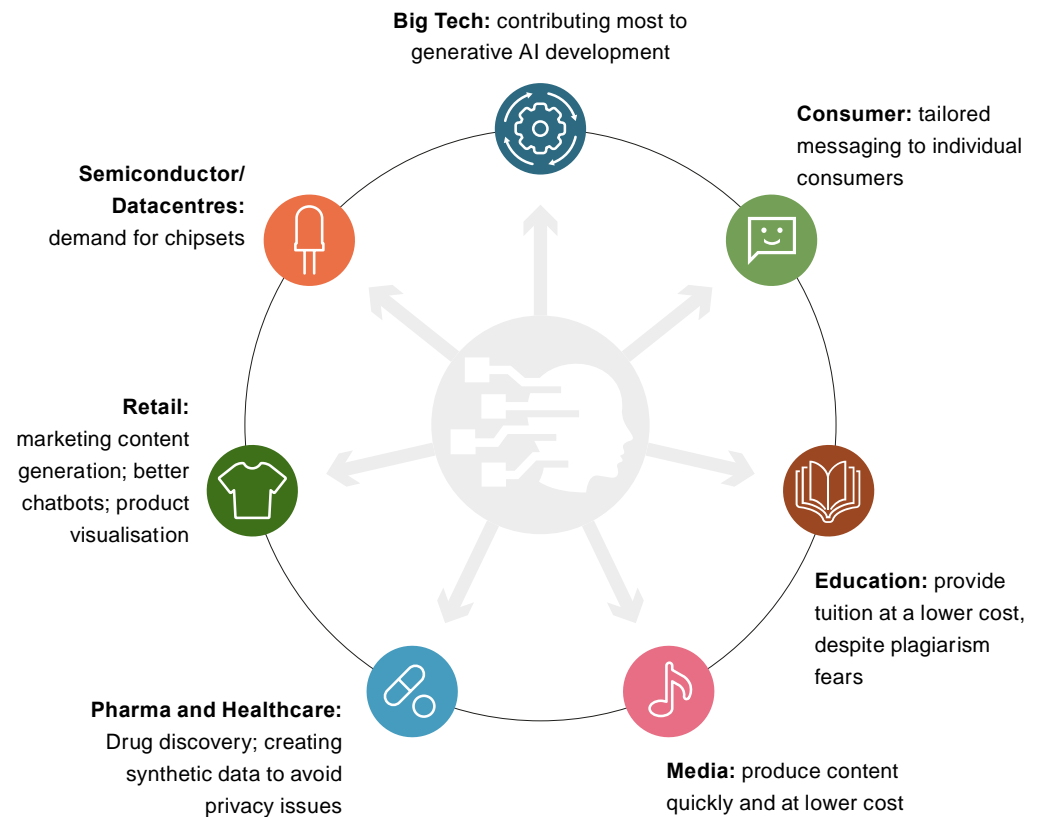
---

**Who will be the winners and losers? And is this appropriately priced in?**

With all disruptive technologies, there will be winners and losers. For investors, determining the likely winners and losers from disruptive technology is often easier than understanding whether the opportunities and challenges from this technology have been appropriately priced in. In this report our sector analysts worldwide discuss the ways in which Generative AI is likely to be commercialised in their sectors – see the [Thematic and Sector Implications](#) section on [page 15](#).

- ◆ **Media:** Music generated from AI has already started to appear on streaming platforms. These models will cause the cost of production to collapse for many types of content. This will clearly have a huge impact on any content-generating industry.
- ◆ **Big Tech:** Generative AI is key for Big Tech companies; indeed, these companies are often those contributing the most to progress in the field of Generative AI. The sharp fall in Alphabet's share price in response to the poorly received public demo of Google Bard highlights the potential cost of getting it wrong in this area for Big Tech companies.
- ◆ **Semiconductor/Datacentres:** Generative AI models typically need advanced chipsets; this is particularly true for the training process but increasingly true even when the models are being used in production. This should stimulate demand for those companies who manufacture advanced chipsets.
- ◆ **Pharma and Healthcare:** The impact of Generative AI on the pharma and healthcare sector has been muted thus far. However, these sectors have been keen adopters of other AI techniques and there are several promising areas for the application of Generative AI to pharma and healthcare.
- ◆ **Education:** Tools such as ChatGPT could be a powerful tool for education if used in the right way. As techniques are developed to reduce the likelihood of LLMs giving incorrect information these tools will be able to provide tuition more broadly and at a lower cost. However, at the moment, tools such as ChatGPT are leading to concerns of a significant increase in plagiarism.
- ◆ **Consumer:** There are a number of areas in which Generative AI can be of use to consumer staples companies, all of which stem fundamentally from the ability to tailor messages more tightly to individual consumers.
- ◆ **Retail:** The retail sector has seen widespread adoption of Predictive AI techniques. Generative AI will have applications in retail, but these are likely to be less disruptive than Predictive AI techniques have been.

## The impact of Generative AI on sectors



Source: HSBC

## Significant ethical considerations

Like all technological developments, there is the possibility of Generative AI techniques being misused. There are several key ethical issues associated with generative natural language processing (NLP) that are worth considering. Some of the most important include:

1. **Bias:** Generative AI models can perpetuate and even amplify existing biases in the data they are trained on. For example, a model trained on a biased dataset of news articles might generate text that reflects those biases. This could perpetuate harmful stereotypes and discrimination.
2. **Privacy:** Generative AI models can be used to generate realistic synthetic data, raising concerns about the protection of individuals' privacy.
3. **Misuse:** Generative AI models can be used to create deepfakes or other manipulated content, which can be used to spread misinformation or cause harm.
4. **Impact on Employment:** Generative AI models can be used to automate the creation of content, raising concerns about the impact on employment in industries such as media and entertainment.
5. **Lack of Transparency:** Generative models can be complex and hard to interpret, making it difficult to understand how they arrived at a certain output, which can lead to lack of trust in the model and its decisions.
6. **Inclusion:** Generative models might not be accessible to everyone. This could lead to issues of social and economic inequality, as individuals who are not able to access these tools might be at a disadvantage.

## AI-mazing economic opportunities

There is the potential for a dramatic increase in productivity from Generative AI. Large tracts of the economy rely in some way on content generation. Even for industries that one might not immediately think of being influenced by this technology there are likely to be considerable resources devoted to producing marketing content. Generative AI will massively reduce the cost of producing such content.

---

Did you spot our guest author for the previous section?

For example, the **section you have just read titled *Significant ethical considerations* was actually written by ChatGPT** – the recently released AI model from OpenAI. This model also was responsible for the somewhat ‘cheesy’ title of this subsection.

### Good content

The first thing to notice here is that the content generated is actually very good: the six ethical issues associated with Generative AI which the model describes are all valid considerations. Furthermore, the explanation of each issue which ChatGPT discussed is a good summary of the issue. However, there are some important ethical issues that ChatGPT did not identify. We discuss the ethical issues of Generative AI in more detail (and the discussion is written by a human expert in this case!) in the [Social Considerations](#) section on [page 7](#). This section will also focus on the social and governance issues that plague Generative AI.

### Appropriate content

The second point is that the tone of the output is appropriate. If we had not explicitly highlighted the section that was generated by AI it is unlikely that readers would have noticed.

### Same content, multiple formats

Another important consideration is the ease with which existing content can be adapted for new formats. We asked ChatGPT to instead produce an extended version of this information in the form of a twitter thread; asking for it to use language that is likely to lead to high engagement.

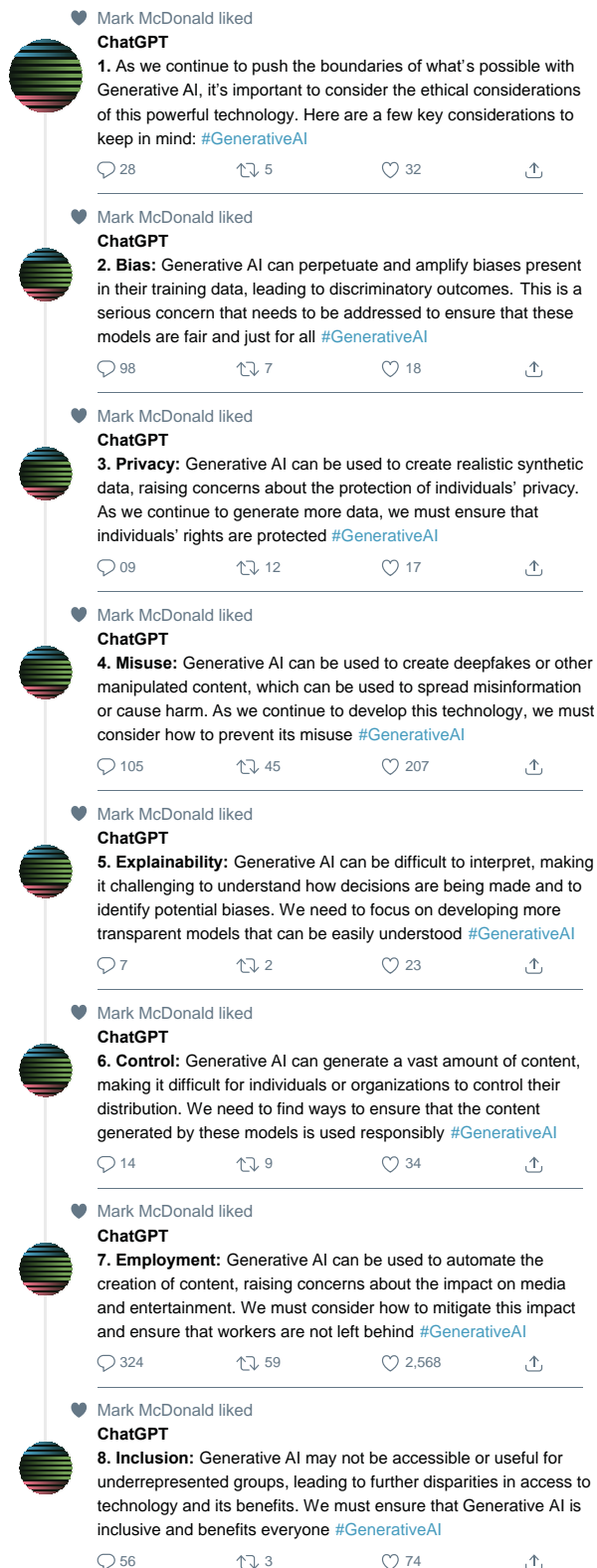
Finally, we asked ChatGPT to put this information into the form of a transcript for a TikTok video. The model happily obliged, even peppering the transcript with directions for what should be on screen during different sections of the video such as “*cut to a shot of a person scrolling through a social media feed*”.

### Already a useful tool

Clearly the technology is not yet perfect. It is, however, already at the point where it can be an extremely useful tool for anyone generating content. Still not convinced? Large sections of the [video](#) accompanying this piece were entirely produced by AI. Please check out the video to see what’s now possible with very low cost.

# Ethical considerations of Generative AI

## We asked ChatGPT to generate a Twitter thread ...



## ... and to script a TikTok video post

*[Opening shot of a computer screen with the text "Generative AI: The Ethical Implications"]*

**Voiceover:** As we continue to push the boundaries of what's possible with Generative AI, it's important to consider the ethical implications of this powerful technology.

*[Cut to a shot of a person scrolling through a social media feed]*

**Voiceover: Bias.** Generative AI can perpetuate and amplify biases present in their training data, leading to discriminatory outcomes.

*[Cut to a shot of a person typing on a computer]*

**Voiceover: Privacy.** Generative AI can be used to create realistic synthetic data, raising concerns about the protection of individuals' privacy.

*[Cut to a shot of a deepfake video]*

**Voiceover: Misuse.** Generative AI can be used to create deepfakes or other manipulated content, which can be used to spread misinformation or cause harm.

*[Cut to a shot of a person looking confused while trying to understand a computer screen]*

**Voiceover: Explainability.** Generative AI can be difficult to interpret, making it challenging to understand how decisions are being made and to identify potential biases.

*[Cut to a shot of a person scrolling through social media on their phone]*

**Voiceover: Control.** Generative AI can generate a vast amount of content, making it difficult for individuals or organizations to control their distribution.

*[Cut to a shot of a person sitting in front of a camera with a worried expression]*

**Voiceover: Employment.** Generative AI can be used to automate the creation of content, raising concerns about the impact on employment in industries such as media and entertainment.

*[Cut to a shot of a person from an underrepresented group using a computer]*

**Voiceover: Inclusion.** Generative AI may not be accessible or useful for underrepresented groups, leading to further disparities in access to technology and its benefits.



Source: HSBC, Getty Images

# Social considerations

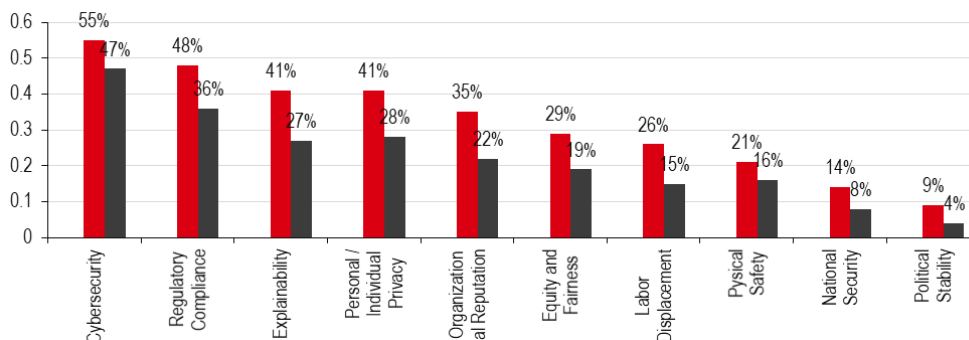
- ◆ Generative AI has many potential applications for business, but social impacts need to be carefully assessed
- ◆ Content generated can raise concerns around biases, ethics, and fairness, and expose corporates to various risks
- ◆ Generative AI can also be influential for job markets, education systems and regulatory priorities

As Generative AI undergoes rapid development, its impacts on broader society are rapidly evolving. The technology can bring many advantages including increased efficiency, improved quality of content generated and even cost benefits. Generative AI can help businesses make better decisions, be more creative and improve their operations. However, despite the value Generative AI can bring, as with many new technologies, social concerns are apparent. Social biases are often reflected in models and thus can perpetuate these biases further, raising concerns around ethics and fairness. Additionally, unemployment, misinformation, and privacy risk often surround the AI space and, to no surprise, are of particular relevance to Generative AI as it is rapidly integrated across regions, sectors and in everyday life. As the industry matures, these risks can dissipate, but they should be closely watched, cautiously considered, and fundamentally understood by investors.

**The social impacts of Generative AI should be closely watched by investors and corporates**

As investors pour money into the Generative AI sector, we think it is pertinent to assess and address the risks around the potential for corporate and societal impacts. Indeed, while many corporates identify social risks associated with AI, they are less likely to be already taking action to mitigate these risks (Chart A1). To help investors navigate this complex and fast-changing landscape, we look at several of these risks in more detail below.

**A1. AI risks corporate consider relevant vs are taking steps to mitigate**



Source: Artificial Intelligence Report 2022, HSBC



## Reliability and accuracy

### Generative AI is not fool proof

In producing content – images, longer text, emails, social media content, voice recordings, program code, or structured data – Generative AI applications use machine learning to make predictions based on previous data, which can reveal problems with accuracy and reliability.

Instances of errors generated by platforms like OpenAI's ChatGPT, are not uncommon. For example, news sites report that CNET editors fed the bot article outlines and when the draft was reviewed and edited, errors were found in more than half of the articles published by the editor-bot teams: errors ranged from minor mistakes to issues that required "substantial correction".

Even when it comes to objective facts, Generative AI can also make mistakes. As OpenAI says on its website "*ChatGPT sometimes writes plausible-sounding but incorrect or nonsensical answers*". This was also demonstrated during the launch of Google's new AI chatbot, Bard. The system made a factual error saying that James Webb Space Telescope snapped "the very first image of a planet outside our solar system," even though the milestone happened 17-years before the telescope launched.

### Generative AI may spread misinformation...

While these errors show imperfections in AI-generating systems and raise questions over its real world applications, it also raises questions around **the spreading of misinformation**. If you are unknowledgeable about the launch of the James Webb Space Telescope, you are less likely to catch the inaccurate facts. Indeed, this is further explored in a Northwestern University study that used ChatGPT to generate artificial medical research abstracts to test whether scientists can spot them. While the scientists identified the majority of generated abstracts, they incorrectly identified 32% of generated abstracts and 14% of genuine abstracts.<sup>2</sup> This shows that while a less knowledgeable group might not catch flaws and discrepancies in Generative AI, the technology also has the ability to fool experts.

In a society with extensive communication platforms, information is traveling fast and it is becoming increasingly difficult to verify information online, especially with entrance of Generative AI. While Generative AI technology can have many corporate benefits, the lack of reliability and accuracy can pose risks to corporate integrity and reputation, and impact the bottom line. Indeed, after Google's Bard showed the inaccurate answer on the telescope, parent company Alphabet experienced an 8% drop in its share price that day.



**ChatGPT sometimes writes plausible-sounding but incorrect or nonsensical answers**

OpenAI website

## Disinformation

### Generative AI also can facilitate the spreading of false or misleading ideas

In addition to the imperfections and factual errors made by Generative AI, the technology also raises the risk that it may be used to spread disinformation: the deliberate intention of spreading false or misleading ideas. Indeed, ChatGPT will produce work around false narratives when asked. For example, researchers at NewsGuard asked ChatGPT to write responses based on false or misleading ideas, and the bot complied about 80% of the time<sup>3</sup>.

<sup>2</sup> Abstracts written by ChaptGPT fool scientists, Nature, 2023

<sup>3</sup> The Next Great Misinformation Superspreaders, NewsGuard, 2023

Because Generative AI can pose risks of increased sharing of disinformation, they can disrupt the credibility of news and information in general. For as long as we have known, photographs, videos and audio have been trusted primary sources of information. Increasing the sharing of false and misleading information can create mistrust in people for what they see and hear online if they cannot tell what is real or not.

---

**Platforms are stepping up efforts to mitigate these risks**

AI generating platforms are trying to mitigate this. For example, OpenAI policies prohibit the use of its technology to build products that target “*Illegal or harmful industries, misuse of personal data, promoting dishonesty, deceiving or manipulating users or trying to influence politics,*” and use their Moderation API tool to warn or block certain types of unsafe content, but this is not perfect. Additionally, their new AI classifier tool can be used to help determine text written by human vs artificial intelligence to identify misinformation campaigns. While these innovations are needed to build trust in the model, they often lag behind technological advances. We think innovations and regulatory policies will develop to combat these risks eventually, nonetheless corporates will need to enhance their due diligence and strategies around verifying online content.

**Deepfakes**

---

**Generative AI poses risks to cybersecurity**

Deepfakes use Generative AI to make artificial videos of fake events by combining images to make new footage that depict events or statements that didn’t actually happen. While deepfakes do have positive applications in many industries, particularly for modelling human behaviour, there are also many possibilities for abuse. This AI-generated content can pose serious ethical implications, in our view, since it can be very difficult, and in some cases impossible, to distinguish between real and fake information. **Deepfakes could be used for identity theft, extortion, reputational damage, ridicule, intimidation and harassment.**<sup>4</sup>

As Generative AI for deepfakes continues to advance, these societal risks will become more important to address. While there have been innovations to help identify deepfakes, they are not yet keeping pace with the technology itself. Some efforts include researchers at University of California, Berkeley creating software for deepfake detection, and OpenAI working on a way to watermark text. Indeed, given the social risks with deepfakes, more controls are likely to be investigated and required in the future.

**Illicit activities**

While AI can be used as a tool to benefit cybersecurity, for example in detecting anomalies or predicting cyber threats, Generative AI can be misused in a way that harms cybersecurity. For example, Generative AI can simulate very realistic phishing emails and phone calls, which can make it simpler for individuals to be tricked into revealing sensitive information or becoming vulnerable to malware.

**Biases**

---

**Generated AI models emulate biases from past human content they are trained on**

Concerns about biases in artificial intelligence are not new. Indeed, social biases including those around sex, race and disabilities, are often absorbed by AI systems from their training data. Since they are trained on past human content they tend to emulate biased language they were exposed to. A report by Stanford University exemplifies this, where an AI model training on BookCorpus (a dataset of books from e-book websites), often produced toxic text (defined as rude, disrespectful or unreasonable comments), most likely as a result of the significant number of romance novels containing explicit content. Models training on internet text that had filtered out toxic content, produced significantly less toxic content (see Chart A2). Indeed, it is important to note that in defining what is toxic and not, the study can contain biases itself. Nonetheless, the fact that that toxic information was omitted when the content was filtered, shows how important the data informing the bot is to its behaviour. The study additionally finds larger models are more capable of reflecting biases in their training data<sup>5</sup>. This means that although language models continue to grow and develop, so does their severity to biases.

<sup>4</sup> Australian Government, eSafety Commissioner

<sup>5</sup> AI Index Report 2022, Stanford University Human-Centered Artificial Intelligence

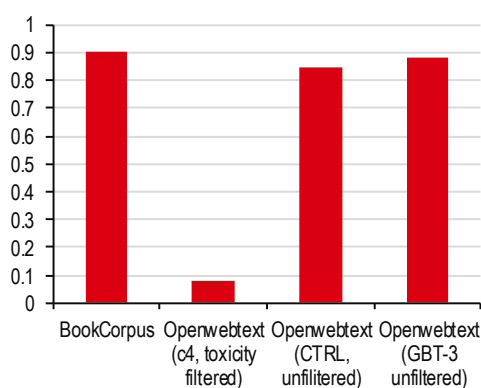
There are widespread examples of Generative AI replicating social biases. For example, when Generative AI models produce outputs which reflect men in more senior positions, or pictures of women as teachers vs men as professors. These biases can help perpetuate inequalities when these AI models are not inclusive or useful to underrepresented groups.

Additionally, the engineers and developers who create AI systems have frequently received blame in their role with creating these biases. For example, several studies show ChatGPT exhibiting left-leaning biases when fed political questions. A possibility for the source of these biases can be from an overrepresentation of data from sources like academic literature that are often left-leaning. However, another possibility is that biases of the programmers are reflected in the model itself. Tech employees overwhelmingly support Democrats and tend to identify as liberal<sup>6</sup>.

**Can a more diverse group of programmers help eliminate biases?**

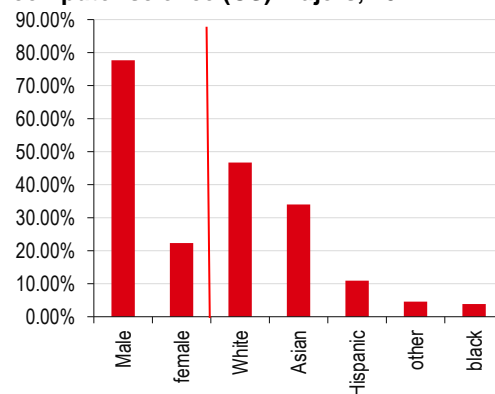
This raises other questions around the role of diversity in Artificial Intelligence. For example, given that tech and the AI space is overwhelmingly favoured by males over females (Chart A3), gender biases may be unintentionally perpetuated<sup>7</sup>. As we discuss in our [Diversity Challenges](#) report (2 December 2021), research shows that when teams have one or more members who represent the gender, ethnicity, culture, generation or sexual orientation of the team's target end user, the entire team is at least 144% more likely to say that it understands that end user<sup>8</sup>. In our view, diversity can be a useful tool within the Generative AI space in aligning stakeholder expectations with the model and by doing so, also eliminating biases.

**A2. Toxicity in language models by language set**



Source: Gehman et al., 2021; Rae et al., 2021; Welbl et al., 2021.; 2022 AI Index Report HSBC

**A3. US diversity in bachelor degree computer science (CS) majors, 2021**



Source: CRA Taulbee Survey 2022, HSBC  
 \*Racial diversity does not include non-US residents

### People are trying, but more effort is needed

Efforts are being made to combat biases in artificial intelligence, but they have not proven successful. Companies like OpenAI are working on filtering out hate speech, and more and more research is being conducted to understand how AI biases develop. Indeed, NeurIPS, one of the largest AI conferences, collected 4 times more research papers on fairness and bias in 2021 than it had in 2017<sup>9</sup>. Additionally, there has been significant research investment in developing ethics diagnostic metrics and benchmarks to understand system biases. However, there is little publically available information. There is also concern that AI-related degree programmes fail to equip designers with appropriate knowledge of ethics.

<sup>6</sup> Predispositions and the Political Behavior of American Economic Elites: Evidence from Technology Entrepreneurs, Stanford Graduate School of Business, 2017

<sup>7</sup> CRA Taulbee Survey 2022, Computing Research Association (CRA)

<sup>8</sup> S Hewlet et al, Diversity's Positive Impact on Innovation and Outcomes, INSEAD, The Global Talent Competitiveness Indx 2018

<sup>9</sup> AI Index Report 2022, Stanford University Human-Centered Artificial Intelligence

Generative AI biases present major challenges for corporates that are looking to integrate this technology within corporate strategy. Indeed, the last thing corporates are looking for is for their automation tool to cause problems such as reputational damage or a legal issue. However, despite these risks, efforts to address ethical concerns associated with using AI are limited. According to a McKinsey survey, while 29% and 41% of respondents recognise “equity and fairness” and “explainability” as risks when adopting AI, only 19% and 27% are taking steps to mitigate those risks (Chart A1). We think this will continue to grow as the risks and their repercussions grow and materialise.

## Is it coming for my job?

---

**James Pomeroy**  
Economist  
HSBC Bank plc  
james.pomeroy@hsbc.com  
+44 20 7991 6714

---

---

**Historically, new technologies have accelerated the transition of roles in the labour market**

---

**and labour markets could experience shifts in skillsets**

We argued in [Robots and Jobs](#), 1 November 2021, that the impact of automation on the labour market is likely to be substantial in the decade to come. Pandemic-related shocks to worker availability and wages are likely to mean more businesses are incentivised to think about how technological developments can help them run more effectively or with fewer staff. And so for Generative AI, the worries immediately turn to whether jobs are on the line. Will previously human performed processes be displaced by AI generation?

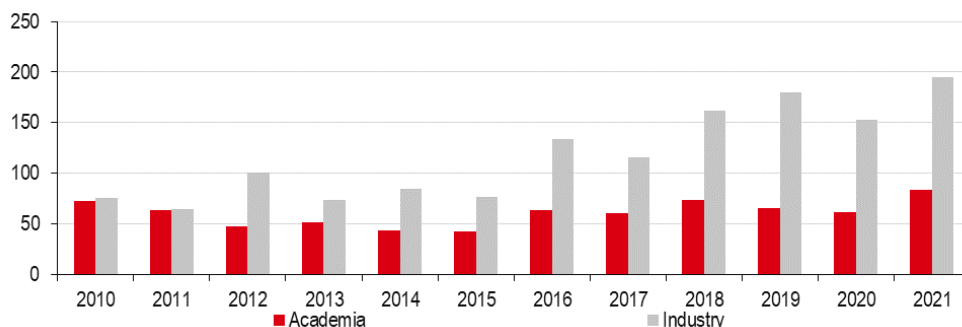
For all the concerns about jobs being lost, history tells us that this phenomenon has typically been overblown, where new technologies have simply been accelerating the transition of roles in the labour market. Before the days of computers there used to be people whose job was “calculator”. The advent of cheap computing power means that those specific jobs don’t exist anymore, but this instead acted as a platform for other jobs, such as in analysis, to be created. In financial markets a wave of electronic trading has replaced human jobs as market makers in many asset classes. However, trading activity has increased notably since then and it is likely that many institutions have far more people employed in the trading process than before, but now it’s quants, database administrators and engineers rather than traders.

Indeed, there are many roles that may be vulnerable to Generative AI – particularly those that have a larger number of process components rather than creative or problem solving ones, such as customer service and administrative roles. Rapid developments in AI clearly pose risks to those sorts of roles if problems can be solved much more quickly. There will still be a role for people sharing information, generating product and even thinking about how to get solutions out of AI-supported processes, but they may require different skill sets than before. For example, the workforce for a customer chat service could be replaced by several computer science experts making sure the bot is properly functioning. Indeed, while AI PhD graduates had more often gone into academia 10 years ago, they now overwhelmingly choose to work in industry (Chart A4). In our view this shows a shift in skills now in demand in the labour market.

The impact on the labour market of all of these changes in technological adoption will depend on a number of things – most notably the speed at which new jobs appear, whether training allows people to move between roles and how quickly AI processes both improve and are embedded into existing work processes.



#### A4. Employment of AI PhDs in academia and industry in North America over time



Source: CRA Taulbee Survey 2022, 2022 AI Index Report HSBC, HSBC

Nonetheless, artificial intelligence can also benefit the sphere of knowledge work without making roles redundant. We argued in [Will AI take your job?](#), 18 January 2023, that it's more likely that AI will take away parts of jobs, especially in the first instance. Almost all knowledge workers – be it lawyers, teachers or even research analysts have part of their role that requires some 'grunt work' which can now easily (and more quickly) be done via AI generation as this report showcases.

Therefore, we expect the outcomes of a greater role of AI in work to be twofold: firstly, a lift to productivity from the speed at which outputs are able to be created. However, due to the nature of picking up productivity gains in knowledge work, this may not show up clearly in official output per hour statistics. Instead, it may be visible in the second impact: more leisure time. The number of hours worked each week in most developed economies stopped falling in the aftermath of the GFC and with these breakthroughs, we could see working weeks fall notably, lifting leisure time and spend.

#### Education

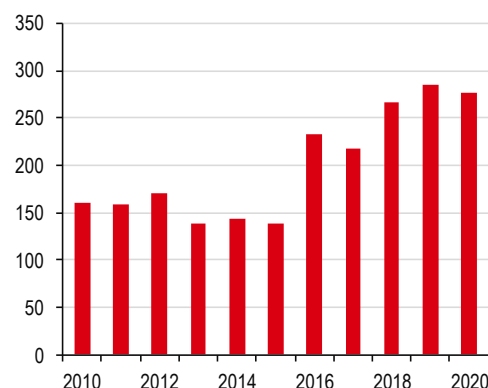
Generative AI leaves many questions around the social implication for educational systems. Indeed, Generative AI has the potential to drastically impact educational systems and the introductions of technology to classrooms has elicited both excitement and distress. Generative AI has received significant backlash regarding concerns about the negative impact on student learning. For example, New York City Department of Education blocked ChatGPT on all devices and networks, due to fears around encouraging quick answers, rather than critical thinking and problem solving skills, and fear over the safety and accuracy of content created. Concerns and confusion around what cheating and plagiarism means for ChatGPT are not clear – see the [Education](#) section on [page 23](#).

Despite criticism by education institutions, Generative AI has also been embraced by some. For example, teaching students how to work with Generative AI to understand biases, misinformation, and building critical thinking skills around how to make Generative AI text better.

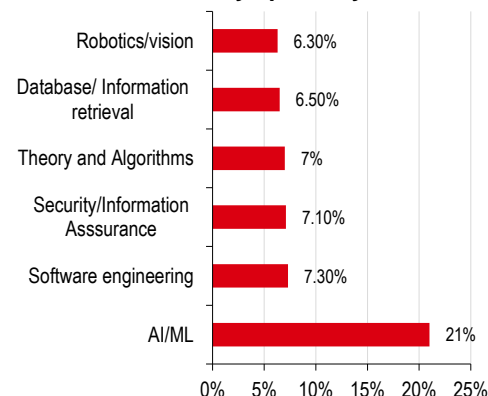
While it's too early to tell the impact that Generative AI can have on the educational system, education and labour markets are intertwined. A change in demand for new skills will often be followed by educational systems changing in light of student learning preferences. Indeed, there has been significant growth in AI interest within higher education (Chart A5). Of computer science (CS) specialisations, AI and Machine Learning (AI/ML) are the most popular among PhD students; 1 in every 5 CS PhD students specialise in AI/ML (Chart A6). Between 2010 and 2020, the number of CS PhD graduates with AI/ML specialties grew by 72%<sup>10</sup>.

**Generative AI has caused both excitement and distress in classrooms**

<sup>10</sup> AI Index Report 2022, Stanford University Human-Centered Artificial Intelligence

**A5. Growth in AI CS PhDs in the US**


Source: CRA Taulbee Survey 2022, 2022 AI Index Report HSBC, HSBC

**A6. New CS PhDs by speciality, 2021**


Source: CRA Taulbee Survey

## Legal implications

Generative AI raises many questions around **originality and property rights**. While Generative AI products are derivatives of existing text or images, the text or images created are not exactly like any previous content. Because businesses could soon be using Generative AI for the majority of written and image based content, Generative AI likely will open up a new frontier around content ownership and intellectual property protections.

Indeed, they are already being seen. Getty Images filed a lawsuit against Stability AI, an AI art generator, for infringement on its intellectual property rights. As Generative AI becomes more mainstream so will these concerns.

Privacy issues also exist for users of Generative AI. These can surface for both the AI maker in gathering information for training the bot, but also for data that a user enters into the model. For example, data entered into the bot could be used by the bot and AI maker for a variety of purposes, including to improve the AI service. Because Generative AI can be used by many services, including those which handle confidential information, such as a law practice or a financial service provider, using an application like this in business could raise privacy risks.

## Regulations

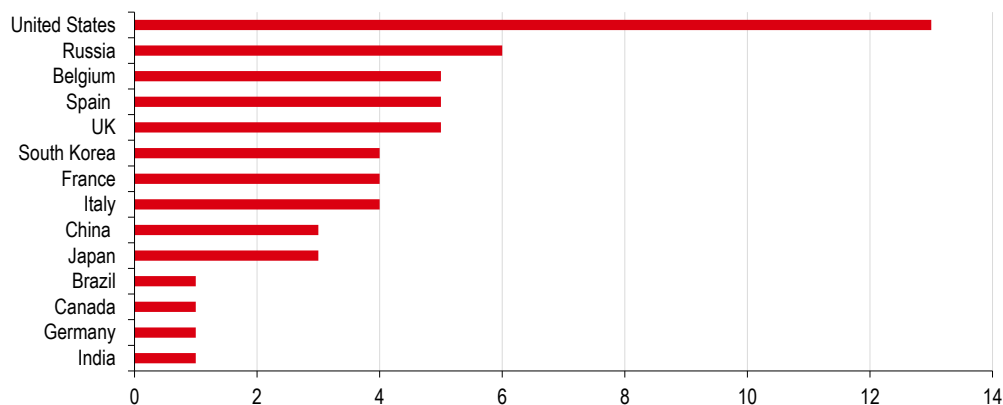
In efforts to address ethical and social concerns surrounding AI, intergovernmental, national and regional organisations have worked towards developing strategies and policies around AI governance. As the AI umbrella expands to include new applications for Generative AI – and new challenges, we think regulatory involvement will be unavoidable.

Indeed, the number of AI-related bills has increased significantly since 2016. Of the 25 countries analysed by Stanford University, 18 new laws containing mentions of AI were passed in 2021. The United States leads AI legislation across the group passing 13 AI-related bills in five years, followed by Russia, Belgium, Spain and the UK<sup>11</sup> (Chart A7). Many of the more recent bills are focused on social concerns. For example, in Belgium an Ethics Committee was created to submit advice on artificial intelligence tools used for digitalisation activities. In the US, the Identifying Outputs of Generative Adversarial Networks Act (IOGAN Act) directed the National Science Foundation to support research dedicated at identifying the outputs such as deepfakes and other comparable technologies.

<sup>11</sup> AI Index Report 2022, Stanford University Human-Centered Artificial Intelligence

These regulations show measures in place to regulate the industry. We believe responsible technology practices require effective and agile governance – both within an organisation and across the regulatory and public policy landscape.

#### A7. Number of AI related bills passed into law by country, from 2016 to 2021



Source: 2022 AI Index report, HSBC

#### Conclusions

Generative AI has many potential applications for business, and they are no doubt exciting. However, beyond its immediate uses, there are some serious social concerns that are worth understanding. While Generative AI is in the early stages, industry stakeholders are more and more acknowledging the implications that Generative AI can have on society, including labour markets, education, legal systems, regulation and communication platforms. We think corporates and investors should be proactive and diligent in monitoring their exposure to the industry, and identifying and mitigating social risk including those around fairness and biases, explainability, privacy, reliability and accuracy.

We think risks posed by Generative AI could ease as the market matures, regulatory initiatives increase, and knowledge of the technology rises.

# Thematic and sector implications

- ◆ AI has already been embedded within search, social feeds and recommendation engine driven business models
- ◆ Generative AI set to re-energise next generation of applications
- ◆ We look at how Generative AI could lead to sector disruption, including new use cases within HSBC's 9 big themes



I'm sorry, Dave. I'm afraid I can't do that.

HAL 9000. From the motion picture 2001: A Space Odyssey (1968)

## AI is re-generating for the 2020s

### The evolution of AI...

In [Artificial intelligence: the new collective super-mind](#) (6 June 2016), we had discussed the evolution of AI from the 1950s (during computer scientist Alan Turing's era), all the way to how modern AI was being monetised by 21<sup>st</sup> century technology giants like Google, Facebook, Netflix and more through their search, social feed and recommendation engine driven business models.

Moreover, in that report, we also highlighted how AI was going to become more embedded into global infrastructure and services: from the knowledge economy, national security, healthcare and all the way to helping to protect our environment. Also, if you look carefully, towards the end of the report, you'll spot that we also highlighted a little start-up called OpenAI. Little did we know that six to seven years later, this start-up's Generative AI chatbot called ChatGPT would gain widespread popularity and spark a debate on how AI might disrupt the global economy.

### Commercialising Generative AI

In this chapter, our analysts worldwide have put thought into how Generative AI technology could be commercialised within their sector, [HSBC's big 9 themes](#) and some of the implications of this technology.

- ◆ **Don't search; give answers (disruptive tech theme):** Might ChatGPT's technology disrupt the nature of search and thus also companies that rely on this type of advertisement driven models?
- ◆ **Metaverse (disruptive tech theme):** How could Generative AI influence the emergence of what some CEOs like Mark Zuckerberg are calling the next internet, namely the Metaverse.
- ◆ **Powering the data revolution (disruptive tech theme):** Will the growth of Generative AI products drive a global demand for datacentre equipment, semiconductors, related processing hardware and telco equipment?



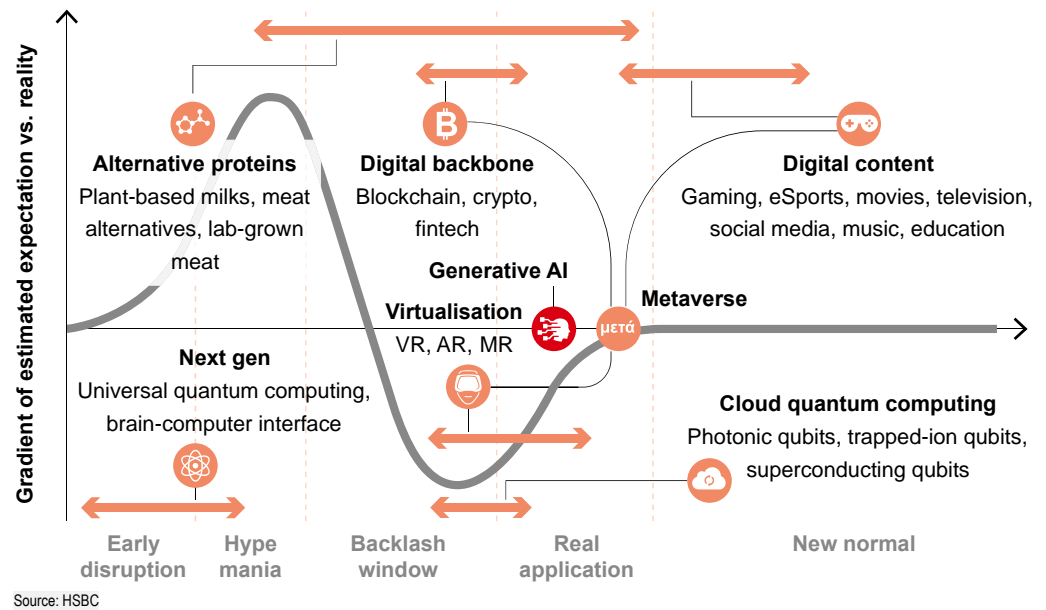
- ◆ **Healthcare and pharma (disruptive tech theme):** AI is also being used by the healthcare sector for drug discovery, medical imaging and clinical decisions. How will Generative AI help in generative biology to improve the economics and shorten the time to market for drugs?
- ◆ **Education (disruptive tech and future consumer theme):** Online education is used on a daily basis by students all around the world, from simple webpages like Wikipedia to MOOCs (massive open online courses) at prestigious universities like MIT to Harvard. How might Generative AI support the next generation of students through virtual tutoring and personalised learning?
- ◆ **Media (disruptive tech and future consumer):** Ad agency clients may not necessarily be asking for Generative AI products yet. But Generative AI for music could put pressure on the market share of large music groups on streaming platforms. This type of AI could put pressure on the market share of large music groups on streaming platforms and add to the level of automation already used within video games, like NPCs (non-player characters), world generation and game testing.
- ◆ **Retail (future consumer theme):** E-commerce has come a long way since the early days of internet shopping from the late 1990s. Could Generative AI be able to automate marketing and help with cost-cutting, as well as enable consumers to visualise clothing better before buying?
- ◆ **Consumer staples (future consumer):** FMCG companies may have the potential to improve hyper-local segmentation for tweaking branding and marketing. Naturally, Generative AI technology could also improve brand chat interactions with customers, giving a more customised push for products.
- ◆ **Leisure (future consumer):** AI has been in use within the hospitality and hotel space for some time. The question is whether Generative AI can push the envelope further to manage revenues, create cost efficiencies, find demand patterns etc. Generative AI could certainly improve integrated chatbots and help with better personalisation. Within gambling, Generative AI could foster more engaging games, better personalisation and better pricing of sports betting in real time – improving margins.
- ◆ **Banks (digital finance theme):** Could the use of Generative AI be more useful for internal banking processes than customer facing ones due to a generally tightly regulated sector?

## HSBC Disruption Framework: Generative AI

### Which tech theme is Generative AI in?

In our report, [The Edge of Disruption](#) (22 November 2020), we outlined our four key disruptive technological themes (connectivity, automation, experiential, and digital health). We additionally created the HSBC Disruption Framework for each of these themes, to help investors understand how mature each innovation was and if it's ready to become the new normal and thus disrupt business models. Here we outline where Generative AI may lie within our framework.

### B1. HSBC Disruption Framework: Experiential infrastructure



### Real applications fuelled by viral success

Generative AI lives within our experiential disruption framework (see Chart B1). Whereas we believe cloud quantum computing tech lay within the very early phase of the “real applications” window, Generative AI can be placed further forwards. This is due to the global viral phenomenon of ChatGPT (100m users in January 2023, since November 2022 launch<sup>12</sup>) and the race this has triggered for a number of industries to commercialise into real products.

<sup>12</sup> ChatGPT reaches 100 million users in two months after launch, Guardian, 2 February 2023

---

**Nicolas Cote-Colisson\***  
 Global Head of Communications  
 Equity Research  
 HSBC Bank plc  
 nicolas.cote-colisson@hsbcib.com  
 +44 20 7991 6826

**Charlene Liu\***  
 Head of Internet and Gaming  
 Research, Asia Pacific  
 The Hongkong and Shanghai  
 Banking Corporation Limited,  
 Singapore Branch  
 charlene.r.liu@hsbc.com.sg  
 +65 6658 0615

**Ritchie Sun\*, CFA**  
 Analyst, Internet Research  
 The Hongkong and Shanghai  
 Banking Corporation Limited  
 ritchie.k.h.sun@hsbc.com.hk  
 +852 2822 4392

**Christina Chen\*, CFA**  
 Analyst, Internet Research  
 The Hongkong and Shanghai  
 Banking Corporation Limited  
 christina.z.chen@hsbc.com.hk  
 +852 2822 2912

**Sonam Chamaria\***  
 Associate  
 Bangalore

\* Employed by a non-US affiliate of HSBC Securities (USA) Inc, and is not registered/qualified pursuant to FINRA regulations

---

**It's all about chasing the  
 advertising dollars on Search**

---

**AI: a tool to break current  
 network effects**

## Big Tech

Generative AI is key to Big Tech, and these companies are often those contributing the most to the progress in that field. Generative AI answers questions, which is a central case of the business of search engines, including Google and Bing. Generative AI is now part of the Bing landing page; this is not yet the case at Google. Content generation is another area which could see disruption from Generative AI, this ranges from visual to audio, gaming to video content. Companies like TME are exploring relevant applications. Generative AI is also very important in the domain of social media: a way to improve the efficiency of an advert reach for example which is key to Meta. Lastly, Cloud service providers can benefit from the development of Generative AI due to an increase in demand for computing usage for the purpose of model training etc.

### A more powerful search

- ◆ Microsoft's OpenAI makes the headlines but don't ignore the others

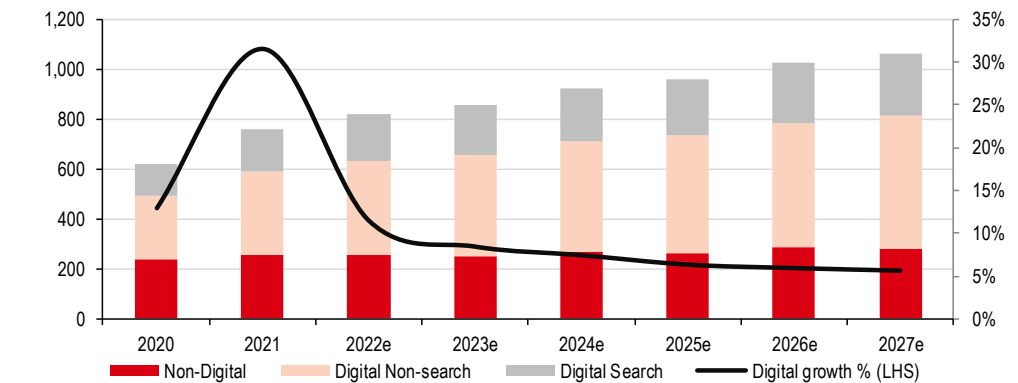
30 November marks the entry of Generative AI into widespread public awareness: This was the day OpenAI opened its AI chatbot ChatGPT to the general public, creating an awful lot of comments (which we assume were not all written with the support of ChatGPT itself). Microsoft has been investing in OpenAI for the last three years and announced the third phase of the partnership on 22 January 2023 with the aim to "*responsibly advance cutting-edge AI research and democratize AI as a new technology platform*" and for developers and industries to access the infrastructure. This was a multi-billion-dollar investment: sources talk about the third investment to be worth USD10bn – after USD1bn in 2019 and another round in 2021, Bloomberg, 23 January 2023.

- ◆ Alphabet to release Bard to the public soon

Given the interest in OpenAI, Alphabet (previously Google) decided to be more vocal with its own chatbot application a few days later: on 6 February, the company introduced Bard, its rival chatbot. However, the promotional video available online showed that Bard returned an inaccurate answer to a question about exoplanets (embarrassingly spotted by an Astrophysicist). This epiphenomenon (it would be wrong to assume that ChatGPT only returns accurate and unbiased answers), which on the day triggered a fall in the share price of c8% intraday, is actually a reflection of the race for creating the best systems for two competing search engines that are Bing (Microsoft) and Google (Alphabet).

**“ there is a strong case for challenging established leadership of Google in the ad-Search market**

After all, users of search engines are looking for answers. If the search experience can turn into getting conceptual information and putting together the infinite amount of information available in the web, there is a strong case for competitors using Generative AI tools to challenge established leadership of Google in the ad-Search market (Google made ad revenues worth USD224.5bn in 2022). Time will tell which of ChatGPT, Bard or others take over, but we see technology as a means to challenge the network effect that has created so much value for Google. The quality of the search function is increasing with the number of users / queries made, hence it is very difficult for challengers to compete on quality of the outcome...unless a new paradigm is shown and this paradigm may be Generative AI.

**Global ad-market split: digital Search is cUSD187bn market; non-Search is cUSD634bn**


Source: GroupM data

As said, a bad answer from Bard should not be the end of the story. Preliminary insights from software engineers show that Google's tech behind Bard will source from a larger data base (the entire internet against a more static base for Bing at present) but also use less computer power, can handle more users and consume less energy than ChatGPT (Constellation Research, 8 February 2023).

◆ Baidu also has Ernie Bot

Baidu announced on 7 February 2023 that its ChatGPT-like AI chatbot ERNIE Bot (文心一言) will complete internal testing by March. Baidu has a comprehensive full-stack of technology, covering four tiers of AI architecture (e.g. chips, deep learning framework, large language models (LLM), and various applications like search/feed). ERNIE Bot is in the LLM layer. While use cases are not yet very clear, Baidu mentioned that ERNIE Bot can complete tasks such as language interpretation, language generation, and text-to-image. Our view: we believe whether ChatGPT is disruptive towards search and the actual P&L impact is still too early to tell at this stage. However, if this function is integrated to other parts of Baidu's ecosystem (e.g. Apollo, Xiaodu), it could improve user experience. Monetisation would likely take time to materialise.

◆ Response from other Big Techs

Opera's parent company Kunlun Tech has announced its intention of integrating ChatGPT into its products. Alibaba, which has been working on Generative AI since 2017, is also working internally on a chatbot (CNBC, 8 February 2023). At the same time, Amazon has released a new language model<sup>13</sup> which is reported to deliver state-of-the-art performance on some NLP benchmarks – whether Amazon will enter the chatbot space remains to be seen.

Meta is another Big Tech which has been doing a lot of the heavy lifting groundwork and is very active in the AI field. Meta has its own LLM OPT-175B which may be as large as ChatGPT and also has its own bot BlenderBot (first version launched in 2020) based on it. When the most advanced version BlenderBot 3 was launched in August 2022 (only available in the US for now), the "publicly available chatbot that improves its skills and safety over time" it was criticised for political misinformation and radical views (The Guardian, 10 August 2022). Hence Meta, unlike OpenAI, kept the application under wraps given the risk of bad press for a listed company like Meta.

Meta also faced another setback after it launched its science-based LLM Galactica in November 2022 – only to shut it down within a week following huge criticism for its incorrect output. According to Yann LeCun, Meta's chief AI scientist, (ZDNet, 23 January 2023): "In terms of underlying techniques, ChatGPT is not particularly innovative [...] it's nothing revolutionary, although that's the way it's perceived in the public. It's just that, it's well put together, it's nicely done." He added "Before we reach human level AI, we will have to reach Cat-Level & Dog-Level AI. We are nowhere near that" (Yann LeCun, 6 February 2023).

<sup>13</sup> <https://www.amazon.science/publications/alexatm-20b-few-shot-learning-using-a-large-scale-multilingual-seq2seq-model>

**Fierce competition for search-advertising can start**



“ that one of my goals for Meta is to build on our research to become a leader in Generative AI in addition to our leading work in recommendation AI

Mark Zuckerberg, Meta CEO, Q4 result call, 1 February 2023

Given the track record on Meta and how its platform was used for manipulation of opinions (Cambridge Analytica), we would understand the caution of a listed company as opposed to a start-up like OpenAI (although backed by Microsoft). But this doesn't mean the company is standing still on Generative AI. Below we list some of the Generative AI applications that Meta has already launched:

- ◆ [Make-a-Video](#): an AI system that allows users to create new content by converting text prompts to generate short high-quality video clips (29 September 2022)
- ◆ [Make-a-Scene](#): a multi-modal Generative AI concept designed to bring imagination to life, allowing users to create illustrations through inputs such as text description and freeform sketches (14 July 22)
- ◆ [Universal Music Translation network](#): a system for translating music across musical instruments and styles, for example: converting a Mozart symphony by an orchestra into the style of a pianist playing Beethoven (5 May 2019)
- ◆ [Voice conversion](#): a text-to-speech system that can convert any voice to a target voice (April 2019)

All the above can help creators and Meta users to generate interesting and engaging posts, making the app more relevant and value added for the users. The more relevant the easier it is to place tailor-made advertising, the very core business of Meta.

#### Cloud service provides the infrastructure

- ◆ Ample market size for cloud operators to capture:

15-20% of costs of each training request are related to computing costs, which can be captured by cloud computing providers. For instance, with 8 A100 GPUs, AWS charges USD20/hour vs RMB50k/month in China. All LLMs depend heavily on computing power and even more computing capacity are needed when providing service, vs training. Demand for computing power increases linearly with the number of users. So the reliance of computing capacity towards cloud computing providers will increase sizably as the LLMs are being used and retrained more frequently.

- ◆ The natural cost advantage for those with in-house capability benefitting players like Microsoft, Amazon, Google and Alibaba.

Each round of training would only take several (high single digit) RMBm for large companies with in-house GPU cluster, so it would be more cost effective for companies with in-house capability to explore Generative AI development than independent start-ups/smaller companies.

- **Using 3P public cloud:** GLM-130b model was trained with 96 instances equipped with 8 A100 GPUs with 40GB GPU memory per GPU in two months. One AWS P4 Instance equipped with 8 A100 GPUs would charge around USD20/hour. The total cloud computing cost would be ~USD2.8m (96machines\*USD20/hour\*61 days\*24hours/day).
- **Using in-house computing capability:** OpenAI trained GPT-3 with in-house 100 V100 GPU. Total computing cost (including depreciation cost of in-house GPU and energy cost) was less than USD750k (10,000 V100 GPUs \* USD9,300/V100 GPU /6 years of depreciation / 365 days per day \*14.8 days of training + 1287 MWh \* USD90/MWh), much less than USD2.8m in the above case.

## Technology

---

**Frank Lee\***

Head of Technology Research,  
Asia

The Hongkong and Shanghai  
Banking Corporation Limited  
frank.lee@hsbc.com.hk  
+852 2996 6916

**Pulkit Aggarwal\***

Associate  
Bangalore

---

*\* Employed by a non-US affiliate of HSBC  
Securities (USA) Inc, and is not registered/  
qualified pursuant to FINRA regulations*

### **A potential boost as an AI workload with real applications**

Generative AI, already gaining some traction in the form of ChatGPT should have a positive impact on the semiconductor industry which is currently going through a cyclical downturn. As Generative AI becomes more relevant, it will positively impact the demand for datacentres and, in turn, the GPUs and CPUs needed to run those datacentres. The improved CPU/GPU demand should increase demand for advanced chips. In the current weak end-demand environment, Generative AI could prove to be helpful in giving the semiconductor industry a boost.

Generative AI coming to the fore should help companies like NVIDIA (NVDA US, USD206.55, Reduce) which remains the biggest player in AI/GPU along with Advanced Micro Devices (AMD US, USD76.77, Hold) which should benefit from the demand for datacentres to run the AI workload as AMD continues to gain market share in server CPUs.

With an increase in adoption for Generative AI, the computing requirement will follow suite which is likely to help TSMC (2330 TT, TWD516, Buy) have a competitive advantage over its peers in advanced technology which would be required to churn out the advanced chipsets for server CPUs as well as the GPUs required to operate the datacentres to run the AI workload.

## Media

---

**Ali Naqvi\***

Analyst

HSBC Bank plc  
ali.naqvi@hsbc.com  
+44 20 7992 2176

**Joseph Thomas\***

Analyst

HSBC Bank plc  
joe.thomas@hsbcib.com  
+44 20 7992 3618

**Charles Pullan\***

Analyst

HSBC Bank plc  
charlie.pullan@hsbc.com  
+44 20 3359 7081

**Nicolas Cote-Colisson\***

Global Head of Communications  
Equity Research

HSBC Bank plc  
nicolas.cote-colisson@hsbcib.com  
+44 20 7991 6826

**Charlene Liu\***

Head of Internet and Gaming  
Research, Asia Pacific

The Hongkong and Shanghai  
Banking Corporation Limited,  
Singapore Branch  
charlene.r.liu@hsbc.com.sg  
+65 6658 0615

**Ritchie Sun\*, CFA**

Analyst, Internet Research

The Hongkong and Shanghai  
Banking Corporation Limited  
ritchie.k.h.sun@hsbc.com.hk  
+852 2822 4392

**Christina Chen\*, CFA**

Analyst, Internet Research

The Hongkong and Shanghai  
Banking Corporation Limited  
christina.z.chen@hsbc.com.hk  
+852 2822 2912

---

\* Employed by a non-US affiliate of HSBC Securities (USA) Inc, and is not registered/qualified pursuant to FINRA regulations

AI-generated advertising has the potential to be a game-changer for marketers – by enabling them to create personalised ads. For example, AI can enable a cosmetic company to analyse the skin-type and requirements of different customers and recommend specific products to them or it can enable a clothing company to use personalised Instagram captions tailor-made to suit different audiences based on demographics. However, content generation applications cover a far wider scope than just the advertising industry. We have already seen virtual characters in games, music generated and sang by AI, resignation letters and novels “written by” AI systems and potential 3D assets that can be used to fill the Metaverse. We also anticipate cost saving benefits via AI generated content. Below we highlighted some examples.

### Ad agencies

Although Generative AI is not currently a major part of the agencies’ offering, we suspect that the agencies will begin to utilise Generative AI as part of their ambitions to increase their exposure to the faster growth data/tech related revenue streams. WPP and Publicis generate 25%-35% of revenue from data and tech driven services and some of these services already rely on AI e.g. procuring optimised real time customer data for advertisers.

Company commentary (2 February) from Publicis (PUB FP, EUR75.48, Buy) suggests that clients are not yet particularly asking for tools like ChatGPT but the company acknowledges the importance of AI. It says that “*AI can’t be modern marketing itself*” and that it will still “*need the strategic and creative mind to make things happen.*”

Industry estimates from Gartner suggest that Generative AI could be more significant in marketing. They estimate that by 2025, 30% of outbound marketing messages from large firms will be synthetically generated, up from less than 2% in 2022.

### Text

Buzzfeed, a journalism platform, is reportedly planning to use artificial intelligence to personalise and enhance its online quizzes and content. COL Digital Publishing Group (300364 CH, CNY13.24, not rated) launched an AI tool to facilitate the writers on its 17k website to draft novels. The tool can generate text with inputs such as key words and the targeted writing style, so that writers can focus on ideas and plots. Jasper.ai helps to write resignation letters and emails for users and charges only USD1 per 750 words.

### Music

Generative AI could lead to more music content across streaming platforms such as Spotify, Apple Music, and TME. UMG said in October 2022 that streaming platforms are currently “ingesting 100,000 tracks a day” and that consumers are “increasingly guided to low-quality content”. We are concerned that increased use of Generative AI could raise the number of tracks added to streaming platforms. We think this could pose a risk to the larger music groups such as Universal Music Group (UMG NA, EUR22.27, Reduce) as this could lead to further market share losses. We would highlight that the music majors (UMG, Warner, Sony plus Merlin) are already losing market share on Spotify. The music majors accounted for 87% of music streams in 2017 but only 75% in 2022.

However, this will benefit music streaming companies which have invested in Generative AI through saving costs and lifting efficiency in music generation. In November 2022, TME created and released over 1,000 tracks containing vocals created by AI tech that mimics the human voice. One of these tracks has already surpassed 100 million streams, becoming the first song by an AI singer to be streamed over 100 million times across the internet. We see more collaboration across platforms on music creation via Generative AI. For example, StarX MusicX Lab under Beijing Kunlun (300418 CH) created five AI generated songs working with music streaming platforms such as Spotify, SoundCloud, QQ Music and NetEase Cloud music.

### Video games

AI is quite common in the gaming industry with application across game development including character creation, designing maps and virtual environments. Generative AI may be seen as a step forward in machine learning and artificial intelligence. Take Two (TTWO US, USD112.02, not rated) sees Generative AI like ChatGPT as a new tool that will allow gaming companies to work more efficiently and probably reduce some of the costs (Q4 2022 earnings call, 6 February 2023). The company added that these tools can help to enhance creativity, but with a limit, at least near term, as to how far AI much can replace human development. We think that Generative AI will likely also help different points in the journey, such as QA testing or other tools which could otherwise be outsourced.

Moreover, Generative AI can enhance in-game immersiveness by improving the game interactive and combat experience. For example, in Justice Mobile, NetEase (NTES US, USD85.21, Buy) has enriched 400+ Non-Player Characters (NPCs) with independent personalities and players can influence the destiny of NPCs during the game by interacting with them, which then can create new sub-plots/storyline. Also, in Justice Mobile, the enemy is designed to have a high level of intelligence with the ability to analyse the distance to players, players' movement and mimic the human thought process to set up a dedicated strategy (e.g. sneak attack) to combat the players.

### Metaverse

Generative AI is a major building block of the future Metaverse. The Metaverse has huge demands for content as developers strive to create 3D assets to fill out virtual worlds. Companies are using AI technologies such as Stable Diffusion, Prometheus AI and Ludo AI for creating virtual art work and other assets for games and other applications in the Metaverse.

In the case of Meta, given it has the aim to make it big in the Metaverse, having pumped in more than USD15bn into that field, we believe Generative AI could prove to be a very fruitful avenue for it, paving the way to creating more realistic and personalised virtual worlds.

## Education

---

**Christina Chen\*, CFA**  
Analyst, Internet Research  
The Hongkong and Shanghai  
Banking Corporation Limited  
christina.z.chen@hsbc.com.hk  
+852 2822 2912

---

\* Employed by a non-US affiliate of HSBC Securities (USA) Inc, and is not registered/qualified pursuant to FINRA regulations

ChatGPT, the AI advanced chatbot launched by OpenAI in late 2022, can not only chat with people, but also generate essays and even write programming code or debug. In this session, we rethink the role of technology and teacher in education, as well as how Generative AI could be ethically leveraged to facilitate learning.

### Used in the right way, an amazing tool

Although ChatGPT still makes simple errors, several future application scenarios could include:

**1) virtual tutoring:** AI-powered chatbots can serve as a personal virtual tutor, providing clear and easy-to-understand answers for questions asked by students. For course work and exams, AI-powered chatbots can immediately point out and fix students' mistakes while also making recommendations for improvement. Teachers, therefore, can delegate time-consuming repetitive tasks (such as grading papers and replying to general questions) to AI-powered chatbots and focus on curriculum research or improving student engagement. **2) personalised learning:** AI-powered chatbots can personalise the learning experience, by providing a tailored and interactive learning plan based on each student's proficiency and learning style, which is not realistic for human teachers and can enhance students' learning efficiency. Specifically, Generative AI can be disruptive for students with learning disabilities, through converting content into more digestible formats (e.g. text-to-speech) that better align with the student's learning capabilities. **3) 24/7 access:** AI-powered tools make learning accessible for all students, at anytime and anywhere, allowing learning outside regular school hours.



**Solutions on the way to tackle plagiarism concerns**

Despite the potential benefits AI-powered chatbots can bring to education in future, ChatGPT has raised concerns for educators around the world that AI chatbots could fuel academic dishonesty and hinder learning, with several education facilities rushed to ban such AI tools.

To tackle the concerns, although not yet a perfect solution, OpenAI has recently released a software tool to detect AI-generated writing from its chatbot. Moreover, the role of teacher and the way students learn and are assessed needs to evolve as we embrace Generative AI. Teachers will be more like facilitators guiding students through the learning process (vs source of knowledge), while course work and assessment need to be designed to focus on developing higher-order thinking skills (such as critical thinking, reasoning ability and creativity) rather than knowledge retention.

In all, just as the invention of calculators did not impede maths education, Generative AI won't substitute but will supplement the existing education system if used effectively and ethically, in our view.

---

**Ankur Agarwal\*, CFA**  
Senior Analyst  
HSBC Bank Middle East Ltd, Dubai  
ankurpagarwal@hsbc.com  
+971 4 423 6558

---

\* Employed by a non-US affiliate of HSBC Securities (USA) Inc, and is not registered/qualified pursuant to FINRA regulations

**Increased access to basic education, transformation of the higher education system**

We believe that Generative AI can help spread education and knowledge in areas of the world that have access to high speed internet but don't have access to schools or quality teachers. This is particularly applicable for emerging markets and Generative AI and ChatGPT can be tools to increase the access of knowledge in these parts of the world. Generative AI has the potential to transform the education system. While basic knowledge and information will become more commoditised or more democratic, we believe that educational institutes that invest in high quality teachers and tools that leverage Generative AI for teaching innovation and creativity to students will be the big winners. For example the demand for basic programming as Generative AI adoption picks up is likely to fade away. This also increases the possibility of Big Tech's (Microsoft, Google, Amazon) foray into education as they will be best placed to re-invent education which has AI as a backbone.

## Healthcare & Pharma

### Summary

AI and other novel data analytic tools have been used by the biopharma industry for over a decade in commercial and marketing (e.g. identifying switchers amongst prescribers) efforts. It is increasingly being adopted in drug discovery, where the most incremental impacts are likely to be. The merit in using AI and machine learning in the pharma and healthcare sector primarily lies in accelerated and streamlined R&D processes. Incorporating advanced algorithm and utilising computing power can improve the companies' R&D efficiency.

While wider application of Generative AI in the pharma and healthcare sector is yet to be seen, one could argue that there are some spaces this technology may be able to fill. For instance, with improved ability to analyse large amounts of data, machine learning algorithms have the potential to become more accurate over time. This is not with the restraint of healthcare data – it can also incorporate any data that are relevant in other fields – such as environmental epidemiology data. Further, it has the potential to unlock enhanced performance of MedTech and diagnostic products.

Ethic and privacy considerations remain major risks for the application of these technologies in this sector. While Generative AI's ability to generate anonymised data may help with the privacy issue, the sector remains cautious on the ethical issue it can potentially raise. AI applications need further refinement, and it still needs time to be fully integrated into biopharmaceutical R&D processes.

### From Predictive AI to Generative AI in the healthcare sector

The biopharmaceutical industry is one of the front-runners when it comes to adopting advances in computing power and new analytical approaches. According to a survey by GlobalData, in 2023, AI is believed to trend as the most disruptive emerging technology in the sector for a fourth consecutive year, ranked by nearly 40% of the healthcare industry professionals surveyed. Artificial intelligence is being used in various aspects of healthcare including drug discovery, medical imaging, and helping with clinical decisions. Because of its access to large amounts of data, AI can reveal patterns with disease and help with treatment. Recently, DeepMind had developed AlphaFold to solve the *protein folding problem* and generate a 3D structure of proteins from their amino acids sequence using AI and homology modelling. In terms of protein structure prediction, AlphaFold gives the scientific community some new perspectives. However, generating protein structure is not entirely independent because it uses existing structures from protein databases. In contrast to the hype around it, it has several other shortcomings like the non-prediction of nuclear magnetic resonance (NMR) structures, and enzyme associated ligand, ions, and co-factors.

While Predictive AI has been around for a while, Generative AI is relatively new in drug discovery. If drug molecules are generated rather than screened from libraries, they might overcome the challenges associated with their absorption, distribution, metabolism, excretion, and toxicity (ADMET) properties. Other drawbacks with predictive deep learning models like neural networks is that it needs a large amount of labelled training data and if the lead molecule is missing from the molecular library (or for a novel target) used for training, then the most appropriate drug might not be discovered.

Generative AI models like reinforcement learning (RL) are useful here as they overcome the limitations of supervised and unsupervised learning algorithms. Earlier RL models used SMILES (simplified molecular-input line-entry system) that used the letter code for molecules instead of their 3D-structure; however, molecules similar in structure could have very different SMILES. This is overcome by using Deep Q-network (DQN)-based RL algorithms, which use information about atom/bond addition or deletion,<sup>14</sup> making Generative AI more useful to create new molecules based on drug target.

**Shubhangi Gupta\*, Ph.D.**  
 Equity Analyst  
 HSBC Securities and Capital  
 Markets (India) Private Limited  
 shubhangi.gupta@hsbc.co.in  
 +91 80 4555 2143

**Yifeng Liu\***  
 Analyst, Healthcare Research  
 HSBC Bank plc  
 yifeng.liu@hsbc.com  
 +44 20 7 9919355

**Sezgi Oezener\*, CFA**  
 Analyst  
 HSBC Trinkaus & Burkhardt GmbH  
 sezgi.oezener@hsbc.de  
 +49 211 9103290

**Rajesh Kumar\***  
 Head, European Life Sciences  
 & Healthcare Research  
 HSBC Bank plc  
 rajesh4kumar@hsbcib.com  
 +44 20 7991 1629

\* Employed by a non-US affiliate of HSBC Securities (USA) Inc, and is not registered/qualified pursuant to FINRA regulations

**Drawbacks with predictive deep learning models like neural networks is that it needs a large amount of labelled training data and if the lead molecule is missing from the molecular library (or for a novel target) used for training, then the most appropriate drug might not be discovered**

14 Tang, B., Ewalt, J., Ng, H.L. (2021). Generative AI Models for Drug Discovery. In: Saxena, A.K. (eds) Biophysical and Computational Tools in Drug Discovery. Topics in Medicinal Chemistry, vol 37. Springer, Cham.  
[https://doi.org/10.1007/7355\\_2021\\_124](https://doi.org/10.1007/7355_2021_124)

### Applications of Generative AI in drug discovery

Generally, the application of AI in the biopharmaceutical industry is predominately at the drug discovery stage and most drugs developed using AI are still in the discovery or preclinical stage. According to GlobalData, about 70% of the drugs developed using AI have yet to reach the clinical stage. It is anticipated that it would take more than nine years for AI to peak in the drug discovery and development process.

**Insilico Medicine has been able to create inhibitors for fibrosis treatment in only 21 days with their AI model called GENTRL**

#### Insilico Medicine

Insilico Medicine, a biotechnology firm, has been able to create DDR1 kinase inhibitors for fibrosis treatment in only 21 days with their AI model called GENTRL.<sup>15</sup> Generally, drug development costs USD1bn and takes about 13 years; with the use of better computing algorithms involved in AI, the cost as well as the time required for drug development can be drastically brought down as seen here.

Researchers from IBM have also developed antimicrobial peptides using Generative AI for multidrug-resistant pathogens like *Klebsiella pneumonia* and also experimentally validated it.<sup>16</sup>

#### Absci

Merck (MRK US, USD109.07, not covered) calls this 'Next Horizon' technology and is collaborating with Absci in a USD610m deal.<sup>17</sup> Absci is a company that has performed generative biology for drug discovery in biologics via its Integrated Drug Creation™ platform. Its model learns how proteins interact with each other; a protein is then given as a prompt and the model can generate the corresponding antibody.<sup>18</sup> Absci claims that the generated antibody is "zero-shot", where the AI algorithm does not use any training data of antibodies that are known to bind to the target of interest, and are lab-validated.<sup>19</sup> This method allows for higher probability for drug success as the parameters are not optimised but the correct antibody is found for an antigen, making it more a personalised medicine. Absci claims that this can accelerate discovery and preclinical process from four-to-six years to two years and bring the cost down to USD5-7m compared to USD10-15m for traditional approaches.

**Merck calls this 'Next Horizon' technology and is collaborating with Absci in a USD610m deal**

**Absci has performed generative biology for drug discovery in biologics**

**Absci claims that this can accelerate discovery and preclinical process from 4-6 years to 2 years and bring the cost down to USD5-7m compared to USD10-15m for traditional approaches**

#### Product pipeline for Absci

| Drug name   | Company name | Therapy area       | Indication                          | Development stage | Drug geography |
|---|--------------|--------------------|-------------------------------------|-------------------|----------------|
| Monoclonal Antibodies for Coronavirus Disease 2019 (COVID-19)                                   | Absci Corp   | Infectious Disease | Coronavirus Disease 2019 (COVID-19) | Discovery         | Global         |
| Proteins for Unspecified Cancer, Unspecified Immunological Disorders and Unspecified Indication | EQRx Inc     | Undisclosed        | Unspecified                         | Discovery         | Global         |
| Proteins for Unspecified Cancer, Unspecified Immunological Disorders and Unspecified Indication | EQRx Inc     | Immunology         | Unspecified Immunological Disorders | Discovery         | Global         |
| Proteins for Unspecified Cancer, Unspecified Immunological Disorders and Unspecified Indication | EQRx Inc     | Oncology           | Unspecified Cancer                  | Discovery         | Global         |

Source: Company data, GlobalData

<sup>15</sup> Tang, B., Ewalt, J., Ng, H.L. (2021). Generative AI Models for Drug Discovery. In: Saxena, A.K. (eds) Biophysical and Computational Tools in Drug Discovery. Topics in Medicinal Chemistry, vol 37. Springer, Cham. [https://doi.org/10.1007/7355\\_2021\\_124](https://doi.org/10.1007/7355_2021_124)

<sup>16</sup> Das, P., Sercu, T., Wadhawan, K. et al. Accelerated antimicrobial discovery via deep generative models and molecular dynamics simulations. Nat Biomed Eng 5, 613–623 (2021)

<sup>17</sup> Merck leans into AI with USD610m in biobucks for Absci drug discovery pact, Annalee Armstrong, FierceBiotech, 7 JAN 2022

<sup>18</sup> How Generative AI and E.coli are speeding up new drug discovery, Sean Michael Kerner, VentureBeat, 10 Jan 2023

<sup>19</sup> Unlocking de novo antibody design with generative artificial intelligence, Amir Shanehsazzadeh et al, bioRxiv, 9th Jan 2023 (DOI:10.1011/2023.01.08.523187)

**BenevolentAI has also collaboration with Astra Zeneca for SLE/lupus and heart failure**

**In drug discovery, AI helps to select targets that are most likely to succeed**

### BenevolentAI

BenevolentAI (BAI NA, EUR3.26, not covered) also provides drug discovery using AI/ML methods. It uses data of genes, omics and molecular data. BenevolentAI has about five drugs in its pipeline including BEN-2293 for atopic dermatitis in Phase II; it also has collaboration with Astra Zeneca for SLE/lupus and heart failure. Its AI platform, including Generative AI,<sup>20</sup> can be applied to both small molecules as well as biologics. In drug discovery, AI helps in various ways – selecting targets that are most likely to succeed, disease agnostic models, accelerating discovery, and in identifying novel targets.

### Exscientia

Exscientia (EXAI, USD6.91, not covered) dedicates itself to a full-array of AI-driven processes to find smarter and faster ways of discover new and better drugs based on both small and large molecules. With its five different elements, Precision Target, Precision Design, Precision Experiment, Precision Medicine and Presentations & Publications, Exscientia is able to showcase the power of Generative AI design tools in drug development and discovery. The company now has a rich portfolio of early and late discovery molecules across oncology, immunology and other indications collaborating with major pharma companies such as BMS and Sanofi. Encouragingly, 1 molecule has reached early clinical Phase I/II stage.

These drug discovery/biotech companies have a traditional biopharma model which involves an upfront payment, then milestones and royalties as the project progresses.

### Recent company comments on AI and ML

| Company           | Event  | Comment  |
|-------------------|--|--|
| AstraZeneca       | AstraZeneca BioPharmaceuticals virtual event   | "So using artificial intelligence and something that we call knowledge graphs, working with companies like BenevolentAI, we're ...to give them a better sense of where novel points of interest, nodes of interest are occurring in disease areas that we're working in."  |
| Roche             | 2020 HY earnings call  | "Within the Tissue Diagnostics business, we've launched 2 CE-IVD algorithms with whole slide analysis... these algorithms were trained by leading pathologists and is using artificial intelligence. It's important because it gives really standardised and good answers in terms of expression of these different genes. You really need to use more modern technology."   |
|                   | Virtual digital technology and advanced analytics event  | "Roche has created quite a centre of excellence in developing these artificial intelligence-based tools, but our vision is really that this pathologist workflow software is a platform, an ecosystem, within the tissue diagnostics lab that is open. So there is a lot of imaging. We do imaging during the time the centre is produced. And then really after, I don't know, 5 steps of production, I think we take an image. And then this image is really analysed with artificial intelligence. And then we can already say after 5 steps, whether this really this sensor is fulfilling the quality standards or not. In the past, we produced that standard to the end and then tested it. And certainly, then the damage was done and completely done for the sensor. So it's just one thing where imaging helps with quality checks and then combined with artificial intelligence." |
|                   | Virtual ESG event  | "I think we last updated at our digitisation event last November, where we basically showed that we use artificial intelligence and to basically screen existing libraries with known structures, which work where we create de novo candidates, which then we test in screenings."  |
| Pfizer            | Barclays Global Healthcare conference  | "Now based on benchmarking, we think we can get the diagnosis rate into a range of 30% to 50%. And we actually think it can get into the higher end of that range. Broad awareness and education programs with our healthcare physicians, the appropriate use of non-invasive diagnostic procedures and then artificial intelligence and machine learning tools that we at Pfizer are developing to help support patient identification."  |
|                   | Barclays Global Healthcare conference  | "Across Pfizer, the other organisations to be able to really rapidly use our investments in digital and artificial intelligence to rapidly design structures that could be used for treatment that would fit the criteria that I mentioned. And actually, within the first 4 months, we had made approximately 600 compounds."   |
|                   | Analyst and investor call to discuss Pfizer-BioNTech COVID-19 Vaccine and Pfizer's novel COVID-19 oral antiviral treatment candidate | "In particular, the 4 months expedited design was enabled by artificial intelligence and machine learning techniques such as virtual screening to rapidly select the most promising molecules to make and profile. We used machine learning tools to predict the molecules with the best oral drug properties built on millions of data points, thanks to our long legacy in designing oral therapeutics."   |
| Novartis          | Investor Event   | "Sense allows us in a central location to use predictive modelling, artificial intelligence to look at all of our clinical trials in real-time. We can predict enrolment, we can look at quality, we can look at speed, this is a real screenshot. This isn't stock footage. We have 2 of these centres set up. We're building more. We're now using the same technology, which is integrating 15 different data systems, to now use that same system in manufacturing operations as well."  |
| Johnson & Johnson | ESG Investor Update webcast 2022   | "During the course of the past year, we have bolstered our global public health R&D pipeline, took steps to advance R&D capacity building in low-, middle-income countries and are unlocking the power of artificial intelligence and data sciences to predict disease outbreaks, advance diagnostics and accelerate our innovation."  |

Source: HSBC Research; company data

<sup>20</sup> Joshua Meyers, Benedek Fabian, Nathan Brown. De novo molecular design and generative models, Drug Discovery Today, Volume 26, Issue 11, 2021, Pages 2707-2715, ISSN 1359-6446

**Flatiron Health, a Roche subsidiary, harnesses the power of Predictive AI and real world data (RWD) to help identify potential eligible patients for clinical trial recruitment**

## Applications of AI in clinical trials

### Flatiron Health

Flatiron Health, a Roche (ROG.SW, CHF334.40, not covered) subsidiary, harnesses the power of Predictive AI and real world data (RWD) to help identify potential eligible patients for clinical trial recruitment, an area of continuing challenge to pharmaceutical R&D activities. Given the large spending proportion on clinical trials for pharma companies, improving efficiency of clinical trial recruitment is a space where a lot of potential may be seen with the merits of AI. Flatiron's database and algorithm are scalable and well positioned to incorporate more complex data types. With the help of natural language processing, for instance, Flatiron is able to capture and process detailed information in verbal communication between clinicians and patients and add these to the equation.

We have witnessed AI and ML strike some successful stories over the past years in pre-clinical discovery and other peripheral areas to clinical research. At the core of pharmaceutical R&D, clinical trials, on the other hand, take a relatively conservative view into AI and ML compared to other sectors in the life science and healthcare ecosystem. This is perhaps due to the highly regulated nature of the area. Traditionally as a data-collecting exercise, the purpose of clinical trials is to demonstrate safety and efficacy profile of a particular therapeutic intervention, and to validate pre-clinical discovery in human participants. Hence any analytical approaches in envisaging these purposes with patient-level data in clinical trials have been always closely scrutinised and this is unlikely to change in the near future. Design and analysis of clinical trials follows a hypothesis-driven paradigm as standard practice, this is the case for clinical studies funded by different sponsors.

With Generative AI, hopes are that some new areas will benefit. Generating synthetic data using routinely-collected patient data (e.g. electronic health record) may help with the commonly-debated issues such as data privacy and misuse, hence fostering the power of ML and AI in providing improved accuracy in some of the real-world evidence tools such as risk prediction, drug discovery and diagnostic imaging.

### AI – Top 10 disruptor companies in healthcare & pharma sector

| Company name                          | Parent/Subsidiary/Independent                       | HQ Country     |
|---------------------------------------|---|----------------|
| BenevolentAI Ltd                      | Parent  | United Kingdom |
| DeepBlue Technology (Shanghai) Co Ltd | Independent   | China          |
| Blue Belt Technologies, Inc.          | Subsidiary (of Smith & Nephew Plc)                  | US             |
| CommonSense Robotics Ltd              | Independent   | Israel         |
| CommercelQ Inc                        | Parent  | US             |
| Hexagon Bio Inc                       | Independent   | US             |
| Healthtel                             | Independent   | US             |
| Andrew Alliance S.A.                  | Subsidiary (of Waters Corp)                         | Switzerland    |
| AMRA Medical AB                       | Parent  | Sweden         |
| Image Stream Medical Inc              | Subsidiary (of Olympus Corporation of the Americas) | US             |

Source: HSBC Research, GlobalData



---

**Ankur Agarwal\*, CFA**  
 Senior Analyst  
 HSBC Bank Middle East Ltd, Dubai  
 ankurpagarwal@hsbc.com  
 +971 4 423 6558

*\* Employed by a non-US affiliate of HSBC Securities (USA) Inc, and is not registered/qualified pursuant to FINRA regulations*

## Retail

We believe that beyond the significant impact AI has on optimising retail supply chains, targeted marketing campaigns, product placement and pricing strategy, the retail landscape can leverage Generative AI in certain areas as well. Key aspects where Generative AI will impact the retail sector:

- ◆ **Reduce the cost of merchandising, and increase higher online sales conversion:** We believe that the advent of Generative AI will improve the customer experience and increase choice that the merchant can offer digitally without increasing the marketing cost or inventory. The consumer's interaction with the product (digitally generated though AI) would simulate their experience of trying a real product in a store and therefore will increase the online sales conversion. It would also imply a higher demand for customised products especially around fashion and apparel retail.
- ◆ **Inventory management will improve across the apparel retail business:** One of the most challenging parts of managing a fashion retail business is to optimise the number of stock keeping units (SKUs) and offer greater choice to the consumer. Generative AI can be a potential panacea for addressing this in the fashion retail industry and give a fillip to on-demand fashion.
- ◆ **Smaller but entrepreneurial consumer businesses may thrive:** Generative AI can help smaller but nimble consumer businesses to take on bigger established brands as cost of advertising will come down and the ability to scale up a brand without hiring expensive global icons from the sports/entertainment sector will increase. Also ability to launch hyperlocal products by leveraging Generative AI will go up.

## Consumer Staples

Although it is very early days, there are a number of areas in which we think that Generative AI can be of use to consumer staples, all of which stem fundamentally from the ability to tailor messages more tightly to individual consumers. Examples of this might include:

- ◆ **Marketing personalisation.** FMCG companies have steadily sought to increase the specificity of their marketing. For example, hyper-local segmentation can be used to tweak brand and marketing messages. Generative AI potentially has the ability to take this one step further by allowing marketing copy or campaigns to be even more finely matched to different consumer profiles. Clearly a level of insight would still be needed from the marketer's perspective to instruct the AI engine, but we think there should be scope to create much more targeted messages without a big increase in creative resources.
- ◆ **Brand chat functions and product recommendations.** More sophisticated chat functions can also allow for better direct interactions between consumers and brands. For example, a brand selling personalised vitamins or supplements could probably have a more useful and sophisticated online dialogue with consumers to help recommend them a suite of products. Or a food company could have an online recipe generator that can match a consumer's preference with recipe containing products from that particular company's portfolio.
- ◆ **Generate higher return on advertising/promotion.** Companies can deliver the same message using AI generated images/characters that resonate with the target consumer and significantly reduce the reliance on celebrities across sports/art globally but more so in emerging markets.

There are also potentially implications for companies' approaches to digital marketing. As of today, there is a lot of emphasis on ensuring that a company's products are always at the top of the page when a consumer carries out a related search. Yet if consumers use Generative AI to carry out searches into particular types of products, it is highly possible that they receive different brand or product recommendations from what might come out top in a Google search. Therefore we can envisage a whole new discipline of marketing where brands seek to ensure that they feature highly in the answer to whatever related question a consumer might ask. Any companies that fail to master this run the risk of falling behind their peers.

---

**Jeremy Fialko\*, CFA**  
 Head of Consumer Staples  
 Research, Europe  
 HSBC Bank plc  
 jeremy.fialko@hsbc.com  
 +44 20 7991 1562

**Ankur Agarwal\*, CFA**  
 Senior Analyst  
 HSBC Bank Middle East Ltd, Dubai  
 ankurpagarwal@hsbc.com  
 +971 4 423 6558

*\* Employed by a non-US affiliate of HSBC Securities (USA) Inc, and is not registered/qualified pursuant to FINRA regulations*

## Leisure

---

**Ali Naqvi\***

Analyst

HSBC Bank plc  
ali.naqvi@hsbc.com  
+44 20 7992 2176

**Joseph Thomas\***

Analyst

HSBC Bank plc  
joe.thomas@hsbcib.com  
+44 20 7992 3618

**Charles Pullan\***

Analyst

HSBC Bank plc  
charlie.pullan@hsbc.com  
+44 20 3359 7081

---

*\* Employed by a non-US affiliate of HSBC Securities (USA) Inc, and is not registered/qualified pursuant to FINRA regulations*

**Hospitality/Hotels:** Artificial intelligence in hospitality has already been helping businesses make more data-driven strategic decisions to optimise performance. This can include revenue management, cost efficiencies etc. The tool is capable of finding demand patterns, forecasting related prices and even planning human resource requirements. It can also help to automate back office tasks. Meanwhile, integrated chatbots can help create more human-like interactions, which can continuously improve. For hoteliers, the technology can help leverage the power of personalisation to improve service efficiency and customer retention. It can further use the large set of customer's data, making marketing efforts more effective.

**Gambling:** Generative AI can be used in a number of ways to help improve the gambling industry, from helping to identify problem gamblers, to providing better customer service, to helping create more immersive gaming experiences and improve pricing capabilities. AI can be used to analyse historical betting patterns and financial history of players which will help effectively identify players at risk of developing gambling addiction. This would make gambling operators' responsible gambling measures more effective. Generative AI can also help make games more engaging and personalised, giving players a diverse experience. It could also potentially enhance pricing capabilities in sports betting by factoring real time updates and thereby improve win margins of operators.

**Bus & Rail:** Meanwhile, in the Bus and Rail sector, it can help in fleet scheduling improvements, fatality reduction and pricing. Through automated scheduling tools, bus operators were able to create or adjust full timetables and vehicle schedules for individual services in minutes, a process that can typically take days. AI powered visual recognition technology enabled operators to alert coach drivers if they seem distracted or fatigued by shaking the seat, which led to reduced fatigue events. Through data driven tools, operators can enhance pricing capabilities, by analysing the travel pattern of passengers across different regions on a real time basis.

**Contract Catering:** Similarly, Contract Catering companies are using AI tools for operational improvements mainly through automated check-out systems in office canteens and fully automated vending systems. They are also using AI tools to analyse the consumption pattern of customers to prepare customised food menus for different regions and sectors. Food consumption patterns also help them to forecast demand of certain food products, leading to better management of inventory and reduced food waste.

## Banking

---

**Robin Down\***

Analyst

HSBC Bank plc

robin.down@hsbcib.com

+44 20 7991 6926

---

*\* Employed by a non-US affiliate of HSBC Securities (USA) Inc, and is not registered/qualified pursuant to FINRA regulations*

Banks are often early adopters of new technology – the cloud, for example, has definitely been a game-changer for financial services. Despite this, Generative AI is likely to be of surprisingly limited use for banks. Part of the reason for this is the very nature of Generative AI – its strength appears to be in taking existing data and being ‘creative’ with it; coming up with new text for example in order to answer a question.

But ‘creativity’ in the use of language is anathema for banks. When dealing with customers, whether that’s through product literature or even a simple chatbot; the language is highly regulated – key facts need to be conveyed, which an AI tool could do, but it also has to be expressed in a certain way so as not to mislead customers. That’s why call-centre operators work from scripts. The last thing a bank would want was an employee or an AI tool that chose to make up the conversation, no matter how factually grounded, from scratch each time.

Clearly, that’s not to say that Generative AI will have zero use for banks – indeed, we have already found generative methods useful in writing this piece – however, the use cases are likely to be limited.

Generative AI could replace, in a modest way, human involvement by helping to produce internal reports and some marketing content. For example, Generative AI may be able to help in preparing simple credit risk reports for SME’s based on financial accounts or producing internal management information reports on monthly operating performance. However, it feels unlikely that this would lead to a significant reduction in bank headcount – which ultimately is what we would be looking for in order for this technology to be particularly disruptive to the banking sector, given that staff costs typically account for 50% of a bank’s cost base.

# Here comes the science bit

- ◆ An intuitive understanding of how these models work is possible without being an expert in the technical details
- ◆ We explain how text-based AI models have become more sophisticated over time...
- ◆ ... and illustrate the most important categories of generative models

## Geek Squad: How do Generative AI models work?

Clearly a full description of how Generative Machine Learning models work is outside of the scope of a piece of sell-side research. However, it can be helpful for investors to have a high-level understanding of the process. The state of the art for Generative AI is improving at a rapid pace and it can feel difficult to keep up. A better understanding of the way in which these models work can help investors to develop an intuition for (1) where are the weaknesses in the current technology and (2) which developments are likely to come next.

### Neural networks

When it comes to dealing with unstructured data types such as text, image, video, and audio, state-of-the-art performance comes from a family of Machine Learning models known as *neural networks*. There is a fair amount of mystique associated with these models. Even the name “neural network” evokes the concept of a synthetic brain and this can easily cause the imagination to go into overdrive picturing some type of hyper-intelligent cyborg.

No rocket science needed

In practice the reality of neural networks is far more prosaic than this. For the purposes of this discussion, you can simply think of a neural network as being a very flexible function made up from a series of basic transformations applied to data. Importantly, whilst each of the transformations is simple by itself, by combining several of these transformations in sequence we can get incredibly complex behaviour. Since these transformations happen in sequence, it is common to refer to them as being different *layers* of the neural network.<sup>21</sup>

### How to train your neural network

Each of the layers in a neural network will have a (sometimes very large) number of parameters associated with it. The process of training a neural network is really the process of helping the model to have “good” values for these parameters. So how on earth do we do this?

We need some data which we use to train the model. We also need other data which we will use to validate and test the model. So we use the training data to train the model, and the validation and test data to determine whether the model is actually working or not.

<sup>21</sup> Note that in all the explanations above, nowhere did we mention the word “neurons”. This may surprise any readers who have tried to read up about neural networks before this. The earliest neural networks were inspired by (a very rough approximation to) how the brain works. As a result of this historical approach, introductory discussions of neural networks usually try to use the idea of neurons “firing” as a way to give an intuitive idea of how neural network models work. However, unless you have a background in neurobiology this simply replaces one system which you don’t understand (a neural network) with another system you don’t understand (the brain).

When we begin, the model parameters are chosen randomly so they are likely to be not good at all. We can quantify how bad by using a *loss function*. The first step of training the model is to slightly change the parameters in order to make them “less bad”; i.e. by moving them a tiny amount in the direction which reduces the value of the loss function. We then repeat this step a large number of times until eventually the model parameters are good.

### Show me the numbers

Neural networks are particularly strong at dealing with unstructured data such as text, image, audio, or video. However, since neural networks are really just a series of mathematical operations, they only work on numbers. As such, we need a way of converting our unstructured data into numbers.

Below we discuss various, increasingly sophisticated, ways in which this can be done for text; there are equivalent methods for other unstructured data types such as images and audio.

### Basic: Bag of words

A natural, but basic, approach is to simply map each word to a different number. Thus, the word “aardvark” might be given the number “1” and the word “zebra” might be the number “10,000”. With this approach, the words in a sentence are easily converted to a stream of integers<sup>22</sup>.

Whilst this approach can often be good enough for many purposes, it has some serious shortcomings. With each word being represented by a separate number there is no way for a machine learning model to understand relationships between words: in such a framework the words “human” and “person” are no more similar to each other than they are to the word “uranium”. So to better understand semantic relationships we need a more sophisticated approach.

### More sophisticated: Word embeddings

An alternative approach is to use something called *word embeddings*. Here, each word is mapped to a separate vector. The key question here is how do we know which vector to give to each word.

The process of training word embeddings is similar to the way in which we train the other parameters of the neural network. We create a matrix where each row corresponds to a specific word, so the first row in the matrix is the word vector for “aardvark” and the 10,000<sup>th</sup> row in the matrix is the word vector for “zebra”. To begin with the numbers in this matrix are randomly chosen. As such, when we use these vectors in a machine learning model they will give bad predictions. But, as we train the model, these vectors will get steadily better.

If we train this model on a task for which we have a lot of text data, then the resulting word vectors should be very good. Words that are similar to each other will end up with similar word vectors. Thus, when we use these vectors as inputs to other models the model will be able to understand a lot more about how language is actually used.

However, although this approach is very powerful, there is still scope for improvement. Since each word only gets a single vector there is no way for the model to represent words that can have different meanings in different contexts. For example, the word embedding for the word “bank” would be the same in the sentence “the bank approved my loan application” as in the sentence “this winery is on the left bank of the Gironde estuary” but the meaning of the word is very different in each sentence. Modern NLP approaches, however, can deal with situations like this.

---

Bag of words: Great name but a very basic modelling approach

---

Word embeddings: allow models to understand similarities between words

<sup>22</sup> In practice these integers would be represented by a “one-hot encoding”. So “aardvark” would be represented by a vector with “1” in the first dimension and zeros in all the others and “zebra” would be represented by a vector with “1” in the 10,000th dimension and zeros in all other dimensions.



## Transformers

Almost all state-of-the-art NLP models are now based on a type of model known as a *Transformer*. The inputs to these models are sequences of word embeddings<sup>23</sup>, so at the input layer there is no understanding of the semantic relationships in a sentence. However, through several layers of a process known as *self-attention* these models pay attention to the links between each pair of words in the sentence. This allows transformers to learn how the context in which a word is used will influence the meaning of the word.

**Transformers: a self-attention mechanism allows the model to learn how the context of a word can change its meaning**

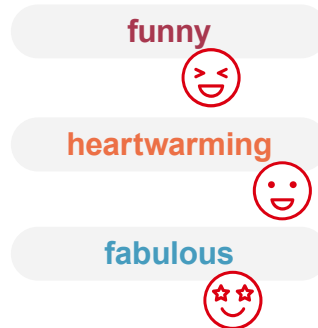
This means that by the time we get to the output layer of the transformer, the vector representing the word is context-sensitive. In other words, the output layer vectors for the word “bank” in the two previous examples would be different in each sentence, even though the input layer vectors would be the same. In the first sentence, the model would be able to detect that the word “loan” near the word “bank” suggests that the “bank” referred to is a financial institution, and, in the second, the proximity of “estuary” suggests that the “bank” is the water’s edge.

In addition to context-sensitive word vectors, transformer models are also able to produce high quality sentence vectors, in which similar sentences are represented by similar vectors. These vectors are very useful in many more traditional NLP use cases – such as text classification and semantic search. Indeed, we use Transformer models in this manner on a regular basis in our research.

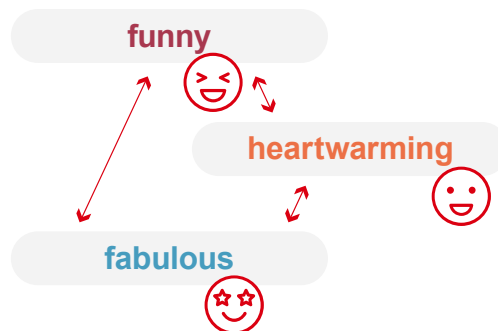
<sup>23</sup> When a sentence is broken into a stream of words, this is known as word tokenisation. For many modern NLP models the text is tokenised in a slightly different manner resulting in word-piece embeddings or byte-pair embeddings being learned rather than the word embeddings described in this section. The rest of the process remains as described regardless of the tokenisation approach used.

## How NLP models became more sophisticated over time

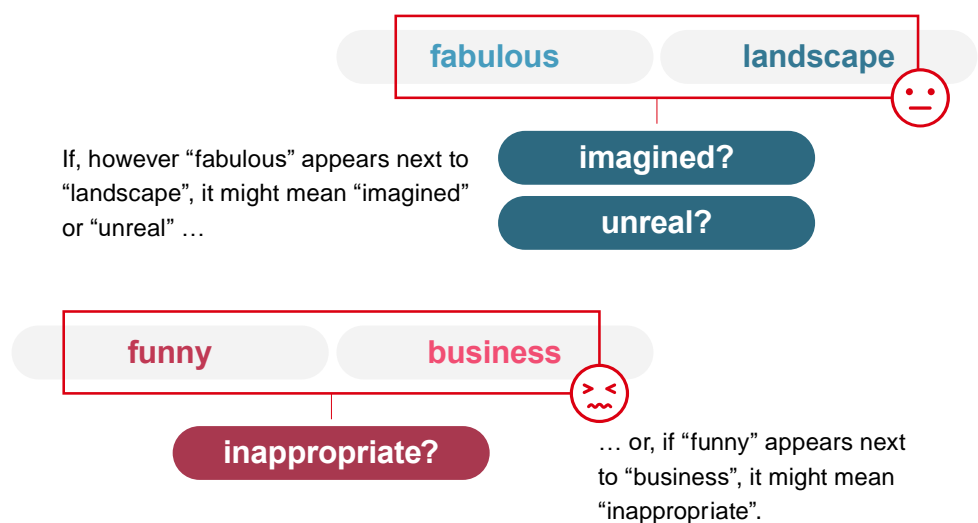
**1. Bag of words:** Each of these words has a positive connotation



**2. Embedding:** Each of these words has a positive connotation and there are relationships amongst all three



**3. Transformer:** Each of these words has a positive connotation and there is some kind of relationship between them, but in some cases, the context in which they are placed can change their meaning:



Source: HSBC

### Language models

In order for a model to learn context-sensitive word embeddings, we need a task where (1) we have lots of data from which the model can learn and (2) the task is challenging and requires the model to learn a lot about the complex manner in which language is used. A very common choice here is a process known as *language modelling*.

With a standard language model we give a transformer a series of words and ask it to predict which word comes next. A common variation on this is *masked language modelling* in which we give the model a piece of text where some words have been randomly removed; we then ask the model to predict which words were removed.

---

Language modelling: a surprisingly challenging task which allows the model to learn sophisticated behaviour about typical language use

Language modelling is a surprisingly challenging task. For example, imagine that you are given the phrase “as a Data Scientist I am good at” and asked to predict which words came next in that sentence. Words such as “coding”, “using jupyter notebooks”, and “statistics” may appear to be likely choices; whereas you would be surprised if the sentence ended with words such as “astrology” or “cage-fighting”. For a machine learning model to be able to make similar judgements in any general piece of text it needs to understand a lot about the way the world works.

Furthermore, it is very easy to find data to train a language model as all that is needed is to remove some words from a block of text. So-called *Large Language Models* (LLM) are models that have a vast number of parameters which need to be learned as part of the training process. The training data for these models is then typically scraped at large scale from the internet. In other words, these models are trained on basically everything on the internet.

With such a huge and varied set of examples from which to learn, these models end up encoding a lot of information about how language is used and how various subjects are discussed. The models can then be used to generate new text in a surprisingly coherent manner.

### What's next?

LLMs such as ChatGPT are well-known to give confident-sounding but untrue responses to questions<sup>24</sup>. Hopefully the description of LLMs above gives an understanding of why this happens: these models are simply generating sequences of text which are plausible continuations of the text which has come before. They are currently not built in a way that can ensure that the text generated is grounded in reality.

---

Can we imbue Generative AI models with truthfulness not “truthiness”?

A large part of the value proposition of Generative AI for Big Tech companies is that they may enable other companies to compete with Google in search (and, more importantly, compete for the associated advertising market). Significant research effort is currently being deployed towards methods that can incorporate information from knowledge bases into the responses of generative text models to search queries.

---

<sup>24</sup> For examples see almost any recent news article about ChatGPT or Google Bard.

## What can Generative AI do?

### Text generation

In this piece we've already focused on the quality of text being generated by text-generating models. However, these techniques are now also being used to generate other types of content than pure text.

For example, text generation models have been adapted to generate code very successfully. Most notable in this area is Github's Copilot<sup>25</sup> – an AI tool that will suggest code for developers. Copilot integrates with many of the code editors commonly used by developers and this is likely to lead to this tool being widely used. The Generative AI model that powers Copilot comes, yet again, from OpenAI<sup>26</sup>. Naturally, there are already open source competitors to Copilot such as Salesforce's CodeT5 model<sup>27</sup>. There is even a Generative AI model which produces Excel formulas<sup>28</sup> from a human-readable description of what the user is trying to do.

### Image generation

The Generative AI models that first captured the public imagination were image-generating models. This makes sense: human brains respond strongly to imagery.

Until recently, the best-performing models for generating images were based on a model architecture known as a Generative Adversarial Model (GAN). GAN are made up of two linked, and competing, models. One model, the generative model, is trained to generate new images and the other, adversarial, model is trained to identify whether a given image is real or model-generated. As the GAN is trained, the adversarial model gets more adept at identifying fake images and the generative model gets better at producing realistic looking images.

GANs were able to produce photorealistic looking images and the output of these models led to a significant amount of popular interest. A big driver of this interest from the general public was the creation of websites<sup>29</sup> which allowed users to generate images simply by refreshing their browser. However, GANs had a quite limited ability for a user to control the model output and so these models came to be viewed as an impressive trick rather than something with clear use-cases.

More recently, text-to-image models have been developed. These models allow a user to provide a text description of an image and will then output an image that corresponds to that description. The first such model that captured the public imagination was DALL-E from OpenAI, but this has quickly been followed by many others.

**Text-to-image models give a powerful impression that the models "understand" what a user is asking them to create**

These text-to-image models give a very powerful impression that the model truly understands what is meant by the input. The models can understand very complex image prompts and produce images in a wide range of styles. For example, the images in Charts C1 and C2 were created using DALL-E.

The image in Chart C1 was generated in response to the prompt "A cute meerkat, wearing a gi, performing martial arts". The image in Chart C2 was generated in response to the prompt "A cybertronic T-rex, LEDs, high detail". The first thing to notice about both of these prompts is that they are quite unusual – these are not common images that the model might be producing by performing small random variations on pre-existing images that it saw during the training data. Rather, these are novel images that have been generated by the model. The second thing to notice is that both images are a faithful representation of the image prompt. It's hard to shake the feeling that these models genuinely understand what we've asked them to draw – even when we know how these models actually work.

<sup>25</sup> <https://github.com/features/copilot/>

<sup>26</sup> <https://openai.com/blog/openai-codex/>

<sup>27</sup> <https://blog.salesforceairesearch.com/codet5/>

<sup>28</sup> <https://excelformulaibot.com/> Given the surprising reliance on Excel for many critical processes in financial market this model may already be having a big hidden impact in financial markets.

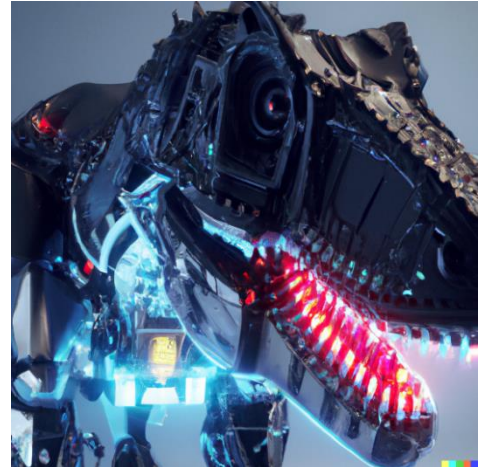
<sup>29</sup> For example <https://thispersondoesnotexist.com/>

C1. A whimsical image from DALL-E



Source: HSBC; generated using OpenAI DALL-E model using the prompt "A cute meerkat, wearing a gi, performing martial arts"

C2. Another surreal image from DALL-E



Source: HSBC; generated using OpenAI DALL-E model using the prompt "A cybernetic T-rex, LEDs, high detail"

To train image-to-text models such as DALL-E, we need pairs of images and an associated text description. One large-scale source of this is images on the internet since images on many websites have an associated text description known as Alt-Text. As a result of the way in which many sites write the Alt-Text to go with their images, the resulting models have learned surprising behaviour in response to specific terms in the image prompt. As users are discovering the influence of some of these inputs we are seeing the development of so-called *prompt engineering*.

As an example, compare the two images in Charts C3 and C4. These images were both trained using a model called Stable Diffusion. The image in Chart C3 was produced in response to the prompt "A beautiful landscape". We found that a user of this model reported that adding the strange-looking phrase "Canon EOS R3, f/1.4, ISO 200, 1/160s, 8K, RAW, unedited, symmetrical balance, in-frame" to the original prompt seems to be a reliable way to get the model to output a photorealistic image.

Chart C4 shows an example image output by Stable Diffusion in response to the prompt "A beautiful landscape, Canon EOS R3, f/1.4, ISO 200, 1/160s, 8K, RAW, unedited, symmetrical balance, in-frame". The similarity between the composition of the images in these two charts is coincidental – we tried several iterations of the prompts in order to get a pair of images that matched well in order to maximise the visual impact of the comparison.

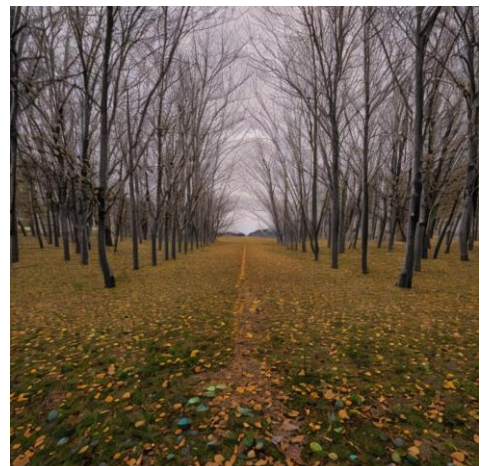
Will "prompt engineering" remain important, or will models learn to respond more naturally to typical human input?

C3. An image produced by the Stable Diffusion model using a simple prompt



Source: HSBC; generated using <https://huggingface.co/spaces/stabilityai/stable-diffusion> with the prompt "A beautiful landscape"

C4. And one generated using an engineered prompt



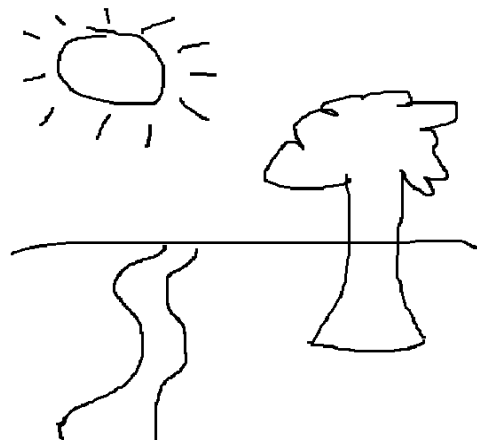
Source: HSBC; generated using <https://huggingface.co/spaces/stabilityai/stable-diffusion> with the prompt "A beautiful landscape, Canon EOS R3, f/1.4, ISO 200, 1/160s, 8K, RAW, unedited, symmetrical balance, in-frame"



The pace of development with image-generation has been impressive recently. Image generation techniques are now being used for tasks as diverse as

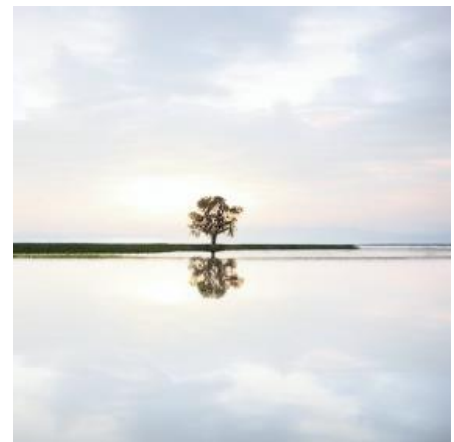
- ◆ Turning quick sketches into full artworks<sup>30 31</sup> – see Charts C5 and C6 below for an example of the input sketch and output image.
- ◆ Enhancing the resolution of poor quality images<sup>32 33</sup>
- ◆ Rendering an image in the style of another image<sup>34</sup>
- ◆ Removing rain from images<sup>35</sup>

**C5. A low quality sketch**



Source: HSBC

**C6. The resulting image**



Source: HSBC; generated using <https://huggingface.co/spaces/huggingface-projects/diffuse-the-rest> with the image in Chart C5 as input along with a prompt of "A photograph of a beautiful landscape"

Many audio-producing AI models have immediate commercial value

### Audio generation

There are several use cases for Generative AI models which can produce audio content:

- ◆ **Text-to-speech:** Given an input of a sequence of words, these models can generate audio of a realistic human voice saying the words. These models have immediate commercial value as they cut out the cost of paying human actors.
- ◆ **Music generation:** There are a range of audio-generations tasks for which Generative AI models have been developed<sup>36</sup>. The most immediately applicable in a commercial environment are models that can generate entirely new content when given inputs such as speed, tempo, and style of music<sup>37</sup>. In addition to this, there are also models that perform music continuation (in which the input to the model is a piece of music and the output of the model is how the model believes the piece should continue) and harmonisation models.
- ◆ **Sound-effect generation:** These models can generate sound-effects to accompany videos<sup>38</sup>. In a movie production this is often done manually in post-production so as these models continue to improve there is immediate commercial application.

<sup>30</sup> <https://www.playform.io/sketch>

<sup>31</sup> [https://github.com/huggingface/diffusers/tree/main/src/diffusers/pipelines/stable\\_diffusion](https://github.com/huggingface/diffusers/tree/main/src/diffusers/pipelines/stable_diffusion)

<sup>32</sup> <https://github.com/leveragegroup/esrgan>

<sup>33</sup> <https://ai.googleblog.com/2021/07/high-fidelity-image-generation-using.html?m=1>

<sup>34</sup> <https://arxiv.org/pdf/1508.06576.pdf>

<sup>35</sup> <https://arxiv.org/pdf/1701.05957.pdf>

<sup>36</sup> Again, OpenAI have been at the forefront here with one of the best-known models being Jukebox (<https://arxiv.org/pdf/2005.00341.pdf>)

<sup>37</sup> For an already commercialised example, see [https://soundraw.io/create\\_music](https://soundraw.io/create_music) and for a very recent example of cutting edge research in this field, see the MusicLM model recently released by Google (<https://google-research.github.io/seanet/musiclm/examples>)

<sup>38</sup> <https://arxiv.org/pdf/2002.10981.pdf>

**Video generation**

A natural evolution of image generation techniques is video generation. Video generation models often need to combine techniques from image and audio generating models. To see an example of the content that can now be produced by these models, please see the [video](#) accompanying this piece, large sections of which were generated by a combination of using ChatGPT to generate the script and Synthesia to generate video from the script. Both Google<sup>39</sup> and Facebook<sup>40</sup> have created video generation models and this is an area of active research. The commercial applications of video generation are obvious.

---

39 <https://imagen.research.google/video/paper.pdf>

40 <https://arxiv.org/abs/2209.14792>

# Disclosure appendix

## Analyst Certification

The following analyst(s), economist(s), or strategist(s) who is(are) primarily responsible for this report, including any analyst(s) whose name(s) appear(s) as author of an individual section or sections of the report and any analyst(s) named as the covering analyst(s) of a subsidiary company in a sum-of-the-parts valuation certifies(y) that the opinion(s) on the subject security(ies) or issuer(s), any views or forecasts expressed in the section(s) of which such individual(s) is(are) named as author(s), and any other views or forecasts expressed herein, including any views expressed on the back page of the research report, accurately reflect their personal view(s) and that no part of their compensation was, is or will be directly or indirectly related to the specific recommendation(s) or views contained in this research report: Mark McDonald, Davey Jose, Camila Sarmiento, James Pomeroy, Nicolas Cote-Colisson, Charlene Liu, Ritchie Sun, CFA, Christina Chen, CFA, Frank Lee, Ali Naqvi, Joseph Thomas, Charles Pullan, Shubhangi Gupta, Ph.D., Yifeng Liu, Sezgi Oezener, CFA, Rajesh Kumar, Jeremy Fialko, CFA, Ankur Agarwal, CFA and Robin Down

## Important disclosures

### Equities: Stock ratings and basis for financial analysis

HSBC and its affiliates, including the issuer of this report ("HSBC") believes an investor's decision to buy or sell a stock should depend on individual circumstances such as the investor's existing holdings, risk tolerance and other considerations and that investors utilise various disciplines and investment horizons when making investment decisions. Ratings should not be used or relied on in isolation as investment advice. Different securities firms use a variety of ratings terms as well as different rating systems to describe their recommendations and therefore investors should carefully read the definitions of the ratings used in each research report. Further, investors should carefully read the entire research report and not infer its contents from the rating because research reports contain more complete information concerning the analysts' views and the basis for the rating.

### From 23rd March 2015 HSBC has assigned ratings on the following basis:

The target price is based on the analyst's assessment of the stock's actual current value, although we expect it to take six to 12 months for the market price to reflect this. When the target price is more than 20% above the current share price, the stock will be classified as a Buy; when it is between 5% and 20% above the current share price, the stock may be classified as a Buy or a Hold; when it is between 5% below and 5% above the current share price, the stock will be classified as a Hold; when it is between 5% and 20% below the current share price, the stock may be classified as a Hold or a Reduce; and when it is more than 20% below the current share price, the stock will be classified as a Reduce.

Our ratings are re-calibrated against these bands at the time of any 'material change' (initiation or resumption of coverage, change in target price or estimates).

Upside/Downside is the percentage difference between the target price and the share price.

### Prior to this date, HSBC's rating structure was applied on the following basis:

For each stock we set a required rate of return calculated from the cost of equity for that stock's domestic or, as appropriate, regional market established by our strategy team. The target price for a stock represented the value the analyst expected the stock to reach over our performance horizon. The performance horizon was 12 months. For a stock to be classified as Overweight, the potential return, which equals the percentage difference between the current share price and the target price, including the forecast dividend yield when indicated, had to exceed the required return by at least 5 percentage points over the succeeding 12 months (or 10 percentage points for a stock classified as Volatile\*). For a stock to be classified as Underweight, the stock was expected to underperform its required return by at least 5 percentage points over the succeeding 12 months (or 10 percentage points for a stock classified as Volatile\*). Stocks between these bands were classified as Neutral.

\*A stock was classified as volatile if its historical volatility had exceeded 40%, if the stock had been listed for less than 12 months (unless it was in an industry or sector where volatility is low) or if the analyst expected significant volatility. However, stocks which we did not consider volatile may in fact also have behaved in such a way. Historical volatility was defined as the past month's average of the daily 365-day moving average volatilities. In order to avoid misleadingly frequent changes in rating, however, volatility had to move 2.5 percentage points past the 40% benchmark in either direction for a stock's status to change.

**Rating distribution for long-term investment opportunities**

**As of 31 December 2022, the distribution of all independent ratings published by HSBC is as follows:**

|             |     |  |
|-------------|-----|--|
| <b>Buy</b>  | 59% | (14% of these provided with Investment Banking Services in the past 12 months) |
| <b>Hold</b> | 34% | (13% of these provided with Investment Banking Services in the past 12 months) |
| <b>Sell</b> | 6%  | (7% of these provided with Investment Banking Services in the past 12 months)  |

For the purposes of the distribution above the following mapping structure is used during the transition from the previous to current rating models: under our previous model, Overweight = Buy, Neutral = Hold and Underweight = Sell; under our current model Buy = Buy, Hold = Hold and Reduce = Sell. For rating definitions under both models, please see “Stock ratings and basis for financial analysis” above.

For the distribution of non-independent ratings published by HSBC, please see the disclosure page available at <http://www.hsbcnet.com/gbm/financial-regulation/investment-recommendations-disclosures>.

To view a list of all the independent fundamental ratings disseminated by HSBC during the preceding 12-month period, please use the following links to access the disclosure page:

Clients of HSBC Private Banking: [www.research.privatebank.hsbc.com/Disclosures](http://www.research.privatebank.hsbc.com/Disclosures)

All other clients: [www.research.hsbc.com/A/Disclosures](http://www.research.hsbc.com/A/Disclosures)

HSBC and its affiliates will from time to time sell to and buy from customers the securities/instruments, both equity and debt (including derivatives) of companies covered in HSBC Research on a principal or agency basis or act as a market maker or liquidity provider in the securities/instruments mentioned in this report.

Analysts, economists, and strategists are paid in part by reference to the profitability of HSBC which includes investment banking, sales & trading, and principal trading revenues.

Whether, or in what time frame, an update of this analysis will be published is not determined in advance.

Non-U.S. analysts may not be associated persons of HSBC Securities (USA) Inc, and therefore may not be subject to FINRA Rule 2241 or FINRA Rule 2242 restrictions on communications with the subject company, public appearances and trading securities held by the analysts.

Economic sanctions imposed by the EU, the UK, the USA and certain other jurisdictions generally prohibit transacting or dealing in any debt or equity issued by Russian SSI entities on or after 16 July 2014 (Restricted SSI Securities). Economic sanctions imposed by the USA also generally prohibit US persons from purchasing or selling publicly traded securities issued by companies designated by the US Government as “Chinese Military-Industrial Complex Companies” (CMICs) or any publicly traded securities that are derivative of, or designed to provide investment exposure to, the targeted CMIC securities (collectively, Restricted CMIC Securities). This report does not constitute advice in relation to any Restricted SSI Securities or Restricted CMIC Securities, and as such, this report should not be construed as an inducement to transact in any Restricted SSI Securities or Restricted CMIC Securities.

For disclosures in respect of any company mentioned in this report, please see the most recently published report on that company available at [www.hsbcnet.com/research](http://www.hsbcnet.com/research). HSBC Private Banking clients should contact their Relationship Manager for queries regarding other research reports. In order to find out more about the proprietary models used to produce this report, please contact the authoring analyst.

**Additional disclosures**

- 1 This report is dated as at 23 February 2023.
- 2 All market data included in this report are dated as at close 21 February 2023, unless a different date and/or a specific time of day is indicated in the report.
- 3 HSBC has procedures in place to identify and manage any potential conflicts of interest that arise in connection with its Research business. HSBC's analysts and its other staff who are involved in the preparation and dissemination of Research operate and have a management reporting line independent of HSBC's Investment Banking business. Information Barrier procedures are in place between the Investment Banking, Principal Trading, and Research businesses to ensure that any confidential and/or price sensitive information is handled in an appropriate manner.
- 4 You are not permitted to use, for reference, any data in this document for the purpose of (i) determining the interest payable, or other sums due, under loan agreements or under other financial contracts or instruments, (ii) determining the price at which a financial instrument may be bought or sold or traded or redeemed, or the value of a financial instrument, and/or (iii) measuring the performance of a financial instrument or of an investment fund.

**Production & distribution disclosures**

7. This report was produced and signed off by the author on 22 Feb 2023 14:05 GMT.
8. In order to see when this report was first disseminated please see the disclosure page available at <https://www.research.hsbc.com/R/34/W7LtMcb>

# Disclaimer

## Legal entities as at 25 May 2022:

'UAE' HSBC Bank Middle East Limited, DIFC; HSBC Bank Middle East Limited, Dubai; 'HK' The Hongkong and Shanghai Banking Corporation Limited, Hong Kong; 'TW' HSBC Securities (Taiwan) Corporation Limited; 'CA' HSBC Securities (Canada) Inc.; 'France' HSBC Continental Europe; 'Spain' HSBC Continental Europe, Sucursal en España; 'Italy' HSBC Continental Europe, Italy; 'Sweden' HSBC Continental Europe Bank, Sweden Filial; 'DE' HSBC Trinkaus & Burkhardt GmbH, Düsseldorf; '000' HSBC Bank (RR), Moscow; 'IN' HSBC Securities and Capital Markets (India) Private Limited, Mumbai; 'JP' HSBC Securities (Japan) Limited, Tokyo; 'EG' HSBC Securities Egypt SAE, Cairo; 'CN' HSBC Investment Bank Asia Limited, Beijing Representative Office; The Hongkong and Shanghai Banking Corporation Limited, Singapore Branch; The Hongkong and Shanghai Banking Corporation Limited, Seoul Securities Branch; The Hongkong and Shanghai Banking Corporation Limited, Seoul Branch; HSBC Securities (South Africa) (Pty) Ltd, Johannesburg; HSBC Bank plc, London, Tel Aviv; 'US' HSBC Securities (USA) Inc, New York; HSBC Yatirim Menkul Degerler AS, Istanbul; HSBC México, SA, Institución de Banca Múltiple, Grupo Financiero HSBC; HSBC Bank Australia Limited; HSBC Bank Argentina SA; HSBC Saudi Arabia Limited; The Hongkong and Shanghai Banking Corporation Limited, New Zealand Branch incorporated in Hong Kong SAR; The Hongkong and Shanghai Banking Corporation Limited, Bangkok Branch; PT Bank HSBC Indonesia; HSBC Qianhai Securities Limited; Banco HSBC S.A.

## Issuer of report

**HSBC Bank plc**  
8 Canada Square  
London, E14 5HQ, United Kingdom  
Telephone: +44 20 7991 8888  
Fax: +44 20 7992 4880  
Website: [www.research.hsbc.com](http://www.research.hsbc.com)

In the UK, this publication is distributed by HSBC Bank plc for the information of its Clients (as defined in the Rules of FCA) and those of its affiliates only. Nothing herein excludes or restricts any duty or liability to a customer which HSBC Bank plc has under the Financial Services and Markets Act 2000 or under the Rules of FCA and PRA. A recipient who chooses to deal with any person who is not a representative of HSBC Bank plc in the UK will not enjoy the protections afforded by the UK regulatory regime. HSBC Bank plc is regulated by the Financial Conduct Authority and the Prudential Regulation Authority. If this research is received by a customer of an affiliate of HSBC, its provision to the recipient is subject to the terms of business in place between the recipient and such affiliate.

HSBC Securities (USA) Inc. accepts responsibility for the content of this research report prepared by its non-US foreign affiliate. The information contained herein is under no circumstances to be construed as investment advice and is not tailored to the needs of the recipient. All U.S. persons receiving and/or accessing this report and wishing to effect transactions in any security discussed herein should do so with HSBC Securities (USA) Inc. in the United States and not with its non-US foreign affiliate, the issuer of this report.

In the European Economic Area, this publication has been distributed by HSBC Continental Europe or by such other HSBC affiliate from which the recipient receives relevant services

In Singapore, this publication is distributed by The Hongkong and Shanghai Banking Corporation Limited, Singapore Branch for the general information of institutional investors or other persons specified in Sections 274 and 304 of the Securities and Futures Act (Chapter 289) ("SFA") and accredited investors and other persons in accordance with the conditions specified in Sections 275 and 305 of the SFA. Only Economics or Currencies reports are intended for distribution to a person who is not an Accredited Investor, Expert Investor or Institutional Investor as defined in SFA. The Hongkong and Shanghai Banking Corporation Limited, Singapore Branch accepts legal responsibility for the contents of reports pursuant to Regulation 32C(1)(d) of the Financial Advisers Regulations. This publication is not a prospectus as defined in the SFA. This publication is not a prospectus as defined in the SFA. It may not be further distributed in whole or in part for any purpose. The Hongkong and Shanghai Banking Corporation Limited Singapore Branch is regulated by the Monetary Authority of Singapore. Recipients in Singapore should contact a "Hongkong and Shanghai Banking Corporation Limited, Singapore Branch" representative in respect of any matters arising from, or in connection with this report. Please refer to The Hongkong and Shanghai Banking Corporation Limited Singapore Branch's website at [www.business.hsbc.com.sg](http://www.business.hsbc.com.sg) for contact details.

In Australia, this publication has been distributed by The Hongkong and Shanghai Banking Corporation Limited (ABN 65 117 925 970, AFSL 301737) for the general information of its "wholesale" customers (as defined in the Corporations Act 2001). Where distributed to retail customers, this research is distributed by HSBC Bank Australia Limited (ABN 48 006 434 162, AFSL No. 232595). These respective entities make no representations that the products or services mentioned in this document are available to persons in Australia or are necessarily suitable for any particular person or appropriate in accordance with local law. No consideration has been given to the particular investment objectives, financial situation or particular needs of any recipient.

This publication has been distributed in Japan by HSBC Securities (Japan) Limited. It may not be further distributed, in whole or in part, for any purpose. In Hong Kong, this document has been distributed by The Hongkong and Shanghai Banking Corporation Limited in the conduct of its Hong Kong regulated business for the information of its institutional and professional customers; it is not intended for and should not be distributed to retail customers in Hong Kong. The Hongkong and Shanghai Banking Corporation Limited makes no representations that the products or services mentioned in this document are available to persons in Hong Kong or are necessarily suitable for any particular person or appropriate in accordance with local law. All inquiries by such recipients must be directed to The Hongkong and Shanghai Banking Corporation Limited. In Korea, this publication is distributed by The Hongkong and Shanghai Banking Corporation Limited, Seoul Securities Branch ("HBAP SLS") for the general information of professional investors specified in Article 9 of the Financial Investment Services and Capital Markets Act ("FSCMA"). This publication is not a prospectus as defined in the FSCMA. It may not be further distributed in whole or in part for any purpose. HBAP SLS is regulated by the Financial Services Commission and the Financial Supervisory Service of Korea. This publication is distributed in New Zealand by The Hongkong and Shanghai Banking Corporation Limited, New Zealand Branch incorporated in Hong Kong SAR.

In Canada, this document has been distributed by HSBC Securities (Canada) Inc. (member IIROC), and/or its affiliates. The information contained herein is under no circumstances to be construed as investment advice in any province or territory of Canada and is not tailored to the needs of the recipient. No securities commission or similar regulatory authority in Canada has reviewed or in any way passed judgment upon these materials, the information contained herein or the merits of the securities described herein, and any representation to the contrary is an offense. In Brazil, this document has been distributed by Banco HSBC SA ("HSBC Brazil"), and/or its affiliates. As required by Resolution No. 20/2021 of the Securities and Exchange Commission of Brazil (Comissão de Valores Mobiliários), potential conflicts of interest concerning (i) HSBC Brazil and/or its affiliates; and (ii) the analyst(s) responsible for authoring this report are stated on the chart above labelled "HSBC & Analyst Disclosures".

This document is not and should not be construed as an offer to sell or the solicitation of an offer to purchase or subscribe for any investment. HSBC has based this document on information obtained from sources it believes to be reliable but which it has not independently verified; HSBC makes no guarantee, representation or warranty and accepts no responsibility or liability as to its accuracy or completeness. The opinions contained within the report are based upon publicly available information at the time of publication and are subject to change without notice. From time to time research analysts conduct site visits of covered issuers. HSBC policies prohibit research analysts from accepting payment or reimbursement for travel expenses from the issuer for such visits.

Past performance is not necessarily a guide to future performance. The value of any investment or income may go down as well as up and you may not get back the full amount invested. Where an investment is denominated in a currency other than the local currency of the recipient of the research report, changes in the exchange rates may have an adverse effect on the value, price or income of that investment. In case of investments for which there is no recognised market it may be difficult for investors to sell their investments or to obtain reliable information about its value or the extent of the risk to which it is exposed.

HSBC Bank plc is registered in England No 14259, is authorised by the Prudential Regulation Authority and regulated by the Financial Conduct Authority and the Prudential Regulation Authority and is a member of the London Stock Exchange. (070905)

If you are an HSBC Private Banking ("PB") customer with approval for receipt of relevant research publications by an applicable HSBC legal entity, you are eligible to receive this publication. To be eligible to receive such publications, you must have agreed to the applicable HSBC entity's terms and conditions for accessing research and the terms and conditions of any other internet banking service offered by that HSBC entity through which you will access research publications ("the Terms"). Distribution of this publication is the sole responsibility of the HSBC entity with whom you have agreed the Terms. If you do not meet the aforementioned eligibility requirements please disregard this publication and, if you are a customer of PB, please notify your Relationship Manager. Receipt of research publications is strictly subject to the Terms and any other conditions or disclaimers applicable to the provision of the publications that may be advised by PB.

© Copyright 2023, HSBC Bank plc, ALL RIGHTS RESERVED. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, on any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of HSBC Bank plc. MCI (P) 017/01/2023, MCI (P) 027/10/2022

[1208367]



## Main contributors



**Mark McDonald**  
**Head of Data Science and Analytics**  
 HSBC Bank plc  
[mark.mcdonald@hsbcib.com](mailto:mark.mcdonald@hsbcib.com)  
 +44 20 7991 5966

Mark is Head of Data Science and Analytics for HSBC Global Research. Mark is the lead author of HSBC's flagship quant publication, Data Matters, and is responsible for HSBC's proprietary Risk On – Risk Off analysis, Surprise Indices, and the Little Mac FX Valuations. Mark also advises investors on building systematic models and applying machine learning techniques to financial markets. Before joining HSBC in 2006, Mark obtained a DPhil in applied mathematics from the University of Oxford. His doctoral research investigating the dynamics of correlation networks in FX markets was sponsored by the HSBC FX Strategy team.



**Davey Jose\***  
**Thematic Analyst, Disruptive Technologies**  
 HSBC Bank plc  
[davey.jose@hsbcib.com](mailto:davey.jose@hsbcib.com)  
 +44 20 7991 1489

Davey Jose is a thematic analyst and Global Lead for Disruptive Technologies in HSBC Global Research, bringing a multi-disciplinary approach to interpreting the wider economy. Davey has over 17 years of experience in the financial services industry, having exclusively worked for HSBC in London. He first joined HSBC's European Advisory Group (M&A multi-sector execution desk), and then was a quants rate analyst. From 2008 to 2015, he was a portfolio manager/analyst on the Global Macro Strategies Desk. Davey has an MA in Pure & Applied Mathematics and Computer Science from Trinity College at the University of Cambridge.



**Camila Sarmiento**  
**ESG Analyst**  
 HSBC Securities (USA) Inc.  
[camila.sarmiento@us.hsbc.com](mailto:camila.sarmiento@us.hsbc.com)  
 +1 212 525 5901

Camila Sarmiento joined HSBC in July 2019, and is an ESG analyst based in NY. As part of the HSBC graduate programme, she previously worked with the equities team covering the LatAm infrastructure and transportation sectors. Camila holds a B.S. in Environmental and Sustainability Science with a concentration in Economics from Cornell University.

\* Employed by a non-US affiliate of HSBC Securities (USA) Inc, and is not registered / qualified pursuant to FINRA regulations

## How to access our research



Log on to the website  
[research.hsbc.com](http://research.hsbc.com)



Download the **HSBC Global Research** app



Subscribe to our **Podcasts** by logging onto the research website and selecting the podcast icon



Add **HSBC Research app** by accessing the symphony market and use the smart search functions



Ask our team your research related questions at  
[askresearch@hsbc.com](mailto:askresearch@hsbc.com)



Access Research via our **third-parties**:

- ◆ AlphaSense
- ◆ Bloomberg
- ◆ Bluematrix
- ◆ Factset
- ◆ Red Deer
- ◆ Refinitiv
- ◆ ResearchPool
- ◆ Sentio
- ◆ S&P Global Market Intelligence
- ◆ Visible Alpha/ ONEaccess